Linea™ CL

Camera User's Manual

2k, 4k, 8k and 16k Monochrome CMOS Line Scan

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

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Notice

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

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

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Linea™ CL Series Overview

Description

Teledyne DALSA introduces a new CMOS camera family with the 2k, 4k, 8k, and 16k resolution Linea monochrome cameras. These new camera models use Teledyne DALSA's single line, 7.04 µm x 7.04 µm (2k, 4k, 8k) or 3.52 µm x 3.52 µm (16k) pixel array, delivering both speed and responsivity at a competitive price.

The Linea CL lines can is a new affordable single line, camera delivering both speed and responsivity at a competitive price. This small, low power camera is designed for applications such as materials grading and inspection, transportation safety, automated optical inspection and general purpose machine vision.

The Linea CL camera is one of a new series of affordable easy to use digital cameras specifically engineered for industrial imaging applications requiring embedded image processing and improved network integration. Linea CL provides features to cycle a user defined sequence of imaging setups, features providing line & frame triggers, image transfer-on-demand, all part of a comprehensive camera package.

Linea uses industry standard CameraLink protocol to dependably capture and transfer images from the camera to the host PC.

Camera Highlights

Teledyne DALSA introduces a new CMOS camera family with the 2k, 4k, 8k, and 16k resolution Linea monochrome cameras. These new camera models use Teledyne DALSA's single line, 7.04 µm x 7.04 µm (2k, 4k, 8k) or 3.52 µm x 3.52 µm (16k) pixel array, delivering both speed and responsivity at a competitive price.

These small, affordable, low power cameras are designed for applications such as materials grading and inspection, transportation safety, automated optical inspection and general purpose machine vision.

Key Features

- High speed: up to 80 kHz (2k, 4k, 8k) and 48 kHz (16k)
- 2048, 4096, 8192, and 16,384 pixel resolutions
- Compact camera body

Programmability

- Multiple regions of interest for calibration and data reduction
- 8-bit or 12-bit output
- Small flat field and lens shading correction
- 8 programmable coefficient sets
- GenICam or ASCII compliant interfacing

Applications

- Automated optical inspection
- Security systems
- High performance sorting systems
- Materials grading and inspection systems
- Web inspection
- General purpose machine vision

Part Numbers and Software Requirements

This manual covers the Linea CL models summarized below. New models area added to this manual as they are released by Teledyne DALSA.

Camera	Resolution	Pixel size	Max. Line Rate	Lens Mount (threaded)	Product Number
Linea 2k CL	2048 x 1	7.04 x 7.04 µm	80 kHz	M42 x 1	LA-CM-02K08A-xx-R
Linea 4k CL	4096 x 1	7.04 x 7.04 µm	80 kHz	M42 x 1	LA-CM-04K08A-xx-R
Linea 8k CL	8192 x 1	7.04 x 7.04 µm	80 kHz	M72 x 1	LA-CM-08K08A-xx-R
Linea 16k CL	16384 x 1	3.52 µm x 3.52 µm	48 kHz	M72 x 1	LA-CM-16K05A-xx-R

Camera	Accessories	Order Number
2k and 4k	M42 x 1 to F-mount adapter for 12mm BFD lens, heavy duty with clip	AC-LA-00115-xx-R
2k and 4k	M42 x 1 to C-mount adapter for 12 mm BFD lens	AC-LC-00001-xx-R
8k and 16k	M72 x 0.75 F, F-mount adapter 12 mm BFD lens, heavy duty	AC-LN-00001-xx-R
8k and 16k	Linea Heatsink	AC-MS-00115-xx-R
	For a list of accessories go to http://www.teledynedalsa.com/imaging/products/cameras/accessories/	
	Optical filters are available from http://www.midwestopticalsystems.com/	

Teledyne DALSA Software Platform	
Sapera LT version 7.50 or higher includes CamExpert GUI application	Available for free download: http://www.teledynedalsa.com/imaging/products/software/sapera/lt/
Sapera provides everything needed to develop imaging applications.	
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 GenCP Software Requirements	
Support of GenICam GenApi version 2.3	General acquisition and control. File access: firmware, FFC, configuration data, upload & download.
Support of GenICam XML schema version 1.1	
GenICam™ support — XML camera description file	Embedded within Linea CL

Camera Specifications Overview

Specifications	Performance
Imager Format	High speed CMOS line scan
Resolution	2048, 4096, 8192, and 16,384 pixels
Pixel Size	7.04 µm x 7.04 µm (2k, 4k, 8k) and 3.52 µm x 3.52 µm (16k)
Pixel Fill Factor	100 %
Line Rate	Up to 80 kHz (2k, 4k, 8k) and up to 48 kHz (16k)
Exposure Time	4 µs to 3 ms
Bit Depth	8-bit or 12-bit, selectable
Connectors and Mechanicals	
Control & Data Interface	Base, Medium, Full, and Deca (8k/16k) Camera Link configurations (2 x SDR-26)
Power Connector	Hirose 6-pin male circular
Power Supply	+ 5 V to + 24 V DC (+4.8 V to +25.2 V maximum limits), 2k and 4k +12 V to + 24 V DC (+11.4 V to +25.2 V maximum limits), 8k and 16k
Power Dissipation	< 4.5 W (2k and 4k), < 8 W (8k), < 11 W (16k)
Size	62.0 mm (W) x 62.0 mm (H) x 30.9 mm (D) (2k and 4k) 76.0 mm (W) x 76.0 mm (H) x 36.7 mm (D) (8k and 16k)
Mass	< 190 g (2k and 4k), < 360 g (8k and 16k)
Operating Temp	0 °C to 65 °C, front plate temperature
Optical Interface	
Sensor to Camera Front Distance	12 mm
Sensor Alignment (aligned to sides of camera)	
Θ y (parallelism) x y z Θ z	0.08° or 100 µm ± 300 µm ± 300 µm ± 300 µm ± 0.3°
Compliance	
Regulatory Compliance	CE, FCC, and RoHS; GenICam

Operating Ranges	Performance				Notes
	2k	4k	8k	16k	
Dynamic Range dB	> 60	> 60	> 60	> 60	
Random Noise DN* rms	< 3.75	< 3.75	< 3.75	< 3.06	FFC enabled
Broadband Responsivity DN / (nJ / cm^2)	320	320	320	80	
Gain Nominal range	1x to 10x	1x to 10x	1x to 10x	1x to 10x	
DC Offset DN	7	7	7	7	FFC enabled
PRNU @ 50% Sat	< 1.5%	< 1.5%	< 1.5%	< 1.5%	
FPN DN	< 7	< 7	< 7	< 5	
SEE nJ / cm^2	12.5	12.5	12.5	50	
NEE pJ / cm^2	11.7	11.7	11.7	38.1	

Operating Ranges	Performance				Notes
	2k	4k	8k	16k	
Antiblooming (x Saturation)	> 100	> 100	> 100	> 100	
Integral non-linearity DN	1.5 %	1.5 %	1.5 %	1.5 %	

*DN = digital number

Test Conditions:

- Values measured using 12-bit @ 1x gain.
- 10 kHz line rate.
- Light source: broadband, quartz halogen, 3250 K with 700 nm IR cut-off filter.
- Front plate temperature: 45º C.

Compliance, EMI Certifications

For compliance and EMI certifications refer to the product page on the Teledyne DALSA website.

For more information on FCC and CE compliance refer to the EMC Declarations of Conformity section.

Supported Industry Standards

GenICam™

Linea cameras are GenICam™ compliant. They implement a superset of the GenICam™ Standard Features Naming Convention specification V1.5.

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

For more information see www.genicam.org.

Teledyne DALSA recommends using Sapera CamExpert as your Camera Link compliant camera interface application. CamExpert is the camera interfacing tool supported by the Sapera library and comes bundled with SaperaLT. Using CamExpert is the simplest and quickest way to send commands to and receive information from the camera.

Sapera uses the GenICam™ Generic Control Protocol (GenCP V1.0) to communicate with the camera over the Camera Link serial port. When communications are first established, Sapera downloads the GenICam™ XML Description file. This file details how to access and control the camera.

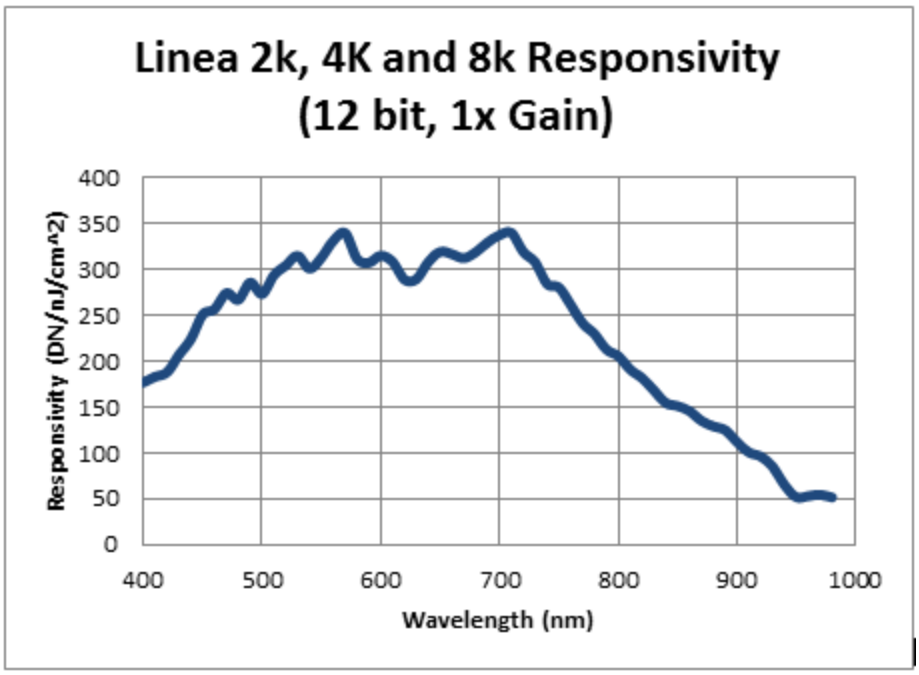
ASCII Commands

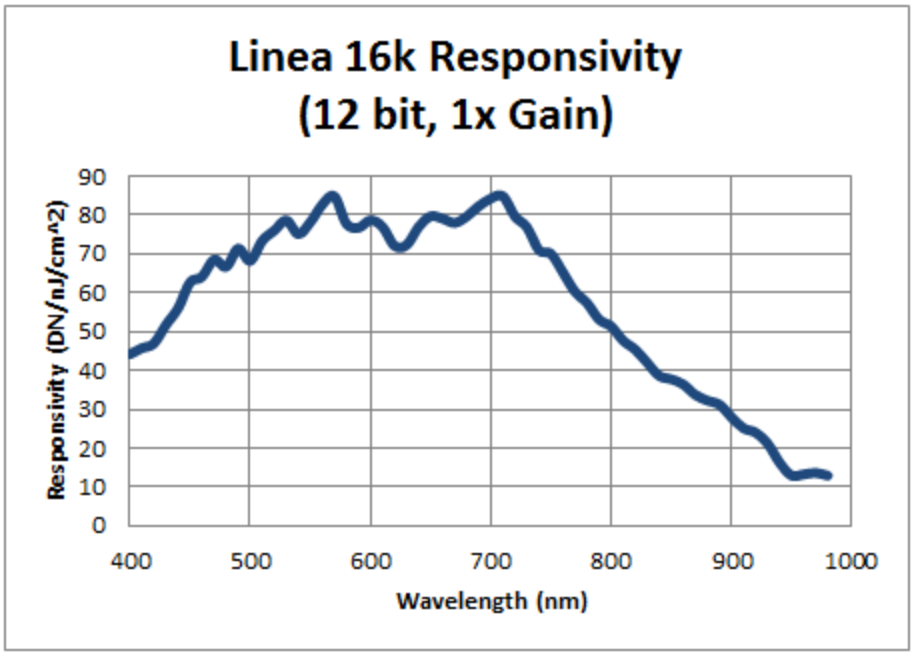
As an alternative to the CamExpert (or equivalent) GUI, you can communicate with this camera using ASCII-based commands. Using a terminal emulating program, establish a serial port connection with the camera.

In the ASCII interface press the ESC key; the communication mode will be switched into the ASCII command mode other than the GenICam mode.
A complete list of the commands and a description of how to access them can be found in Appendix B: ASCII Commands.

Responsivity

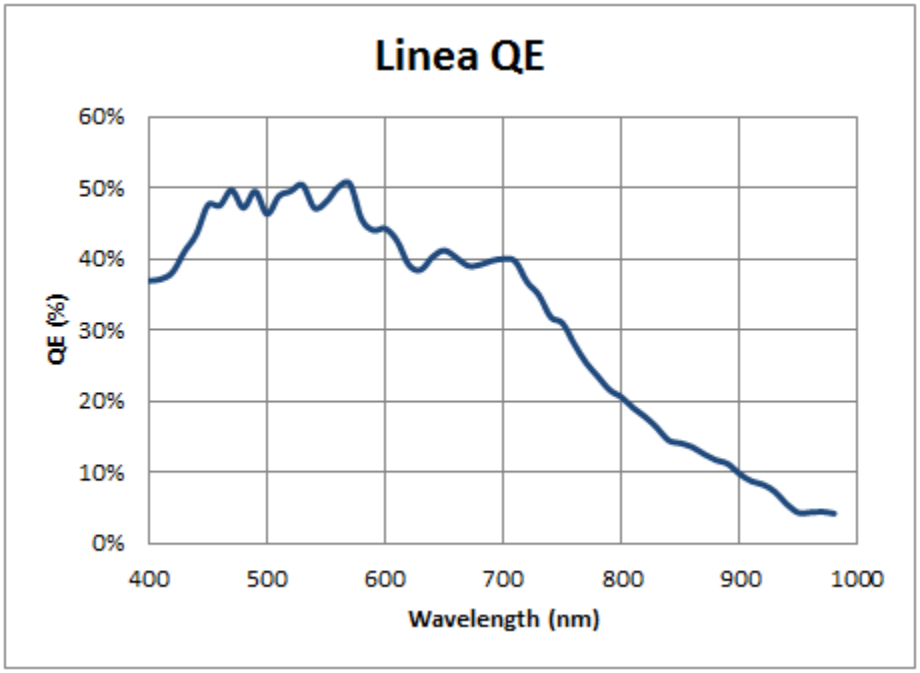
The responsivity graph describes the sensor response to different wavelengths of light (excluding lens and light source characteristics).





Effective Quantum Efficiency

The quantum efficiency graph describes the fraction of photons at each wavelength that contribute charge to the pixel.



Linea CL Camera Setup

System Precautions and Cleaning

Precautions

Read these precautions and this manual before using the camera.

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

- Confirm that the camera's packaging is undamaged before opening it. If the packaging is damaged please contact the related logistics personnel.
- Keep the camera's front plate temperature in a range of 0 °C to 65 °C during operation.
- Do not operate the camera in the vicinity of strong electromagnetic fields. In addition, avoid electrostatic charging, 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.

Cleaning the Device

To clean the device, avoid electrostatic charging by using a dry, clean absorbent cotton cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol.

To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains use a soft cloth dampened with a small quantity of neutral detergent and then wipe dry. Do not use volatile solvents such as benzene and thinners, as they can damage the surface finish.

Electrostatic Discharge and the CMOS Sensor

Image sensors and the camera bodies housing are susceptible to damage from electrostatic discharge (ESD). Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window. If this occurs, the charge normally dissipates within 24 hours and the sensor returns to normal operation.

Recommended System Requirements

To achieve best system performance, the following minimum requirements are recommended:

- High bandwidth frame grabber. For example, Teledyne DALSA Xtium-CL series frame grabbers: http://www.teledynedalsa.com/imaging/products/fg/#digital-cameralink.
- Operating systems: Refer to frame grabber documentation for supported platforms.

Setup Steps: Overview

Take the following steps in order to setup and run your camera system. They are described briefly below and in more detail in the sections that follow.

1. Install and Configure Frame Grabber and Software
2. Connect Camera Link and Power Cables
3. Establish communication with the camera

Step 1: Install and Configure Frame Grabber and Software

Teledyne DALSA recommends its Xtium-CL series frame grabbers or equivalent. Follow the manufacturer's installation instructions.

For additional information on configuring frame grabbers, see Appendix D: Camera, Frame Grabber Communication.

Note: By default, Camera Link mode is set to the standard 8-bit full mode which allows operation of up to 80 kHz (2k, 4k, 8k) or 48 kHz (16k) line rate. Set your Camera Link frame grabber up to receive the standard 8-bit full mode.

A GenICam™ compliant XML device description file is embedded within the camera firmware allowing GenICam™ compliant application to know the camera's capabilities immediately after connection.

Installing Sapera LT gives you access to the CamExpert GUI, a GenICam™ compliant application. Sapera LT is available free of charge for download from the Teledyne Dalsa website.

Step 2: Connect Camera Link and Power Cables

The camera uses Camera Link SDR26 cables for transmitting the Camera Link Base, Medium, Full or Deca configuration.

- Connect the required Camera Link cable(s) from the camera to the frame grabber installed on the computer.
- Connect a power cable from the camera to a power supply that can provide a constant voltage from +5 VDC to +24 VDC (2k and 4k) or +12 VDC to +24VDC (8k and 16k).

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 camera hardware.

Note: the use of cables types and lengths other than those specified may result in increased emission or decreased immunity and performance of the camera.

For more information on Camera Link connector specifications, see Appendix E: Camera Link Connector Information.

The following figure of the Linea CL back end shows connector and LED locations. See the Mechanical Specifications section for details on the connectors and camera mounting dimensions.

Power	
A	Hirose 6-pin • +5V to +24V DC (2k and 4k) • +12V to +24V DC (8k and 16k)
Control & Data	
B	Camera Link 26-pin SDR26 connectors
Status	
C	Diagnostic LED

Power Connector

WARNING! Grounding Instructions
It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. Input voltage requirements: +5 VDC to +24 VDC (2k and 4k models), 1 Amp. +12 VDC to +24 VDC (8k and 16k models), 2 Amp. Before connecting power to the camera, test all power supplies.

Hirose 6-pin Circular Male (Mating Part: HIROSE HR10A-7P-6S)

Pin	Description	Pin	Description
1	+5 V to +24 V DC (2k and 4k) +12 V to +24 V DC (8k and 16k)	4	GND
2	+5 V to +24 V DC (2k and 4k) +12 V to +24 V DC (8k and 16k)	5	GND
3	+5 V to +24 V DC (2k and 4k) +12 V to +24 V DC (8k and 16k)	6	GND

The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

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

- Apply the appropriate voltages.
- Protect the camera with a 1 or 2 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high-quality supplies in order to minimize noise.

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

Power over Camera Link

The Linea 2k and 4k Camera Link cameras are Power over Camera Link (PoCL) compatible*, but are not compliant with the full PoCL specification as their operation is dependent on the frame grabber used. These cameras exceed the 4 W PoCL power specification, but some frame grabbers, such as the Xtium frame grabber from Teledyne Dalsa, are able to supply sufficient power for the camera's operation.

PoCL can be enabled from within CamExpert. Be sure to connect the power supply to the Xtium frame gabber in the PC.

PoCL power can only be supplied through the Data 1 (base) camera link port.

* The 8k and 16k models do **not** support PoCL.

Camera Status LED

The Linea CL has one multicolor LED to provide a simple visible indication of camera state. The table below summarizes the operating states of the camera and the corresponding LED states. When more than one condition is active, the LED indicates the condition with the highest priority.

LED State	Definition
LED is off	No power or hardware malfunction
Blinking **Green**	Powering up or calibrating
Green	Ready
Red	Error. Check the built-in self test (BiST) register for the specific error

Step 3: Establish Communication with the Camera

The camera is designed to power up with a GenICam-compliant interface. CamExpert provides an easy-to-use GUI that can be used to set up and operate the camera.

