e2v

ELiiXA® UC8/UC4
Color Line Scan Camera

ELIIXA UC8/UC4 Camera
User Manual

Summary

1 CAMERA OVERVIEW 4
1.1 Features 4
1.2 Key Specifications 4
1.3 Description 5
1.4 Typical Applications 5
1.5 Models & Part Numbers 6
2 CAMERA PERFORMANCES 7
2.1 Camera Characterization 7
2.2 Image Sensor 7
2.2.1 Raw response of the sensor 8
2.2.2 Response with BG38 filter (for RGB and RGB+B&W versions) 8
2.2.3 Response N-BK7 Band-cut Filter for RGB + Nir version 9
3 CAMERA HARDWARE INTERFACE 10
3.1 Mechanical Drawings 10
3.2 Input/output Connectors and LED 11
3.2.1 Status LED Behaviour 11
3.2.2 Power Connector 11
3.2.3 Camera Link Output Configuration 12
4 STANDARD CONFORMITY 14
4.1 CE Conformity 14
4.2 FCC Conformity 14
4.3 RoHs Conformity 14
5 SETTING UP THE CAMERA IN THE SYSTEM 15
6 CAMERA SOFTWARE INTERFACE 16
6.1 Control and Interface 16
6.2 Serial Protocol and Command Format 17
6.2.1 Syntax 17
6.2.2 Command Processing 17
6.3 Camera Commands 18
6.3.1 Information, Status and Communication 19
6.3.2 Output modes and Spatial Rebuild 23
6.3.3 Exposure and Synchronization 28
6.3.4 Gain and Offset 33
6.3.5 Color Management 39
6.3.6 Flat Field Correction 46

6.3.7 Save & Restore Settings 54

7 APPENDIX A: Camera Status Details 55

7.1 Table 1 : Processing Status 55
7.2 Table 2 : Internal Task Status 55
7.3 Table 3 : Error Diagnostic Status 56

8 APPENDIX C : Thermal Management 57

9 APPENDIX E: Optical Mounts available 58

APPENDIX F: Color Matrix Examples 59

APPENDIX F: Color Matrix Examples 60

10 APPENDIX G: Revision History 61

1 CAMERA OVERVIEW

1.1 Features

- Sensor: 3 or 4 x 4096 pixels 10 x 10 µm
- Multi-line with 3 Versions (each of them in Full or Low speed):
  - RGB
  - RGB + Monochrome
  - RGB + Near Infra Red
- Rows Spacing of Two Pixels (Centre to Centre)
- Boosted Blue Response
- Line Rate Up to 18 KHz
- Camera Link® Interface (Dual Base, Medium)
- Mechanics: 70 x 76 x 54 mm^3
- Automated White Balance and Flat Field Correction
- Bidirectional Scanning
- Tuneable Spatial Correction
- Internal 4x4 Color Matrix Correction

1.2 Key Specifications

Sensor Characteristics at Maximum Pixel Rate		
Resolution	Pixels	3 or 4 x 4096
Pixel Size (square)	µm	10 x 10
Spacing between rows	µm	20 (center to center)
Line Length	mm	40,96
Max Line Rate	kHz	18 (Full Speed Version) or 13 (low speed Version.)
Radiometric Performance at Maximum Pixel Rate		
Bit Depth	Bits	8, 10 or 12
Responsivity	LSB/(nJ/cm^2)	136
Response Non linearity	%	±1
PRNU (not corrected)	%	< 10
Dynamic Range	dB	62
Functionalities (Programmable via Control Interface)		
Gain	Up to 25.4 dB	
Offset	-4096 to +4096 LSB	
Trigger Mode	Timed (Free run) and triggered (Ext Trig, Ext ITC) modes	

Mechanical and Electrical Interface		
Size (w x h x l)	mm	70 x 76 x 54
Weight	g	470 (without mount)
Lens Mount		F, T2, M42 x 1 compliant with AVIIVA SM2 series
Sensor Alignment	µm	±100
Sensor flatness	µm	±35
Power Supply	V	Single 12 to 24
Power Dissipation	W	< 15
Current Consumption	A	Max 2A at the startup
General features		
Operating Temperature	°C	0 to 65 (front face)
Storage Temperature	°C	-40 to 70
Regulatory	CE, FCC and RoHS compliant	

