TELEDYNE e2v
Everywhereyoulook™

ELIIXA+ Family
CMOS Multi-Line Camera

User Manual

ELIIXA+ 16K/8K CXP COLOR

CoaXPress

Table of Contents

1 CAMERA OVERVIEW

1.1 Features

- Cmos Colour Sensor :
  - 16384 RGB Pixels, 5 x 5µm (Full Definition)
  - 8192 RGB Pixels 10x10µm (True Colour)
- Interface : CoaXPress® (4x 6Gb/sLinks)
- Line Rate :
  - Up to 47500 l/s In 16k Full Definition Mode
  - Up to 95000 l/s in 8k True Colour Mode
- Bit Depth : 24bits (RGB 8bits)
- Scan Direction
- Flat Field Correction
- Low Power Consumption : <19W
- Compliant with Standard Lenses of the Market

1.2 Key Specifications

Note : All values in LSB is given in 8 bits format

Characteristics	Typical Value		Unit
Sensor Characteristics at Maximum Pixel Rate			
Resolution	16384	8192	RGB Pixels
pixel size (square)	5	10	µm
Max line rate	47.5	95	
Radiometric Performance at Maximum Pixel Rate and minimum camera gain			
Bit depth	3 x 8		Bits
Response non linearity	< 1		%
PRNU HF Max	3		%
Dynamic range	65		dB
Response (Peak) : True Color or Full Def. Enhanced			
Red	11.8		LSB 8bits/(nJ/cm²)
Green	11.2		LSB 8bits/(nJ/cm²)
Blue	7.8		LSB 8bits/(nJ/cm²)

Functionality (Programmable via GenICam Control Interface)		
Analog Gain	Up to 12 (x4)	dB
Offset	-4096 to +4096	LSB
Trigger Mode	Timed (Free run) and triggered (Ext Trig, Ext ITC) modes	
Sensor Modes	• True Color Enhanced : 8192 RGB Pixels of 10x10µm • True Color Single : 8192 RGB Pixels of 10x10µm • Full Definition Enhanced : 16384 RGB Pixels 5x5µm • Full Definition Single : 16384 RGB Pixels 5x5µm	
Mechanical and Electrical Interface		
Size (w x h x l)	100 x 156 x 36	mm
Weight	700	g
Lens Mount	M95 x 1	-
Sensor alignment (see chapter 4)	±100	µm
Sensor flatness	±35	µm
Power supply	Power Over CoaXPress : 24	V
Power dissipation – Typ. while grabbing	< 19	W
General Features		
Operating temperature	0 to 55 (front face) or 70 (Internal)	°C
Storage temperature	-40 to 70	°C
Regulatory	CE, FCC and RoHS compliant	

1.3 Description

e2v's next generation of line scan cameras are setting new, high standards for line rate and image quality. Thanks to e2v's recently developed multi-line CMOS technology, the camera provides an unmatched 95,000 lines/s and combines high response with an extremely low noise level; this delivers high signal to noise ratio even when short integration times are required or when illumination is limited. The 5µm pixel size is arranged in four active lines and dual line filter configuration allowing the camera to be operated in several modes: True colour mode with 10µm RGB pixels to provide equivalent colour fidelity to 10µm pixel tri-linear solutions with advanced immunity to web variation or Full definition mode with a unique16,384 RGB pixel resolution.

1.4 Typical Applications

- Printing Inspection
- High Resolution Document Scanning
- Printed Circuit Board Inspection
- Flat Panel Display Inspection
- High Quality Raw material Surface Inspection

1.5 Models

Part Number	Definition / Max Speed	Details
EV71YC4CCP1605-BA0	16k/47.5kHz – 8k/95kHz	New Sensor Generation with Model Name ELIIXA2C4CCP1605

GEN<i>CAM

2 CAMERA PERFORMANCES

2.1 Camera Characterization

	Unit	True Color (8k)		Full Definition Single		Enhanced Modes	
		Typ.	**Max**	**Typ.**	**Max**	**Typ.**	**Max**
Dark Noise RMS	LSB	0.12	1.2	0.11	1.2	0.12	1.2
Dynamic Range	-	2125:1	-	2125:1	-	2125:1	-
RMS Noise (3/4 Sat)	LSB	2.2	-	2.15	4	2.2	4
Full Well Capacity	e- (per color)	13650	-	13650	-	13650	-
SNR (3/4 Sat)	dB	40	-	40	-	40	-
Peak Response (460/530/660nm)	LSB 8bits/ (nJ/cm2)	8/10/12	-	4/5/6	-	8/10/12	-
Non Linearity	%	0,3	-	0,3	-	0,3	-
Without Flat Field Correction :							
FPN rms	LSB	0.21	1	0.23	1	0.22	1
FPN pk-pk	LSB	1	2	1	2	1	2
PRNU hf (3/4 Sat)	%	0.13	0,35	0.123	0,35	0.14	0,35
PRNU pk-pk (3/4 Sat)	%	1.1	3	1	3	1.25	3

Test conditions :

- All values are given at Nominal Gain (0dB) : Preamp Gain x1, Amp Gain 0dB
- Figures in LSB are for a 8bits format
- Measured at exposure time = 400µs and line period = 400µs in Ext Trig Mode (Max Exposure Time)
- Maximum data rate

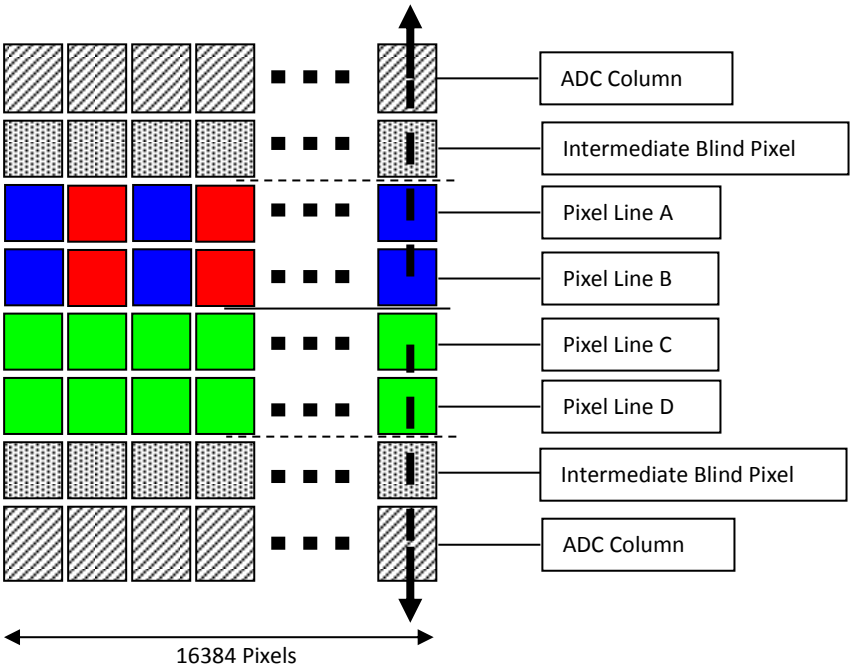
2.2 Image Sensor and color modes

The Eliixa+ Colour 16k sensor is composed of two pairs of sensitive lines.

The Colour version has been completed with RGB colour Filter and disposed as detailed beside.

Each pair of lines uses the same Analog to Digital Column converter (ADC Column). An appropriate (embedded) Time delay in the exposure between each line this allows to combine two successive exposures in order to double the sensitivity of a single line.

This Time Delay Exposure is used only in the Full Definition Enhanced mode (See Below).



2.2.1 Full Definition Single Mode (FDS)

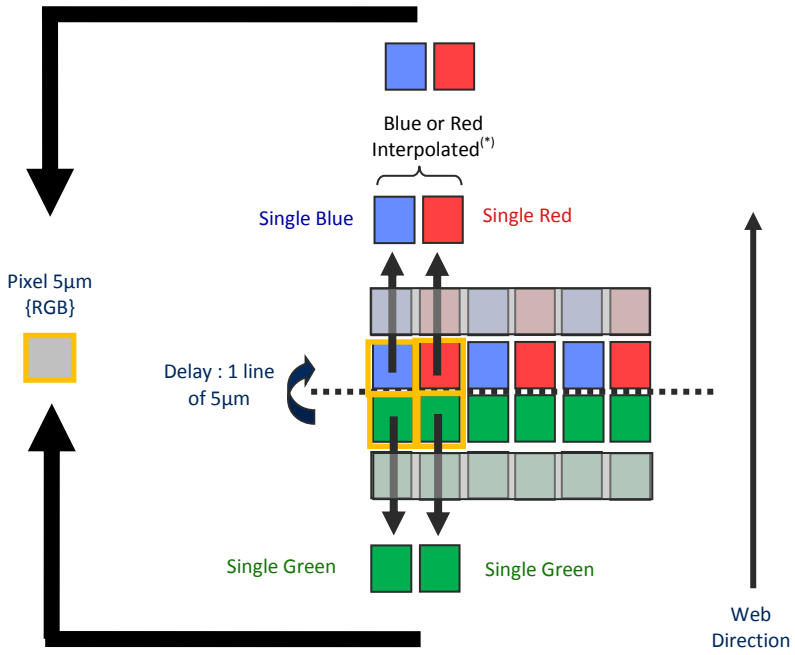
5µm Pixels (R,G,B)

Same definition than B&W

Requires x3 the data flow of the B&W

- Sensitivity is half of the TC mode available : Equivalent to 3 x Pixels of 5µm (with their respective colour filters).

- "Full Exposure control" not needed in this mode as the Time Delay Exposure is not active. The Exposure time can be control as for a single line mode.



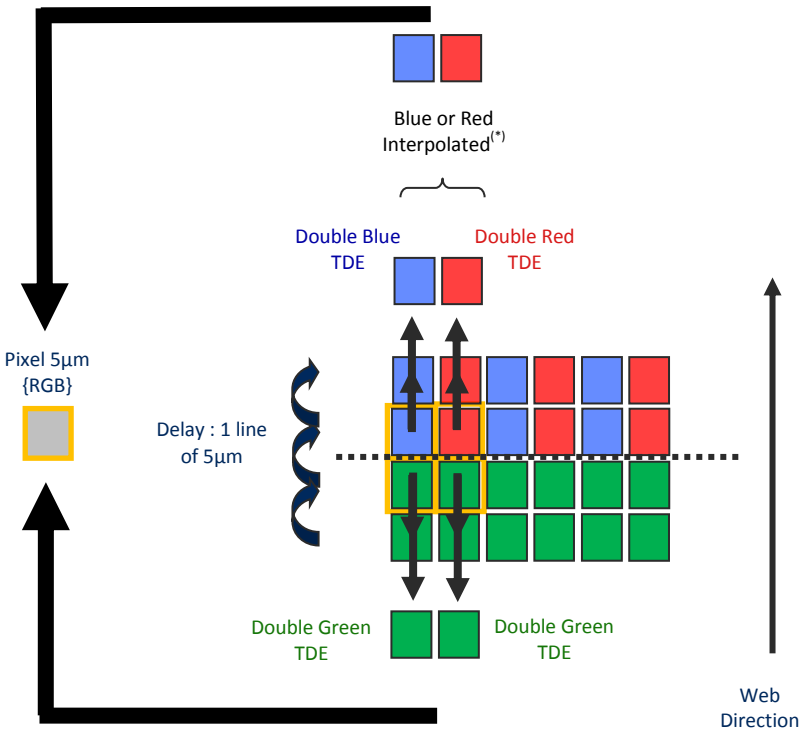
2.2.2 Full Definition Enhanced Mode (FDE)

5µm Pixels (R,G,B)

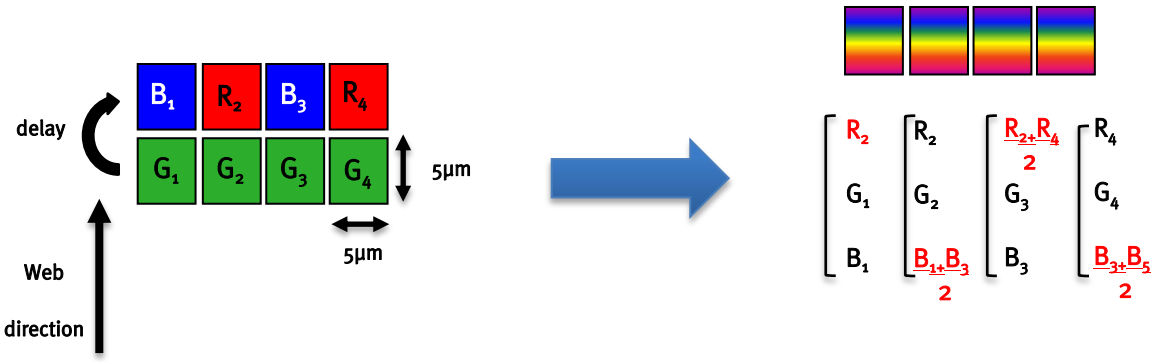
Same definition than B&W

Requires x3 the data flow of the B&W

- Sensitivity is the same as the TC mode available : Equivalent to 6 x Pixels of 5µm (with their respective colour filters).
- "Full Exposure control" is activated in this mode as the Time Delay Exposure is active.



2.2.3 Color Interpolation in Full Definition modes.

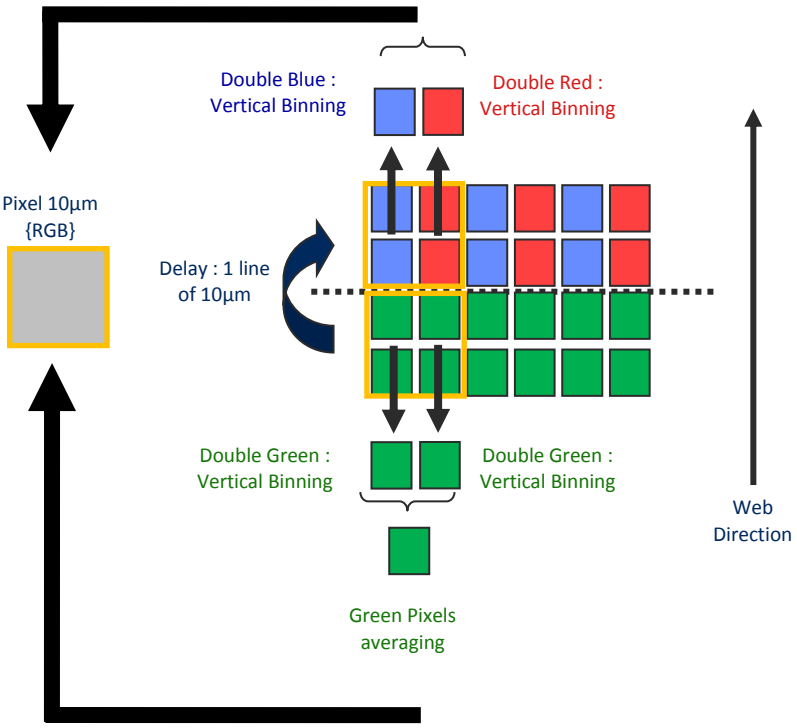


This color mode (5µm) requires the indication of "Forward/Reverse" to the camera in order to manage the delay between the two coloured lines.

2.2.4 True Colour Enhanced Mode (TCE)

10µm Pixels (R,G,B)
Twice less pixels than B/W
Requires x3/2 the data flow of B&W

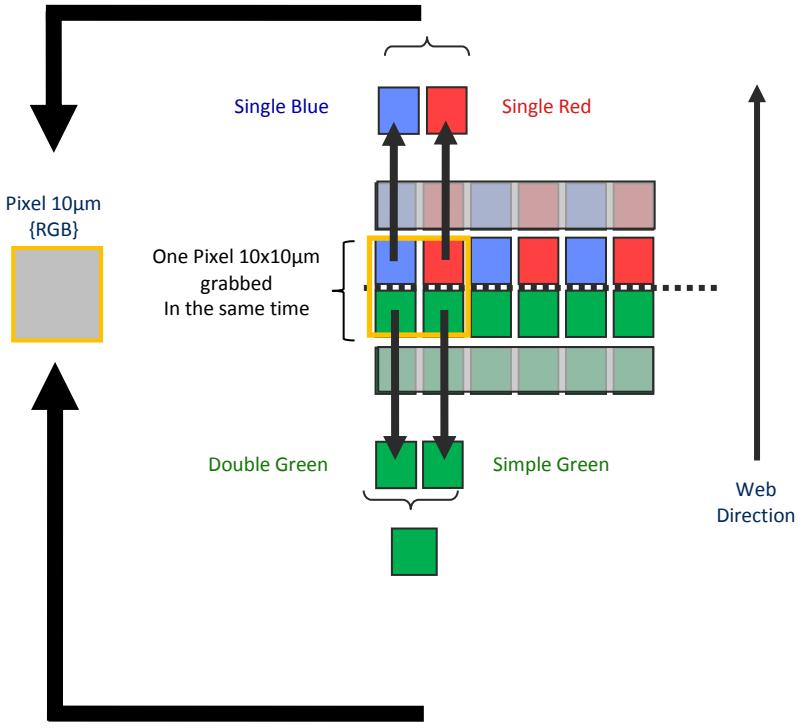
- High Sensitivity True Color mode: Equivalent to 6 x Pixels of 5µm (with their respective colour filters).
- "Full Exposure control" not needed in TC as the TDI is not active (only binning). The Exposure time can be control as for a single line mode.