The camera also comes with Teledyne DALSA's three letter command (TLC) interface option, which can be accessed using a suitable terminal program such as HyperTerminal™. If you want to use the TLC interface, refer to Appendix B: ASCII Commands.

To establish communication with the camera:

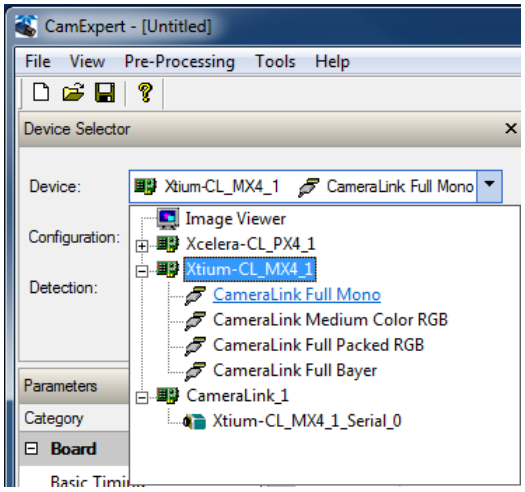
1. Power on the camera
2. Connect to the frame grabber
3. Connect to the camera

Power on the camera

Turn on the camera's power supply. You may have to wait while the camera readies itself for operation. The camera must boot fully before it will be recognized by the camera interface application (for example, CamExpert) — the LED displays steady green once the camera is ready.

Connect to the frame grabber

1. Start Sapera CamExpert (or equivalent Camera Link compliant application) by double clicking the desktop icon created during the software installation.
2. CamExpert will search for installed Sapera devices. In the Devices list area on the left side, the connected frame grabber will be shown.

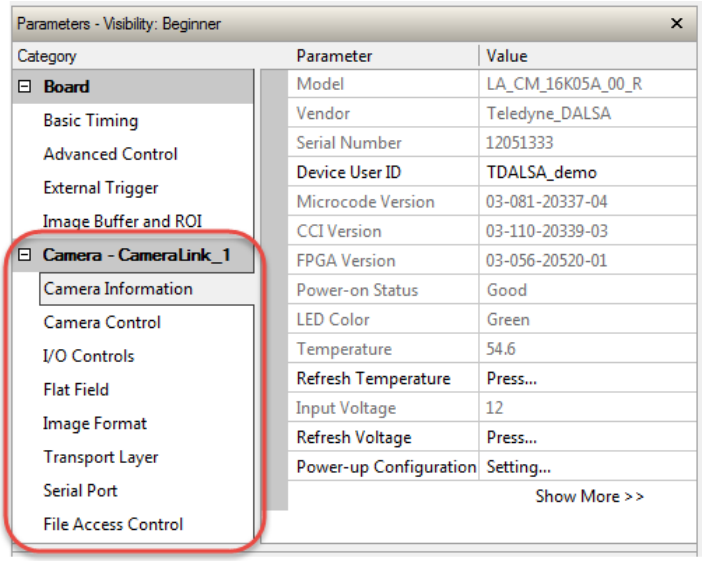


3. Select the frame grabber device by clicking on the name.

Note: The first time you set up the camera you will need to establish a communication link between the camera and frame grabber.

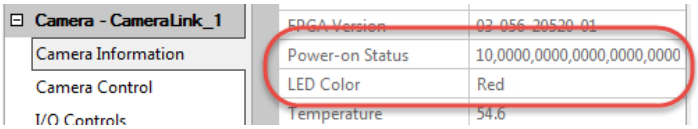
Connect to the camera

1. Start a new Sapera CamExpert application (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. In CamExpert, for Teledyne DALSA frame grabbers, the camera appears below the Board category.



Check LED Status

If the camera is operating correctly at this point, the diagnostic LED is steady green. If the LED is red, check the Power-on Status field and refer to Appendix C: Error and Warning Messages.



Software Interface

All the camera features can be controlled through the CamExpert interface. For example, under the Camera Control menu in the camera window you can control the line rate and exposure times.

Operate the Camera

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

Using CamExpert with Linea CL Cameras

The Sapera CamExpert tool is the interfacing tool for GenCP compliant Camera Link cameras, and is supported by the Sapera library and hardware. When used with a Linea CL camera, CamExpert allows a user to test most of the operating modes. Additionally CamExpert saves the Linea CL user settings configuration to the camera or saves multiple configurations as individual camera parameter files on the host system (*.ccf).

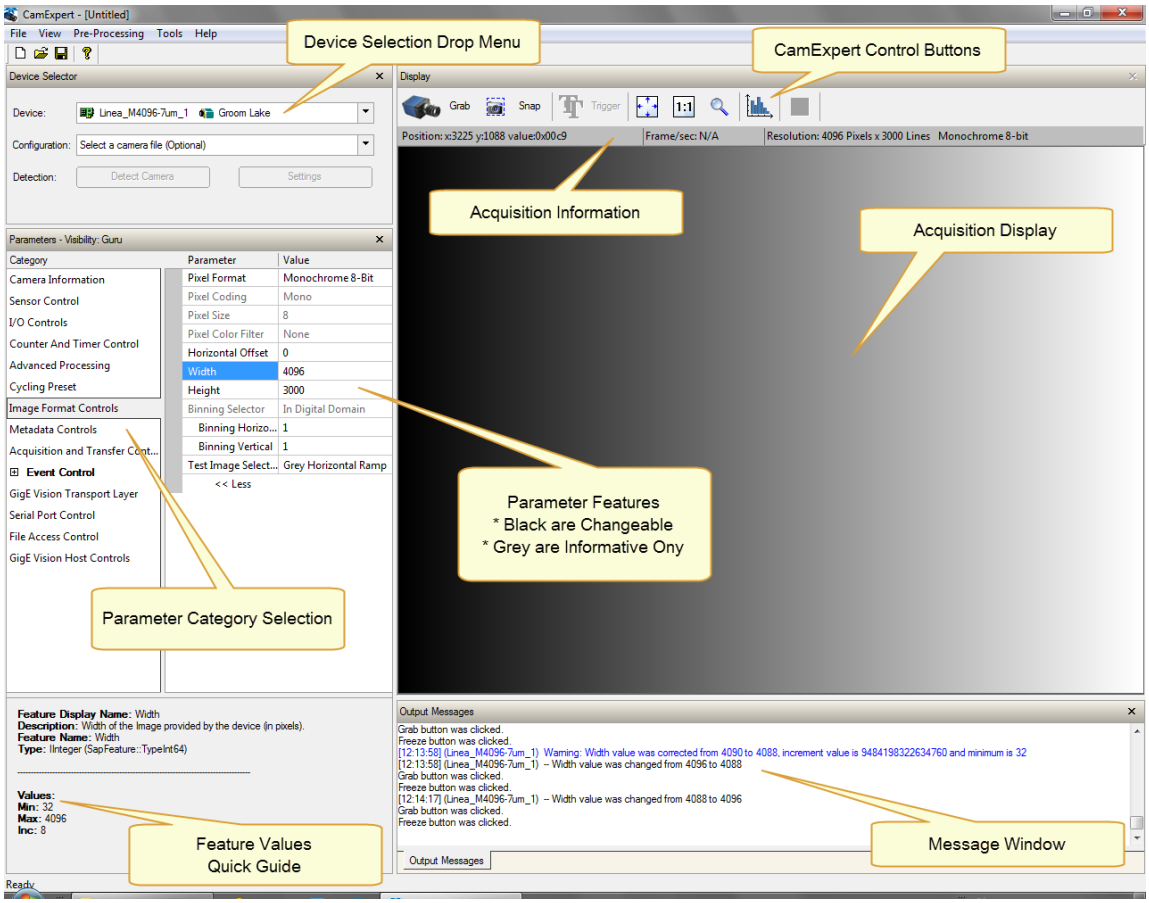
An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

Click on any parameter and a short description is displayed below the Category pane. The same context sensitive help is available by clicking on the  button then click on a camera configuration parameter. Click on the  button to open the help file for more descriptive information on CamExpert.

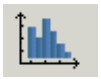
Note: The examples shown may not entirely reflect the features and parameters available from the camera model and camera mode used in your application.

CamExpert Panes

The various areas of the CamExpert tool are described in the figure below. Device Categories and Parameter features are displayed as per the device's XML description file. The number of parameters shown is dependent on the View mode selected (Beginner, Expert, Guru – see description below).



- **Device Selector pane**: View and select from any installed Sapera acquisition device. After a device is selected, CamExpert will only present parameters applicable to that device. Optionally select a camera file included with the Sapera installation or saved by the user.
- **Parameters pane**: Allows viewing or changing all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.
- **Display pane**: Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.
- **Control Buttons**: The Display pane includes CamExpert control buttons. These are:

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

- **Output pane**: Displays messages from CamExpert.

CamExpert View Parameters Option

All camera features have a Visibility attribute which defines its requirement or complexity. The states vary from Beginner (features required for basic operation of the device) to Guru (optional features required only for complex operations).

CamExpert presents camera features based on their visibility attribute. CamExpert provides quick Visibility level selection via controls below each Category Parameter list [<< Less More >>]. The user can also choose the Visibility level from the *View · Parameters Options* menu.

Creating a Camera Configuration File in the Host

- When using the Teledyne DALSA Sapera SDK – the CCF is created automatically via a save.
- When using a 3rd party SDK application, if that SDK supports **GenAPI 2.4**, then the process is automatic. Simply follow the 3rd party *Save Camera* method as instructed.
- If the SDK is based on **GenAPI 2.3** or lower, the user must call the command DeviceFeaturePersistenceStart before using the SDK *Save Camera* method and the command DeviceFeaturePersistenceEnd at the end of the save function.

Camera Operation

The following sections describe typical operations performed with the camera. The descriptions rely on the feature-based Camera Link GenCP protocol, using the Sapera CamExpert application. If you are using a different application, the display configuration will differ but the category, parameter (feature) names and possible values remain the same. References to related ASCII commands are provided.

Factory Settings

The camera has been calibrated and configured at the factory to be ready for operation when first powered up. The camera ships and powers up for the first time with the following factory settings:

- Camera Link Full, 8-bit pixels
- Maximum horizontal width (2048, 4096, 8192, or 16,384 pixels)
- Internal trigger, line rate 10 kHz
- Internal exposure control, exposure time 50 µs
- No horizontal/vertical binning
- Offset 0, Gain 1x (lowest value)
- Flat field calibration is not active as this feature is dependent on your light source and lens.

Typical Setup and Evaluation

Optical Configuration

Typically, the first thing you want to do is to evaluate the camera's image quality under operating conditions similar to those that you are likely to use in your application. To do this, take the following steps:

- The illumination, lens magnification, and focus should be set up as per you application.
- Getting the magnification right is best accomplished by setting the object-to-sensor distance. Use the formula *lens focal length x (2 + 1/magnification + magnification)* to calculate this distance. Magnification equals the sensor pixel size (7.04 µm or 3.52 µm) / (your object pixel size in µm).
- The back focal distance from the front plate to the sensor is 12mm. For complete mechanical specifications refer to the Mechanical Specifications section.

Camera Timing & Control

It is easiest and quickest to evaluate the camera using the internal timing setups for line rate and exposure time. The camera starts up in the default configuration of camera link full, 10 kHz line rate and 50 µsec exposure time.

- If this line rate is too slow for your application, you will get a compressed image in the scan direction. To increase the line rate, use the Internal Line Rate parameter in the Camera Control category.
- Adjust the exposure time; refer to the Exposure Controls section.
- Set your camera direction; refer to the Pixel Readout Direction (Mirroring Mode) section.

Acquiring an Image

You can now begin imaging.

- Use the system gain to adjust the camera output to achieve the desired response. The system gain range is from 1x to 10x. Refer to the Gain and Black Level (Offset) section.
- Once you have a suitable response, you can now focus the lens.
- The image may be darker at the edges due to lens vignetting, but this will be improved once the camera is calibrated.
- Calibration is performed using a white reference where your object is normally located. Refer to the Calibrating the Camera section. When calibrated, you should see an image from the camera that is flat field corrected with the lens at the target level you set.

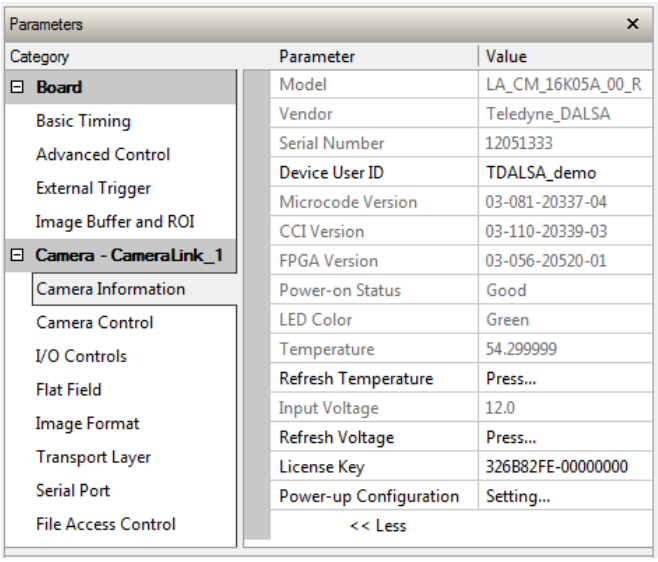
You are now ready to evaluate the image quality of the Linea camera under your operating conditions.

Check Camera and Sensor Information

Camera and sensor information can be retrieved via a controlling application—for example, the CamExpert GUI shown in the following examples. Parameters such as camera model, firmware version, sensor characteristics, and so forth, are read to uniquely identify the connected device.

The parameters used to select, load and save user sets are grouped together under the Camera Information category. There are 8 user sets available and one factory set.

The Camera Information category groups these parameters.



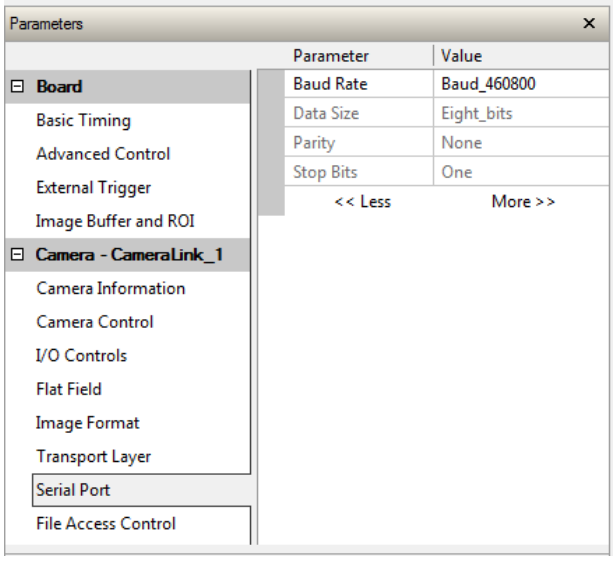
Verify Temperature and Voltage

To determine the voltage and temperature at the camera, use the **Refresh Voltage** and **Refresh Temperature** features.
The temperature returned is the internal temperature in degrees Celsius. For proper operation this value should not exceed 80 °C. If the camera exceeds the designated temperature it will stop imaging and the LED will turn red. After you have diagnosed and remedied the issue use the **Restart Camera** function.

Note: The voltage displayed is the camera's input voltage. The voltage measurement feature of the camera provides results within 1% of the actual voltage. The measurement can be used to set the applied voltage to the camera.

Set Baud Rate

The baud rate sets the speed (in bits per second—bps) of the serial communication port and is available as part of the Serial Port category.



Serial Port	
Parameter	**Description**
Baud Rate	Sets the baud rate used by the camera's serial port. Possible values are: • 9600 (factory default) • 19200 • 57600 • 115200 • 230400* • 460800* Note: During connection, by default, CamExpert automatically sets the camera to maximum allowable baud. *A Teledyne DALSA PX4 or equivalent frame grabber is required to achieve these baud rates.
Data Size	8 (read-only)
Parity	None (read-only)
Number of Stop Bits	1 (read-only)

Related ASCII Commands	
sbr	set baud rate

Camera Link Configuration

The following Camera Link configurations are available:

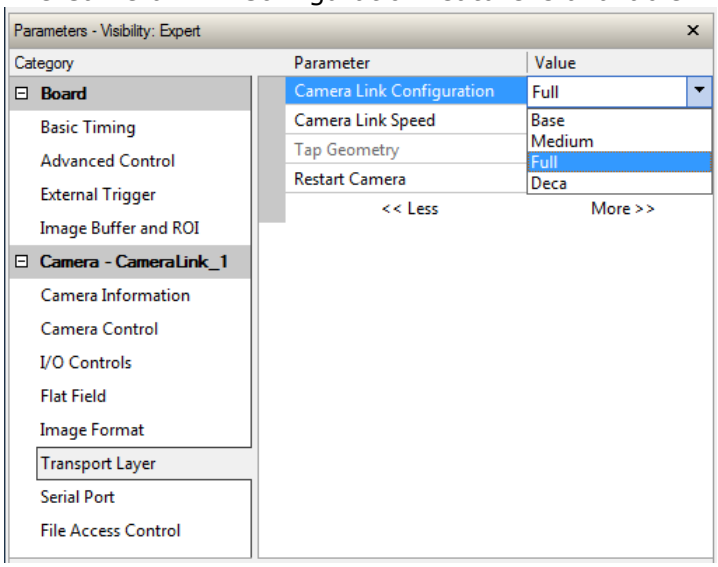
Name	Taps	Bits Per Pixel	Cables
Base	2	8, 12	1
Medium	4	8, 12	2
Full	8	8	2
Deca*	10	8	2

*8k and 16k models only

Available Camera Link speeds are model dependent:

Camera Model	Available Camera Link Speeds
2k, 4k, and 8k	77 MHz 50 MHz
16k	85 MHz 62 MHz

The Camera Link Configuration feature is available in the camera's Transport Layer category:



Related ASCII Commands	
clm	camera link mode
spf	set pixel format

Pixel Format

Use the Pixel Format feature, found in the **Image Format** category, to select the format of the pixel to use during image acquisition as either Mono 8 or Mono 12 bit depth.

Image Format	
Parameter	**Description**
Pixel Format	Sets the sensor pixel format. Possible values are: • Mono 8* • Mono 12 *Only available format for Full and Deca Camera Link configurations.

Related ASCII Commands	
spf	set pixel format

Internal Test Image Generator

The Linea CL camera includes a number of internal test patterns which easily confirm camera cable connections or driver installations, without the need for a camera lens or proper lighting. The patterns are subject to Linea CL processing such as Binning functions.

Use CamExpert to easily enable and select any test pattern from the drop menu while the camera is not in acquisition mode. Select live grab to see the pattern output.

The Test Pattern feature is available in the Image Format category:

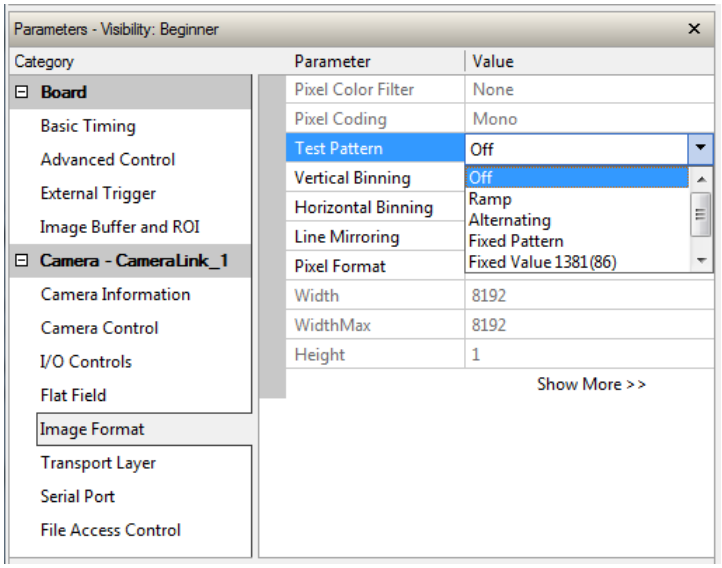


Image Format	
Parameter	**Description**
Test Pattern	Enable camera sensor test pattern. Possible values are:

	Off	Image is from the camera sensor.
	Ramp	Image is filled horizontally with an image that goes from the darkest possible value to the brightest.
	Alternating	Alternating values. For 12-bit output, pixel values alternate between 1381 (0x565) and 2746 (0xABA). For 8-bit output, pixel values alternate between 86 (0x56) and 172 (0xAC).
	Fixed Pattern	8 pixel cycling pattern. For 12-bit output, the pattern is 0x120|0x020|0x130|0x030|0x140|0x040|0x150|0x050. For 8-bit output, the pattern is 0x12|0x02|0x13|0x03|0x14|0x04|0x15|0x05.
	Fixed Value 1381(86)	Fixed Grey Value. For 12-bit output: pixel value = 1381 (0x565). For 8-bit output: pixel value = 86 (0x56).
	Fixed Value 32(2)	Fixed Grey Value. For 12-bit output: pixel value = 32 (0x20). For 8-bit output: pixel value = 2 (0x2).