1.3 Description

The ELiiXA Color camera is the ideal candidate for the most demanding applications requiring multi wavelength detection (including NIR). Using e2v's unique technology, the CCD sensor features unmatched performance: line rate up to 18 KHz, row spacing of two pixels center to center, enhanced blue response, three lines (RGB) and four lines (RGB and fourth line either monochrome or NIR). The camera package is designed to increase efficiency and save cost at vision system level:

- Easy calibration (Automatic Tap balance and flat field correction, white balance, Color correction)
- versatile implementation (trigger modes, output modes, bidirectional scanning, spatial correction)

and with an all-in-one approach, a single ELiiXA camera can replace a two camera system of a conventional color camera and a monochrome or NIR camera.

The Fourth monochrome line will give you more accuracy to define colors in CIE color system and the NIR version will help you to see even what the eyes can't see.

1.4 Typical Applications

- Web Inspection: Printing, Currency
- High-end Inspection: Food, Pharmaceutical, Medical, Packaging
- Surface Inspection: Ceramic tiles, Wood, Printed Circuit Board
- Scanning: High-end Document Process, Film scanning, Postal sorting
- Metrology : Color matching

1.5 Models & Part Numbers

Part Number	Sensor	Speed	Additional Filter included
EV71YUC8CL4010-BA0	RGB	Full Speed : 18 KHz	BG38 2mm IR cut-off
EV71YUC8CL4010-BA1	RGB + B&W	Full Speed : 18 KHz	BG38 2mm IR cut-off
EV71YUC8CL4010-BA2	RGB + NIR	Full Speed : 18 KHz	Band-cut Filter on N-BK7 Glass
EV71YUC4CL4010-BA0	RGB	Low Speed : 13 KHz	BG38 2mm IR cut-off
EV71YUC4CL4010-BA1	RGB + B&W	Low Speed : 13 KHz	BG38 2mm IR cut-off
EV71YUC4CL4010-BA2	RGB + NIR	Low Speed : 13 KHz	Band-cut Filter on N-BK7 Glass