2.2.5 True Colour Single Mode (TCS)

10µm Pixels (R,G,B)
Twice less pixels than B/W
Requires x3/2 the data flow of B&W

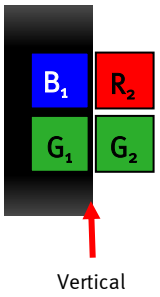
- Sensitivity Half of the TCE mode: Equivalent to 6 x Pixels of 5µm (with their respective colour filters).
- "Full Exposure control" not needed in TC as the TDI is not active (only binning). The Exposure time can be control as for a single line mode.
- Not sensitive to the Scanning direction and the variation of the aspect ratio of the image.



2.2.6 Interpolation Corrections for True Color Modes

Column Interpolation Correction

This interpolation is used to compensate the color error in the Red or the Blue in case of a vertical transition on the web : The Red of the blue value of each colored pixel is corrected if the variation between two neighbour green pixels is significant.



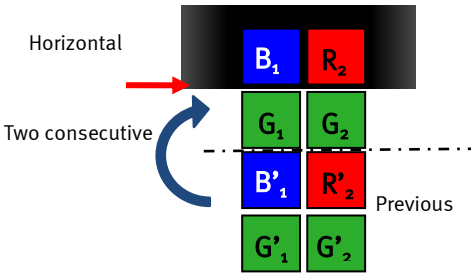
$B_1' = \alpha_B \times B_1$ and α_B is the blue correction, calculated with the variation $(G_1–G_2)$

$R_2' = \alpha_R \times R_2$ and α_R is the red correction, calculated with the variation $(G_1–G_2)$

- This interpolation is available for all pixel sizes : 5x5µm but also 10x10µm
- It can be disabled by the customer. By default, it is enabled.

Line Interpolation Correction

This interpolation is used to compensate the color error in the Red or the Blue in case of a horizontal transition on the web in the same "True Color" pixel : A line is memorized and the Red of the blue value of each colored pixel is corrected if the variation between two consecutive green values (previous to next line) is significant :

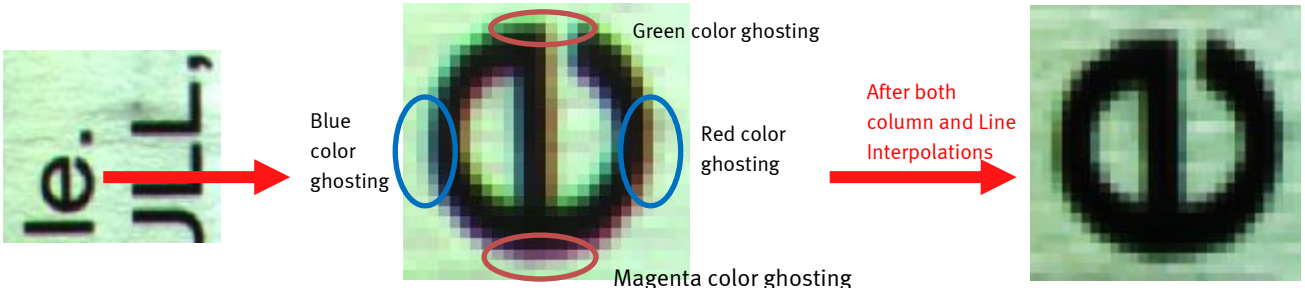


$B_1' = \alpha_B \times B_1$ and α_B is the blue correction, calculated with the variation $(G_1–G'_1)$

$R_2' = \alpha_R \times R_2$ and α_R is the red correction, calculated with the variation $(G_2–G'_2)$

- This interpolation is available only for pixel size 10x10µm (True Color Single only)
- It can be enabled by the customer. By default, it is disabled
- This interpolation requires the Forward/Reverse indication sent to the camera for the memorized line.

Effects of the interpolation Corrections for True Color

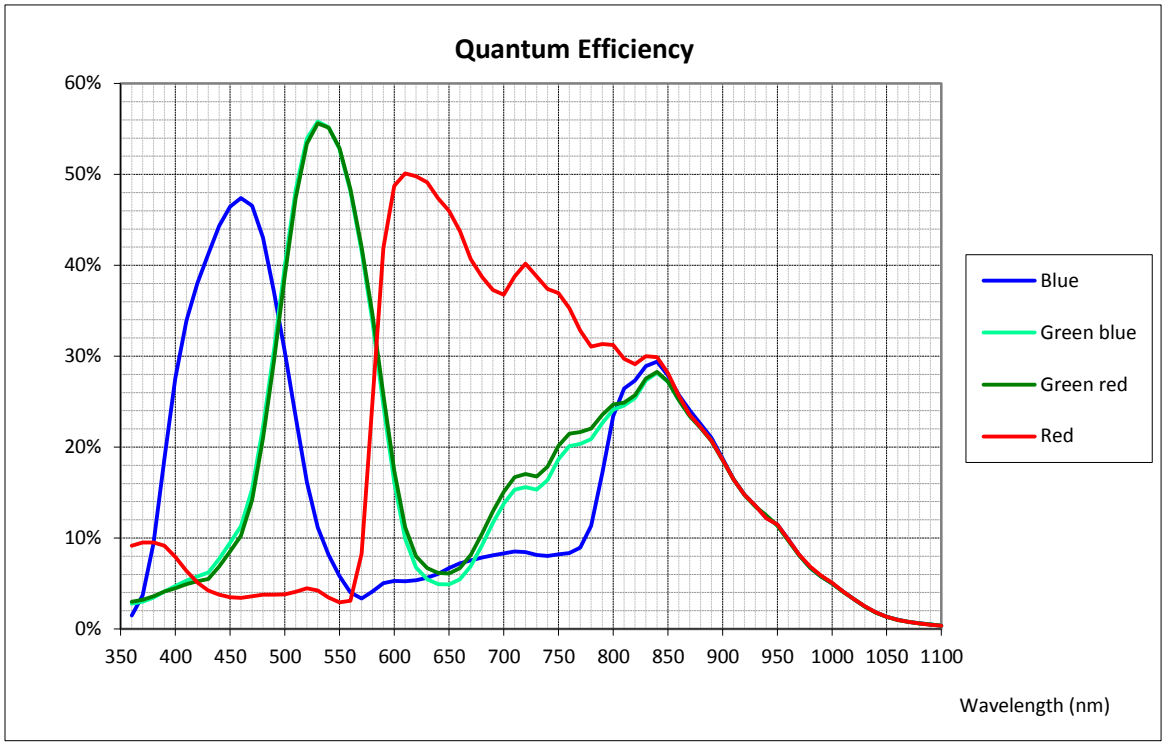


Horizontal transition effect reduced by the "Line Interpolation"

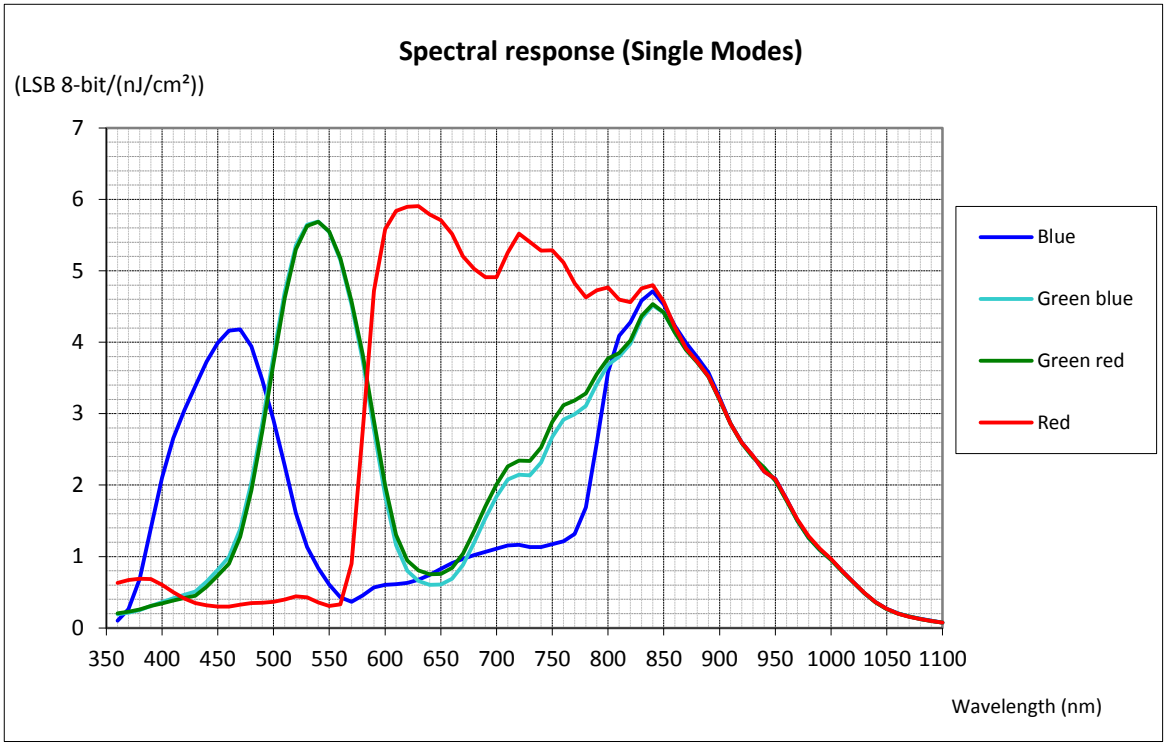
Vertical transition effect reduced by the "Column Interpolation"

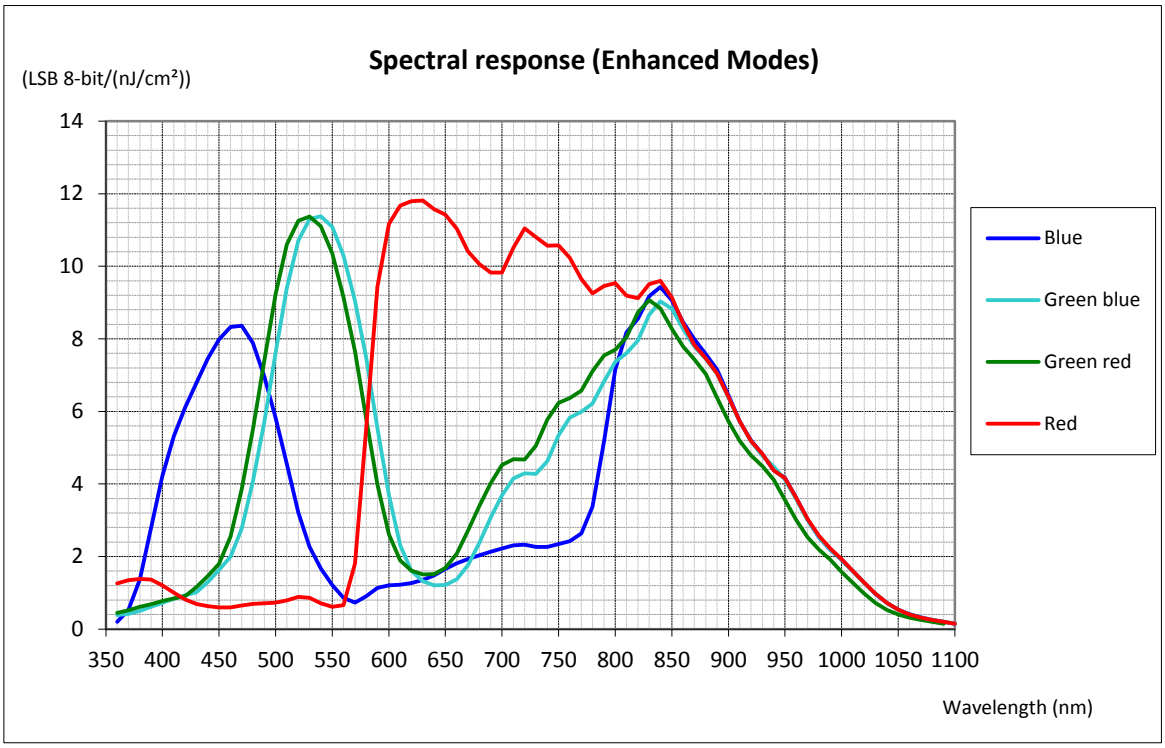
2.3 Response & QE curves

2.3.1 Quantum Efficiency



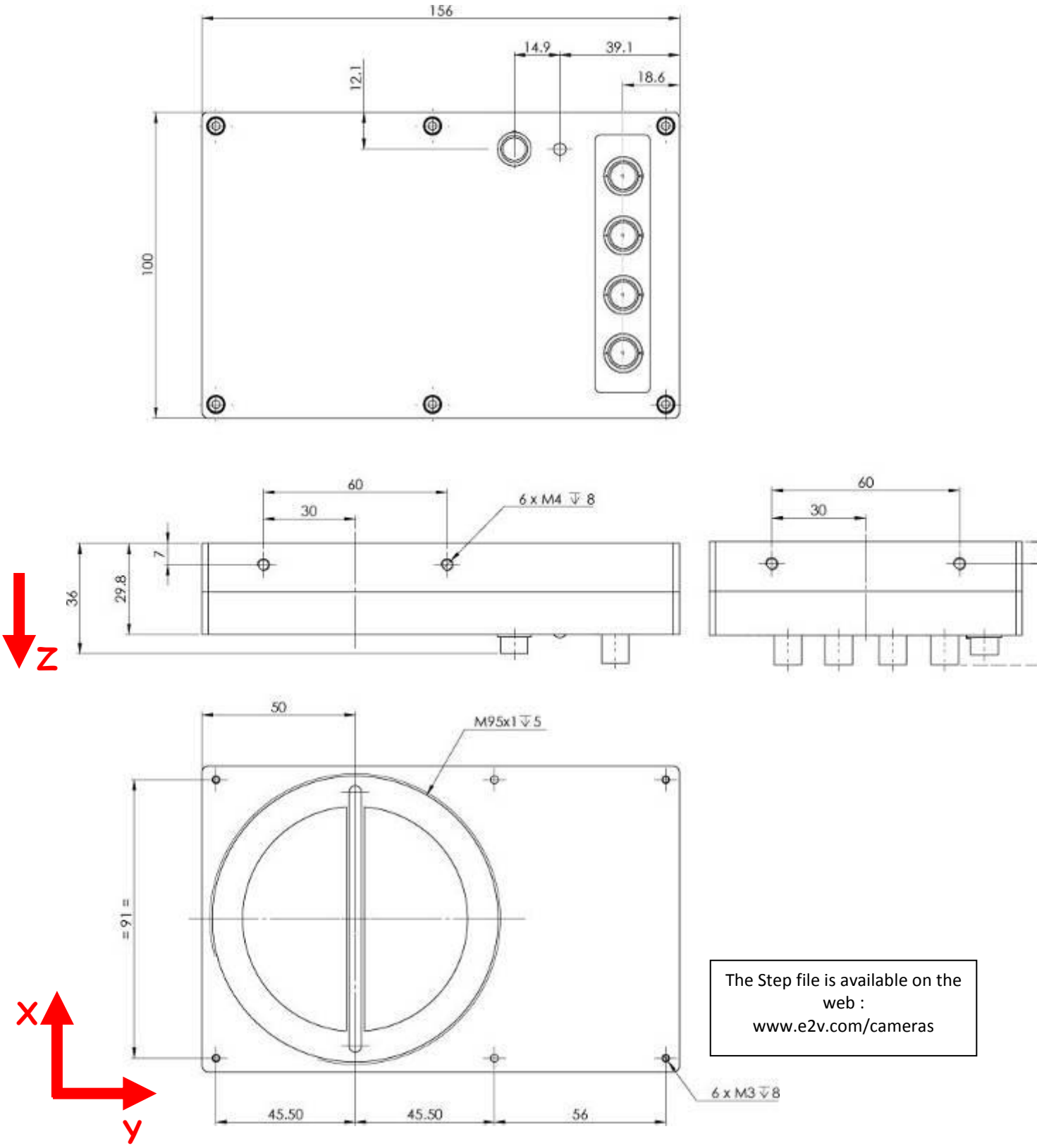
2.3.2 Spectral Response




Spectral response (Enhanced Modes)
(LSB 8-bit/(nJ/cm²))
14
12
10
8
6
4
2
0
350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100
Wavelength (nm)
Blue
Green blue
Green red
Red

3 CAMERA HARDWARE INTERFACE

3.1 Mechanical Drawings



The Step file is available on the web :
www.e2v.com/cameras

Sensor alignment	
Z = -9.4 mm	±100µm
X = 9 mm	±100 µm
Y = 50mm	±100 µm
Flatness	±25 µm
Rotation (X,Y plan)	±0,1°
Tilt (versus lens mounting plane)	50µm

3.2 Input/output Connectors and LED

3.2.1 Power Over CoaXPress

The ELIIXA+ CXP is compliant with the Power Over CoaXPress : There is no Power connector as the power is delivered through the Coaxial Connectors 1 and 2.
In the Standard, the Power Over CoaXPress allows to deliver 13W (under 24V) per Channel.
The ELIIXA+ CXP requires 19W then two connectors are required for the power : The two first are used for this purpose.