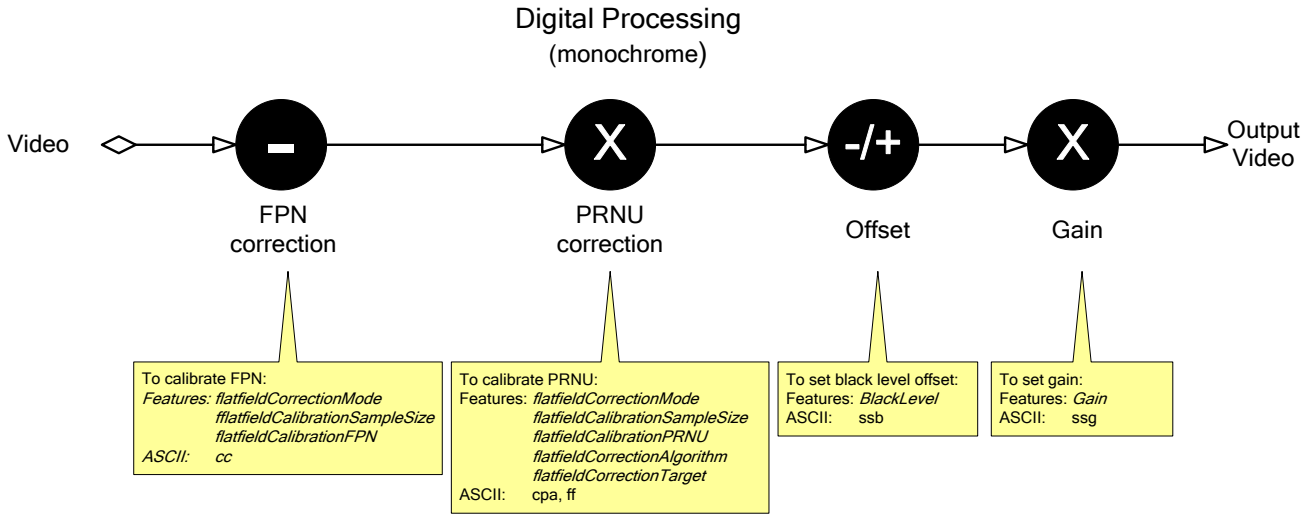
Related ASCII Commands	
svm	set video mode

Calibrating the Camera

Important Note: to ensure best results, the conditions under which you calibrate the camera (for example, temperature and illumination) should be as close to the actual operating conditions as possible.

The goal of calibration is for the camera to produce a uniform output image at a desired level while imaging a uniform white object under conditions equal to the optical setup for the user's application. Flat field coefficients consist of an offset and gain for each pixel. These are the first user corrections applied to the image. The flat field coefficients are saved and loaded with the user set.

The following diagram illustrates the camera's digital processing chain and associated GeniCam features and ASCII commands.



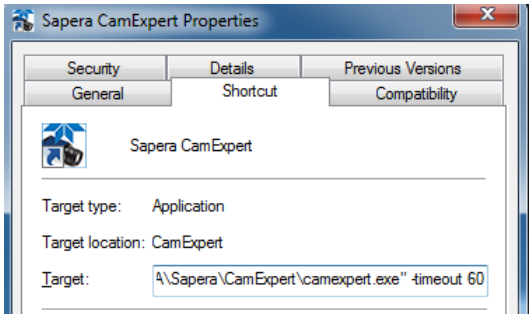
To calibrate the camera's flat field coefficients:

- Configure the camera to the required exsync and exposure timing, plus adjust the light level for normal operation. If used, any horizontal or vertical binning should also be applied.
- Set the system gain to a value that best suits the application; refer to the section Gain and Black Level (Offset) for more information on setting these values.
- The lens should be at the required magnification and aperture and slightly unfocused to avoid introducing granularity or details in the reference image (when calibration is complete, refocus the lens).
- As the white reference is located at the object plane, any markings or contaminants on its surface (that is, dust, scratches, smudges) will end up in the calibration profile of the camera. To avoid this, use a clean white plastic or ceramic material rather than trying to rely on a paper reference. (Ideally, the white object will be moving during the calibration process, as the averaging process of the camera will diminish the effects of any small variation in the white reference.)
- Adjust the system gain until the peak intensity is at the desired DN level and then calibrate the fixed pattern noise (FPN). Use a lens cap to ensure that no light reaches the sensor.

- Once complete, remove the lens cap and perform a photo response non-uniformity (PRNU) calibration using the desired target value (in DN). You want all the pixels to match. This target value should be higher than the peak values you saw while first setting up the camera.
- After several seconds the PRNU calibration will end and the correction coefficients will be enabled. The system gain remains as first set.
- The coefficients and gain parameters, timing and control configuration can be stored in any one of eight user sets and automatically retrieved at power-up or by user selection.

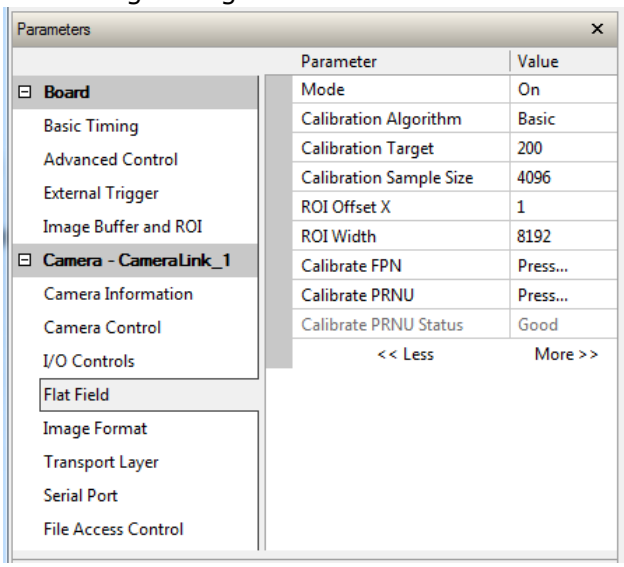
CamExpert has a default timeout of 20 seconds per command, which is too short for the FFC calibration to run fully. You can change the default timeout by setting a command line argument in the short-cut:

- Right-click on the short-cut in the start menu and select Properties.
- In the Target field, add the switch **–timeout 60** (See below)
  This increases the command timeout to 60 seconds.
  Note that you must include a character space between the closing quotation mark in the target and the hyphen before the timeout value.
- Repeat for desktop short-cut



Flat Field Parameters

This Flat Field category contains a number of features that are used to correct image distortion due to lens vignetting and uneven illumination.



Flat Field	
Parameter	**Description**
Mode	**Off** – Flat field correction coefficients are not applied. **On** – Flat field correction coefficients are applied. **Initialize** – Sending this value will reset all current coefficients (offsets to 0 and gains to 1x).
Calibration Algorithm	**Basic** – Direct calculation of coefficients based on current average line values and target. **Low Pass Filter** – A low pass filter is first applied to the current average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniform white or it is not possible to defocus the image.
Calibration Target	After calibration all pixels will be scaled to output this level. Range depends on pixel format: • 8-bit: 0 to 255 DN • 12-bit: 0 to 4095 DN
Calibration Sample Size	Number of lines to average when calibrating. Possible values: 2048 or 4096
ROI Offset X	Together with "ROI Width", specifies the range of pixels to be calibrated. Pixel coefficients outside this range are not changed. It is possible to calibrate different regions sequentially.
ROI Width	Width of ROI, in pixels.
Calibration FPN	Save average line (of "Calibration Sample Size" rows). This is the first user correction applied – it is subtracted from each line.

	This feature may not be of use to many users as the camera already subtracts true "dark current", but it may be useful for some to provide a per pixel offset correction. • Range 0 to 511 DN (12-bit) or 0 to 31 DN (8-bit) • Default value is 0 DN for each pixel
Calibration PRNU	Use "Correction Algorithm" to calculate the per pixel gain to achieve the specified target output. • Range 0 to 15.9998x • Default 1x

Gain and Black Level (Offset)

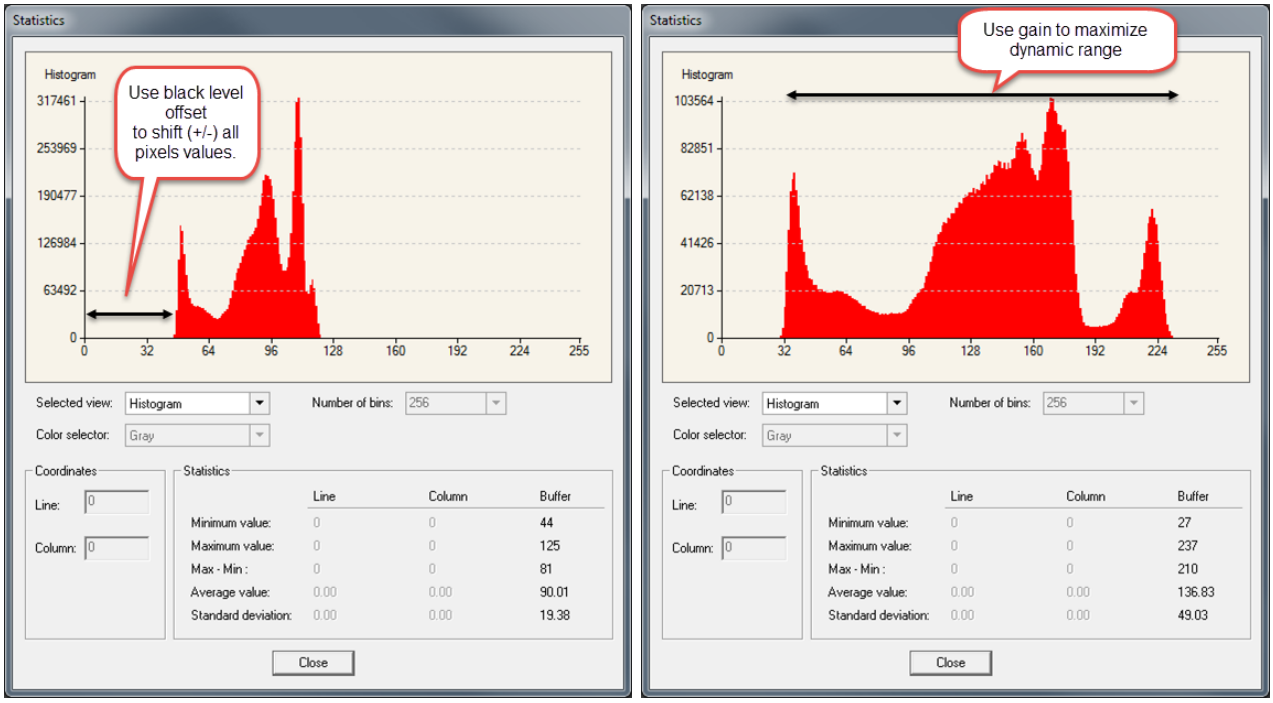
The gain and black level controls can make small compensations to the acquisition in situations where lighting varies and the lens iris cannot be easily adjusted. Optimal gain and black level adjustments maximizes the Linea CL dynamic range for individual imaging situations.

Use the Offset and Gain features to maximize the use of the output dynamic range (especially when pixel format is less than 12-bits). Typical use is to subtract minimum pixel value expected and then adjust the gain to up the maximum pixel value to approach full scale.

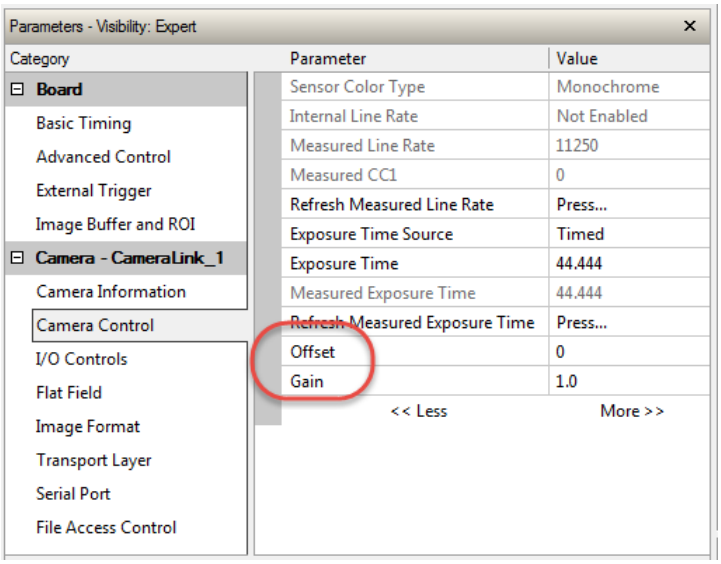
Features and limitations are described below.

- **Black Level** offset is expressed as a digital number providing a +/- offset from the factory setting. The factory setting optimized the black level offset for maximum dynamic range under controlled ideal dark conditions.
- **Digital Gain** is expressed as a multiplication factor. Note that increasing digital gain does not increase the low level resolution and increases the sensor noise proportionately.

A histogram or line profile (available in CamExpert) can provide useful information to determine the optimal settings for the typical image expected for an application. For example, the following histograms illustrate the effect of offset and gain applied to the original image to try to maximize the dynamic range.



The parameters that control gain and black level are grouped together in the Camera Control category.



Camera Control		
Offset	Single value added to each pixel. Apply a digital addition after an FPN correction: ± 1/8 of available range. Positive values may be used to measure dark noise. Depending on the the pixel format, different offset ranges are available:	
	12-bit mode	available range is -512 to +511.
	8-bit mode	available range is -32 to +31.
Gain	Floating point digital multiplier applied to each pixel. Set the gain as an amplification factor applied to the video signal across all pixels: 1x to 10x.	

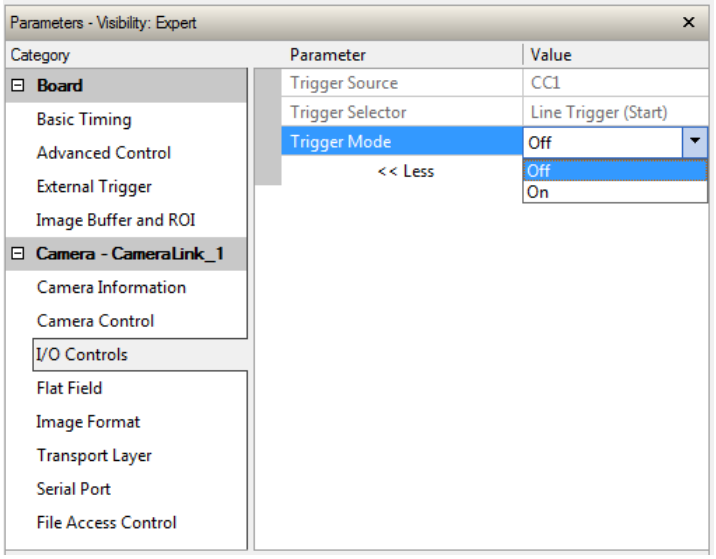
Related ASCII Commands	
ssb	set sensor blacklevel
ssg	set sensor gain

Trigger Modes

The camera's image exposures are initiated by a trigger event. The trigger event is either a programmable internal signal used in free running mode, an external input used for synchronizing exposures to external triggers, or a programmed function call message by the controlling computer. These triggering modes are described below.

Note: The Trigger Mode feature can only be adjusted when the Exposure Time Source parameter is set to "Timed".

The Trigger Mode feature is available in the camera's I/O Controls category:



I/O Controls	
Parameter	**Description**
Trigger Mode	• **Off:** Internal trigger (trigger disabled): The camera free-running mode has a programmable internal timer for line rate and a programmable exposure period. • **On:** External trigger (trigger enabled)**:** Exposures are controlled by an external trigger signal. The external trigger signal is the Camera Link control line CC1.

Related ASCII Commands	
stm	set trigger mode

Exposure Controls

Exposure control is defined as the start of exposure and exposure duration. Exposure control modes define the method and timing of controlling the sensor integration period. The integration period is the amount of time the sensor is exposed to incoming light before the video line data is transmitted to the controlling computer.

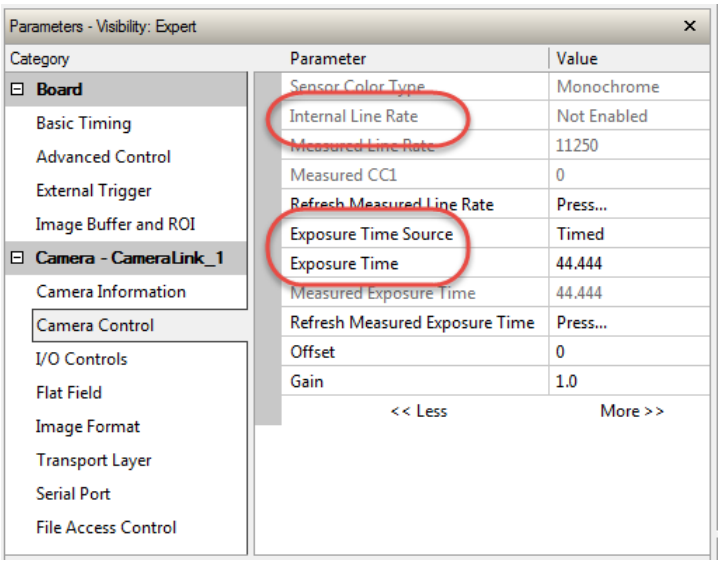
The camera can grab images in one of three ways, as described in the following table.

Description	Line Rate	Exposure Time	Trigger Source
Internal Programmable Exposure	Internal, programmable	Internal programmable	Internal
External Programmable Exposure	Controlled by EXSYNC pulse	Internal programmable	External
External Trigger Width Exposure	Controlled by EXSYNC pulse	External (EXSYNC)	External

You determine the three imaging modes using a combination of the Exposure Time Source parameters (including I/O parameters), Exposure Time and Internal Line Rate parameters.

- The feature **Exposure Time Source** selects the controlling method for the exposure.
- The start of exposure can be driven by an internal timer signal, an external trigger signal, or a software function call.
- For External Trigger signals, the relationship between an external line trigger and the exposure period is only applicable while the external line trigger does not exceed the maximum allowable line rate.
- If the external line rate exceeds the maximum line rate allowed for a mode, the camera will continue to output data at its maximum line rate. Though no image artifacts associated with over-speed will occur, you may notice that under over-speed conditions the image will appear compressed and the apparent distance travelled will be reduced.