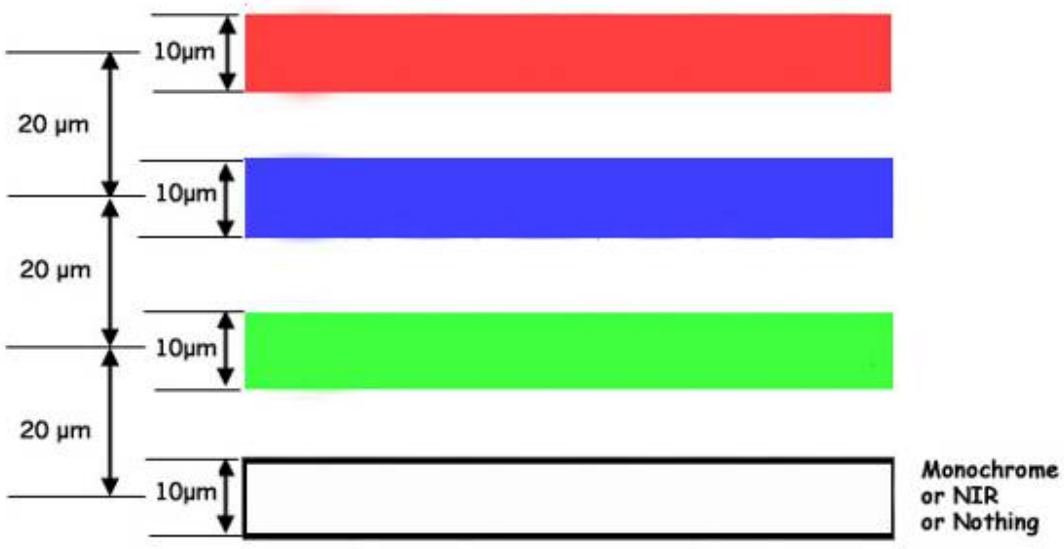
2 CAMERA PERFORMANCES

2.1 Camera Characterization

	Unit	Min Gain			Min Gain +10dB			Min Gain +20dB		
		Min	Typ.	Max	Min	Typ.	Max	Min	Typ.	Max
Dark Noise RMS	LSB		2,5	3,5		5			25	
Dynamic Range		1170	1640		585	820		135	165	
FPN rms	LSB		1	2		2			7	
FPN pk pk	LSB		5			11			50	
PRNU rms	%		0,2			0,3			0,8	
PRNU pk pk	%		3			4,5			7	

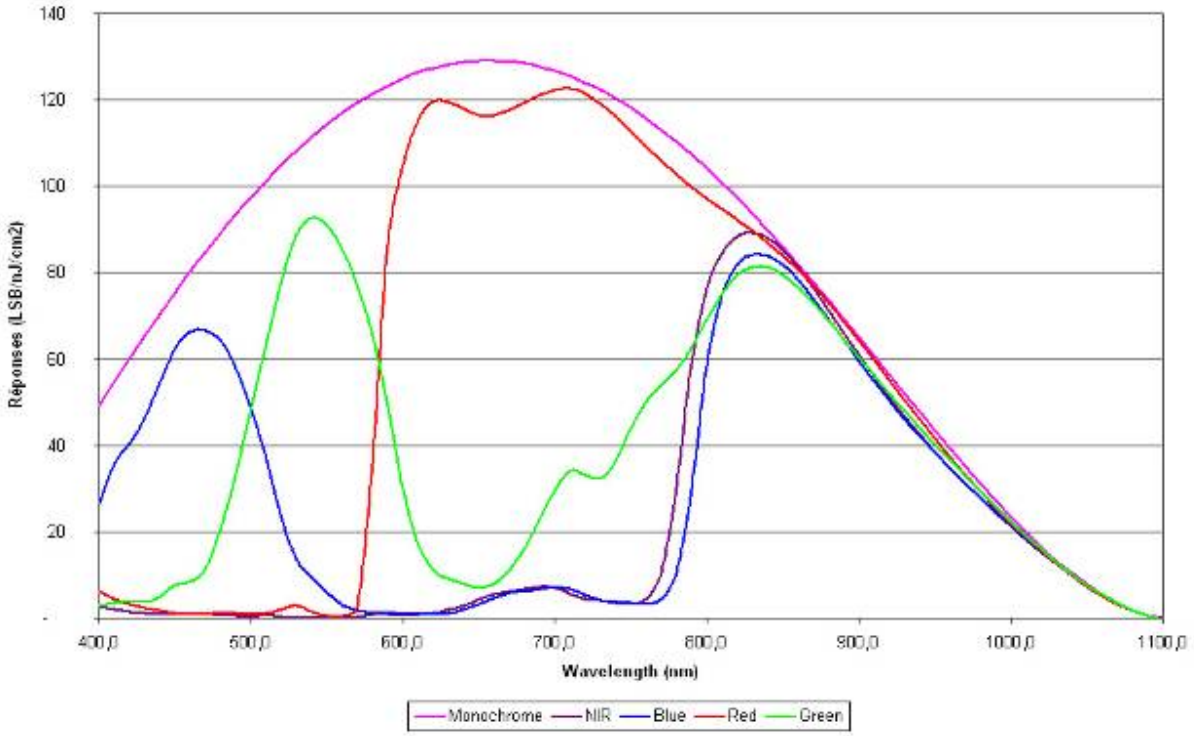
Note : These figures in LSB are for a 12bits format.