If you want to Power ON the Camera you have to connect the Coaxial connector output 1 of the camera to the coaxial connector 1 of the Frame Grabber.

Note 1 : Only the connector 1 position is mandatory. They other 3 connectors can be inverted but the camera still needs the 2 first connectors to get it power and be able to start up.

Note 2 : Removing the 2 first connectors will shut down the Camera : You can reset the Camera by quickly (**less than 1s**) connect/disconnect the Connector CXP1 but after a longer shut down, you'll have to reboot the PC with the Camera full connected to the frame grabber in order to synchronize the discovery of each power line.

Note 3 : With some frame grabber you have access to a specific command (from the Frame Grabber interface) for shutting down/up the power of the CoaxPress : This solution, with the complete reboot, is the better solution to ensure a complete power On of the Camera.

3.2.2 Status LED Behaviour

The Power LED behavior detail is the following :

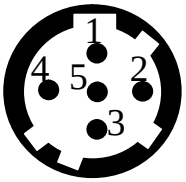
Colour and State		Meaning
Off		No power
Solid orange		System booting
Fast flash green Shown for a minimum of 1s even if the link detection is faster		Link detection in progress
Slow flash alternate red / green		Device / Host incompatible
Slow pulse green		Device / Host connected, but no data being transferred
Slow pulse orange		Device / Host connected, waiting for event (e.g. trigger, exposure pulse)
Solid green whenever data transferred (i.e. blinks synchronously with data)		Device / Host connected, data being transferred
500ms red pulse In case of multiple errors, there shall be at least 200ms green before the next error is indicated		Error during data transfer (e.g. CRC error, single bit error detected)
Fast flash red		System error (e.g. internal error)

3.2.3 Trigger Connector

Camera connector type: Hirose HR10A-7R-5SB or compliant

Cable connector type: Hirose HR10A-7P-5P (male) or compliant, Provided with the Camera

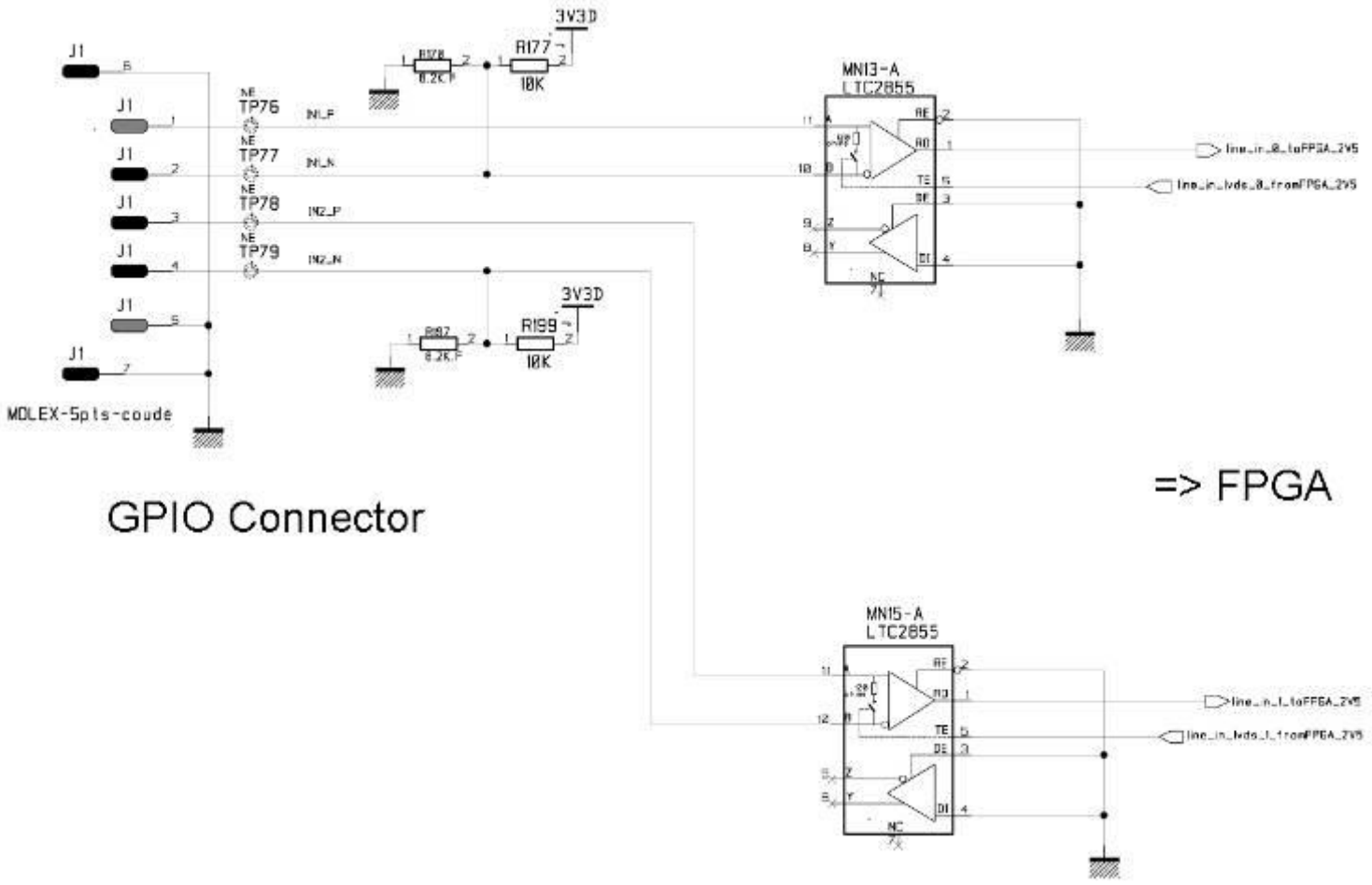
Signal	Pin
LVDS IN1+ / TTL IN1	1
LVDS IN1-	2
LVDS IN2+ / TTL IN2	3
LVDS IN2-	4
GND	5



Receptacle viewed from camera back

IN1/IN2 are connected respectively to Line0/Line1 and allow to get external line triggers or the forward/Reverse “Live” indication.

On the Connector side, the 120Ω termination is validated only if the input is switched in LVDS or RS422. The electrical schematic is detailed below :



4 STANDARD CONFORMITY

The ELIIXA+ cameras have been tested using the following equipment:

- A shielded Trigger cable
- A 10m CoaXPress Cable for the data transfer, certified at 6Gb/s

e2v recommends using the same configuration to ensure the compliance with the following standards.

4.1 CE Conformity

The ELIIXA+ cameras comply with the requirements of the EMC (European) directive 2004/108/CE (EN50081-2, EN 61000-6-2) (see next page).

4.2 FCC Conformity

The ELIIXA+ cameras further comply with Part 15 of the FCC rules, which states that: Operation is subject to the following two conditions:

- This device may not cause harmful interference, and
- This device must accept any interference received, including interference that may cause undesired operation

This equipment has been tested and found to comply with the limits for 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.

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

4.3 RoHs Conformity

ELIIXA+ cameras comply with the requirements of the RoHS directive 2011/65/EU.

5 GETTING STARTED

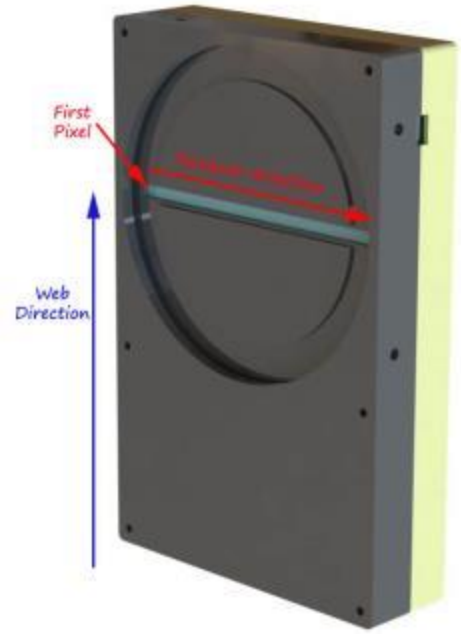
5.1 Out of the box

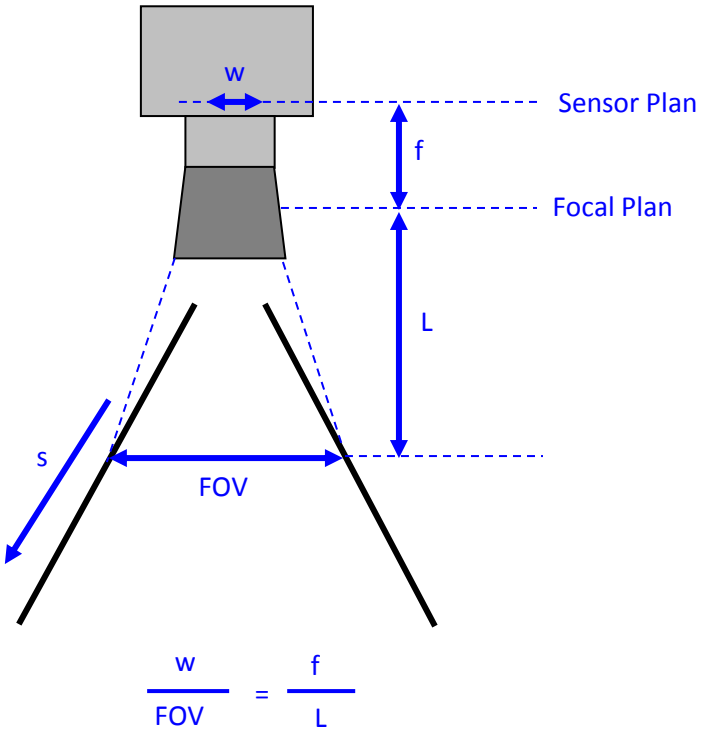
The contains of the Camera box is the following :

- One Camera ELIIXA+
- Trigger connector (Hirose HR10A-7P-5P-male or compliant)

There is no CDROM delivered with the Camera : This User Manual , and any other corresponding documents can be dowlaoded on the Web site.
Main Camera page : **www.e2v.com/cameras**
Select the appropriate Camera Page (ELIIXA+)

5.2 Setting up in the system





The Compliant Lenses and their accessories are detailed in Appendix E

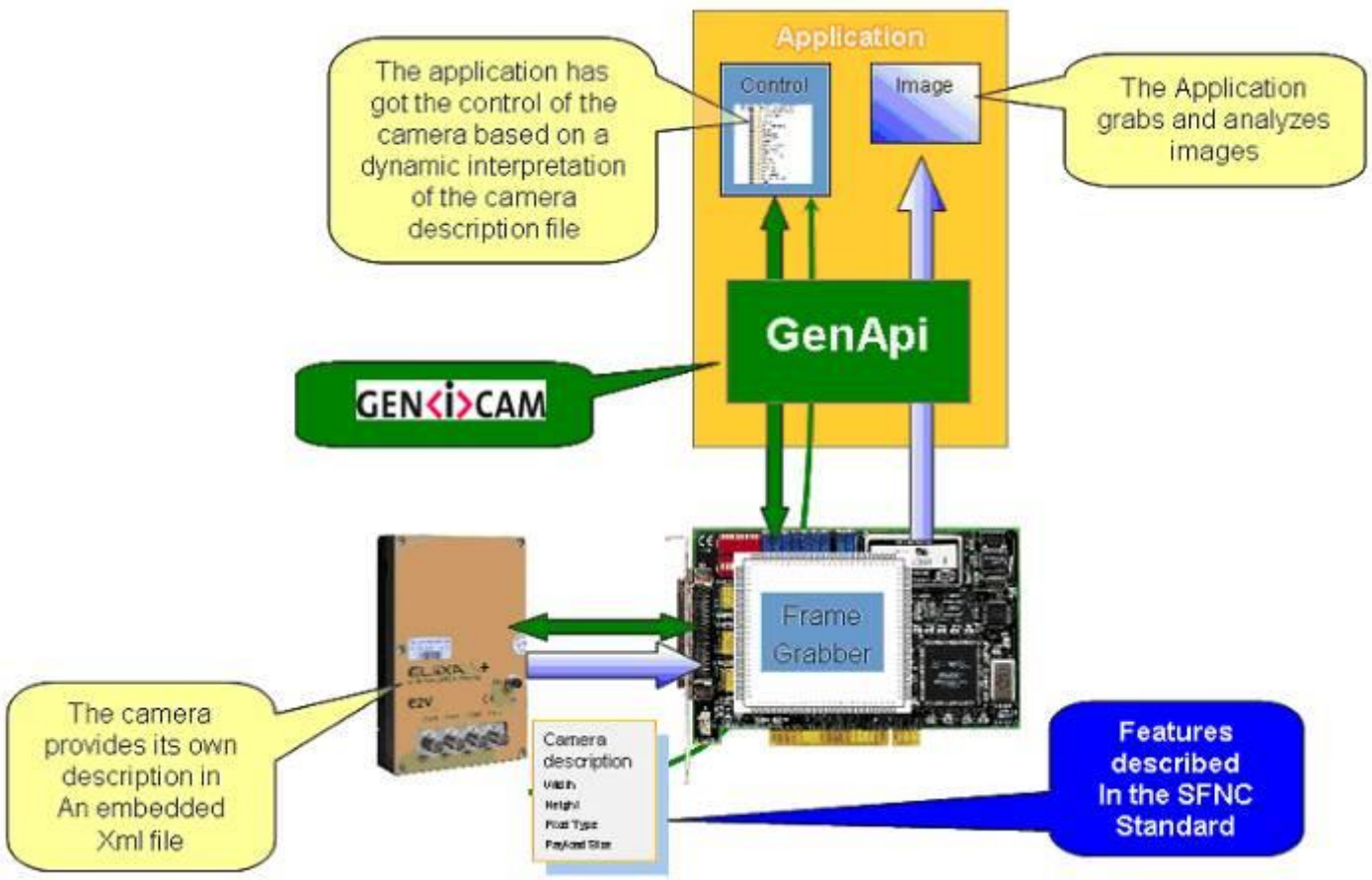
6 CAMERA SOFTWARE INTERFACE

6.1 Control and Interface

The ELIIXA+ CoaxPress Camera is compliant with GenICam 2.1 and the SFNC 1.5 standards.

This means that the Camera embeds its own definition and parameter description in an xml file.

Most of these Parameters are compliant with the SNFC. The specific parameters (non SNFC) are still compliant with GenICam and can be detailed through the GenICam API process to the application.



The Frame Grabber software is supposed to propose a feature Brother, based on GenICam, which lists and allows the modification of the parameters of the Camera.

This feature brother based on GenICam API uploads the xml file of the parameters description embedded in the Camera.

Then the following description of the parameters and commands is based on the GenICam name of these parameters. Behind each parameter is a register address in the Camera memory.

The mapping of these registers is not given in this manual because it can change from one version or the firmware to the next one.