The relevant exposure control features are grouped in the Camera Control category:



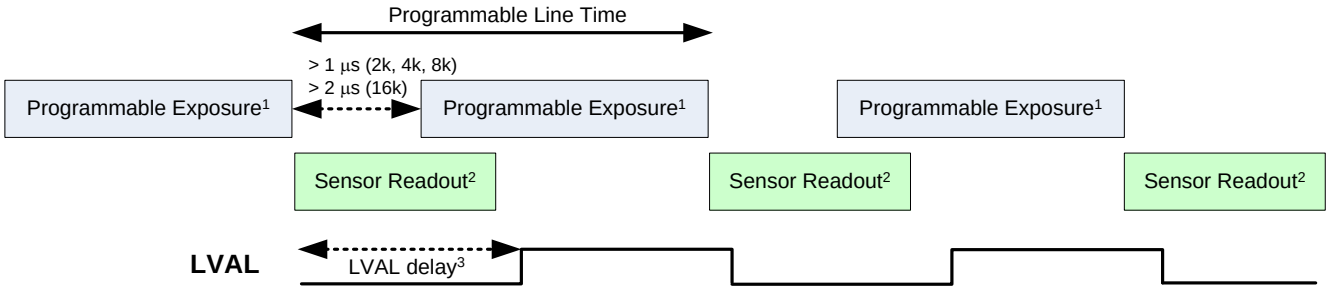
Camera Control		
Parameter	**Description**	
Internal Line Rate	Camera line rate in a range from 300 Hz up to 80 kHz (2k, 4k, 8k) or 48 kHz (16k). This feature is only available when the camera is in Internal Mode (free running): that is, the line trigger is disabled (Trigger Mode off).	
Exposure Time Source	Set the operation mode for the camera's exposure. Trigger Width is only available when Trigger Mode is enabled.	
	Trigger Width	Uses the width of the current line trigger signal pulse to control the exposure duration.
	Timed	The exposure duration time is set using the Exposure Time feature and the exposure starts with the Line Start event.
Exposure Time	Sets the exposure time (in microseconds). Exposure Time Source feature must be set to Timed.	

Related ASCII Commands	
ssf	set sensor framerate
sem	set exposure mode
set	set exposure time

Internal Programmable Exposure

The Linea CL in the Internal Programmable Exposure mode is the default free- running mode with the external trigger off and internal exposure control. This mode is not synchronized to an external signal. Line rate is the dominant factor when adjusting the line rate or exposure time. When setting the line rate exposure time will decrease (if necessary) to accommodate the new line rate. When adjusting the exposure time the range is limited by the line rate and has the following features:

- The *Trigger Source* feature (see I/O Control category) selects an internal signal as trigger.
- Programmable internal trigger, where the maximum line rate limit is related to the *Exposure Time* feature.
- Exposure duration is user programmable (exposure maximum is dependent on the line rate). Minimum exposure (in µs) is model dependent.



1. Exposure time > 4µs (all models)
2. Sensor readout time = 12.5µs (2k, 4k, 8k) or 20.8µs (16k)
3. LVAL delay = ~14.5µs (2k, 4k), 26µs (8k) or 41µs (16k)

To calculate the maximum line rate:

$$\text{Maximum line rate} = \frac{1}{(exposure\ time + low\ time*)}$$

*Exposure time must be greater than 4 μs, and low time greater than 1 μs (2k, 4k and 8k models) or greater than 2 μs (16k model)

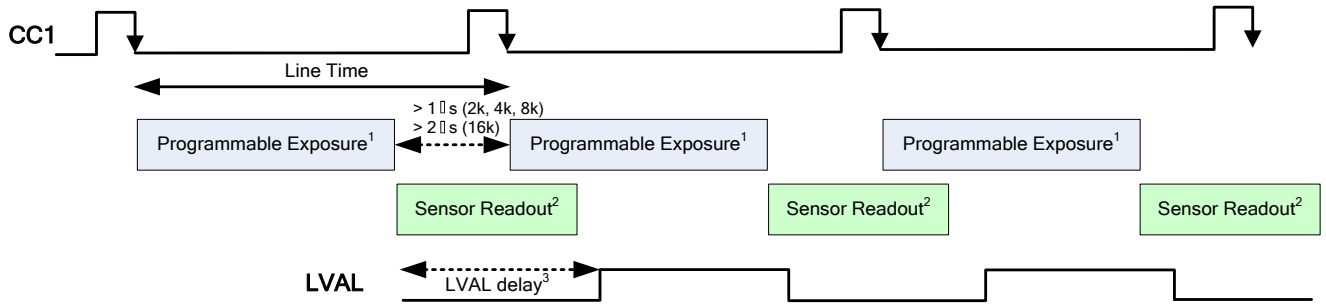
GenICam parameters to set:

- I / O Controls > Trigger Mode > Off
- Camera Control > Internal Line Rate > *user value*
- Camera Control > Exposure Time > *user value*

External Programmable Exposure

The External Programmable Exposure mode is similar to Internal Programmable except for the exposure start being an external user input.

- The TriggerSource feature (see I/O Control category) selects an external signal line as trigger.
- Line rates and exposure limits are as defined for Internal Programmable Exposure.
- The falling edge of the EXSYNC (CC1) signal triggers the start of the internal exposure.



1. Exposure time > 4μs (all models)
2. Sensor readout time = 12.5μs (2k, 4k, 8k) or 20.8μs (16k)
3. LVAL delay = ~14.5μs (2k, 4k), 26μs (8k) or 41μs (16k)

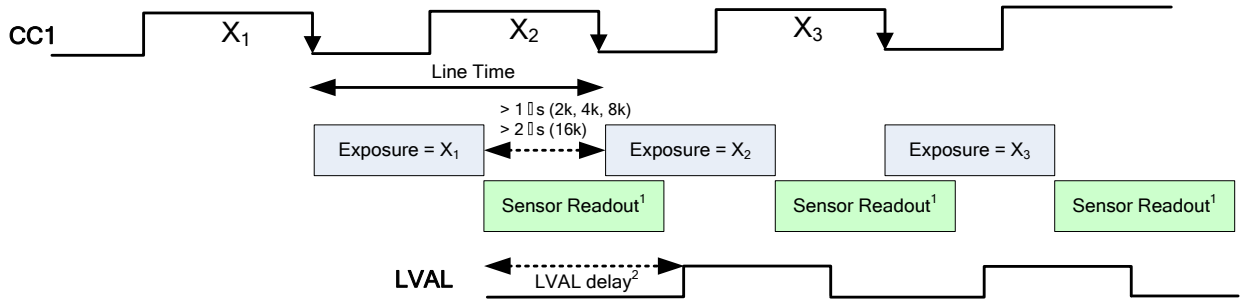
GenICam parameters to set:

- I / O Controls > Trigger Mode > On
- Camera Control > Exposure Time Source > Timed
- Camera Control > Exposure Time > *user value*

External Trigger Width Exposure

An alternative external trigger mode allows the external signal width to control the exposure duration. Line readout time remains similar to programmable exposure modes.

- EXSYNC (CC1) sets both the line period and the exposure time.
- The EXSYNC high duration sets the exposure time and the falling edge triggers the start of exposure.



1. Sensor readout time = 12.5µs (2k, 4k, 8k) or 20.8µs (16k)
2. LVAL delay = ~14.5µs (2k, 4k), 26µs (8k) or 41µs (16k)

Note:

$$\text{Maximum line rate} = \frac{1}{(exposure\ time + low\ time*)}$$

*Exposure time must be greater than 4 µs, and low time greater than 1 µs (2k, 4k and 8k models) or greater than 2 µs (16k model)

Warning! When running external line rate and external exposure time, the line rate must not exceed 1 / (exposure time + low time). Under these conditions the exposure time will become indeterminate and result in image artifacts. This is not the case when running internal exposure control.

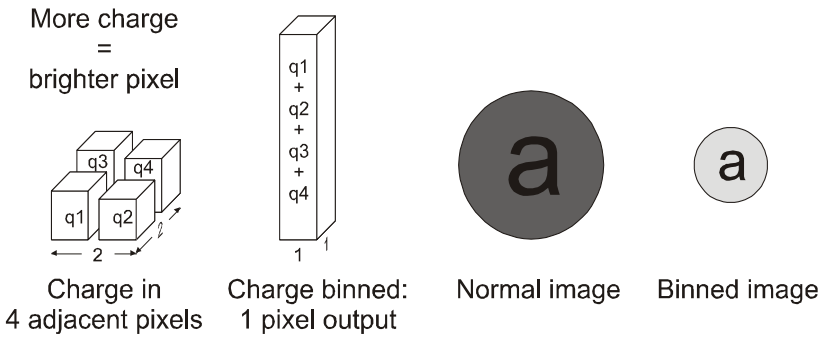
GenICam parameters to set:

- I / O Controls > Trigger Mode > On
- Camera Control > Exposure Time Source > Trigger Width

Binning

Binning is the combining of two or more image sensor pixels to form a new combined pixel. A binned image using the same exposure settings as a non-binned image will show an improved signal-to-noise ratio, reduced scanning times (due to lower spatial resolution) and save as a smaller image file size compared with a non-binned image, at the expense of lower image resolution.

In 2 x 2 binning, 4 physical pixels on the sensor are combined into one image pixel. This operating mode is ideal for applications that require faster acquisition and processing times and require greater signal collection.



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

The **Vertical Binning** and **Horizontal Binning** features in the **Image Format** category represents the number of horizontal pixels that will be combined (added) together.

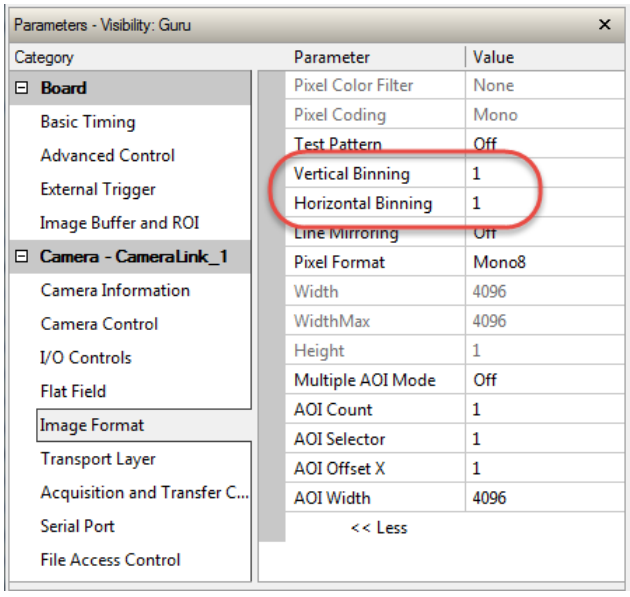


Image Format	
Parameter	**Description**
Vertical Binning	This feature represents the number of vertical photo-sensitive cells that are combined (added) together: 2.
Horizontal Binning	This feature represents the number of horizontal photo-sensitive cells that are combined (added) together.

Related ASC`II Commands	
sbh	set binning horizontal
sbv	set binning vertical

Pixel Readout Direction (Mirroring Mode)

The Line Mirroring feature, in the Image Format category, sets the tap readout from left to right or from right to left. This feature is especially useful if you want to mount the camera "upside down."

Image Format	
Parameter	**Description**
Line Mirroring	Off: All pixels are read out from left to right. On: All pixels are read out from right to left.

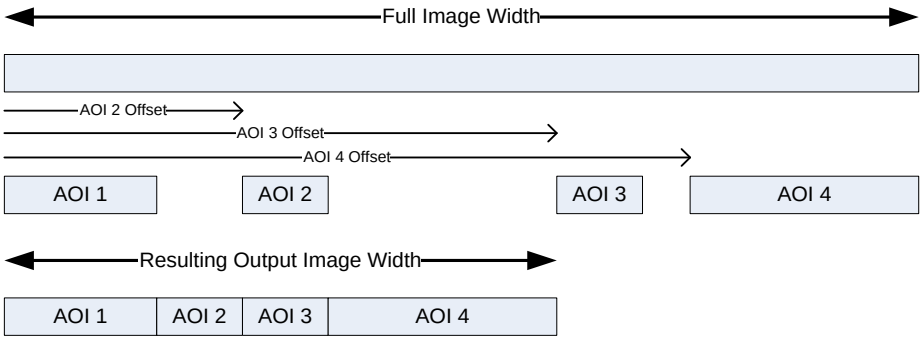
Related ASCII Commands	
smm	set mirroring mode

Area of Interest (AOI) Setup

The Area of Interest (AOI) feature can be used to reduce the amount of image-data output from the camera. Use this feature when there are areas in the image that contain unneeded information.

An example where you would use this feature is in an application that is inspecting several separated lanes of objects with one camera and the image between the lanes can be ignored.

The AOI feature allows from one to four specific areas of the pixel line to be specified where image data will be output. Since the AOI feature reduces the amount of data output, this has the additional benefit of allowing the cameras to operate at higher line rates when using base or medium camera link modes.



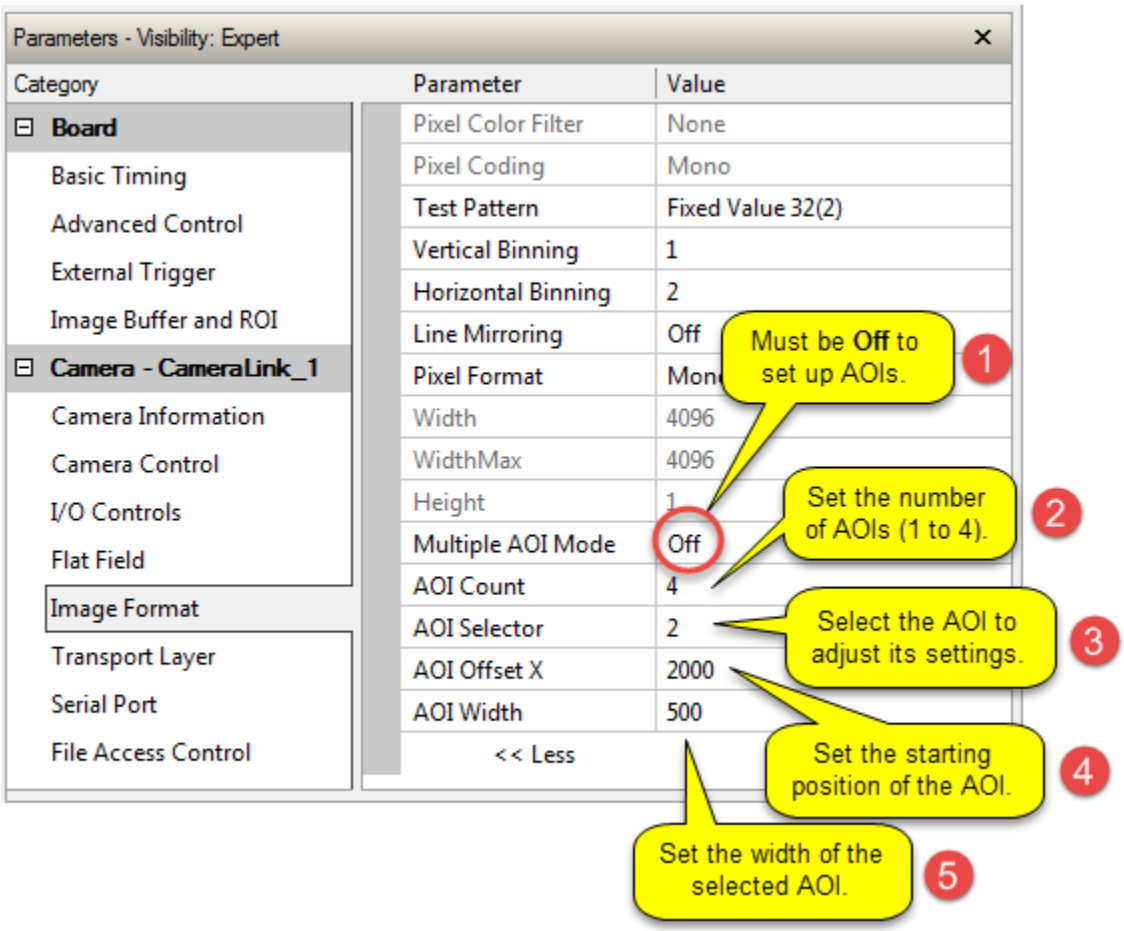
For example, in the 4k camera model, if the total number of pixels for the specified AOI`s is less than 1 K when using base Camera Link mode at 77 MHz, the maximum line rate can be 80 kHz; versus 56 kHz if all 4k pixels were output.

Note: The setup of AOI is always with respect to the sensor. Therefore, if you are using the mirroring mode with AOI, be aware that pixel one will be on the right side of the displayed image.

The AOI commands are grouped in the Image Format category.

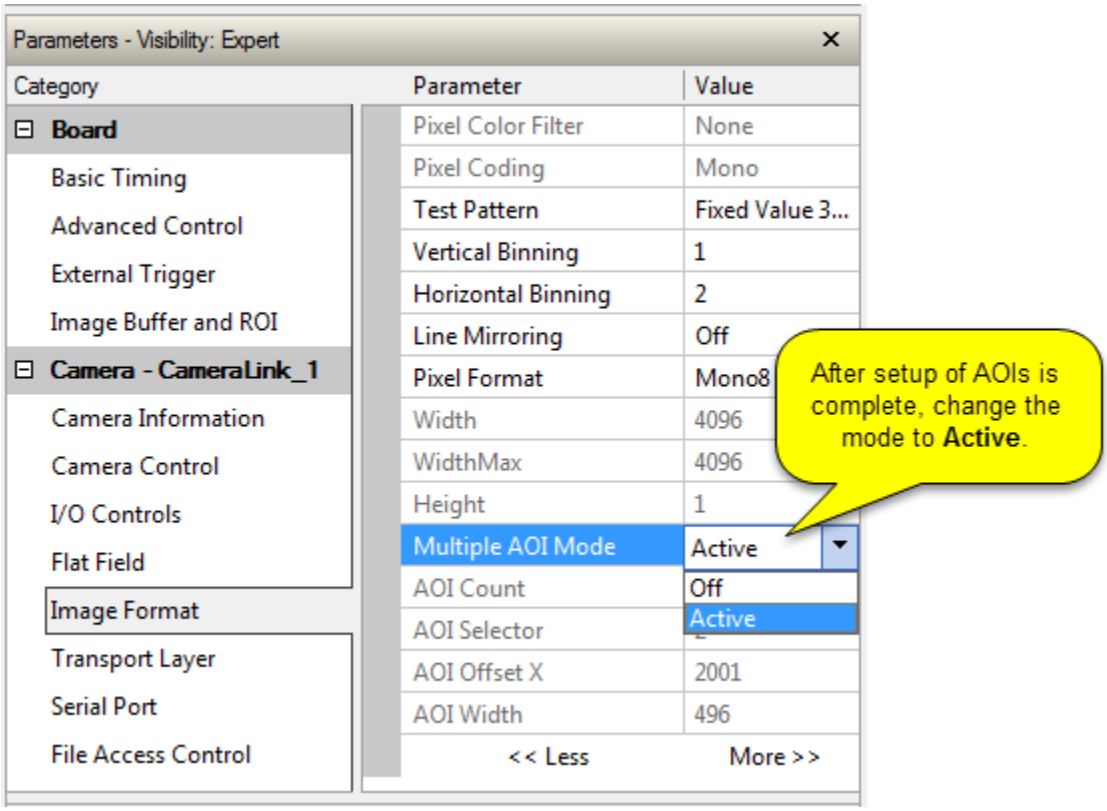
To set up an AOI for the camera:

- The AOI mode must first be in the off position.
- Use the AOI Count to select the total number of AOIs desired to a max of 4.
- To set up each AOI individually use the AOI Selector to point to the AOI to be set up.
- AOI Offset X is used indicate the starting pixel of the AOI. The starting pixel of the region must be 1 + a multiple of 8 (base, medium, and full modes) or 10 (deca mode).
- AOI Width is used to indicate the width of the AOI. Minimum region width is 40 pixels and must be a multiple of 8 (base, medium, and full modes) or 10 (deca mode).