2.2 Image Sensor

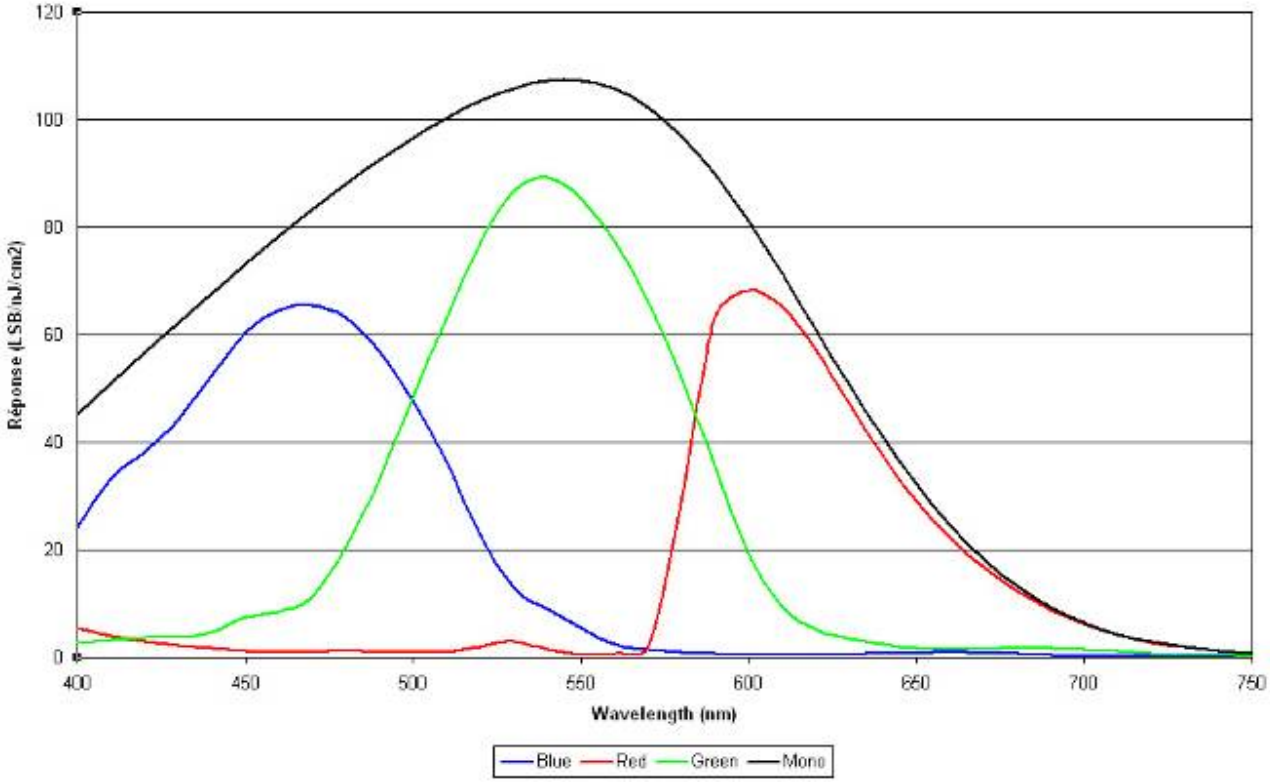


Note: The real order of the color line is Red-Blue-Green but the Camera outputs in Red-Green-Blue order on the Camera Link connector.