7 Camera Commands

7.1 Device Control

These are Identification values of the Camera. They can be accessed in the “Device Control” section

Feature	CXP @	Size (Bytes)	R/W	Description
DeviceVendorName	0x02000	32	RO	Get camera vendor name as a string (including ‘\0’)
DeviceModelName	0x02020	32	RO	Get camera model name as a string (including ‘\0’)
DeviceFirmwareVersion	0x02090	32	RO	Get camera synthetic firmware version (PKG version) as a string (including ‘\0’)
DeviceVersion	0x02070	32	RO	Get camera version as a string (hardware version) (including ‘\0’)
DeviceManufacturerInfo	0x02040	48	RO	Get camera ID as a string (including ‘\0’)
DeviceUserID	0x020C0	16	RW	Get device user identifier as a string (including '\0')
DeviceID	0x020B0	16	RO	Read Serial Nb
ElectronicBoardID	0x08000	32	RO	Read Electronic Board ID
ElectronicBoardTestStatus	0x08020	16	RO	Read Electronic board status
DeviceSFNCVersionMajor	Xml	-	-	
DeviceSFNCVersionMinor	Xml	-	-	
DeviceSFNCVersionSubMinor	Xml	-	-	
DeviceTemperature	0x08E04	4	RO	Read Main board internal temperature (format signed Q10.2 = signed 8 bits, plus 2 bits below comma. Value from -512 to +511) in °C
DeviceTemperatureSelector	Xml	-	-	Device Temperature selector
Standby	0x08E08	4	RW	**0** :Disable standby mode (“False”) **1** :Enable standby mode (“True”), no more video available but save power and temperature
STATUS REGISTER				
StatusWaitForTrigger	0x08E0C	4	RO	Bit 0: true if camera waits for a trigger during more than 1s
Status trigger too fast				Bit 1: true if camera trigger is too fast
StatusSensorConnexion				Bit 2: true if sensor pattern checking has failed
Status3V7				Bit 3: true if 3V7 failure
Status3V3				Bit 4: true if 3V3 failure
Status1V0				Bit 5: true if 1V0 failure
Status1V8				Bit 6: true if 1V8 failure
Status1V8ANA				Bit 7: true if 1V8ANA failure
StatusWarningOverflow				Bit 8: true if a an overflow occurs during FFC calibration or Tap balance (available only for integrator/user mode)
StatusWarningUnderflow				Bit 9: true if a an underflow occurs during FFC calibration or Tap balance (available only for integrator/user mode)
Status2V5				Bit 10: true if 2V5 failure
CC3 Scrolling direction				Bit 11: 0 : forward, 1: reverse
StatusErrorHardware				Bit 16 : true if hardware error detected

7.2 Image Format

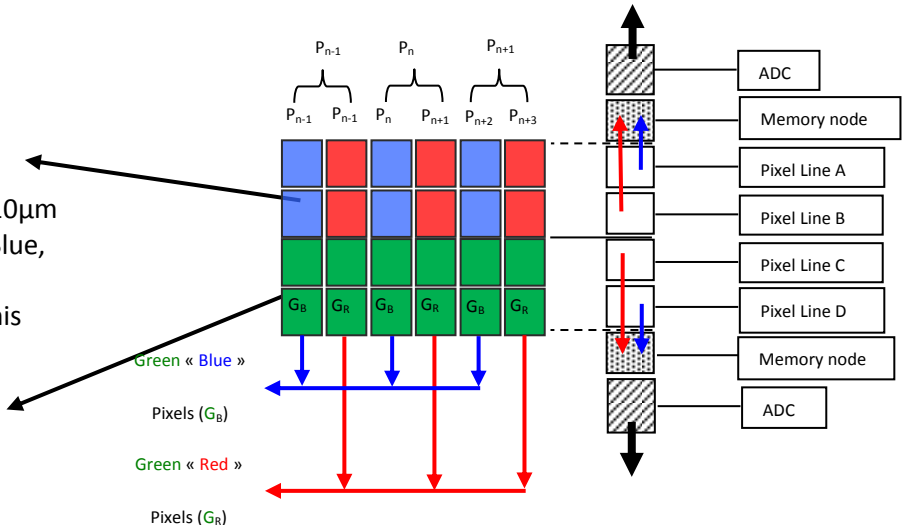
Feature	CXP @	Size (Bytes)	R/W	Description
Width	0x07000	4	RO	Depends on SensorWidth
Height	0x07004	4	RO	
AcquisitionMode	0x07008		RW	**1:** Continuous
AcquisitionStart	0x0700C		WO	**0:** Start the acquisition
AcquisitionStop	0x07010		WO	**0:** Stop the acquisition
PixelFormat	0x07014	4	RO	**0x0401**: RGB Mono8
SensorWidth	0x08200	4	RO	Get sensor physical width.
SensorHeight	Xml		RO	
WidthMax	Map on SensorWidth		RO	
HeightMax	Xml		RO	
SensorMode	0x08204	4	RW	**0** : True Color Mode Enhanced (8192 pixels outputted) **1** : Full Definition Single Mode (16386 Pixels Outputted) **2** : Full Definition Enhanced Mode (16386 Pixels Outputted) **3** : True Color Mode Single (8192 pixels outputted)
ReverseReading	0x08210	4	RW	**0**: Set reverse reading to “disable” **1**: Set reverse reading to “enable”
TestImageSelector	0x08214	4	RW	**0**:Set test (output FPGA) image pattern to “Off”, processing chain activated **1**: Set test (output FPGA) image pattern to “GreyHorizontalRamp”, processing chain disabled **2**: Set test (output FPGA) image pattern to “White pattern”, processing chain disabled **3**: Set test (output FPGA) image pattern to “gray pattern”, processing chain disabled **4**: Set test (output FPGA) image pattern to “Black pattern”, processing chain disabled **5**: Set test (output FPGA) image pattern to “GreyVerticalRampMoving”, processing chain disabled
Color Selection	0x08230	4	RW	Disable color components **Bit 0** : Disable Red color **Bit 1** : Disable Blue color **Bit 2** : Disable Green colors (both $Green_{Red}$ and $Green_{Blue}$)

7.2.1 Structure of the Sensor

Pixels in « True Color » modes :

$P_n = R_{(n)}, G_{B(n)}, B_{(n)}$

Each Pixel has to be considered as a 10x10µm pixel including 2xGreen + 1xRed and 1x Blue, all Pixels of 5x5µm.
The Enhanced mode has the double of this information



Pixels in « Full Definition » modes :

$P_n = R_{(n-1)}, G_{B(n)}, B_{(n)}$

$P_{n+1} = R_{(n+1)}, G_{R(n+1)}, B_{(n)}$

Each pixel has to be considered as a 5x5µm pixels. The Red or Blue information is alternatively interpolated from the neighbour pixel. The Enhanced mode has the double of this information : In this mode, the sensor works in TDI Mode and requires a specific mode (“Full Exposure Control”) when the User wants to control the exposure

7.2.2 Test Image Pattern Selector

This selection Defines if the data comes from the normal Sensor operation and FPGA Chain or from digital patterns generated at the end of the FPGA. This is mainly useful to detect some interfacing or connection issues.

- To switch to Cmos sensor image
- Grey Horizontal Ramp (Fixed) : **See AppendixA**
- White Pattern (Uniform white image : 255)
- Grey Pattern (Uniform middle Grey : 128 on each color)
- RGBW Pattern **See AppendixA**
- Grey vertical Ramp (moving)

When any of the Test pattern is enabled, the whole processing chain of the FPGA is disabled.

Note : When the camera is set with the RGBW pattern test, it’s no more taking in account the Line Trigger and working in Free Run (line period controlled by the camera)

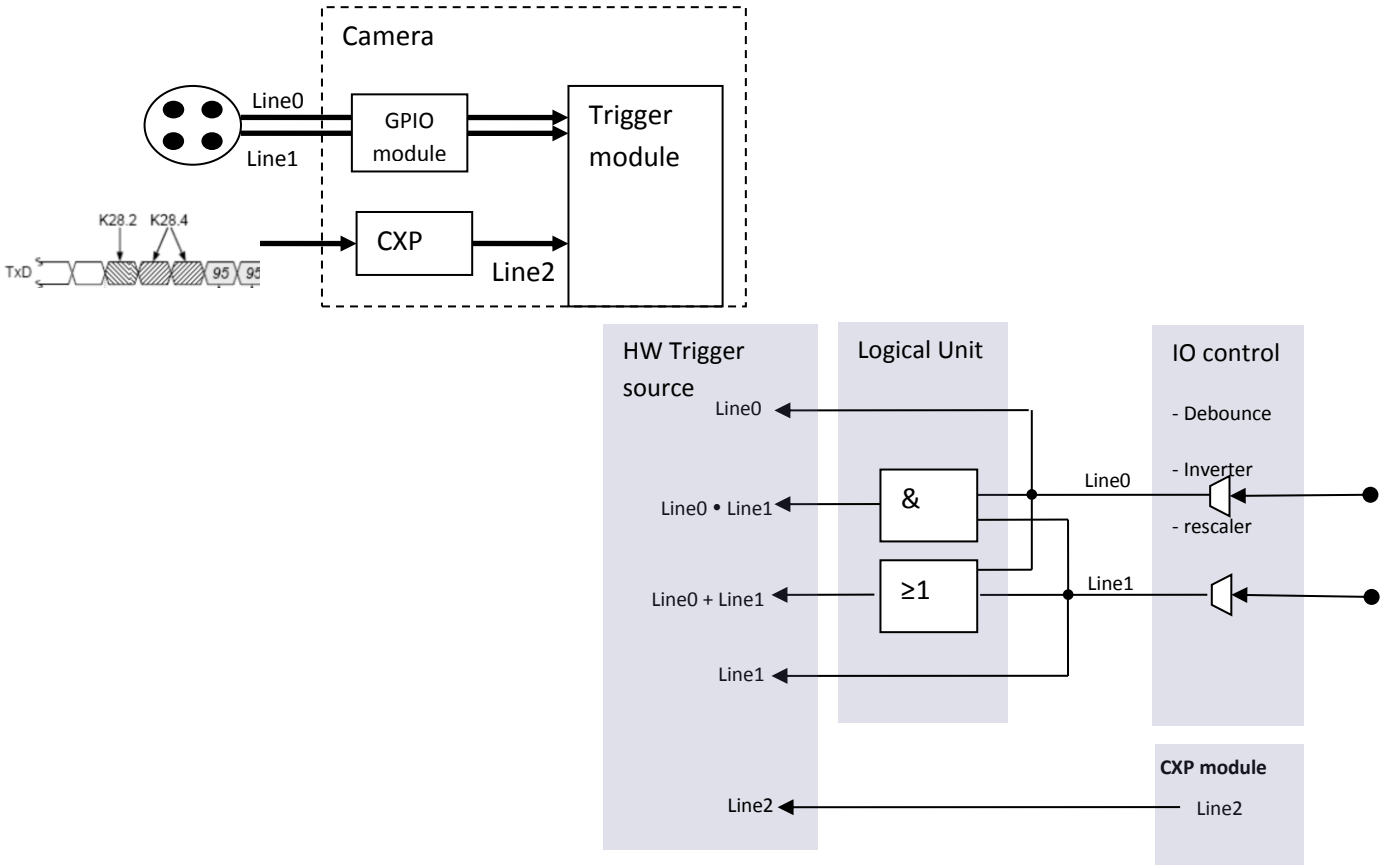
7.3 Acquisition Control

The Acquisition Control section describes all features related to image acquisition, including the trigger and exposure control. It describes the basic model for acquisition and the typical behavior of the device.

Feature	CXP @	Size (Bytes)	R/W	Description
LinePeriod	0x08400	4	RW	Set line period, from from 1 (0,1µs) to 65535 (6553,5µs), step 1 (0,1µs)
LinePeriodMin	0x08404	4	RO	Get current line period min (0..65535 step 0,1µs)
AcquisitionLineRate	Xml		RO	= 1 / LinePeriod en Hertz
ExposureTime	0x08408	4	RW	Set exposure time, from 1 (0,1µs) to 65535 (6553,5µs), step 1 (0,1µs)
TriggerPreset	0x0840C	4	WO	**0**: Set trigger preset mode to Free run timed mode, with exposure time and line period programmable *(*)* **1**: Set trigger preset mode to Triggered mode with exposure time settings *(**)* **2**: Set trigger preset mode to Triggered mode with maximum exposure time **3**: Set trigger preset mode to Triggered mode with exposure time controlled by one signal *(**)* **4**: Set trigger preset mode to Triggered mode with exposure time controlled by two signals **5**: Set trigger preset mode to Freerun mode, with max exposure time and programmable line period
ScanDirectionMode	0x0820C	4	RW	**0**: Set scan direction to "forward" **1**: Set scan direction to "reverse" **2**: Set scan direction to "Externally controlled direction via External Line on I/O Connector (0 : forward, 1 : reverse)
ExternalLine	0x08570	4	RW	**0**: Line0 **1**: Line1
TriggerTooSlow	0x08418	4	RW	Set/get trigger too slow value in ms From 1 (1 ms) to 5368 (5368 ms) step 1ms
(*) NOT AVAILABLE WHEN SENSOR IS SET IN "FULL DEFINITION ENHANCED" MODE. (**) "FULL EXPOSURE CONTROL" MODE ACTIVATED WHEN SENSOR IS SET IN "FULL DEFINITION ENHANCED" MODE.				

An **Acquisition** is defined as the capture of a sequence of one or many **Frame**(s). This Acquisition mode and its command is managed by the Frame Grabber.
A **Frame** is defined as the capture of **Width** pixels x **Height** lines.
As for the Acquisition Mode, the **Frame Management** (Start, stop …) is also manage by the Frame Grabber.
The ELIIXA+ CXP Camera is considered as a LineScan Camera (as in the CameraLink version) then only deals with the Line/Exposure Triggers.

A **Line** starts with an optional **Exposure** period and ends with the completion of the sensor read out.
The Line/Exposure Triggers can be connected :
Either on the GPIO connector of the Camera (2x Lines Triggers : Line0/1 available if Forward/reverse command is controlled by software)
Or by the CoaxPess Cable : Only one Trigger available (Line2).
If the single CoaxPress Trigger is used, the Synchronization mode using 2xTriggers can't be used.



7.3.1 External Triggers on GPIO Connector

An External GPIO connector allows the camera to used 2 lines for triggering (Line0 and Line1)

The end-user has the responsibility of the definition of the triggering system.

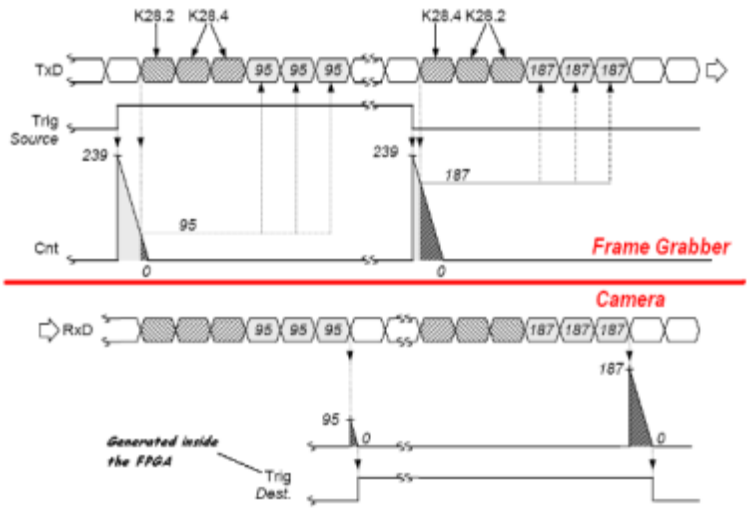
The mapping describes all features available to define a trigger system

7.3.2 CXP Trigger

CXP specification allows the frame grabber to send triggers through the low speed link0 (@20MHz)

The CXP specification describes the behavior of the trigger, where only the edge of the signal and a timer to limit the latency is described.

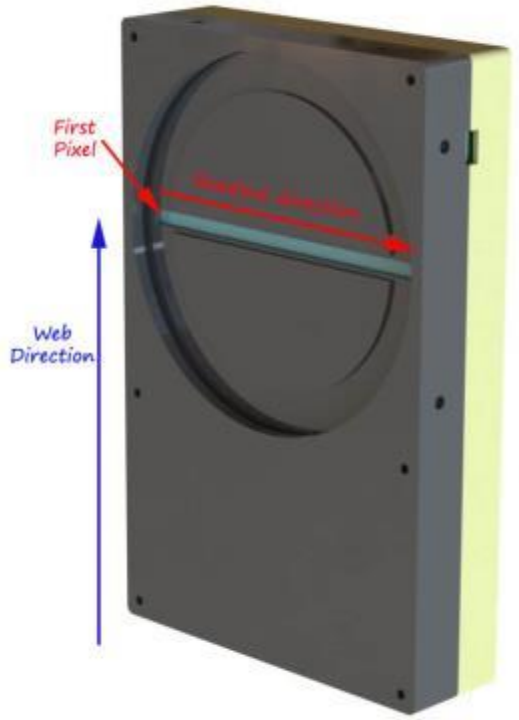
For the camera, the CXP trigger is consider to be the “line2”. The Frame grabber itself can also manage several lines, timers, counter and finally send this single CXP trigger to the camera.



7.3.3 Scan Direction

Forward/reverse information has to be set correctly For the re-ordering of the colors.

The Forward direction is defined as detailed below :



Note : The delay for the Camera to take in account a change in the ScanDirection value is **200ms**

This information can be set dynamically by using one of the two External Trig lines (Line0 or Line1) of the GPIO connector (change the direction “on the fly”).