Parameters - Visibility: Expert
Category
Parameter
Value
Board
Basic Timing
Advanced Control
External Trigger
Image Buffer and ROI
Camera - CameraLink_1
Camera Information
Camera Control
I/O Controls
Flat Field
Image Format
Transport Layer
Serial Port
File Access Control
Pixel Color Filter
None
Pixel Coding
Mono
Test Pattern
Fixed Value 32(2)
Vertical Binning
1
Horizontal Binning
2
Line Mirroring
Off
Pixel Format
Mon
Width
4096
WidthMax
4096
Height
1
Multiple AOI Mode
Off
AOI Count
4
AOI Selector
2
AOI Offset X
2000
AOI Width
500
<< Less
Must be Off to set up AOIs.
1
Set the number of AOIs (1 to 4).
2
Select the AOI to adjust its settings.
3
Set the starting position of the AOI.
4
Set the width of the selected AOI.
5

To initiate operation of the AOI once setup:

- The AOI mode must be changed to Active.
- Be sure to set the frame grabber image width to the sum of all AOI widths set up in the camera.

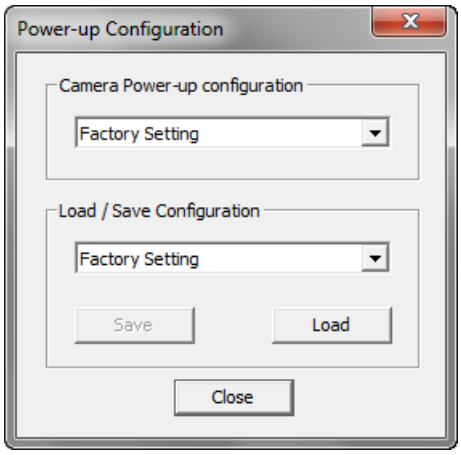


Related ASCII Commands	
sac	set AOI count
sad	set AOI selector, offset and width
sam	set AOI mode

Saving and Restoring Camera Settings

The parameters used to select, load and save user sets are grouped together under the Camera Information category. There are 8 user sets available and one factory set.

Camera Configuration Selection Dialog



CamExpert provides a dialog box which combines the features to select the camera power up state and for the user to save or load a camera state from Linea CL memory.

Camera Power-up Configuration

Either the Factory or one of the User Settings can be used as the default setting and is the set loaded when the camera is reset of powered up.

The first drop list selects the camera configuration state to load on power-up (see feature *UserSetDefaultSelector*). The user chooses from one factory data set or one of 8 possible user saved states.

User Set Configuration Management

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

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

Active Settings for Current Operation

The active setting for the current operation is the set of configurations that are active while the camera is currently running, including all unsaved changes you have made to the settings before saving them.

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

To save these settings for reuse the next time you power up or reset the camera, or to protect against losing them in the case of power loss, you must save the current settings. Once saved, the current settings become the selected **User Set**.

User Setting

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

To restore the last saved user settings, select the **User Set** parameter you want to restore and then select the **User Set Load** parameter.

Factory Settings

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

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

Related ASCII Commands	
usd	user set default
usl	user set load
uss	user set save

Camera Firmware Updates

The user can upload new firmware using the File Access Control features via Sapera CamExpert.

To update the camera firmware several files must be updated. Files include the following:

Type	File
Device Firmware	Microcode (.hex file)
XML	XML file
Miscellaneous	FPGA Code (.bin file)
	CCI (.hex file)

After all files have been transferred to the camera (the order is not relevant), reboot or reset the camera and restart CamExpert to verify the file versions displayed in the Camera Information category.

Warning! The camera firmware file versions must all be compatible or the camera risks becoming inoperable. **Only after all required files are uploaded to the camera can the camera be reset or rebooted to activate the new firmware.**

Before updating any firmware files verify that the file versions are correct. If in doubt, contact your Teledyne DALSA representative if you have any questions before proceeding.

Related ASCII Commands	
fcs	firmware configuration store

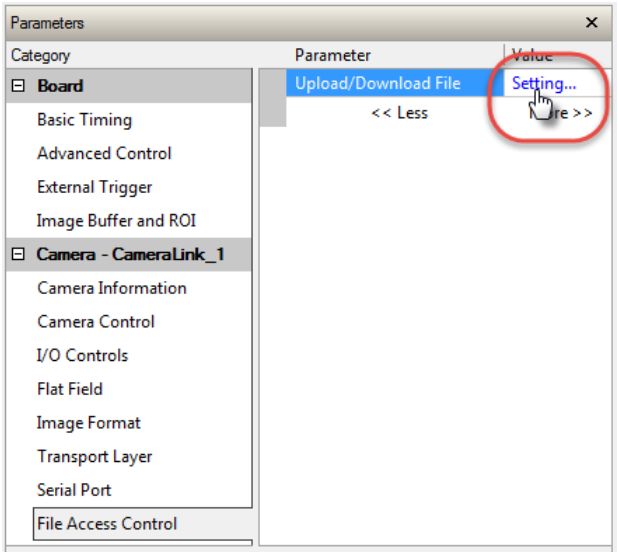
Download a List of Camera Parameters

For diagnostic purposes you may want to download a list of all the parameters and values associated with the camera. To do this use the File Access Control features via Sapera CamExpert:

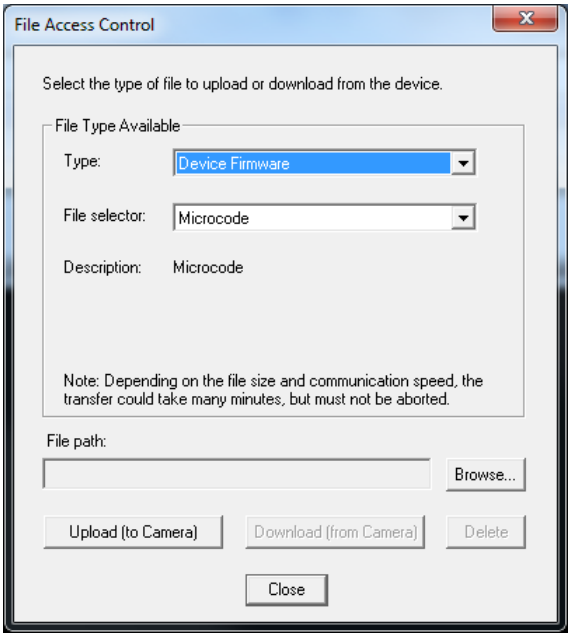
- Select "Miscellaneous" file type
- In the "File selector" drop down box select "CameraData".
- Click "Download".
- Save the text file and send the file to Teledyne DALSA customer support if required.

File Access via the CamExpert Tool

- In the File Access Category, click on the "Setting…" button to open the File Access Control dialog.



- From the file type drop menu, select the file type that will be uploaded to the Linea CL. This CamExpert tool allows quick firmware changes or updates.



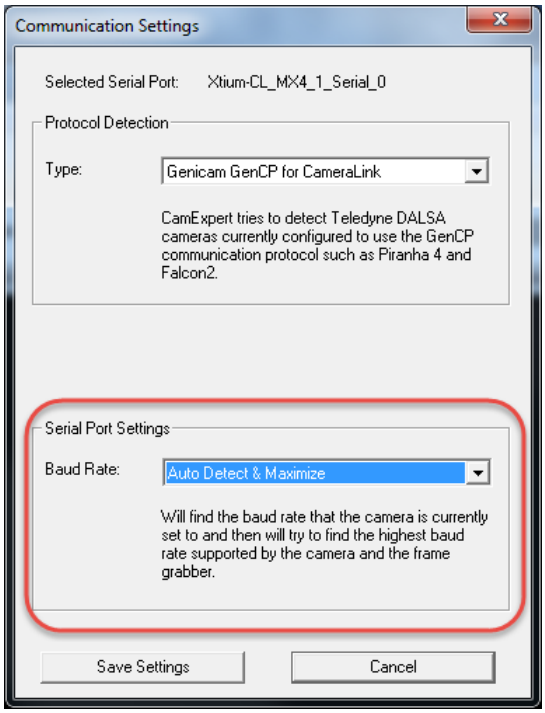
- From the File Selector drop menu, select the Linea CL memory location for the uploaded data. This menu presents only the applicable data locations for the selected file type.
- Click the Browse button to open a typical Windows Explorer window.
- Select the specific file from the system drive or from a network location.
- Click the Upload button to execute the file transfer to the Linea CL.
- Note that firmware changes require a device reset command from the Transport Layer Controls.

Resetting the Camera

The Restart Camera feature, part of the Transport Layer category, resets the camera. This is a warm (software) reset and does not cycle the camera power. The camera resets with the default settings, including a baud rate of 9600.

Transport Layer	
Parameter	**Description**
Restart Camera	Resets the camera and puts in the default settings, including a 9600 baud rate.

If camera detection is enabled, Teledyne DALSA frame grabber serial port settings are by default configured to auto-detect and maximize the baud rate. To verify the setting, use the Sapera Configuration utility. Alternatively, in CamExpert use the **Tools > Camera Detection > Settings** menu command to open the Communication Settings dialog.

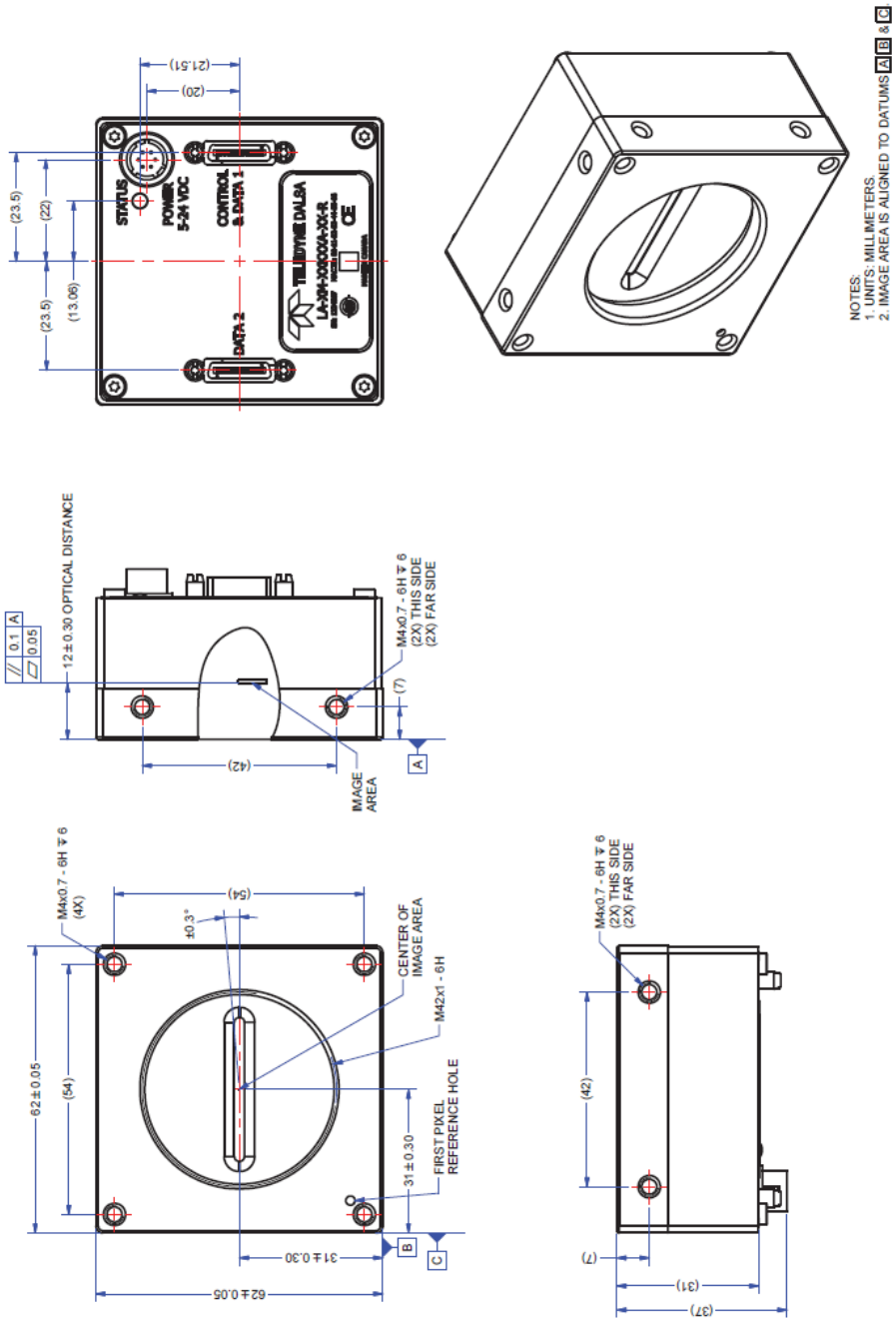


Related ASCII Commands	
rc	reset camera

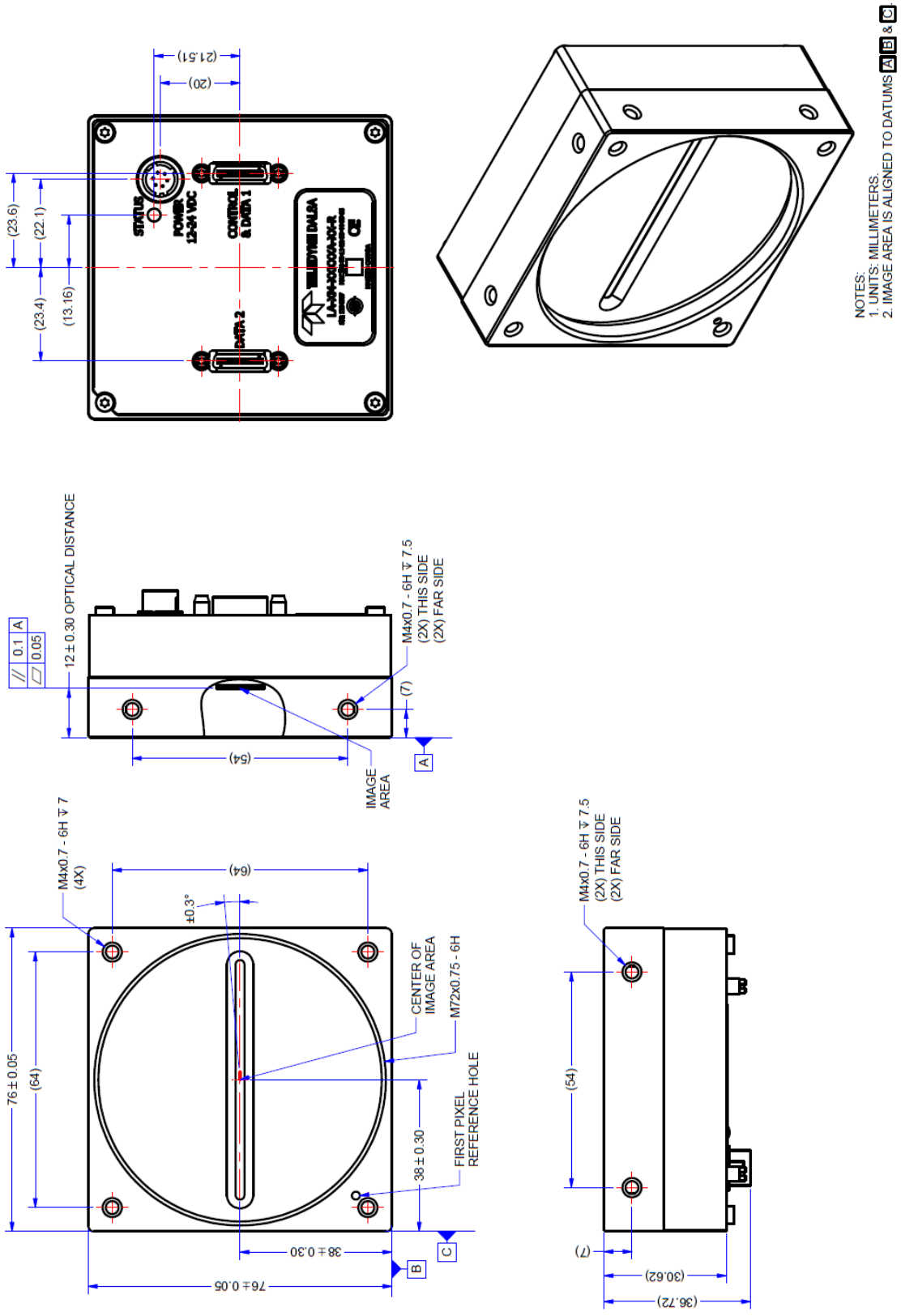
Technical Specifications

Mechanical Specifications

2k and 4k Cameras



8k and 16k Cameras



Additional Notes on Linea CL Identification and Mechanical

Identification Label

Linea CL cameras have an identification label applied to the back side, with the following information:

- Model Part number
- Serial number
- 2D Barcode
- CE logo
- "Made in Canada" Statement

EMC Declarations of Conformity

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

FCC Statement of Conformance

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

1. The product may not cause harmful interference; and

2. The product must accept any interference received, including interference that may cause undesired operation.

FCC Class A Product

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

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

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

CE 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.

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 amount and wavelengths of light required to capture useful images depend on the particular application. Factors include the nature, speed, and spectral characteristics of objects being imaged, exposure times, light source characteristics, environmental and acquisition system specifics, and more. The Teledyne DALSA Web site, http://www.teledynedalsa.com/, provides an introduction to this potentially complicated issue. Click on Knowledge Center and then select Application Notes and Technology Primers. Review the sections of interest.

It is often more important to consider exposure 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. For example, $5\mu J/cm^2$ can be achieved by exposing $5mW/cm^2$ for 1ms just the same as exposing an intensity of $5W/cm^2$ for $1\mu s$.

Light Sources

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

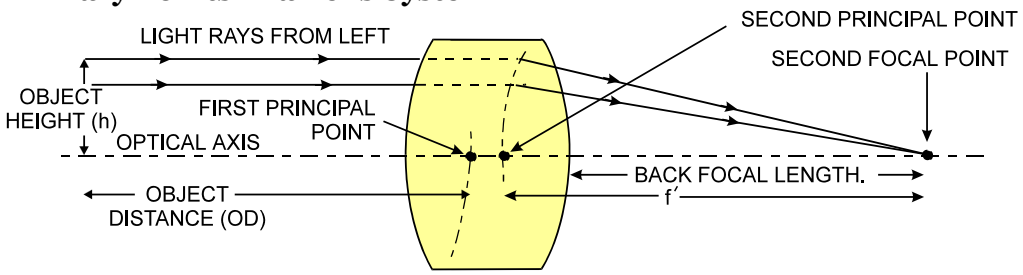
- LED light sources are relatively inexpensive, provide a uniform field, and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity.
- Halogen light sources generally provide very little blue relative to infrared light (IR).
- Fiber-optic light distribution systems generally transmit very little blue relative to IR.
- Some light sources age such that over their life span they produce less light. This aging may not be uniform—a light source may produce progressively less light in some areas of the spectrum but not others.

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



Magnification and Resolution

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

$m = \frac{h'}{h}$	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:

$m = \frac{f'}{OD}$

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

$\frac{h'}{h} = \frac{f'}{OD}$	This is the governing equation for many object and image plane parameters.

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

$\frac{10\mu m}{100\mu m} = \frac{45mm}{OD}$	$OD = 450mm(0.450m)$

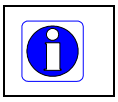
Sensor Handling Instructions

This section reviews proper procedures for handling, cleaning, or storing the Linea CL camera. Specifically the camera sensor needs to be kept clean and away from static discharge to maintain design performance.

Electrostatic Discharge and the Sensor

Cameras sensors containing integrated electronics are susceptible to damage from electrostatic discharge (ESD).

Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. With charge buildup, problems such as higher image lag or a highly non-uniform response may occur. The charge normally dissipates within 24 hours and the sensor returns to normal operation.



Important: Charge buildup will affect the camera's flat-field correction calibration. To avoid an erroneous calibration, ensure that you perform flat-field correction only after a charge buildup has dissipated over 24 hours.

Protecting Against Dust, Oil and Scratches

The sensor window is part of the optical path and should be handled like other optical components, with extreme care.

Dust can obscure pixels, producing dark patches on the sensor response. 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 the illumination is diffuse.