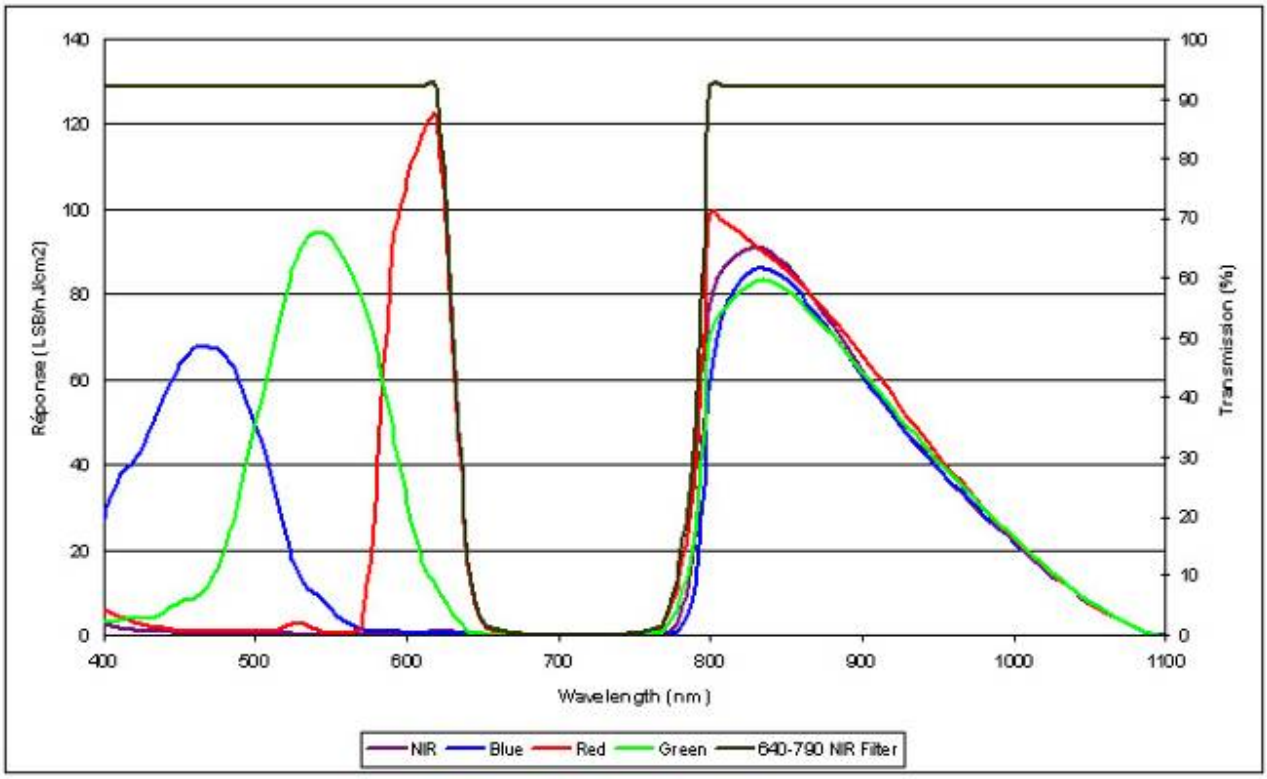
2.2.1 Raw response of the sensor



2.2.2 Response with BG38 filter (for RGB and RGB+B&W versions)



2.2.3 Response N-BK7 Band-cut Filter for RGB + Nir version



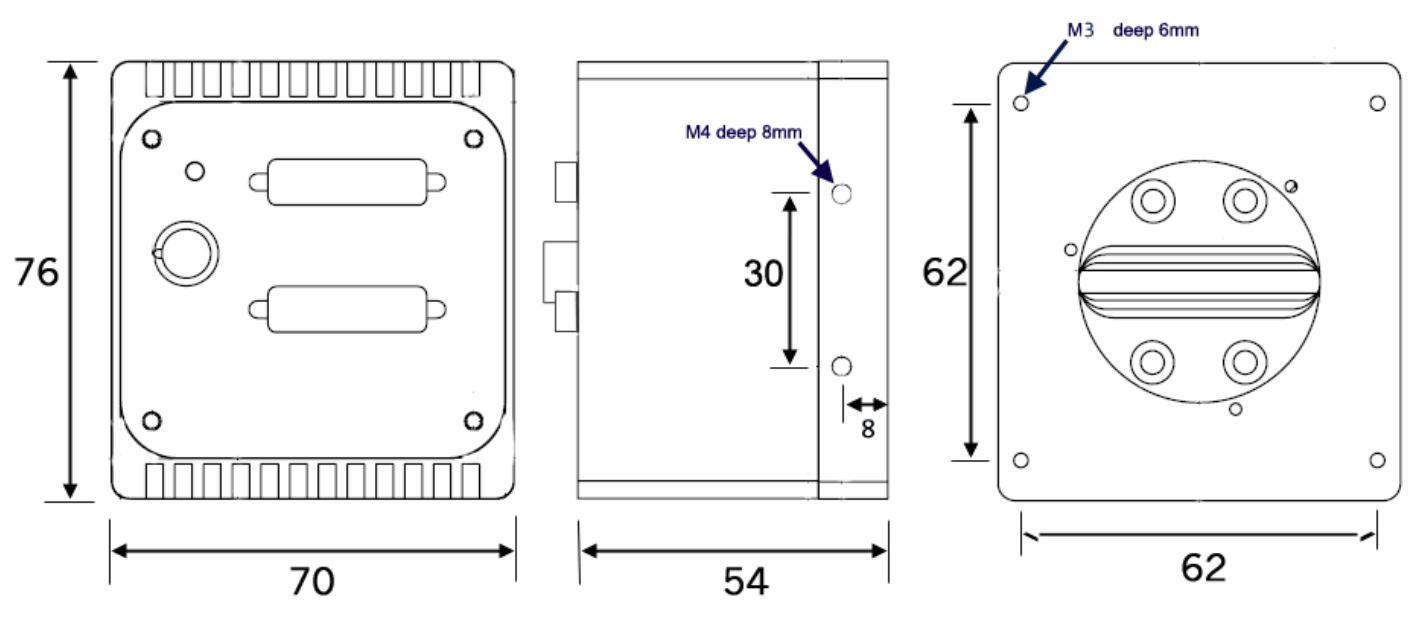
The sensor has been designed to give in the Near Infra Red (800-1100nm) an equal answer of each Red, Green and Blue colors than the Nir line itself.
In order to remove simply the Near Infra Red component from each Red, Green and Blue colors, we can define the following Color Correction Matrix:

$$(R'\ B'\ G'\ Nir') = \begin{pmatrix} 1 & 0 & 0 & -1 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} R \\ B \\ G \\ Nir \end{pmatrix}$$

Depending on your light source, some other combination of filter can be provided.
For more information, please, contact the Hotline Camera : hotline-cam@e2v.com

3 CAMERA HARDWARE INTERFACE

3.1 Mechanical Drawings



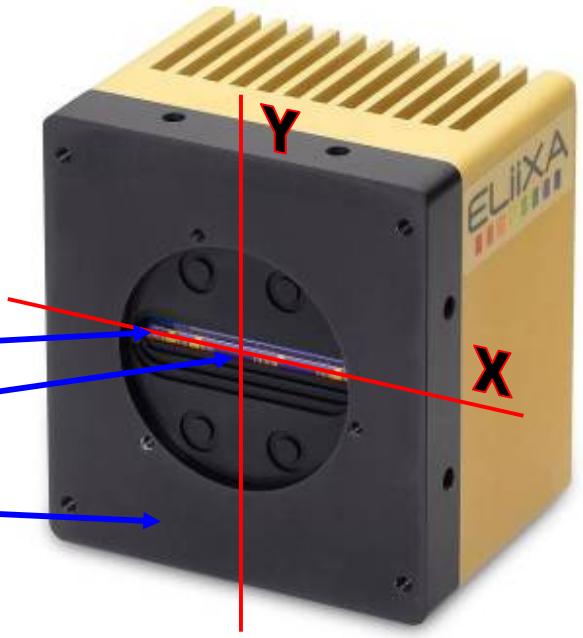
Sensor alignment	
Z = 10,9mm	±150µm
X = 14,52mm	±100 µm
Y = 38mm	±100 µm
Planarity	±35 µm
Rotation (X,Y plan)	±0,2°
Tilt (versus lens mounting plane)	±35µm

References :