In these case, the Trigger low level signification is :

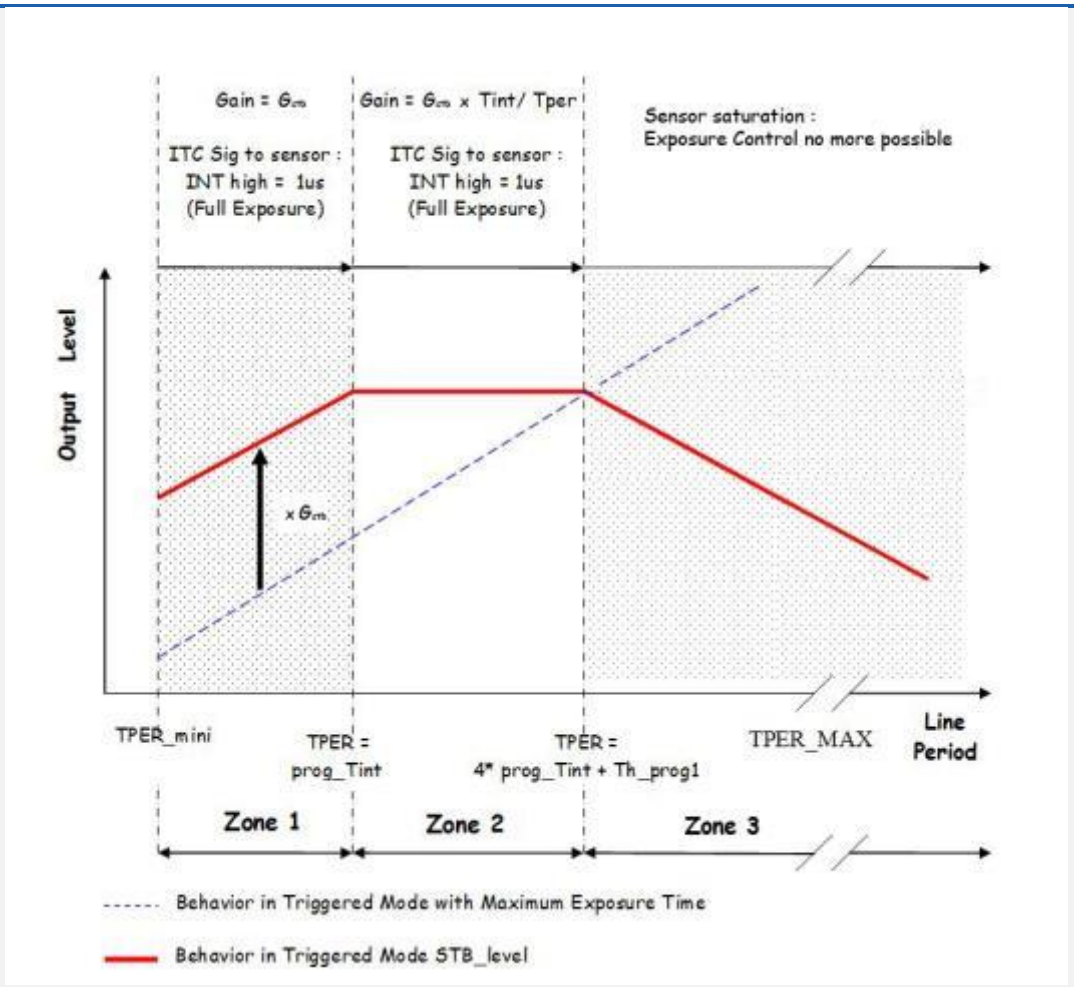
- “0” : Forward.
- “1” : Reverse

7.3.4 Full Exposure Control Mode

The Full Exposure Control

In Full Definition Enhanced Sensor Mode, the Sensor is working as a double TDI (Time Integration Delay) : The two Top Pixels and the two bottom Pixels are working together in TDI with a delay between their exposure and outputting by the same Memory node and ADC. The summation of the pixels is done in the “charge domain” before the Digital Conversion.

In TDI, control of the exposure is not possible: Only the full Exposure during the Line Period is possible. In order to allow the User to control the exposure in this Sensor mode (Synchronization Modes 1 and 3, described in the Acquisition control chapter), The ELIIXA+ Camera implement a “Full Exposure Control Mode” :



When the User selects a synchronization mode which requires the control of the exposure, the camera enters a specific mode:
The Line Period (measured) is **Tper**, its minimum value is **$TPer_{mini}$** (10µs on this camera) and the exposure time set by the User is **Prog_Tint.**

Zone 1 : If Tper < Prog_Tint
Not relevant. **Prog_Tint** has to be smaller than **Tper.** The Camera can't be use in that area

Zone 2 : If Tper < 4 x Max ($TPer_{mini}$, Prog_Tint) + 10µs
The Sensor works in Full Exposure during the whole Line Period (LP) and the gain applied on the output is variable (max x 4), set by User = **G_{stb}**
The Output is multiplied by the following Gain = **G_{stb} x Prog_Tint / Tper**

Zone 3 : If Tper >= 4 x Max ($TPer_{mini}$, Prog_Tint) + 10µs
The risk is the sensor saturates then the calculation above is no more valid : after showing an incorrect white balance, the image level will decrease down to 0 as the Line Period is increasing.
=> The Camera can't be use in that area

Gain for the "Full Exposure Control Mode"

G_{stb} : The User Can set this Gain with a value up to x4 (Gain Section). The value recommended is the one which allows to cover the variation of the line period : 10% of variation requires a Gain at least of x1.2 (+/- 10%).
By default this value is set at x4.

7.3.5 GenICam Triggers

Feature Name	CXP @	R/W	Size (Bytes)	Bit field	Description
ExposureMode	0x08414	RW	4	[31-30]	Operation mode for the exposure control: **0**: Off **1**: Timed **2**: TriggerWidth **3**: TriggerControlled
TriggerSelector	Not a register	-			Select the trigger to control { ExposureStart, ExposureEnd, ExposureActive}
TriggerSelector = ExposureActive					
TriggerMode	0x08420	RW	4	[31]	Specifies the operation mode of the trigger for the acquisition : **0**: Off **1**: On
TriggerSource				[30-26]	Specifies the source for the trigger : **0**:Software **1**: Line0 **2**: Line1 **3**: Line2 **4**: TimerStart1 **5**: TimerStart2 **6**: TimerEnd1 **7**: TimerEnd2 **8**: CounterStart1 **9**: CounterStart2 **10**: CounterEnd1 **11**: CounterEnd2 **17**: Line0 OR line1 **18**: Line0 AND Line1 **19**: RescalerLine
TriggerActivation				[25-23]	Specifies the activation mode of the trigger : **0**: RisingEdge **1**: FallingEdge **2**: AnyEdge, **3**: LevelHigh **4**: LevelLow
TriggerDelayAbs				[20-16]	Specifies the absolute delay in µs to apply after the trigger reception before effectively activating it (0,31/30MHz,step 1/30MHz µs)
TriggerSoftware	0x08424	RW	4		Generate a software trigger to start the acquisition when trigger mode is active and trigger source is software
TriggerSelector = ExposureEnd					
TriggerMode, …	0x08430	RW	4		Same as above
TriggerSoftware	0x08434	RW	4		
TriggerSelector = ExposureStart					
TriggerMode, …	0x08440	RW	4		Same as above
TriggerSoftware	0x08444	RW	4		

7.3.6 Trigger Presets

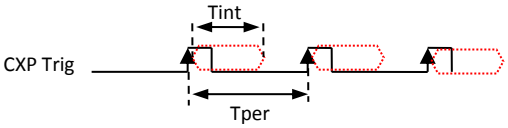
Several triggers are pre-defined to help the user to define its trigger configuration.

For external trigger, 5 modes are available (Same than in the Camera Link version) :

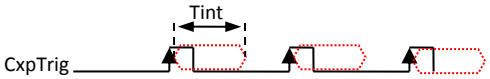
	Exposure Mode	Acquisition Mode	TriggerSelector					
			ExposureActive		ExposureStart		ExposureStop	
Mode 0	Timed	Continuous	TriggerMode	Off	TriggerMode	Off	TriggerMode	Off
			TriggerSource	NA	TriggerSource	NA	TriggerSource	NA
			TriggerActivation	NA	TriggerActivation	NA	TriggerActivation	NA
Mode 1	Timed	Continuous	TriggerMode	Off	TriggerMode	On	TriggerMode	Off
			TriggerSource	NA	TriggerSource	Line0	TriggerSource	NA
			TriggerActivation	NA	TriggerActivation	RisingEdge	TriggerActivation	NA
Mode 2	Off	Continuous	TriggerMode	Off	TriggerMode	On	TriggerMode	Off
			TriggerSource	NA	TriggerSource	Line0	TriggerSource	NA
			TriggerActivation	NA	TriggerActivation	RisingEdge	TriggerActivation	NA
Mode 3	TriggerWidth	Continuous	TriggerMode	On	TriggerMode	Off	TriggerMode	Off
			TriggerSource	Line0	TriggerSource	NA	TriggerSource	NA
			TriggerActivation	LevelLow	TriggerActivation	NA	TriggerActivation	NA
Mode 4	TriggerControled	Continuous	TriggerMode	Off	TriggerMode	On	TriggerMode	On
			TriggerSource	NA	TriggerSource	Line0	TriggerSource	Line1
			TriggerActivation	NA	TriggerActivation	RisingEdge	TriggerActivation	RisingEdge
Mode 5	Off	Continuous	TriggerMode	Off	TriggerMode	Off	TriggerMode	Off
			TriggerSource	NA	TriggerSource	NA	TriggerSource	NA
			TriggerActivation	NA	TriggerActivation	NA	TriggerActivation	NA

For CXP triggers, only one line is available where only the rising and falling edge is defined.

- Mode 0 :



Mode 1 :



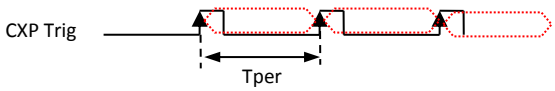
- Mode 2 :

Mode 3 :

- Mode 4 :

Not available because only 1 Trigger CXP

Mode 5 :



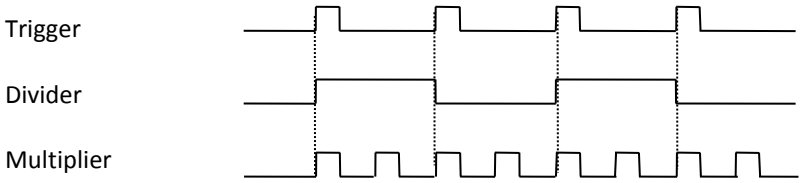
The Timing diagrams associated to each Synchronization mode and the Timing values associated are detailed in the APPENDIX B of this document.
Mode 0 is not available in Full Definition Enhanced Sensor Mode.
Modes 1 and 3 will require the use of the “Full Exposure Control” described chapter 7.2.2

7.3.7 Rescaler

Feature Name	CXP @	R/W	Size (Bytes)	Bit field	Description
TriggerRescalerSource	0x08540	RW	4	[31-30]	RescalerSize (see **Erreur ! Source du envoi introuvable.**) Bit0: 0: line0 selected for rescaler 1: line1 selected for rescaler Bit1: Bypass Rescaler
TriggerRescalerMultplier				[29-18]	mult factor for rescaler function Rescaler will create "mult" pulse between input trig
TriggerRescalerDivider				[17-6]	div factor for rescaler function Rescaler will take 1 pulse each "div" pulse
TriggerRescalerGranularity				[5-4]	0: 1 *20 = 20 ns 1: 4 *20 = 80 ns 2: 16 *20 = 320 ns 3: 256 *20 = 5120 ns
TriggerRescalerAverage				[3-1]	average trigger delay computed with: 0: 1 previous trigger delay 1: 2 previous trigger delay 2: 4 previous trigger delay 3: 8 previous trigger delay 4: 16 previous trigger delay 5: 32 previous trigger delay 6: 64 previous trigger delay 7: 128 previous trigger delay
TriggerRescalerCountInt	0x08544	RW		[31-16]	count_int overflow
TriggerRescalerCountIntOverflow				[15]	count_int counter of rescaler bloc count between 2 input trig

The camera has two registers per line which can define a rescaler: a multiplier and a divider.

With these two registers, the end-user can change the frequency of the line.



The generated line has always a 50% duty cycle. With the combination of a multiplier and divider, the system can generate any frequency

The system must sample the input signal to compute its frequency.

Two parameters define the sample settings:

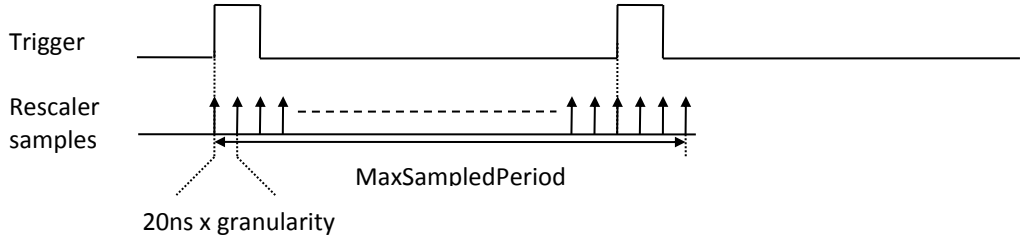
- RescalerSize
- Granularity

The Rescaler Size defines the maximum number of samples : 16bit (65536 samples).

The Granularity allows the rescaler to generate the sample periodicity. Four values are possible: 1, 4, 16 or 256 system clock cycles.

The system clock period is 20ns. So the time between samples is (Granularity x 20ns)

With these two parameters, the user must determine the best sample range. It is the user responsibility to configure the rescaler.



The MaxSampledPeriod must be as close as possible to the trigger period while still being longer

MaxSampledPeriod = 20ns x granularity x $2^{rescalerSize}$

The array below gives the MaxSampledPeriod in millisecond :

granularity	Precision (ns)	Max Sample Period (ms)
1	20	1.31
4	80	5.24
16	320	20.97
256	5120	335.54

The trigger frequency is calculated at each Trigger pulse.

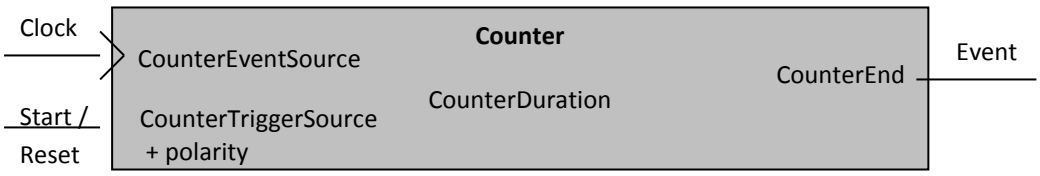
7.4 Digital I/O Control

Feature Name	CXP @	R/W	Size (Bytes)	Bit field	Description
LineStatusAll	0x08460	RW	4		Return the current status of all lines (bit0 for Line0, bit1 for Line1, bit2 for Line2)
LineSelector	Not a register	-			Select which physical line of the external device connector to configure {Line0, Line1, Line2 }
LineSelector = Line0					
LineMode	0x08470	RW	4	[31]	Define the physical line as input {Input} **0**: Input **1**: Output
LineInverter				[30]	Define the signal inversion: **0**: False **1**: True
LineDebounceFilter				[29]	Activate debounce filter {True, False}
LineStatus				[28]	Return the current status of the selected : **0**: False **1**: True
LineFormat				[25-24]	Select the electrical format of the selected line (line0 or line1): **0**: TTL **1**: LVDS **2**: RS422
LineSelector = Line1					
LineMode	0x08480	RW	4	[31]	Same as above
LineInverter				[30]	Same as above
LineDebounceFilter				[29]	Same as above
LineStatus				[28]	Same as above
LineFormat				[25-24]	Same as above
LineSelector = Line2					
LineMode	0x08490	RW	4	[31]	Same as above
LineInverter				[30]	Same as above
LineDebounceFilter				[29]	Same as above
LineStatus				[28]	Same as above
LineFormat				[25-24]	Same as above

7.5 Counters and Timers Control

7.5.1 Counters

Here is a following description of the counters :

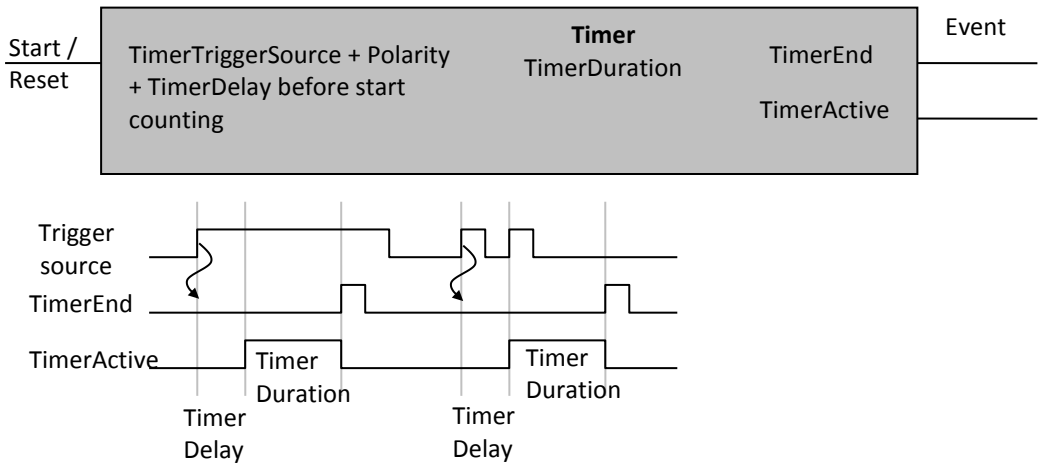


Feature Name	CXP @	R/W	Size (Bytes)	Bit field	Description
CounterSelector	Not a register	-			Select which counter to configure {Counter1, Counter2}
CounterSelector = Counter1					
CounterTriggerSource	0x084B0	RW	4	[31-27]	Select the signal that start (reset) the counter: **0**: Off **9**: ExposureStart **10**: ExposureEnd **11**: Line0 **12**: Line1 **13**: Line2 **16**: Counter1End **17**: Counter2End **18**: Timer1End **19**: Timer2End
CounterTriggerActivation				[26-24]	Select the type of activation for the trigger to start (reset) the counter : **0**: RisingEdge **1**: FallingEdge **2**: AnyEdge, **3**: LevelHigh **4**: LevelLow
CounterEventSource				[23-19]	Select the event that will be the source to increment the counter : **0**: Off **9**: ExposureStart **10**: ExposureEnd **11**: Line0 **12**: Line1 **13**: Line2 **16**: Counter1End **17**: Counter2End **18**: Timer1End **19**: Timer2End **20**: TimeStampTick **21**: MissedTrigger
CounterEventActivation				[18-16]	Select the type of activation for the event that increment the counter : **0**: RisingEdge **1**: FallingEdge