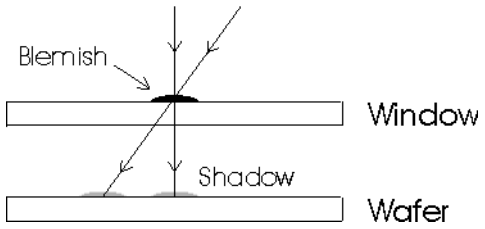
Dust can normally be removed by blowing the window surface using a compressed air blower, unless the dust particles are being held by an electrostatic charge, in which case either an ionized air blower or wet cleaning is necessary.

Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber finger cots and rubber gloves can prevent oil contamination. However, the friction between the rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, avoid touching the sensor.

Scratches can be caused by improper handling, cleaning or storage of the camera. When handling or storing the camera without a lens, always install the protective cap. Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels changes with the angle of illumination.

An important note on window blemishes

When flat field correction is performed, window cleanliness is paramount. The figure below shows an example of what can happen if a blemish is present on the sensor window when flat field correction is performed. The blemish will cast a shadow on the wafer. FFC will compensate for this shadow by increasing the gain. Essentially FFC will create a white spot to compensate for the dark spot (shadow). As long as the angle of the incident light remains unchanged then FFC works well. However when the angle of incidence changes significantly (i.e. when a lens is added) then the shadow will shift and FFC will makes things worse by not correcting the new shadow (dark spot) and overcorrecting where the shadow used to be (white spot). While the dark spot can be potentially cleaned, the white spot is an FFC artifact that can only be corrected by another FFC calibration.



Cleaning the Sensor Window

Even with careful handling, the sensor window may need cleaning. The following steps describe various cleaning techniques to clean minor dust particles to 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 air 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, Dalsa recommends using lint-free ESD-safe cloth wipers that do not contain particles that can scratch the window. The Anticon Gold 9”x 9” wiper made by Milliken is both ESD safe and suitable for class 100 environments. Another ESD acceptable wiper is the TX4025 from Texwipe.
- An alternative to ESD-safe cloth wipers is Transplex swabs that have desirable ESD properties. There are several varieties available from Texwipe. 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.

Appendix A: GenICam Commands

This appendix lists the available GenICam camera features. Access these features using the CamExpert interface.

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

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.

Additionally the Standard column will indicate which parameter is a member of the custom DALSA Features Naming Convention (denoted by **DFNC**), versus the GenICam Standard Features Naming Convention (SFNC not shown).

Camera Information Category

Camera information can be retrieved via a controlling application. Parameters such as camera model, firmware version, etc. are read to uniquely identify the connected Linea CL device. These features are typically read-only. GenICam applications retrieve this information to identify the camera along with its characteristics.

The Camera Information Category groups information specific to the individual camera. In this category the number of features shown are identical whether the view is Beginner, Expert, or Guru. Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.

Camera Information Feature Descriptions

The following table describes these parameters along with their view attribute.

Display Name	Feature & Values	Description	Standard & View
Vendor	DeviceVendorName	Displays the device vendor name. (RO)	Beginner
Model	DeviceModelName	Displays the device model name. (RO)	Beginner
CCI Version	DeviceVersion	Displays the device version. This tag will also highlight if the firmware is a beta or custom design. (RO)	Beginner
FPGA Version	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device, such as the firmware design type. (RO)	Beginner
Microcode Version	DeviceFirmwareVersion	Displays the currently loaded firmware version number. Firmware files have a unique number and have the .cbf file extension. (RO)	Beginner
Serial Number	DeviceID	Displays the device's factory set camera serial number. (RO)	Beginner
Device User ID	DeviceUserID	Feature to store a user-programmable identifier of up to 15 characters. The default factory setting is the camera serial number. (RW)	Beginner
Power-on User Set	UserSetDefaultSelector	Selects the camera configuration set to load and make active on camera power-up or reset. The camera configuration sets are stored in camera non-volatile memory. (RW)	Beginner
Factory	*Factory*	Load factory default feature settings.	
UserSet1 to UserSet8	*UserSet1*	Select the user defined configuration (UserSet1 to UserSet8) as the Power-up Configuration.	
User Set Selector	UserSetSelector	Selects the camera configuration set to load feature settings from or save current feature settings to. The Factory set contains default camera feature settings. User camera configuration sets contain features settings previously saved by the user. (RW)	Beginner
Factory Set	*Factory*	Select the default camera feature settings saved by the factory.	
User Set 1 to User Set 8	*UserSet1*	Select the User Defined Configuration space (UserSet1 to UserSet8) to save to or load from features settings previously saved by the user.	
Load User Set	UserSetLoad	Loads the camera configuration set specified by the User Set Selector feature, to the camera and makes it active. (W)	Beginner
Save User Set	UserSetSave	Saves the current camera configuration to the user set specified by the User Set Selector feature. The user sets are located on the camera in non-volatile memory. (W)	Beginner
Power-on Status	deviceBISTStatus	Return the status of the device Built-In Self test. Possible return values are device-specific: refer to Appendix C: Error and Warning Messages.	DFNC Beginner
Device Temperature	DeviceTemperature	Displays the device temperature in degrees Celsius	Beginner
Refresh Temperature	refreshTemperature	Gets the current device temperature and refreshes the DeviceTemperature value.	DFNC Beginner
Input Voltage	deviceInputVoltage	Displays the device power input voltage.	DFNC Beginner
Refresh Voltage	refreshVoltage	Gets the current device input voltage and refreshes the deviceInputVoltage value.	DFNC Beginner
LED Color	deviceLEDColor	Displays the current status LED state.	DFNC Beginner
Good	*Green*	Camera status OK.	
Blink Green	*BlinkGreen*	Camera is currently powerering-up or busy.	
BIST Error	*Red*	Camera built-in self-test failure.	
License Key	securityUpgrade	License key for CCI feature upgrade.	DFNC Guru

Camera Control Category

The Linea CL camera controls, as shown by CamExpert, groups sensor specific features. This group includes controls for line rate, exposure time, and so forth.

Camera Control Feature Descriptions

The following table describes these features along with their view attribute.

Display Name	Feature & Values	Description	Standard & View
Sensor Color Type *Monochrome*	sensorColorType *Monochrome*	Defines the camera sensor color type. < RO > *Sensor color type is monochrome.*	Beginner DFNC
Internal Line Rate	AcquisitionLineRate	Specifies the camera internal line rate, in Hz.	Beginner
Measured Line Rate	measureLineRate	Displays the line rate provided to the camera by either internal or external source < RO >	DFNC Beginner
Measured CC1	measureCC1Rate	Displays the CC1 signal rate provided to the camera. <RO>	DFNC Beginner
Refresh measured line rate	refreshMeasureLineRate	Updates the *measureLineRate* value.	DFNC Beginner
Exposure Time Source *Timed* *Trigger Width*	ExposureMode *Timed* *TriggerWidth*	Sets the operation mode for the camera's exposure. *The exposure duration time is set using the Exposure Time feature and the exposure starts with a LineStart event.* *Uses the width of the trigger signal pulse to control the exposure duration. Use the Trigger Activation feature to set the polarity of the trigger. The Trigger Width setting is applicable when the LineStart trigger is enabled and a signal is selected as trigger source.*	Beginner
Exposure Time	ExposureTime	Sets the exposure time (in microseconds) when the Exposure Mode feature is set to Timed.	Beginner
Measured Exposure Time	measureExposureTime	Displays the exposure time used by the camera sensor.	DFNC Beginner
Refresh Measured Exposure Time	refreshMeasuredExposureTime	Updates the *measuredExposureTime* value.	DFNC Beginner
Offset	BlackLevel	Analog black level (offset) in DN. Controls the black level as an absolute physical value. This represents a DC offset applied to the video signal.	Beginner
Gain	Gain	Sets the digital gain applied to the image.	Beginner

I/O Controls Category

The Linea CL I/O controls, as shown by CamExpert, groups features used to configure external inputs and acquisition actions based on those inputs, plus camera output signals to other devices.

I/O Control Feature Descriptions

The following table describes these features along with their view attribute and minimum camera firmware version required.

Display Name	Feature & Values	Description	Standard & View
Trigger Selector	TriggerSelector	Displays the type of trigger to configure with the various Trigger features. <RO>	Beginner
LineStart	*LineStart*	*Selects a trigger starting the capture of a single line.*	
Trigger Mode	TriggerMode	Controls the enable state of the selected trigger.	Beginner
Off	*Off*	*The selected trigger is turned off.*	
On	*On*	*The selected trigger is turned active.*	
Trigger Source	TriggerSource	Diplays the internal signal or physical input line used as the trigger source. <RO> The selected trigger must have its TriggerMode set to ON.	Beginner
CC1	*CC1*	*CC1 used as the external trigger source.*	

Flat Field Category

The Linea CL Flat Field controls, as shown by CamExpert, groups features used to calibrate the camera's flat field correction coefficients. Parameters in black are user set in CamExpert or programmable via an imaging application.

Flat Field Feature Descriptions

The following table describes these features along with their view attribute.

Display Name	Feature & Values	Description	Standard & View
Mode *Off* *On* *Initialize*	flatfieldCorrectionMode *Off* *On* *Initialize*	Sets the mode for flat field correction. Flat field correction is disabled. Flat field correction is enabled. Reset all FPN coefficients to 0 and all flat field coefficients to 1.	DFNC Beginner
Calibration Algorithm *Basic* *Low Pass Filter*	flatfieldCorrectionAlgorithm *Basic* *LowPass*	Selects the algorithm to use for calibration of flat field coefficients. *Direct calculation of coefficients based on average line values and target value.* *A low pass filter is first applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or it is not possible to defocus the image.*	DFNC Beginner
CalibrationTarget	flatfieldCalibrationTarget	Sets the target pixel value for the gain (PRNU) calibration. Ranges are: 8-bit output: 0-255 12-bit output: 0-4095	DFNC Beginner
CalibrationSampleSize *2048* *4096*	flatfieldCalibrationSampleSize *Lines_2048* *Lines_4096*	Sets the number of line to average during a flat field calibration. Average 2048 lines. Average 4096 lines.	DFNC Beginner
ROI Offset X	flatfieldCalibrationROIOffset	Set the starting point of a region of interest where a flat field calibration will be performed	DFNC Beginner
ROI Width	flatfieldCalibrationROIWidth	Sets the width of the region on interest where a flat field calibration will be performed	DFNC Beginner
Calibrate FPN	flatfieldCalibrationFPN	Initiates the FPN calibration process.	DFNC Beginner
Calibrate PRNU	flatfieldCalibrationPRNU	Initiates the PRNU or Flatfield process.	DFNC Beginner
Calibrate PRNU Status *Good* *Clipping* *Time Out* *Too Many Outliers*	flatfieldCalibrationPRNUStatus *Good* *Clipping* *ExsyncTimeOut* *TooManyOutliers*	Returns the PRNU calibration status. Calibration successful. Coefficients are clipped to minimum or maximum value. Calibration failed due to time out. Calibration failed because the image is too noisy.	DFNC Beginner

Image Format Control Category

The Linea CL Image Format controls, as shown by CamExpert, groups parameters used to configure camera pixel format, image cropping, and the binning function. Additionally, a feature control to select and output a camera internal test image simplifies qualifying a camera setup without a lens.

Image Format Control Feature Description

The following table describes these features along with their view attribute.

Display Name	Feature & Values	Description	Standard & View
Pixel Coding	PixelCoding	Output image pixel coding format of the sensor. <RO>	Beginner
Mono	*Mono*	Monochrome format.	
Pixel Color Filter	PixelColorFilter	Indicates the type of color filter applied to the image. <RO>	Beginner
None	*None*	No filter applied on the sensor.	
Test Pattern	TestImageSelector	Selects the type of test image output by the camera.	Beginner
Off	*Off*	Image is from the camera sensor.	
Ramp	*Ramp*	Image is filled horizontally with an image that goes from the darkest possible value to the brightest.	
Alternating	*A5*	Alternating values. For 12-bit output, pixel values alternate between 1381 (0x565) and 2746 (0xABA). For 8-bit output, pixel values alternate between 86 (0x56) and 172 (0xAC).	
Fixed Pattern	*Each_Tap_Fixed*	8 pixel cycling pattern. For 12-bit output, the pattern is 0x120|0x020|0x130|0x030|0x140|0x040|0x150|0x050. For 8-bit output, the pattern is 0x12|0x02|0x13|0x03|0x14|0x04|0x15|0x05.	
Fixed Value 1381(86)	*All_1365*	Fixed Grey Value. For 12-bit output: pixel value = 1381 (0x565). For 8-bit output: pixel value = 86 (0x56).	
Fixed Value 32(2)	*All_1*	Fixed Grey Value. For 12-bit output: pixel value = 32 (0x20). For 8-bit output: pixel value = 2 (0x2).	
Vertical Binning	BinningVertical	Number of vertical photo-sensitive cells to combine together. This increases the intensity of the pixels but reduces the vertical resolution of the image.	Beginner
Horizontal Binning	BinningHorizontal	Number of horizontal photo-sensitive cells to combine together. This increases the intensity of the pixels but reduces the horizontal resolution.	Beginner
Line Mirroring	ReverseX	Horizontal image flip function.	Beginner
Off	*Off*	Video output in normal order	
On	*On*	Video output in a reverse order	
Pixel Format	PixelFormat	Output image pixel coding format of the sensor..	Beginner
Mono8	*Mono8*	Mono8: Monochrome 8-Bit. Note: Camera Link Full configurations support this format only.	
Mono12	*Mono12*	Mono12: Monochrome 12-Bit Note: Camera Link Base or Medium configurations can use this format.	

Width	Width	Width of the Image provided by the device (in pixels).	Beginner
Height	Height	Height of the Image provided by the device (in lines).	Beginner
Multiple AOI Mode	multipleAOIMode	Enable the Multiple AOI (Area of Interest) per image feature. The AOI Count is set by the Multiple AOI Count feature.	DFNC Expert
Off	*Off*	Single AOI per image.	
Active	*Active*	The AOI per image feature is active.	
AOI Count	multipleAOICount	Specifies the number of AOIs (Area of Interest) available for the X axis.	DFNC Expert
AOI Selector	multipleAOISelector	Select an AOI (Area of Interest) when Multiple AOI Mode is enabled. Selector range is from 1 to the MultipleAOICount value.	DFNC Expert
AOI Offset X	multipleAOIOffsetX	Horizontal offset (in pixels) from the origin to the selected AOI (Area of Interest). The offset is set as a multiple of 8 or 10 (deca mode) + 1. The maximum offset is the image width – 40.	DFNC Expert
AOI Width	multipleAOIWidth	Width of the selected AOI (Area of Interest) provided by the device (in pixels). The minimum region width is 40 pixels and must be a multiple of 8 or 10 (deca mode).	DFNC Expert

Transport Layer Category

The Linea CL Transport Layer, as shown by CamExpert, groups features for Camera Link configuration.

Transport Layer Descriptions

The following table describes these features along with their view attribute.

Display Name	Feature & Values	Description	Standard & View
Restart Camera	DeviceReset	Used to restart the camera (warm restart (does not cycle power)).	Beginner
XML Major Version	DeviceManifestXMLMajorVersion	Together with DeviceManifestXMLMinorVersion specifies the GenICam™ feature description XML file version (RO)	Invisible
XML Minor Version	DeviceManifestXMLMinorVersion	Together with DeviceManifestXMLMajorVersion specifies the GenICam™ feature description XML file version (RO)	Invisible
Last GenCP Status	genCPStatus	Returns the last error. If a feature read or write fails then Sapera only returns that it fails – read this feature to get the actual reason for the failure. Reading this feature clears it.	DFNC Invisible
Refresh GenCP Status	refreshGenCPStatus	Updates the *genCPStatus* value.	DFNC Beginner
Camera Link Configuration	ClConfiguration	Camera Link Output configuration.	Beginner
Base	*Base*	Camera Link Base configuration.	
Medium	*Medium*	Camera Link Medium configuration.	
Full	*Full*	Camera Link Full configuration.	
Deca	*Deca*	Camera Link Deca configuration.	
Camera Link Speed	clDeviceClockFrequency	Set the camera link clock rate	Beginner
77MHZ	*Speed_77MHZ*	2k, 4k and 8k models only.	
50MHZ	*Speed_50MHZ*	2k, 4k and 8k models only.	
85MHZ	*Speed_85MHZ*	16k model only.	
62MHZ	*Speed_62MHZ*	16k model only.	
Tap Geometry	DeviceTapGeometry	(RO)	Beginner

Device Streaming Registers

Start – End Command Requirements

Important: Every start command must have a corresponding end command. If not the camera can be in an unpredictable state. This pertains to *DeviceRegistersStreamingStart*, *DeviceRegistersStreamingEnd*, *DeviceFeaturePersistenceStart*, and *DeviceFeaturePersistenceEnd*.

Display Name	Feature & Values	Description	Standard & View
Device Registers Streaming Start	DeviceRegistersStreamingStart	Announces the start of registers streaming without immediate checking for consistency.	Invisible
Device Registers Streaming End	DeviceRegistersStreamingEnd	Announces end of registers streaming and performs validation for registers consistency before activating them.	Invisible
Device Feature Streaming Start	DeviceFeaturePersistenceStart	Announces the start of feature streaming without immediate checking for consistency.	Invisible
Device Feature Streaming End	DeviceFeaturePersistenceEnd	Announces end of feature streaming and performs validation for feature consistency before activating them.	Invisible
Register Check	DeviceRegistersCheck	Performs an explicit register set validation for consistency.	Invisible
Registers Valid	DeviceRegistersValid	States if the current register set is valid and consistent.	Invisible

File Access Control Category

The File Access control in CamExpert allows the user to quickly upload various data files to the connected Linea CL. The supported data files are for Linea CL firmware updates and Flat Field coefficients.

Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.

File Access Control Feature Descriptions

Display Name	Feature & Values	Description	Standard & View
File Selector	FileSelector	Selects the file to access. The file types which are accessible are device-dependent.	Guru
FPGA Code	*FPGA_Code*	Upload new FPGA to the camera which will execute on the next camera reboot cycle.	
MicroCode	*MicroCode*	Upload new micro codeto the camera which will execute on the next camera reboot cycle.	
CCI	*CCI*	Upload new CCI to the camera which will execute on the next camera reboot cycle.	
XML	*XML*	Upload new XML to the camera which will execute on the next camera reboot cycle.	

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

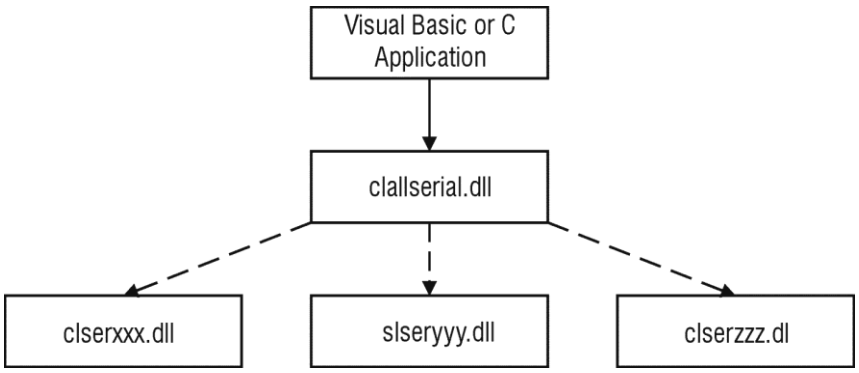
Appendix B: ASCII Commands

The following commands can be used to control the Teledyne DALSA Linea cameras.

Accessing the Three Letter Commands (TLC)

To access the TLC an ASCII-based communications interface application, such as HyperTerminal.

Additionally it is possible to use the functions of `clserxxx.dll` or `clallserial.dll` as defined in the Camera Link Specification. The following figure illustrates the Serial DLL hierarchy as mentioned in the Camera Link Specification.



Port Configuration

Baud: 9,600
Bits: 8
Parity: None
Stop bits: 1
Flow Control: None

Echo typed characters locally.