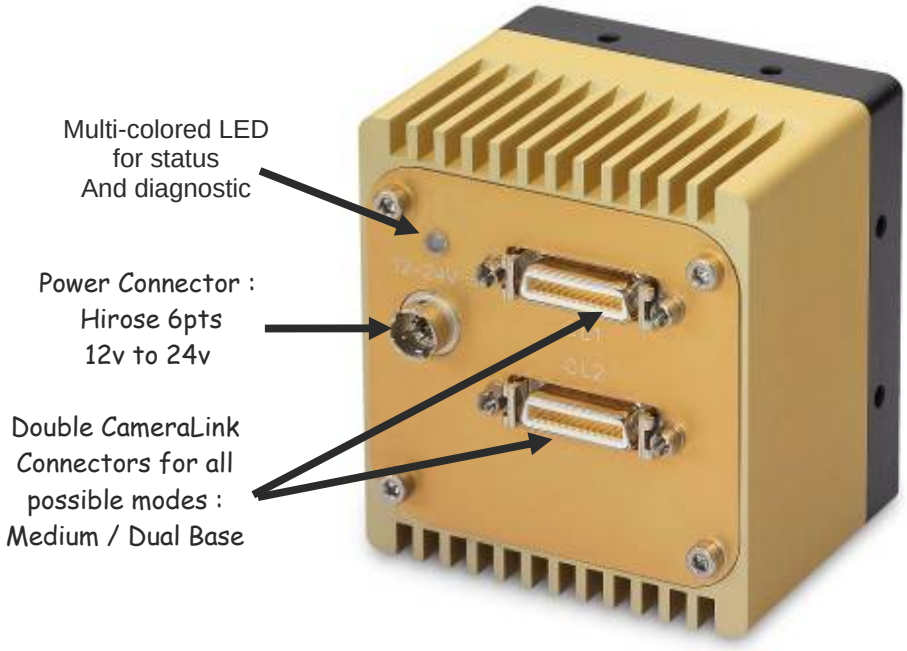
First Pixel

Optical axe as (X,Y) reference

Front face as Reference Face



3.2 Input/output Connectors and LED



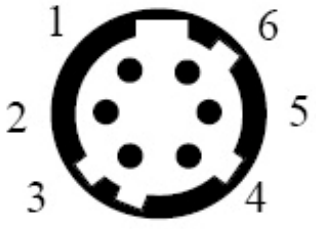
3.2.1 Status LED Behaviour

After less than 2 seconds of power establishment, the LED first lights up in RED. Then after a Maximum of 8 seconds, the LED must turn in one of the following colors:

Color and state	Meaning
Green and continuous	OK
Green and blinking slowly	Waiting for Ext Trig (Trig1 and/or Trig2)
Red and continuous	Camera out of order : Internal firmware error

3.2.2 Power Connector

Camera connector type: Hirose HR10A-7R-6PB (male)
Cable connector type: Hirose HR10A-7P-6S (female)



Camera side description

Signal	Pin	Signal	Pin
PWR	1	GND	4
PWR	2	GND	5
PWR	3	GND	6

Power supply from 12v to 24v
Power 15W max with an inrush current of 2A during power up

3.2.3 Camera Link Output Configuration

Modes	Connector CL1	Connector CL2	Notes
Dual Base 3 + 1			
RGB 8bits + Nir/Mono 8bits	RGB: 3x80 or 3x60MHz	Nir or Mono 1x80 or 1x60MHz	1
RGB 8bits + Nir/Mono 10bits	RGB: 3x80 or 3x60MHz	Nir or Mono 1x80 or 1x60MHz	1
RGB 8bits + Nir/Mono 12bits	RGB: 3x80 or 3x60MHz	Nir or Mono 1x80 or 1x60MHz	1
Dual Base 3 + 3			
RGB 8bits + RGNir/RGMono 8bits	RGB: 3x80 or 3x60MHz	RGNir/RGMono 3x80 or 3x60MHz	1
RGB 8bits + RBNir/RBMono 8bits	RGB: 3x80 or 3x60MHz	RBNir/RBMono 3x80 or 3x60MHz	1
RGB 8bits + GBNir/GBMono 8bits	RGB: 3x80 or 3x60MHz	GBNir/GBMono 3x80 or 3x60MHz	1
Medium			
RBGNir / RBGMono 8bits	RGB: 3x80 or 3x60MHz	Nir or Mono 1x80 or 1x60MHz	2
RBGNir / RBGMono 10bits	Camera Link Standard Medium mode in 4x80 or 4x60MHz		2
RBGNir / RBGMono 12bits	Camera Link Standard Medium mode in 4x80 or 4x60MHz		2
Dual Base Interlaced 8bits (RGB -BA0- Camera Only)			
RBG odd + RBG even 8bits	RGB odd: 3x40 or 3x30MHz	RGB even: 3x40 or 3x30MHz	3