Feature Name	CXP @	R/W	Size (Bytes)	Bit field	Description
					2: AnyEdge, **3**: LevelHigh **4**: LevelLow
CounterStatus		RO		[15-13]	Get counter status : **0**: CounterIdle **1**: CounterTriggerWait **2**: CounterActive, **3**: CounterCompleted **4**: CounterOverflow
CounterDuration	0x084B4	RW	4	[31-0]	Set the counter duration (or number of events) before CounterEnd event is generated
CounterReset	0x084B8	WO	4	[31-0]	Reset the selected counter
CounterValue	0x084BC	RO	4	[31-0]	Read the current value of the selected counter
CounterValueAtReset	0x084C0	RO	4	[31-0]	Read the value of the selected counter, when the counter was reset by a trigger or by an explicit CounterReset.
CounterResetSource	0x084C4	RW	4	[31-27]	Select the signal that reset the counter: **0**: Off **1**: Software **2**: Line0, **3**: Line1 **4**: Line2
CounterResetActivation				[26-24]	Select the type of activation for the counter reset source : **0**: RisingEdge **1**: FallingEdge **2**: AnyEdge, **3**: LevelHigh **4**: LevelLow
CounterSelector = Counter2					
CounterTriggerSource	0x084D0		4	[31-27]	Same as above
CounterTriggerActivation				[26-24]	Same as above
CounterEventSource				[23-19]	Same as above
CounterEventActivation				[18-16]	Same as above
CounterStatus		RO		[15-13]	Same as above
CounterDuration	0x084D4	RW	4	[31-0]	Same as above
CounterReset	0x084D8	WO	4	[31-0]	Same as above
CounterValue	0x084DC	RO	4	[31-0]	Same as above
CounterValueAtReset	0x084E0	RO	4	[31-0]	Same as above
CounterResetSource	0x084E4	RW	4	[31-27]	Same as above
CounterResetActivation				[26-24]	Same as above

7.5.2 Timers

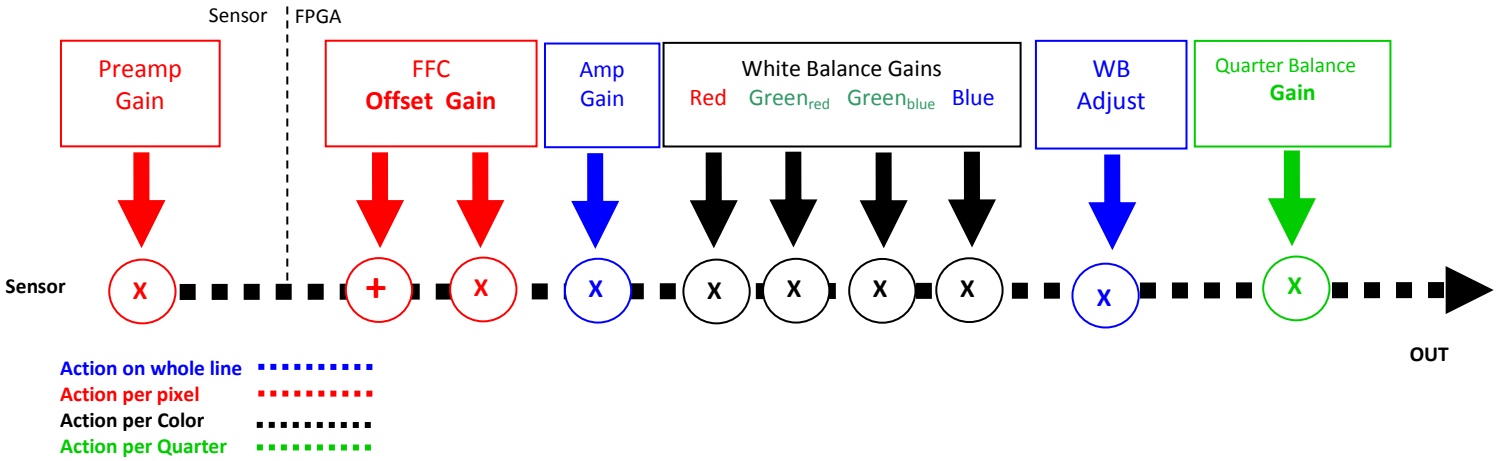
Here is a following description of the Timers :



Feature Name	CXP @		Size (Bytes)	Bit field	Description
TimerSelector	Not a register	-			Select which timer to configure {Timer1, Timer2}
TimerSelector = Timer1					
TimerTriggerSource	0x08500	RW	4	[31-27]	Select which internal signal will trigger the timer: **0**: Off **9**: ExposureStart **10**: ExposureEnd **11**: Line0 **12**: Line1 **13**: Line2 **16**: Counter1End **17**: Counter2End **18**: Timer1End **19**: Timer2End
TimerTriggerActivation				[26-24]	Select the type of signal that will trig the timer: **0**: RisingEdge **1**: FallingEdge **2**: AnyEdge, **3**: LevelHigh **4**: LevelLow
TimerDelay				[23-19]	Set the delay in µs from the TimerTrigger to the actual Timer pulse output ((0,31/30MHz, step 1/30MHz)
TimerStatus		RO		[18-17]	Get counter status **0**: TimerIdle **1**: TimerTriggerWait **2**: TimerActive, **3**: TimerCompleted
TimerDuration	0x08504	RW	4	[31-0]	Set the length of the ouput pulse in µs (0,6553.5, step 0.1)
TimerValue	0x08508	RO	4	[31-0]	Return the actual value of the selected timer (0,65535/30MHz, step 1/30MHz)

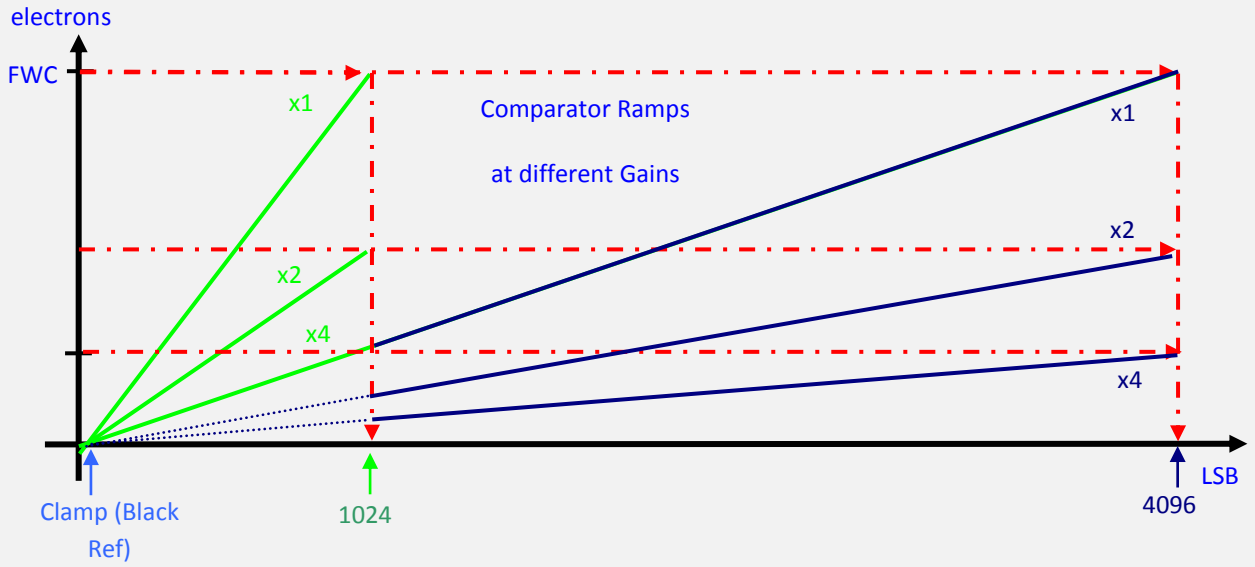
Feature Name	CXP @		Size (Bytes)	Bit field	Description
TimerSelector = Timer2					
TimerTriggerSource	0x08510	RW	4	[31-27]	Same as above
TimerTriggerActivation				[26-24]	Same as above
TimerDelay				[23-19]	Same as above
TimerStatus		RO		[18-17]	
TimerDuration	0x08514		4	[31-0]	Same as above
TimerValue	0x08518		4	[31-0]	Same as above

7.6 Gain and Offset



Analog Gain in the ADC

The only analog Gain available in the ELIIXA+ is located at the sensor level, in the ADC converter.
This "Preamp Gain" is in fact a variation of the ramp of the comparator of the ADC.
Then 3 Values are available : x1, x2 and x4. A gain x1 in a 12 bits conversion is equivalent to x4 in 10 bits.



Feature	CXP @	R/W	Size (Bytes)	Description
GainAbs GainSelector= AnalogAll	0x08600	RW	4	Set pre amplifier gain to: **0**: (-12dB) **1**: (-6dB) **2**: (0dB) (analog gain) Change balances and compensation
GainAbs GainSelector= gainAll	0x08604	RW	4	Set gain from 0dB(0) to +8 dB (6193)
Gain Abs GainSelector=DigitalAll	0x08608	RW	4	Set contrast expansion digital gain from 0 (0 dB) to 255 (+14 dB), step 1 (TBD dB)
BlackLevelRaw BlackLevelSelector=All	0x0860C	RW	4	Set common black from -4096 to 4095, step 1
GainAbs GainSelector=QuarterGain<j>	0x08610 to 0x0861C	RW	4 * 4	tap<j> digital gain from -128 to 127 by step 1 (0.0021dB). Dynamically updated on AnalogAll gain changes
Gain GainSelector=DigitalRed	0x08630	RW	4	Set gain for Red color form 0 (0db) to 6193 (8dB) Used for White balance
Gain GainSelector=DigitalBlue	0x08634	RW	4	Set gain for Blue color form 0 (0db) to 6193 (8dB) Used for white balance
Gain GainSelector=DigitalGreen(red)	0x08638	RW	4	Set gain for Green Red color form 0 (0db) to 6193 (8dB) Used for white balance
Gain GainSelector=DigitalGreen(blue)	0x0863c	RW	4	Set gain for Green Blue color form 0 (0db) to 6193 (8dB) Used for white balance
AutoWhiteBalance Start	0x8640	RW	4	Auto White Balance controle 0 – Abort Auto White Balance 1 – Start Auto White Balance
AutoWhiteBalance Status	0x8644	RO	4	Auto White Balance Status
White Balance Enable	0x8648	RW	4	0 : disable White Balance 1: Enable White Balance
ColumnInterpolation	0x864C	RW	4	Column Interpolation: 0 : disable 1: enable
LineInterpolation	0x8650	RW	4	Line Interpolation: 0 : disable 1: enable
WBAdjust	0x8658	RW	4	White Balance Adjust Enable 0: Disable 1: Enable
WBAdjustAutoTargetLevel	0x865C	RW	4	Set level Target adjust from 1 to 255, step 1
WBAdjustGain	0x8660	RW	4	White Balance Ajust Gain Value from 1 to 8191 (x0.00024 to x1.99976)
Full Exposure Control Gain	0xA100	RW	4	Gain for Full Definition Enhanced mode and Exposure Control Synchro Mode only. Val from 0 (x1) to 49151 (x3.999)
WhiteBalanceRoiStart	0x00008670	RW	4	Set auto white Balance ROI Start value Range [0: Width – AutoWhiteBalanceRoiWidth - 1] By Step of 1
WhiteBalanceRoiWidth	0x00008674	RW	4	Set auto white Balance ROI Width value Range [2: Width – AutoWhiteBalanceRoiStart] By Step of 2

7.6.1 White Balance

As described in chapter 6.2.2.1, the structure of the sensor differentiates Green pixels facing Blue or Red pixels. Then the white balance is associated with 4 color Gains :

- Red Gain
- $Green_{Red}$ Gain
- $Green_{Blue}$ Gain
- Blue Gain

The Color Selection or enabling (Image Format Chapter) can affect the way you're performing the white balance : For example, if you disable the Blue and the Red color, the "White Balance" will be performed only between the two Green Gains.
The White Balance can now be performed on a User-defined ROI defined by two parameters : Start and Width.
The dissociation of Green (blue) and Green (Red) is justified by the possible difference of response of the two types of Green because of their respective neighbor color influence and then the necessity to tune them separately.
As usual, for a perfect White balance, provide to the Camera a non-saturating white (gray) target in the center of the sensor.
The White balance has to be performed after the Flat Field Correction as each color is performing its own FFC with its own reference.
In any case, the best tuning of the Camera Gains is performed from the left to the right of the Gain Chain described above : Preamp Gain first and quarter Gains last (if required).

The Auto White balance can be started only if the Camera is grabbing (start Acquisition Active) otherwise. No action will be done while launching the Auto White Balance calibration.

White Balance Adjust : A good usage.

When there are several Cameras to set up in a system on a single line, the most difficult is to have a uniform lightning whole along the line.
If each Camera performs its own White Balance then its own Flat field correction, relative to the max of each color line, the result will be a succession of Camera lines at different levels.
=> The White Balance Adjust function allows to set the same target value for all the Cameras in the system and then to get a perfect uniform line whole along the system with a precision of 1 LSB to the Target.
The Maximum correction is x2 the highest value of the line.

Colum and Line Interpolation.

Please, refer to chapter §2.2 for a detailed explanation of these two interpolations available for the User.

7.7 Flat Field Correction

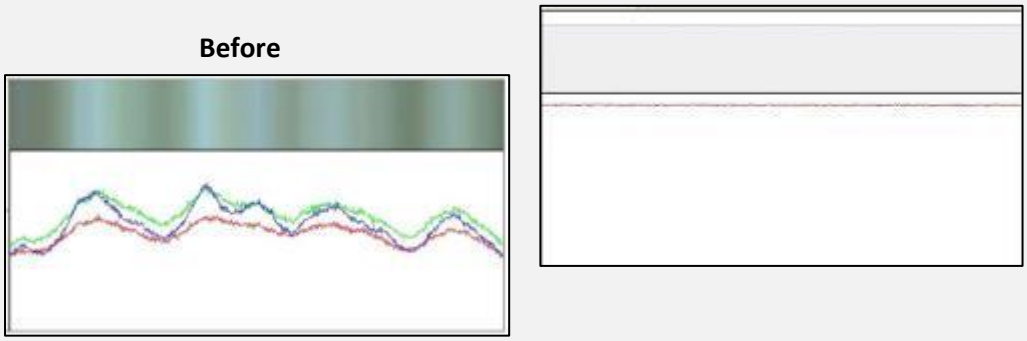
Feature	CXP @	R/W	Size (Bytes)	Description
FFCEnable	0x08800	RW	4	**0**: Disable Flat Field Correction ("False") - In user/integrator mode : the factory FFC bank is written into the FPGA and the FFC stays enabled **1**: Enable Flat Field Correction ("True")
FPNReset	0x08804	WO	4	**0**: Reset FPN coefficients
PRNUReset	0x08808	WO	4	**0**: Reset PRNU coefficients
FPNValueAll	0x10000	RW	64K	Memory containing FPN Format: S9.1 => -256..+255.5 step ½ Size=(CCDSize*2)*2 : (RedBlue Line + Green Line)
FPNValueSize	Xml	RO	2	Integer providing FPN value size in byte
PRNUValueAll	0x20000	RW	64K	Memory containing PRNU Format: U2.12 : Value from 0 to 4095 (1+coeff/1024) => x1..x4.999 step 1/1024 Size=(CCDSize*2)*2 : (RedBlue Line + Green Line)
PRNUValueSize	Xml	-	2	Integer providing PRNU value size in byte
FFCCalibrationCtrl	0x0880C	RW	4	FFC calibration - In Read Mode: **0** = finished **1** = running - In Write Mode: **0** = Abort PRNU calibration by setting it to "Off" (no effect if already stopped) **1** = Launch PRNU calibration by setting it to "Once" (no effect if already launched)
FPNCalibrationCtrl	0x08810	RW	4	FPN calibration - In Read Mode: **0** = finished **1** = running - In Write Mode: **0** = Abort FPN calibration by setting it to "Off" (no effect if already stopped) **1** = Launch FPN calibration by setting it to "Once" (no effect if already launched)
LowFrequencyFilterWidth	0x08820	RW	4	Configure windows (width) around the pixel (+/- val) 0 : filter is disable 1-255 : nb pixels around the pixel to filter

How is performed the Flat Field Correction ?

What is the Flat Field correction (FFC) ?

The Flat Field Correction is a digital correction on each pixel which allows :

- To correct the Pixel PRNU (Pixel Response Non Uniformity) and DSNU (Dark Signal Non Uniformity)
- To Correct the shading due to the lens
- To correct the Light source non uniformity



How is calculated / Applied the FFC ?

The FFC is a digital correction on the pixel level for both Gain and Offset.