Rules

- The interface is not case sensitive
- One command and argument(s) per line
- To enter a floating point number prefix it with a "F" – for example "ssg 0 f1.5"
- Error codes returned are the same as the GenICam™ interface – see Diagnostics | Error Codes
- Follow each command with the carriage return character – 0x0D

1. Cycle power to the camera: by either a) issuing the reset camera command (rc), or b) powering the camera OFF and then ON.
2. Load the ASCII interface using the required port configuration settings.
3. Wait for a stable status LED color (green or red) before proceeding. Note that all entries in HyperTerminal will be ignored until a stable LED color is obtained.
4. In case of HyperTerminal, press the <ESC> key.
5. Once <ESC> has been entered the USER prompt appears.

The camera responds to a simple ASCII-based protocol. A carriage return <CR> ends each command.

Example: to return the current detector settings
gcp <CR>

A complete list of the available detector commands, their format and parameters can be displayed by sending the help (**h**) command.

Notes on Using Alternatives to HyperTerminal

- If you are using interfaces other than HyperTerminal, the ASCII character, ESC, is decimal 27 and needs to be issued. From the command line insert ESC by using ALT+2+7 of the activated Num-Pad. In some cases this needs to be followed by a carriage return or a linefeed to send this to the camera.
- In ASCII the ESC character may look like this: "←".

ASCII to GenCP

To switch from the ASCII-command interface to the GenCP interface, the camera must be either reset (RC) or the power must be cycled. Note that GenCP and ASCII commands cannot be accessed simultaneously.

Note: the HyperTerminal application is not available on the Windows 7 OS.

Alternatives to HyperTerminal
The following alternative ASCII-interfaces have been tested and shown to work with this camera: PuTTY and TeraTerm. Note that PuTTY does not have Xmodem capability while TeraTerm does. Xmodem is required to update code in the camera.

DeviceFeaturePersistenceStart, and *DeviceFeaturePersistenceEnd*.

Disabling the Esc Key for Direct Access to ASCII Commands

By default the Esc key is enabled and an Esc key sequence has to be issued in order to access the ASCII commands. Using the DEK 1 command the need to issue an Esc key is disabled and access to the ASCII commands are available immediately upon camera boot up. Note: access to GENCP is no longer available with the Esc key disabled unless a DEK 0 command is issued and the camera re-booted.

Command Reference

CCF: Calibrate User FPN

Display Name	**Calibrate User FPN**	
Mnemonic	**CCF**	
Argument(s)	# of lines to average	• 2048 • 4096
Description	Calibrate user FPN dark flat field coefficients	

CLM: Camera Link Mode

Display Name	**Camera Link Mode**	
Mnemonic	**CLM**	
Argument(s)	Mode	0. Base 1. Medium 2. Full 3. Deca (8k and 16k models)
Description	Camera Link Mode	

CLS: Camera Link Speed

Display Name	**Camera Link Speed**	
Mnemonic	**CLS**	
Argument(s)	Frequency	0. 77 MHz (2k, 4k, 8k), 85 MHz (16k) 1. 50 MHz (2k, 4k, 8k), 62 MHz (16k)
Description	Camera Link clock frequency	

CPA: Calibrate Flatfield

Display Name	**Calibrate Flatfield**	
Mnemonic	**CPA**	
Argument(s)	Algorithm	0. Basic 1. Low-pass Filter
	# of lines to average	• 2048 • 4096
	Target	0 to 4095 DN in 12- bit mode 0 to 255 DN in 8-bit mode
Description	Calibrate user PRNU flat field coefficients	
Notes	• Perform flat field calibration using the average of <# lines>. • With filter algorithm this average line is then smoothed and outlier pixels are interpolated. Use this feature if your white reference is not featureless. • Adjust pixel gain such that output will be <target>. • The target is first divided by horizontal binning factor and gain and then the offset is subtracted. Therefore the output will go to the target. • Because the PRNU can be less than 1, the target may be below the current maximum value. • Coefficients are saved and loaded with user set (e.g. USS / USL) • The cpa command takes several seconds to complete. The slower the line rate, the longer it will take.	

DEK: Disable Esc Key

Display Name	**Disable Esc Key**	
Mnemonic	**DEK**	
Argument(s)	Mode	0. Esc key is enabled 1. Esc key is disabled
Description	Allow the use of the Esc key to be disabled so that upon boot-up the camera will directly enter the ASCII command mode. With the Esc key disabled the GENCP cannot be accessed.	
Notes	To access the GenCP, you have to first issue the DEK 0 command in order to enable the ESC key. Then reboot the camera.	

FCS: Firmware Configuration Store

Display Name	**Invisible**	
Mnemonic	**FCS**	
Argument(s)	File	3. FPGA .bin file 4. Microcode .hex file 5. CCI .hex file 6. XML file
Description	Uploads firmware files to the camera. Use XMODEM to send files.	
Notes	**WARNING**! All firmware files must be compatible or the camera can be rendered unusable. Only reset/reboot the camera after all required files have been uploaded. Once all files have been transferred reset/reboot the camera and verify the versions with the gcp command.	

FFM: Flatfield Mode

Display Name	**Flatfield Mode**	
Mnemonic	**FFM**	
Argument(s)	Mode	0. Disable use of user FPN and PRNU flat field correction coefficients. 1. Enable use of user FPN and PRNU flat field correction coefficients. 2. Reset user FPN coefficients to zero and user PRNU coefficients to one.
Description	Set flat field mode	

GCP: Display Camera Configuration

Display Name	**Display Camera Configuration (Get Camera Parameters)**
Mnemonic	**GCP**
Argument(s)	
Description	Display current value of camera configuration parameters
Notes	Model LA_CM_02K08A_00_R Microcode 03-081-20320-01 CCI 03-110-20316-01 FPGA 03-056-20487-01 Serial # 12035699 BiST: Good DefaultSet 1 Ext Trig Off Line Rate 11250 [Hz] Meas L.R. 11250 [Hz] Max L.R. 22058 [Hz] Exp. Mode Timed Exp. Time 44444 [ns] Meas E.T. 44444 [ns] Max E.T. 88000 [ns] Test Pat. 0:Off Vert. Bin 1 Hor. Bin 1 Flat Field Off Offset 0 System Gain 1.00 Mirror Off AOI Mode: Off CL Speed 77MHz CL Config Full Pixel Fmt 8 bits CPA ROI 1-2048

GET: Get Value

Display Name	**Get Value**
Mnemonic	**GET**
Argument(s)	<'parameter>
Description	The "get" command displays the current value(s) of the feature specified in the string parameter. Note that the parameter is preceded by a single quote "'". Using this command will be easier for control software than parsing the output from the "gcp" command.

H:Help

Display Name	**Help**
Mnemonic	**H**
Argument(s)	
Description	Display list of three letter commands (2k help screen shown)
Notes	USER>h LA (03-081-20315-00): Command Line Interpreter Jan 15 2014, 17:46:53 ccf - Calibrate User FPN <2048|4096> clm - Camera Link Mode <0:Base 1:Med 2:Full> cls - Camera Link Speed <0 - 77MHz, 1 - 50MHz> cpa - Calibrate Flatfield <0:basic 1:filter><2048|4096><DN target> dek - disable ESC key <0/1> ffm - Flat Field Mode <0:Off 1:On 2:Initialiaze> gcp - Display Camera Configuration get - Get value '<string> h - Help ? - help '<string> lpc - Load Pixel Coefficients <set 0-8> rc - Reset Camera roi - Set Flatfield ROI <1st pixel> <last pixel> rpc - Reset Flatfield Coefficients sac - Set AOI Count <value 1-4> sad - Set AOI Selector, Offset and Width <selector 1-AOI Count> <1st pixel> <width >= 40> sam - Set AOI Mode <1-enable, 0-disable> sbh - Horizontal Binning <1|2> sbr - Set Baud Rate <9600|57600|115200|230400|460800> sbv - Vertical Binning <1|2> sem - Exposure Mode <0:Int 1:Ext> set - Exposure Time <ns> smm - Mirroring <0:Off 1:On> spf - Pixel Format <0:8 bits 2:12 bits> ssb - Offset <DN> ssf - Internal Line Rate <Hz> ssg - Gain <0:System> f<gain> stm - External Trigger <0:Off 1:On> sui - Set User ID svm - Test Pattern <0-6> usd - Default User Set <0-8> usl - Load User Set <0-8> uss - Save User Set <1-8> vt - Temperature vv - Input Voltage

LPC: Load Pixel Coefficients

Display Name	**Load Pixel Coefficients**	
Mnemonic	**LPC**	
Argument(s)	Set selector	0. Factory set 1-8. User sets
Description	Load user set	
Notes	• Loads FPN coefficients and PRNU coefficients from a user set (only coefficeints, no other camera parameters)	

RC: Reset Camera

Display Name	**Reset Camera**
Mnemonic	**RC**
Argument(s)	
Description	Resets the camera to the saved user default settings. These settings are saved using the usd command.
Notes	The micro-controller reboots: • Load any file updates • Clear over temperature condition • Perform start up camera tests (BiST) • Load FPGA code • Configure FPGA and sensor. • Load default user set • Baud rate set to 9600

ROI: Set Flatfield ROI

Display Name	**Set Flatfield ROI**	
Mnemonic	**ROI**	
Argument(s)	First pixel	1 to 2048 (2k) 1 to 4096 (4k) 1 to 8192 (8k) 1 to 16,384 (16k)
	Last pixel	1 to 2048 (2k) 1 to 4096 (4k) 1 to 8192 (8k) 1 to 16,384 (16k)
Description	Flat field region of interest	
Notes	• Specifies the pixels that CCF and CPA will calibrate ○ Pixel coefficients outside this region are not changed • Last pixel must be greater than or equal to first pixel	

RPC: Reset Flatfield Coefficients

Display Name	**Reset Flatfield Coefficients**
Mnemonic	**RPC**
Argument(s)	
Description	Reset all user FPN values to zero and all user PRNU coefficients to one
Notes	

SAC: Set AOI Count

Display Name	**Set AOI Count**	
Mnemonic	**SAC**	
Argument(s)	Number of AOI's	1 to 4
Description	Set AOI Counter	

SAD: Set AOI Selector

Display Name	**Set AOI Selector**	
Mnemonic	**SAD**	
Argument(s)	Selector	1 to 4
	Offset	1 to (image width – 40) (must be a multiple of 8 or 10 (deca mode) + 1)
	Width	No less than 40 pixels
Description	Define an AOI	
Notes	• Must not overlap with an already existing AOI	

SAM: Set AOI Mode

Display Name	**Set AOI Mode**	
Mnemonic	**SAM**	
Argument(s)	Mode	0. Off / Disable 1. Active / Enable
Description	Set AOI mode	
Notes		

SBH: Set Binning Horizontal

Display Name	**Set Binning Horizontal**	
Mnemonic	**SBH**	
Argument(s)	Binning	1. Single pixel 2. Binning of 2 pixels
Description	Set horizontal binning	

SBR: Set Baud Rate

Display Name	**Set Baud Rate**	
Mnemonic	**SBR**	
Argument(s)	Baud rate	9600 57600 115200 230400* 460800* 921600*
Description	Set baud rate	
Notes	• Send command and then change speed of HyperTerminal • *A PX4 or equivalent frame grabber is required in order to achieve these baud rates.	

SBV: Set Binning Vertical

Display Name	**Set Binning Vertical**	
Mnemonic	**SBV**	
Argument(s)		1. Single pixel 2. Binning of 2 pixels
Description	Set vertical binning	

SEM: Set Exposure Mode

Display Name	**Set Exposure Mode**	
Mnemonic	**SEM**	
Argument(s)	Mode	0. Internal ("Timed") 1. External ("Trigger Width")
Description	Set exposure time mode	
Notes	• In internal mode the exposure time is controlled by the SET command • In external mode the sensor is exposed while CC1 signal is high • External mode is only available when the trigger mode is also external (STM 1) • SEM 1 overrides internally generated independent exposure times • When CC1 signal falls line is read	

SET: Set Exposure Time

Display Name	**Exposure Time**	
Mnemonic	**SET**	
Argument(s)	Exposure time	4, 000 to 3, 332, 000 [ns]
Description	Set internal exposure time in nanoseconds – 22.2 ns (2k, 4k, 8k) or 37 ns resolution (16k).	
Notes	For 2k, 4k 8k models: Line time > (Exposure time + 1, 000 ns) For 16k models: Line time > (Exposure time + 2, 000 ns)	

SMM: Set Mirroring Mode

Display Name	**Mirroring**	
Mnemonic	**SMM**	
Argument(s)	Mode	0. Off 1. Image is flipped on the horizontal axis
Description	Set mirroring mode	

SPF: Pixel Format

Display Name	**Pixel Format**	
Mnemonic	**SPF**	
Argument(s)	Selector	0. 8-bits 2. 12-bits
Description	Set pixel format	
Notes	12-bit pixel format is only available with Base or Medium Camera Link Configurations.	

SSB: Set Sensor Blacklevel

Display Name	**Offset**		
Mnemonic	**SSB**		
Argument(s)	Offset	8-bit 12-bit	-32 to 31 -512 to 511
Description	Set contrast offset – single value added to all pixels after PRNU/flat field coefficients (before gain).		
Notes	• Range changes depending on pixel format (SPF)		

SSF: Set Sensor Framerate

Display Name	**Internal Line Rate**	
Mnemonic	**SSF**	
Argument(s)	Line rate	300 to 80, 000 [Hz], 2k, 4k, and 8k models 300 to 48, 000 [Hz], 16k model
Description	Set internal line rate in Hz	
Notes	For 2k, 4k 8k models: Line time > (Exposure time + 1, 000 ns) For 16k models: Line time > (Exposure time + 2, 000 ns)	

SSG: Set Sensor Gain

Display Name	**Gain**	
Mnemonic	**SSG**	
Argument(s)	Gain	<0:System> f<gain>
Description	Use the system gain to adjust the camera output to achieve the desired response. The system gain range is from 1x to 10x.	
Notes	To enter a floating point number prefix it with a "F" – for example "ssg 0 f1.5"	

STM: Set Trigger Mode

Display Name	**External Trigger**	
Mnemonic	**STM**	
Argument(s)	Mode	0. Internal 1. External
Description	Set trigger mode	
Notes	• In internal mode line rate is controlled by SSF command • In external mode readout starts on falling edge of CC1 signal and is available only when STM = 1 (external trigger on) • Exposure time equals high time of EXSYNC on signal on CC1	

SVM: Set Video Mode

Display Name	**Test Pattern**	
Mnemonic	**SVM**	
Argument(s)	Mode	0. Sensor Video 1. Ramp 2. No used 3. 1381_2746 4. Each_tap_fixed 5. All_1381 6. All_32
Description	Select test pattern	
Notes		

USD: User Set Default

Display Name	**Default User Set**	
Mnemonic	**USD**	
Argument(s)	Set selector	0. Factory set 1-8. User sets
Description	Select user set to load when camera is reset	
Notes	• The settings include all those listed by the GCP command plus the user FPN coefficients, and user PRNU coefficients	

USL: User Set Load

Display Name	**Load User Set**	
Mnemonic	**USL**	
Argument(s)	Set selector	0. Factory set 1-8. User sets
Description	Load user set	
Notes	• Loads and makes current all the settings listed by the GCP command plus the user FPN coefficients, and user PRNU coefficients	

USS: User Set Save

Display Name	**Save User Set**	
Mnemonic	**USS**	
Argument(s)	Set selector	1 to 8
Description	Save user set	
Notes	• Saves all the current settings listed by the GCP command plus the user FPN coefficients, and user PRNU coefficients	

VT: View Temperature

Display Name	**Temperature**
Mnemonic	**VT**
Argument(s)	
Description	Display internal temperature in degrees Celsius
Notes	• Measured with an accuracy of ± 1.5 ºC.

VV: View Voltage

Display Name	**Voltage**
Mnemonic	**VV**
Argument(s)	
Description	Display supply voltage
Notes	• Measured with an accuracy ± 0.1 V.

Appendix C: Error and Warning Messages

BiST: Built in Self Test

The BiST error flags are binary flags with each bit being independent from each other. The message from the BiST should be "Good" meaning everything is functioning correctly but if a hardware failure does occur in the camera one or more these flags could be set. Any of these errors will result in the status light turning red.

Definition	BiST Flag
I2C error	1
Unable to configure fpga	10
Unable to configure fpga	100
EXT_SRAM Failure	1000
ECHO_BACK Failure	1,0000
FLASH_TIMEOUT	10,0000
FLASH_ERROR	100,0000
NO_FPGA_Code	1000,0000
NO_COMMON_SETTINGS	1,0000,0000
NO_FACTORY_SETTINGS	10,0000,0000
NO_USER_SETTINGS	100,0000,0000
NO_FLAT_FIELD Corrections	1000,0000,0000
NO MISC corrections	1,0000,0000,0000
NO_FPN Correction	10,0000,0000,0000
NO_FPN Correction	100,0000,0000,0000
NO_PRNU Correction	1000,0000,0000,0000
NO_FEED Through Correction	1,0000,0000,0000,0000
NO_LINEARITY Correction	10,0000,0000,0000,0000
SYNC_ERROR	100,0000,0000,0000,0000
OVER_TEMPERATURE	1000,0000,0000,0000,0000
SPI Failure	1,0000,0000,0000,0000,0000
NO_USER_FPN	10,0000,0000,0000,0000,0000
PLL_LOCK_FAILED	100,0000,0000,0000,0000,0000
INVALID_CCI	1000,0000,0000,0000,0000,0000
No LUT	1,0000,0000,0000,0000,0000,0000
Incompatible FPGA code	10,0000,0000,0000,0000,0000,0000

Operational Error Codes

Code	Description
0X8002	Invalid Parameter
0xC01C	CPA_TOO_MANY_OUTLIERS
0x401E	USER_FPN_CLIPPING
0x401F	FLAT_FIELD_CLIPPING

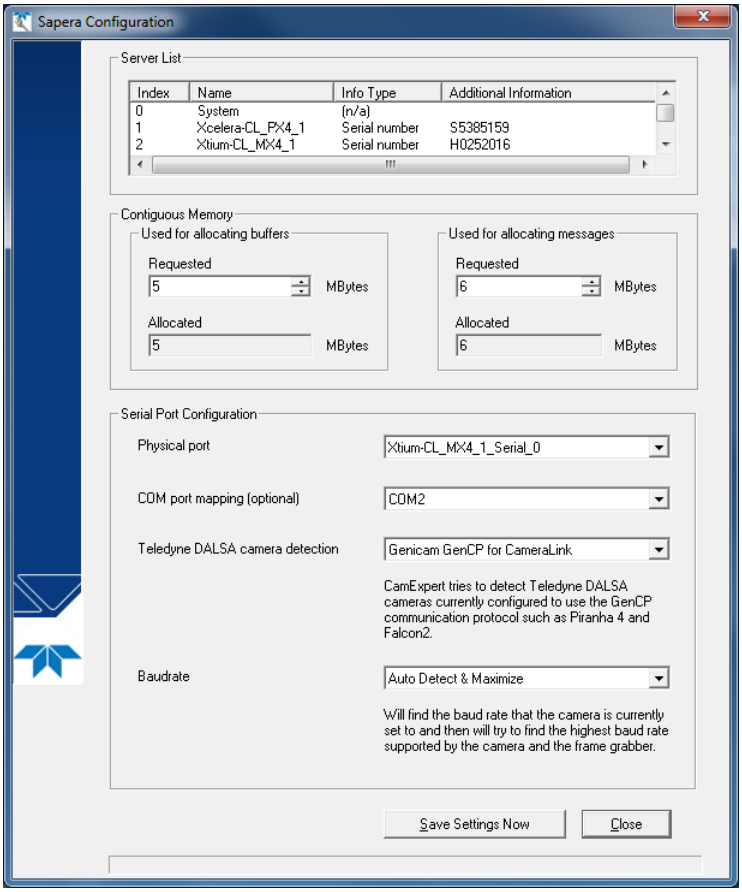
Appendix D: Camera, Frame Grabber Communication

Setting Up Communication between the Camera and the Frame Grabber

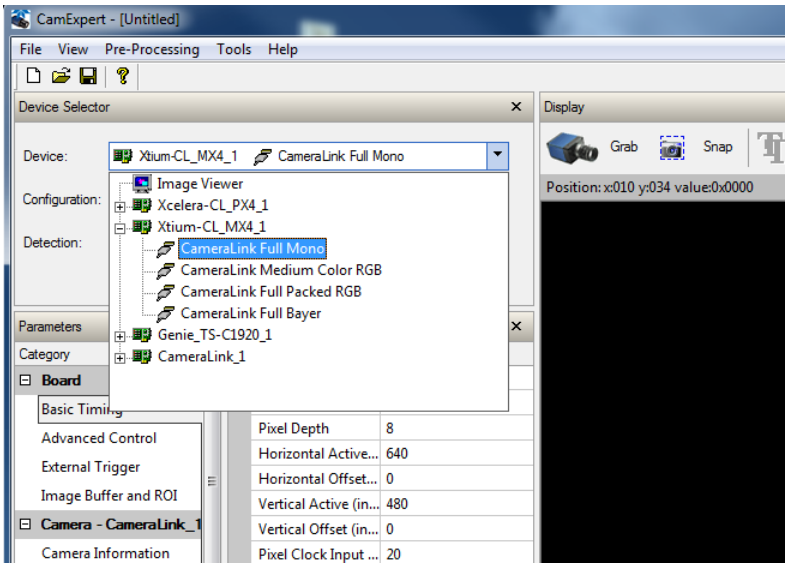
Teledyne DALSA Camera Link cameras support the GenCP Camera Link standards.