Each Pixel is corrected with :

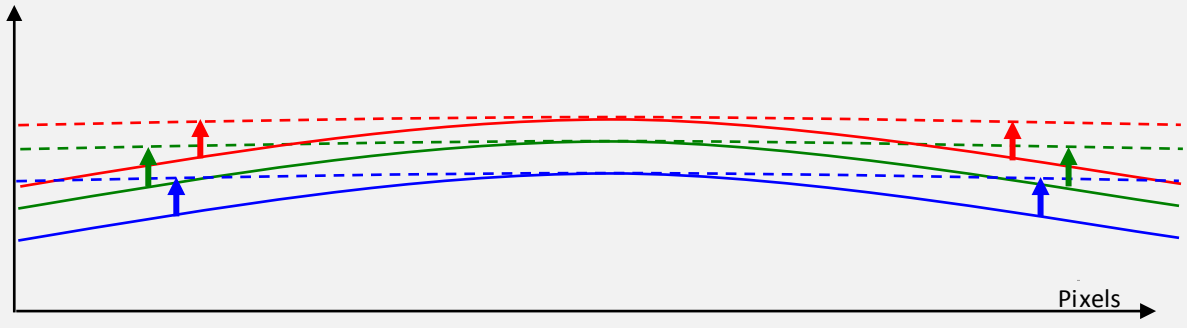
- An Offset on 10 bits (Signed Int S9.1). They cover a dynamic of ±256LSB in 12bits with a resolution of 1/2 LSB 12bits. Offet : the MSB is the sign, the rest of 9bits is from 0 .. 256 with precision of 1/2
- A Gain on 12 bits (Unsigned Int U2.12) with a max gain value of **x4.999**

  The calculation of the new pixel value is : **P' = (P + Off).(1 + Gain/1024).** Gain : 0 to 4095

The FFC processing can be completed with an automatic adjustment to a global target. This function is designed as "**FFC Adjust**". This adjustment to a User target is done by an internal hidden gain which is re-calculated each time the FFC is processed while the FFC adjust function is enabled.

The FFC is always processed with the max pixel value of the line as reference. If enabled, the FFC adjust module (located at the output of the FFC module) calculates the adjustment gain to reach the target defined by the User.

When the FFC result is saved in memory, the adjust gain and target are saved in the same time in order to associate this gain value with the FFC result.



Standard FFC computed on the max of the line for each color ($Green_{Blue}$ and $Green_{Red}$ are treated separately). Then the White Balance will overlay the colors

How to perform the Flat Field Correction ?

FPN/DSNU Calibration

- ⇨ Cover the lens
- ⇨ Launch the FPN Calibration : Grab and calculation is performed in few seconds

PRNU Calibration

The User must propose a white/grey uniform target to the Camera (not a fixed paper).
The Gain/Light conditions must give a non saturated image in any Line.
The Camera must be set in the final conditions of Light/ Gain and in the final position in the System.
I f required, set a user target for the FFC adjust and enable it.

- ⇨ White uniform (moving) target.
- ⇨ Use The FFC Low Band Filter if the Target can't move. This will remove the defects of the target itself
- ⇨ Enable and Set your White Balance Target is necessary
- ⇨ Launch the FFC
- ⇨ Enable the FFC
- ⇨ You can save the FFC result (both FPN+PRNU in the same time) in one of the 4 x FFC User Banks.
- ⇨ The user target and Gain are saved with the associated FFC in the same memory.
- ⇨ Remove the FFC Low Band filter (set to 0) if used during the Process.

Advices

The UNIIQA+ Cameras have 4 x FFC Banks to save 4 x different FFC calibrations. You can use this feature if your system needs some different conditions of lightning and/or Gain because of the inspection of different objects : You can perform one FFC to be associated with one condition of Gain/setting of the Camera (4 Max) and recall one of the four global settings (Camera Configuration + FFC + Line Quarters Balance) when required.

7.7.1 Automatic Calibration

Some Warnings can be issued from the PRNU/FPN Calibration Process as “pixel Overflow” of “Pixel Underflow” because some pixels have been detected as too high or too low in the source image to be corrected efficiently.
The Calculation result will be proposed anyway as it’s just a warning message.
The Status Register is the changed and displayed in CommCam “Status” section :
Register status is detailed chap §6.3.3.

7.7.2 Manual Flat Field Correction

The FFC Coefficients can also be processed outside of the Camera or changed manually by accessing directly their values in the Camera : This is the “Manual” FFC.

This will allow the user to upload/download out/in the Camera the FFC coefficients in/from a binary or text file that can be processed externally.

7.7.3 Save & Restore FFC

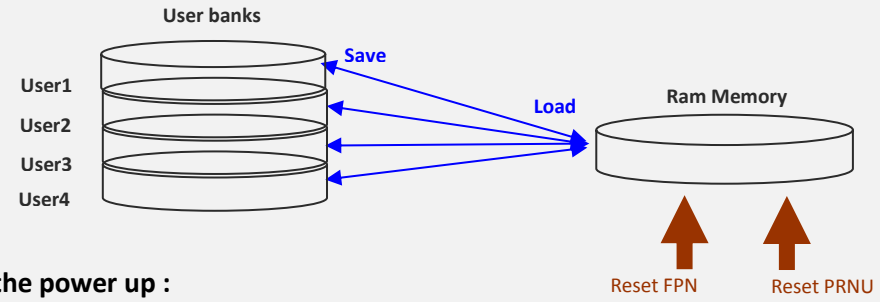
The new-processed FFC values can be saved or restored in/from 4 x User banks.

Both Gains and Offsets in the same time but also the FFC Adjust User target and associated gain.

These functions are available in the Flat Field correction/Save & Restore FFC section :

Feature	CXP @	R/W	Size (Bytes)	Description
RestoreFFCFromBank	0x08C10	RW	4	Restore current FFC (including FPN and FFCGain) from FFC bank number <val>, from 1 to 4; <val> comes from FFC SetSelector **1,2,3,4**: User Bank
SaveFFCToBank	0x08C14	RW	4	Save current FFC (including FPN and FFCGain) to FFC bank number <val>, from 1 to 4; <val> comes from FFC SetSelector **1,2,3,4**: User Bank
FFCSetSelector	Xml			FFC bank selector

FFC User Bank Usage



At the power up :
- Last User Bank used is loaded in RAM

Reset a User bank :
- Reset the RAM (FPN/PRNU individually)
- Save in the bank to reset

7.8 Statistics and Line Profile

This function allows the User to get some statistics on a pre-defined ROI. On request, the Camera acquires and then calculates some key values as the min, the max, the average or the standard deviation in this Region of Interest.

The grab and calculation command and also the collection of the results is not performed in real time as it is done through the serial connection.

This function and the results are available in the “Line Profile Average” Section :

The Calculated values are detailed as following :

- **Pixel average Value** (*PixelROIMean*) : Average gray level value calculated on whole Region of interest
- **Pixel Standard deviation** (*PixelROIStandardDeviation*) : standard deviation of all the pixel gray level values of Region of interest
- **Pixel Min value** (*PixelROIMin*) : Minimum gray level pixel value on the whole region of interest.
- **Pixel Max Value** (*PixelROIMax*) : Maximum gray level pixel value on the whole region of interest

Feature	CXP @	R/W	Size (Bytes)	Description
LineAverageProfile	0x09000			Launches the Line Profile calculation on the selected ROI 0 = Abort the Line Average Profile 1 = Run the Line Average Profile
PixelAccessLineNumer	0x09004			Set the number of line to accumulate - <val> : 1,256,512,1024
PixelRoiStart	0x09008			Roi start for pixel statistic computing (0 to SensorWidth - 1-1)
PixelRoiWidth	0x0900C			Roi width for pixel statistic computing (1 to SensorWidth)
RED				
*Color*PixelROIMean	0x09010	RO	4	Get ROI Mean, Unsigned format value : U12.4
*Color*PixelROIStandardDeviation	0x09014	RO	4	Get ROI Stand deviation, Unsigned format value : U12.4
*Color*PixelROIMin	0x09018	RO	4	Get ROI Min, Unsigned format value : U12.4
*Color*PixelROIMax	0x0901C	RO	4	Get ROI Max , Unsigned format value : U12.4
BLUE				
*Color*PixelROIMean	0x09020	RO	4	Get ROI Mean, Unsigned format value : U12.4
*Color*PixelROIStandardDeviation	0x09024	RO	4	Get ROI Stand deviation, Unsigned format value : U12.4
*Color*PixelROIMin	0x09028	RO	4	Get ROI Min, Unsigned format value : U12.4
*Color*PixelROIMax	0x0902C	RO	4	Get ROI Max , Unsigned format value : U12.4
GREEN (Red)				
*Color*PixelROIMean	0x09030	RO	4	Get ROI Mean, Unsigned format value : U12.4
*Color*PixelROIStandardDeviation	0x09034	RO	4	Get ROI Stand deviation, Unsigned format value : U12.4
*Color*PixelROIMin	0x09038	RO	4	Get ROI Min, Unsigned format value : U12.4
*Color*PixelROIMax	0x0903C	RO	4	Get ROI Max , Unsigned format value : U12.4
GREEN (Blue)				
*Color*PixelROIMean	0x09040	RO	4	Get ROI Mean, Unsigned format value : U12.4
*Color*PixelROIStandardDeviation	0x09044	RO	4	Get ROI Stand deviation, Unsigned format value : U12.4
*Color*PixelROIMin	0x09048	RO	4	Get ROI Min, Unsigned format value : U12.4
*Color*PixelROIMax	0x0904C	RO	4	Get ROI Max , Unsigned format value : U12.4

7.9 Privilege Level

There are 3 privilege levels for the camera :

- Factory (0) : Reserved for the Factory
- Integrator (1) : Reserved for system integrators
- User (2) : For all Users.

The Cameras are delivered in Integrator mode. They can be locked in User mode and a specific password is required to switch back the Camera in Integrator mode. This password can be generated with a specific tool available from the hotline (hotline-cam@e2v.com)

Feature	CXP @	R/W	Size (Bytes)	Description
PrivilegeLevel	0x08E00	RW	4	Get camera running privilege level - In Read Mode: **0** = Privilege Factory **1** = Privilege Advanced User **2** = Privilege User - In Write Mode: **1** = Lock camera o “Advanced User” **2** = Lock camera to “User” **other values** = Unlock camera privilege depending on <val> (min=256; max=2^{32}-1)

7.10 Image Control

And Image issued from the grab can be stored in the camera and replay on demand :

Feature	CXP @	R/W	Size (Bytes)	Description
SaveImageControl	0x08664	RW	4	Record the Current Image Read : 0 : No Record in Progress 1 : Record in Progress Write : 0 : Stop Record 1 : Start Record
PlayImageControl	0x08668	WO	4	Play Image : 0 : Play “Live” Image 1 : Play Recorded Image
ImageControlAccess	0x0866C	RW	2*16384	Manual access to the recorded Image

7.11 Save & Restore Settings

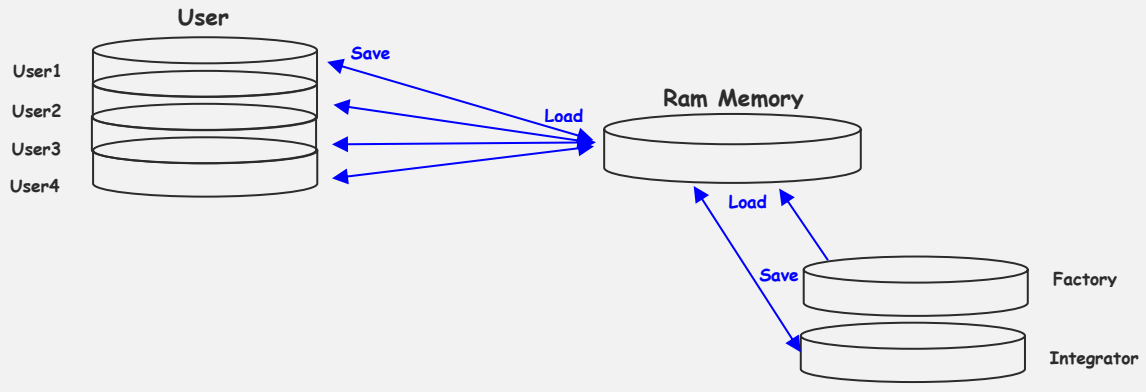
The settings (or Main configuration) of the Camera can be saved in 4x different User banks and one Integrator bank. This setting includes also the FFC enable parameter.

This function is available in the User Set Control section :

Feature	CXP @	R/W	Size (Bytes)	Description
UserSetLoad	0x08C00	RW	4	Restore current UserSet from UserSet bank number <val>, from 0 to 5; <val> comes from UserSetSelector **0**: Factory Bank **1,2,3,4**: User Bank **5**: Integrator Bank
UserSetSave	0x08C04	RW	4	Save current UserSet to UserSet bank number <val>, from 1 to 5; <val> comes from UserSetSelector **1,2,3,4**: User Bank **5**: Integrator Bank (Not available in User Mode)
UserSetControl	Xml	-		User bank selector

The integrator bank (User Set5) can be written only if the Camera is set in integrator mode (Privilege level = 1). This integrator bank can be used as a « Factory default » by a system integrator.

Configuration Bank Usage

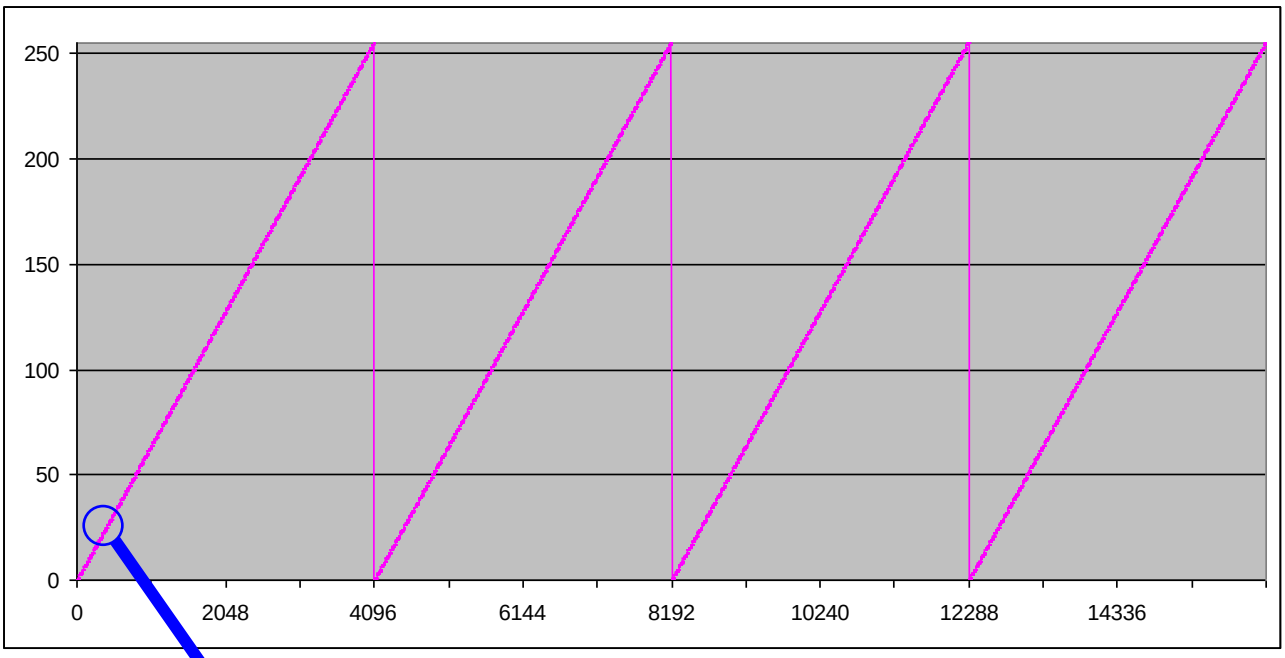


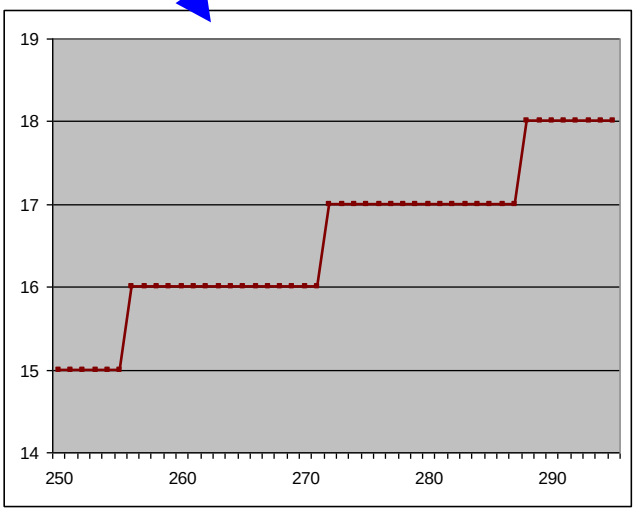
At the power up : Last User Bank used is loaded in RAM
"Integrator" Bank (5) can be locked by switching the Camera in "User" mode (cf : Privilege feature). Then it can't be saved any more without switching back the Camera in "Integrator" Mode.

APPENDIX

Appendix A. Test Patterns

A.1 Fixed Horizontal Ramps





An increment of 1 LSB is made every 16 pixels

When it reaches 255, turns back to 0 and starts again

A.2 Color RGBW Fixed Pattern

This pattern is composed blocks of 512 pixels showing alternatively Red, Green, Blue and White colors :

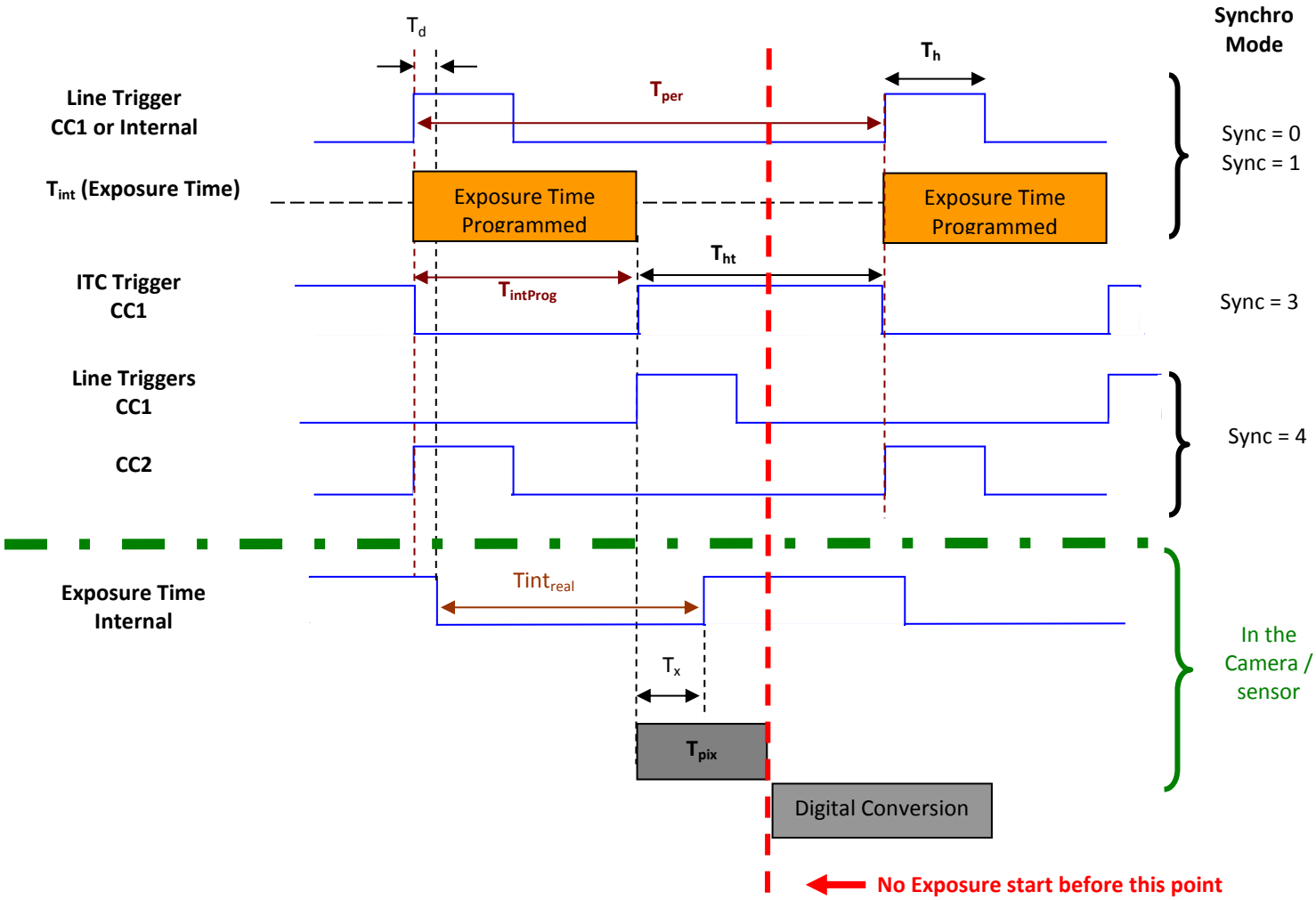
Note : When the camera is set with this pattern test, it's no more taking in account the Line Trigger and working in Free Run (line period controlled by the camera)

A.3 Vertical wave

The Test pattern 1 is a vertical moving wave : each new line will increment of 1 gray level : Form 0 to 255 before switching down to 0 and increasing again.

Appendix B. Timing Diagrams

B.1 Synchronization Modes with Variable Exposure Time



T_{pix} : Timing Pixel. During this uncompressible period, the pixel and its black reference are read out to the Digital converter. During the first half of this timing pixel (read out of the black reference), we can consider that the exposure is still active.

Digital Conversion : During the conversion, the analog Gain is applied by the gradient of the counting ramp (see next chapter : Gain & Offset). The conversion time depends on the pixel format :

- 8 or 10 bits : **6µs**
- 12 bits : **18µs**

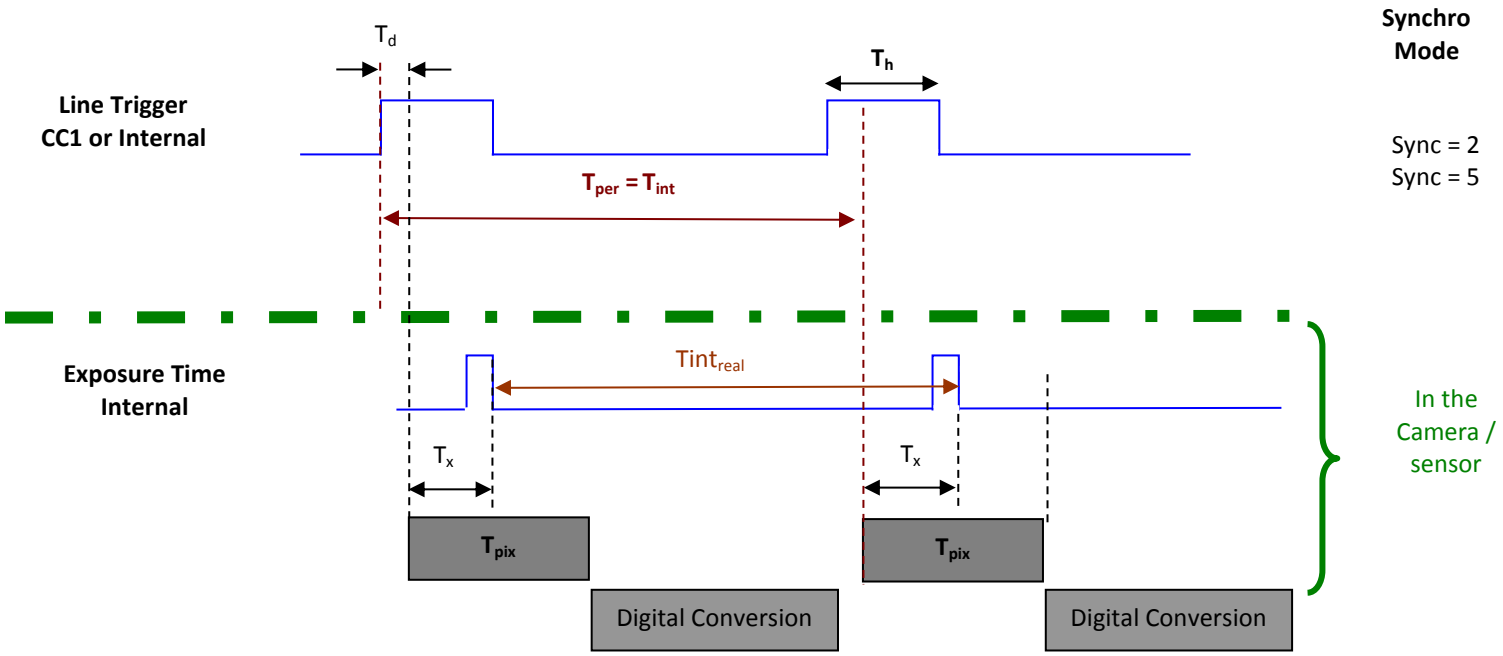
This conversion is done in masked time, eventually during the next exposure period.

T_d : Delay between the Start exposure required and the real start of the exposure.

If T_{per} is the Line Period (internal or external coming from the Trigger line), in order to respect this line Period, the Exposure Time as to be set by respecting : $\mathbf{T_{int} + T_{pix} <= T_{per}}$
Then, the real exposure time is : $\mathbf{Tint_{real} = T_{int} + T_x - T_d}$.
In the same way, The high level period of the Trig signal in sync=3 mode, $\mathbf{T_{ht} >= T_{pix}}$

For a Line Period of LinePer, the maximum exposure time possible without reduction of line rate
is : $\mathbf{Tint_{max} = T_{per}-T_{pix}}$ (T_{pix} is defined above) but the effective Exposure Time will be about $\mathbf{Tint_{real} = T_{int} + T_x. - T_d}$

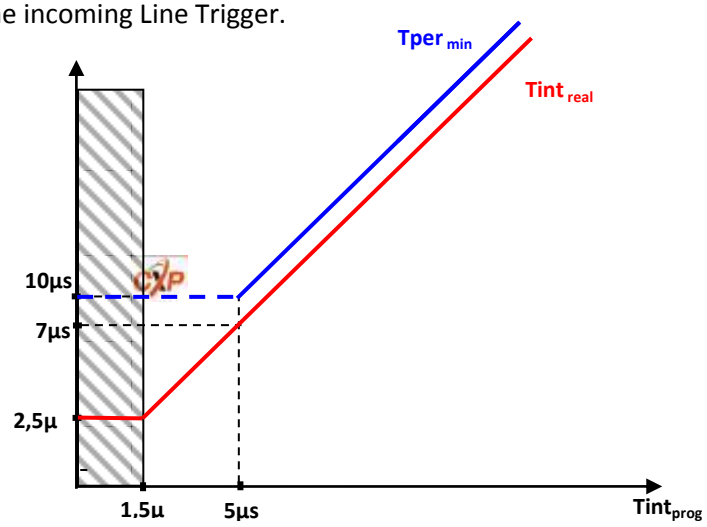
B.2 Synchronisation Modes with Maximum Exposure Time



In these modes, the rising edge of the Trigger (internal or External) starts the readout process (T_{pix}) of the previous integration. The Real exposure time ($Tint_{real}$) is finally equal to the Line Period (T_{per}) even if it's delayed from ($T_x + T_d$) from the rising edge of the incoming Line Trigger.

B.3 Timing Values

Label	Min	Unit
T_{pix}	5	µs
T_x	3,1	µs
T_h	0,120	µs
T_{ht}	T_{pix}	µsec
T_d	1,1	µs



Appendix C. Data Cables

- CXP cables and the separate lanes of a CXP-multi-cable shall be coaxial with a characteristic impedance of 75Ω ± 4 Ω. When a series connection of CXP-cables is considered, all of the BNC connectors used have to be of the 75Ω type, including any inline couplers.
- A CXP cable and the separate lanes of a CXP-multi-cable shall have a return loss better than or equal to :

Frequency Range	Return Loss
0-500MHz	-20dB
500MHz – 3.2GHz	-15dB

- The maximum length of a CoaXPress cable is the lowest figure from three different requirements: power supply voltage drop, high speed link requirements and low speed link requirements.
  - Power Supply Voltage Drop : A CXP cable and the separate lanes of a CXP multi-cable shall each have a total DC roundtrip resistance of less than 4.98Ω for each of the coax cables.
  - High Speed Link Requirement : A CXP cable and the separate lanes of a CXP-multi-cable that are specified for a given bit rate shall have an attenuation that is less or equal to the following attenuation at its corresponding frequency (example with Belden 1694A Cable) :

Bit Rate (Gbps)	Maximum Attenuation (dB)	@ Frequency (GHz)	Belden 1694A (m)
1.250	-21.2	0.625	130
2.500	-26	1.25	110
3.125	-26.8	1.5625	100
5.000	-20.9	2.5	60
6.250	-15.8	3.125	40

  - Low Speed Link Requirement : A CXP cable and the separate lanes of a CXP-multi-cable shall have a signal attenuation at 30 MHz of less than, or equal to, -4.74dB.
  - Cable Current Capacity : A CXP cable and the separate lanes of a CXP-multi-cable shall each be designed to carry 1A in normal operation.
  - A CXP-cable and the separate lanes of a CXP-multi-cable shall have attenuation versus frequency characteristic exhibiting cable-like behaviour over the frequency ranges as indicated in the table below. A series connection of cables shall also fulfil this requirement as if it is one cable including all of its connectors and inline couplers.

Cable Rating (Gbps)	Frequency Range	
	From	To
1.250	1	0.625
2.500	1	1.25
3.125	1	1.5625
5.000	1	2.5
6.250	-15.8	3.125

Appendix D. Lenses Compatibility

QIOPTICS (LINOS)				
	Nominal Magnification	**Magnification Range**	**M95 Focus tube Reference**	**Lens Reference Part number**
Inspec.x. L 5.6/105	0,33 X	0,25 – 0,45 X	2408-012-000-41	0703-085-000-20
Inspec.x. L 5.6/105	0,5 X	0,4 – 0,65 X	2408-012-000-41	0703-084-000-20
Inspec.x. L 5.6/105	0,87 X	0,6 – 0,9 X	2408-012-000-43	0703-083-000-20
Inspec.x. L 5.6/105	1 X	0,85 – 1,2 X	2408-012-000-43	0703-082-000-20
Inspec.x. L 4/105	3 X	2,8 – 3,3 X	2408-012-000-46	0703-104-000-20
Inspec.x. L 4/105	3,5 X	3,3 – 3,7 X	2408-012-000-44	0703-095-000-21
Inspec.x. L 3.5/105	5 X	4,8 – 5,2 X	2408-012-000-45	0703-102-000-20

SCHNEIDER KREUZNACH				
	Nominal Magnification	**Magnification Range**	**Working Distance (at nom. Mag.)**	**Reference Part number**
SR 5.6/120-0058	1 X	0,88 – 1,13 X	212 mm	1002647
SR 5.6/120-0059	0,75 X	0,63 – 0,88 X	252 mm	1002648
SR 5.6/120-0060	0,5 X	0,38 – 0,63 X	333 mm	1002650
SR 5.6/120-0061	0,33 X	0,26 – 0,38 X	453 mm	1004611
Accessories	V mount 25mm macro-extension tube		Necessary to combine the whole lens system	20179
	V mount to Leica adapter			20054
	Unifoc 76			13048
	Adapter M58x0.75 – M95x1			1062891
	Extension tube M95x1, 25mm		To be combined to reach the appropriate magnification	1062892
	Extension tube M95x1, 50mm			1062893
	Extension tube M95x1, 100mm			1062894

MYUTRON			
	Nominal Magnification	**Working Distance**	
XLS03-E	x0,3	477mm	M95 Custom Mount available Aperture (∞) : 4.7
XLS53-E	x0,5	324mm	
XLS75-E	x0,75	246mm	
XLS010-E	x1	197mm	
XLS014-E	x1,4	170mm	
XLS203-E	x2	146mm	

EDMUND OPTICS			
	Nominal Magnification	**Working Distance (at nom. Mag.)**	**Reference Part number**
TechSpec F4	1 X	151 mm	NT68-222
TechSpec F4	1,33 X	158,5 mm	NT68-223
TechSpec F4	2,0 X	129 mm	NT68-224
TechSpec F4	3,0 X	110 mm	NT68-225
Accessories	Large Format Tip/Tilt Bolt Pattern Adapter, 2X		NT69-235
	Large Format Focusing Module		NT69-240
	Large Format Adapter Set		NT69-241

NIKON			
Rayfact F4	0,05 X – 0,5 X	1820,4mm – 230,3mm	Rayfact ML90mm F4

Appendix E. Frame Grabbers Compliance

Brand	F.G. Name	Detailed Reference	tested
Active Silicon	Firebird FBD-4XCXP6 in PCIe x8 (Gen2)	Software V1.2.0	OK
Aval Data	APX-3664	-	By AvalData
Bitflow	Cyton-CXP4	-	On testing
Matrox	Radient eV-CXP	MIL9 + Update 50 Build60	OK
Silicon Software	MicroEnable 5 AQ8-CXP6B	Software V5.3.8	OK

Appendix F. Revision History

Manual Revision	Comments / Details	Firmware version
Rev A	First release	1.0.4
Rev B	Firmware update	1.1.0
Rev C	True color Single Mode	1.2.0
Rev D	Change Documentation Template Column and Line Interpolation Low Band FFC Filter Trigger too slow White Balance Adjust Trigger Average in Rescaler	1.3.0 1.4.0
Rev E	New Sensor Version (New Model Name) Variable Gain for “Full Exposure Control Mode” PRNU Coefficient changed of Format.	2.0.0
Rev F	New Interpolation in Full Definition Save and Replay image	2.1.0
Rev G	Reverse Reading function	2.2.0
Rev H	New Teledyne-e2v Chart ROI For White Balance	2.3.1