To configure Teledyne DALSA GenCP Camera Link Cameras:

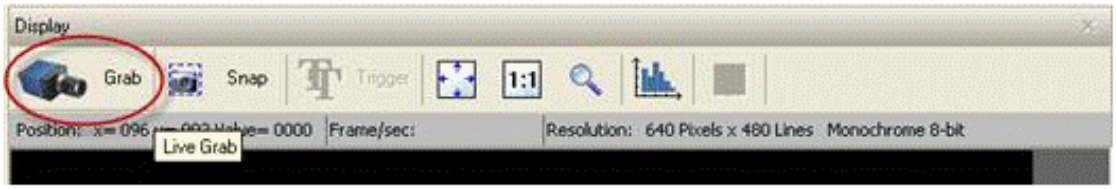
1. Install the Teledyne DALSA frame grabber in the host computer; refer to the hardware installation manual.
2. Install Sapera LT and the Teledyne DALSA frame grabber driver.
3. Connect the camera to the frame grabber; refer to the camera installation manual.
4. Power up the camera and wait until the status LED is solid green.
5. Run the Sapera Configuration utility and select the frame grabber serial port connected to the camera. Set **Teledyne DALSA camera detection** to **Automatic Detection** and **Baudrate** to **Auto Detect & Maximize**.
6. If the camera will be configured using three-letter text commands via a terminal program, then set **COM port mapping (optional)** to an available COM port (for example, COM2).



7. Start the CamExpert application. In the **Device** tab, select an available **CameraLink mode**.



8. Modify the camera and frame grabber parameter settings as required. At present, when using GenCP cameras, the camera and frame grabber parameters must be adjusted separately. Test the image acquisition by clicking the **Grab** button.



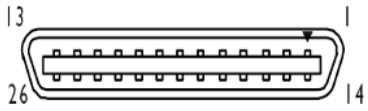
9. Save the frame grabber configuration to a new *.ccf file.

Appendix E: Camera Link Connector Information

Data Connector: Camera Link

The camera uses two Camera Link SDR26 cables transmitting the Camera Link Base, Medium, or Full configuration. The figure below shows the SDR26 Camera Link Connector and the tables that follow list the Camera Link Base, Medium, and Full configurations.

For detailed information on Camera Link please refer to the Camera Link Road Map available from the Knowledge Center on the Teledyne DALSA Web site: (http://www.teledynedalsa.com/mv/knowledge/appnotes.aspx).



Camera Link Connector

Data 2			Control / Data 1		
Camera Connector	**Right Angle Frame Grabber Connector**	**Channel Link Signal**	**Camera Connector**	**Right Angle Frame Grabber Connector**	**Channel Link Signal**
1	1	inner shield	1	1	PoCL
14	14	inner shield	14	14	inner shield
2	25	Y0-	2	25	X0-
15	12	Y0+	15	12	X0+
3	24	Y1-	3	24	X1-
16	11	Y1+	16	11	X1+
4	23	Y2-	4	23	X2-
17	10	Y2+	17	10	X2+
5	22	Yclk-	5	22	Xclk-
18	9	Yclk+	18	9	Xclk+
6	21	Y3-	6	21	X3-
19	8	Y3+	19	8	X3+
7	20	100 ohm	7	20	SerTC+
20	7	terminated	20	7	SerTC-
8	19	Z0-	8	19	SerTFG-
21	6	Z0+	21	6	SerTFG+
9	18	Z1-	9	18	CC1-
22	5	Z1+	22	5	CC1+
10	17	Z2-	10	17	CC2+
23	4	Z2+	23	4	CC2-
11	16	Zclk-	11	16	CC3-
24	3	Zclk+	24	3	CC3+
12	15	Z3-	12	15	CC4+
25	2	Z3+	25	2	CC4-
13	13	inner shield	13	13	inner shield
26	26	inner shield	26	26	PoCL

*Exterior Overshield is connected to the shells of the connectors on both ends. Unused pairs should be terminated in 100 ohms at both ends of the cable. Inner shield is connected to signal ground inside camera

Full Configuration

8- bits Camera Link Full Configuration

Connector 1: Channel link X		Connector 2: Channel link Y		Connector 3: Channel link Z	
Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name
Tx0/Rx0	D0(0)	Tx0/Rx0	D3(0)	Tx0/Rx0	D6(0)
Tx1/Rx1	D0(1)	Tx1/Rx1	D3(1)	Tx1/Rx1	D6(1)
Tx2/Rx2	D0(2)	Tx2/Rx2	D3(2)	Tx2/Rx2	D6(2)
Tx3/Rx3	D0(3)	Tx3/Rx3	D3(3)	Tx3/Rx3	D6(3)
Tx4/Rx4	D0(4)	Tx4/Rx4	D3(4)	Tx4/Rx4	D6(4)
Tx5/Rx5	D0(7)	Tx5/Rx5	D3(7)	Tx5/Rx5	D6(7)
Tx6/Rx6	D0(5)	Tx6/Rx6	D3(5)	Tx6/Rx6	D6(5)
Tx7/Rx7	D1(0)	Tx7/Rx7	D4(0)	Tx7/Rx7	D7(0)
Tx8/Rx8	D1(1)	Tx8/Rx8	D4(1)	Tx8/Rx8	D7(1)
Tx9/Rx9	D1(2)	Tx9/Rx9	D4(2)	Tx9/Rx9	D7(2)
Tx10/Rx10	D1(6)	Tx10/Rx10	D4(6)	Tx10/Rx10	D7(6)
Tx11/Rx11	D1(7)	Tx11/Rx11	D4(7)	Tx11/Rx11	D7(7)
Tx12/Rx12	D1(3)	Tx12/Rx12	D4(3)	Tx12/Rx12	D7(3)
Tx13/Rx13	D1(4)	Tx13/Rx13	D4(4)	Tx13/Rx13	D7(4)
Tx14/Rx14	D1(5)	Tx14/Rx14	D4(5)	Tx14/Rx14	D7(5)
Tx15/Rx15	D2(0)	Tx15/Rx15	D5(0)	Tx15/Rx15	Not Used
Tx16/Rx16	D2(6)	Tx16/Rx16	D5(6)	Tx16/Rx16	Not Used
Tx17/Rx17	D2(7)	Tx17/Rx17	D5(7)	Tx17/Rx17	Not Used
Tx18/Rx18	D2(1)	Tx18/Rx18	D5(1)	Tx18/Rx18	Not Used
Tx19/Rx19	D2(2)	Tx19/Rx19	D5(2)	Tx19/Rx19	Not Used
Tx20/Rx20	D2(3)	Tx20/Rx20	D5(3)	Tx20/Rx20	Not Used
Tx21/Rx21	D2(4)	Tx21/Rx21	D5(4)	Tx21/Rx21	Not Used
Tx22/Rx22	D2(5)	Tx22/Rx22	D5(5)	Tx22/Rx22	Not Used
Tx23/Rx23	Not Used	Tx23/Rx23	Not Used	Tx23/Rx23	Not Used
Tx24/Rx24	LVAL	Tx24/Rx24	LVAL	Tx24/Rx24	LVAL
Tx25/Rx25	FVAL	Tx25/Rx25	FVAL	Tx25/Rx25	FVAL
Tx26/Rx26	Not Used	Tx26/Rx26	Not Used	Tx26/Rx26	Not Used
Tx27/Rx27	D0(6)	Tx27/Rx27	D3(6)	Tx27/Rx27	D6(6)

Tap 1 bits are D0(x)...Tap 8 bits are D7(x)

80-bit Camera Link Deca Configuration, 10 tap/8-bit mode

Connector 1: Channel link X		Connector 2: Channel link Y		Connector 3: Channel link Z	
Camera/Frame Grabber Pin	**Bit Name**	**Camera/Frame Grabber Pin**	**Bit Name**	**Camera/Frame Grabber Pin**	**Bit Name**
Tx0/Rx0	D0(0)	Tx0/Rx0	D3(2)	Tx0/Rx0	D6(5)
Tx1/Rx1	D0(1)	Tx1/Rx1	D3(3)	Tx1/Rx1	D6(6)
Tx2/Rx2	D0(2)	Tx2/Rx2	D3(4)	Tx2/Rx2	D6(7)
Tx3/Rx3	D0(3)	Tx3/Rx3	D3(5)	Tx3/Rx3	D7(0)
Tx4/Rx4	D0(4)	Tx4/Rx4	D3(6)	Tx4/Rx4	D7(1)
Tx5/Rx5	D0(5)	Tx5/Rx5	D3(7)	Tx5/Rx5	D7(2)
Tx6/Rx6	D0(6)	Tx6/Rx6	D4(0)	Tx6/Rx6	D7(3)
Tx7/Rx7	D0(7)	Tx7/Rx7	D4(1)	Tx7/Rx7	D7(4)
Tx8/Rx8	D1(0)	Tx8/Rx8	D4(2)	Tx8/Rx8	D7(5)
Tx9/Rx9	D1(1)	Tx9/Rx9	D4(3)	Tx9/Rx9	D7(6)
Tx10/Rx10	D1(2)	Tx10/Rx10	D4(4)	Tx10/Rx10	D7(7)
Tx11/Rx11	D1(3)	Tx11/Rx11	D4(5)	Tx11/Rx11	D8(0)
Tx12/Rx12	D1(4)	Tx12/Rx12	D4(6)	Tx12/Rx12	D8(1)
Tx13/Rx13	D1(5)	Tx13/Rx13	D4(7)	Tx13/Rx13	D8(2)
Tx14/Rx14	D1(6)	Tx14/Rx14	D5(0)	Tx14/Rx14	D8(3)
Tx15/Rx15	D1(7)	Tx15/Rx15	D5(1)	Tx15/Rx15	D8(4)
Tx16/Rx16	D2(0)	Tx16/Rx16	D5(2)	Tx16/Rx16	D8(5)
Tx17/Rx17	D2(1)	Tx17/Rx17	D5(3)	Tx17/Rx17	D8(6)
Tx18/Rx18	D2(2)	Tx18/Rx18	D5(4)	Tx18/Rx18	D8(7)
Tx19/Rx19	D2(3)	Tx19/Rx19	D5(5)	Tx19/Rx19	D9(0)
Tx20/Rx20	D2(4)	Tx20/Rx20	D5(6)	Tx20/Rx20	D9(1)
Tx21/Rx21	D2(5)	Tx21/Rx21	D5(7)	Tx21/Rx21	D9(2)
Tx22/Rx22	D2(6)	Tx22/Rx22	D6(0)	Tx22/Rx22	D9(3)
Tx23/Rx23	D2(7)	Tx23/Rx23	D6(1)	Tx23/Rx23	D9(4)
Tx24/Rx24	LVAL	Tx24/Rx24	D6(2)	Tx24/Rx24	D9(5)
Tx25/Rx25	FVAL	Tx25/Rx25	D6(3)	Tx25/Rx25	D9(6)
Tx26/Rx26	D3(0)	Tx26/Rx26	D6(4)	Tx26/Rx26	D9(7)
Tx27/Rx27	D3(1)	Tx27/Rx27	LVAL	Tx27/Rx27	LVAL
TxCLKIn/RxCLKOut	Pixel Clock		Pixel Clock	TxCLKIn/RxCLKOut	Pixel Clock

Tap 1 bits are D0(x)...Tap 10 bits are D9(x)

Camera Link Bit Definitions

BASE Configuration	T0		
Pixel Format	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**
Mono 8	Tap 1 LSB..Bit 7 Pixels (1, 3, 5, ... 4093, 4095)	Tap 2 LSB..Bit7 Pixels (2, 4, 6, ... 4094, 4096)	xxxxxxx
Mono 12	Tap 1 LSB.. Bit 7 Pixels (1, 3, 5, ... 84093, 4095)	Tap 1 Bits 8,9,10,11 Pixels (1, 3, 5, ... 4093,4095) Tap 2 Bits 8,9,10,11 Pixels (2,4,6, ... 4094, 4096)	Tap 2 LSB..Bit 7 Pixels (2,4,6, ... 4094, 4096)

Medium Configuration	T0					
Pixel Format	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**	**Port D Bits 0 thru 7**	**Port E Bits 0 thru 7**	**Port F Bits 0 thru 7**
Mono 8	Tap 1 LSB..Bit 7 Pixels (1, 5, 9, ... 4089, 4093)	Tap 2 LSB..Bit 7 Pixels (2, 6, 10, ... 4090, 4094)	Tap 3 LSB..Bit 7 Pixels (3, 7, 11, ... 4091, 4095)	Tap 4 LSB...Bit 7 Pixels (4, 8, 12, ... 4092, 4096)	xxxxxxxx	Xxxxxxxx
Mono 12	Tap 1 LSB.. Bit 7 Pixels (1, 5, 9, ... 4091, 4095)	Tap 1 Bits 8,9,10,11 Pixels (1, 5, 9, ... 4091, 4095) Tap 2 Bits 8,9,10,11 Pixels (2, 6, 10, ... 4092, 4096)	Tap 2 LSB..Bit 7 Pixels (2, 6, 10, ... 4092, 4096)	Tap 4 LSB...Bit 7 Pixels (4, 8, 12, ... 4090, 4094)	Tap 3 LSB...Bit 7 Pixels (3, 7, 11, ... 4089, 4093)	Tap 3 Bit 8,9,10,11 Pixels (3, 7, 11, ... 4089, 4093) Tap 4 Bits 8,9,10,11 Pixels (4, 8, 12, ... 4090, 4094)

Full Configuration	T0							
Pixel Format	**Port A LSB...Bit 7**	**Port B LSB...Bit 8**	**Port C LSB...Bit 8**	**Port D LSB...Bit 8**	**Port E LSB...Bit 8**	**Port F LSB...Bit 8**	**Port G LSB...Bit 8**	**Port H LSB...Bit 8**
Mono 8	Tap 1 LSB... Bit 7 Pixels (1, 9, 17, ... 4081, 4089)	Tap 2 LSB... Bit 7 Pixels (2, 10, 18, ... 4082, 4090)	Tap 3 LSB... Bit 7 Pixels (3, 11, 19, ... 4083, 4091)	Tap 4 LSB... Bit 7 Pixels (4, 12, 20, ... 4084, 4092)	Tap 5 LSB... Bit 7 Pixels (5, 13, 21, ... 4085, 4093)	Tap 6 LSB... Bit 7 Pixels (6, 14, 22, ... 4086, 4094)	Tap 7 LSB...Bit 7 Pixels (7, 15, 23, ... 4087, 4095)	Tap 8 LSB... Bit 7 Pixels (8, 16, 24, ... 4088, 4096)

Deca Configuration	T0									
Pixel Format	**Port A LSB… Bit 7**	**Port B LSB… Bit 8**	**Port C LSB… Bit 8**	**Port D LSB… Bit 8**	**Port E LSB… Bit 8**	**Port F LSB… Bit 8**	**Port G LSB… Bit 8**	**Port H LSB… Bit 8**	**Port I LSB… Bit 8**	**Port K LSB… Bit 8**
Mono 8	Tap 1 LSB… Bit 7 Pixels (1, 11, 21, … 4081, 4091)	Tap 2 LSB… Bit 7 Pixels (2, 12, 22, … 4082, 4092)	Tap 3 LSB… Bit 7 Pixels (3, 13, 23, … 4083, 4093)	Tap 4 LSB… Bit 7 Pixels (4, 14, 24, … 4084, 4094)	Tap 5 LSB… Bit 7 Pixels (5, 15, 25, … 4085, 4095)	Tap 6 LSB… Bit 7 Pixels (6, 16, 26, … 4086, 4096)	Tap 7 LSB…Bit 7 Pixels (7, 17, 27, … 4087)	Tap 8 LSB… Bit 7 Pixels (8, 18, 28, … 4088)	Tap 9 LSB… Bit 7 Pixels (9, 19, 29, … 4089)	Tap 10 LSB… Bit 7 Pixels (10, 20, 30, … 4090)

Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	Spare
CC3	Spare
CC4	Spare

For additional Camera Link documentation refer to the Teledyne DALSA Web site's Knowledge Center application notes.

Camera Link Drive Capability

The camera link cable drive capability on the cameras can reach up to 10 meters. This capability has been *tested using a number of frame grabbers (listed in the table below) and was tested using standard* Camera Link cables. The cable length drive achieved on the various frame grabbers is as follows:

Cable Length	Frame Grabber (Manufacturer / Part Number)
7 meter	TeledyneDALSA Xcelera-CL PX4 / OR-X4C0-XPF00
10 meter	TeledyneDALSA Xtium-CL PX4 / OR-Y4C0-XPX00

Input Signals, Camera Link

The camera accepts control inputs through the Camera Link SDR26F connector. The camera ships in internal sync, and internally programmed integration.

EXSYNC (Line Readout Trigger)

Line rate can be set internally using the GenICam features. The external control signal EXSYNC is optional and enabled through the user interface. This camera uses the falling edge of EXSYNC to trigger pixel readout.

The EXSYNC signal tells the camera when to integrate and readout the image. It can be either an internally generated signal by the camera, or it can be supplied externally via the serial interface. Depending upon the mode of operation the high time of the EXSYNC signal can represent the integration period.

Note: The EXSYNC signal is measured at CC1 and will give a "true" measurement (i.e. within the measurement resolution of 22.2 ns (2k, 4k, 8k) or 37 ns resolution (16k)) even though the camera will only trigger at a maximum of 80 kHz (2k, 4k, and 8k) or 48 kHz (16k).

Output Signals, Camera Link Clocking Signals

These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the Camera Link Implementation Road Map, available at our Knowledge Center, for the standard location of these signals.

Clocking Signal	Indicates
LVAL (high)	Outputting valid line
DVAL	Not used
STROBE (rising edge)	Valid data
FVAL	Set to 0

Document Revision History

Revision	Description	Date
00	Initial release.	April 6, 2014.
01	8k and 16k models descriptions and features added.	December 4, 2014
02	-Maximum line rate for the 16k model revised from 50 kHz to 48 kHz. -16k responsivity revised to 66 DN from 80 DN. -8k and 16k mass revised to < 360 g from < 250 g. -16k power dissipation revised to < 11 W from < 14 W. -Updated manual format and corrected errors.	July 16, 2015
03	-Updated 16k specs. -Added additional calibration information. -8k and 16k heak sink accessory part number revised to AC-MS-00115-00-R.	November 25, 2015
04	-Updated Declaration of Conformity information	August 10, 2020

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