Notes :

1) On RGB Models only one mode : RGB 8bits 3x80 or 3x60MHz. The Connector CL2 is not used.
2) On RGB models, the medium 8 bits is equivalent to a base 8 bits because there is no fourth channel.

Connector CL1 assignment table:

Port/Bit	Dual Base 3x8 + 1x8bits	Dual Base 3x8 + 1x10bits	Dual Base 3x8 + 1x12bits	Dual Base 3x8 + 3x8bits	Medium 10 bits	Medium 12 bits	Dual Base Interlaced RGB
Port A0	R0	R0	R0	R0	R0	R0	R0
Port A1	R1	R1	R1	R1	R1	R1	R1
Port A2	R2	R2	R2	R2	R2	R2	R2
Port A3	R3	R3	R3	R3	R3	R3	R3
Port A4	R4	R4	R4	R4	R4	R4	R4
Port A5	R5	R5	R5	R5	R5	R5	R5
Port A6	R6	R6	R6	R6	R6	R6	R6
Port A7	R7	R7	R7	R7	R7	R7	R7
Port B0	G0	G0	G0	G0	R8	R8	G0
Port B1	G1	G1	G1	G1	R9	R9	G1
Port B2	G2	G2	G2	G2	nc	R10	G2
Port B3	G3	G3	G3	G3	nc	R11	G3
Port B4	G4	G4	G4	G4	B8	B8	G4
Port B5	G5	G5	G5	G5	B9	B9	G5
Port B6	G6	G6	G6	G6	nc	B10	G6
Port B7	G7	G7	G7	G7	nc	B11	G7
Port C0	B0	B0	B0	B0	B0	B0	B0
Port C1	B1	B1	B1	B1	B1	B1	B1
Port C2	B2	B2	B2	B2	B2	B2	B2
Port C3	B3	B3	B3	B3	B3	B3	B3
Port C4	B4	B4	B4	B4	B4	B4	B4
Port C5	B5	B5	B5	B5	B5	B5	B5
Port C6	B6	B6	B6	B6	B6	B6	B6
Port C7	B7	B7	B7	B7	B7	B7	B7

Connector CL2 assignment table:

Port/Bit	Dual Base 3x8 + 1x8bits	Dual Base 3x8 + 1x10bits	Dual Base 3x8 + 1x12bits	Dual Base 3x8 + 3x8bits	Medium 10 bits	Medium 12 bits	Dual Base Interlaced RGB
Port D0	M0	M0	M0	R0	M0	M0	R0
Port D1	M1	M1	M1	R1	M1	M1	R1
Port D2	M2	M2	M2	R2	M2	M2	R2
Port D3	M3	M3	M3	R3	M3	M3	R3
Port D4	M4	M4	M4	R4	M4	M4	R4
Port D5	M5	M5	M5	R5	M5	M5	R5
Port D6	M6	M6	M6	R6	M6	M6	R6
Port D7	M7	M7	M7	R7	M7	M7	R7
Port E0	nc	M8	M8	G0	G0	G0	G0
Port E1	nc	M9	M9	G1	G1	G1	G1
Port E2	nc	nc	M10	G2	G2	G2	G2
Port E3	nc	nc	M11	G3	G3	G3	G3
Port E4	nc	nc	nc	G4	G4	G4	G4
Port E5	nc	nc	nc	G5	G5	G5	G5
Port E6	nc	nc	nc	G6	G6	G6	G6
Port E7	nc	nc	nc	G7	G7	G7	G7
Port F0	nc	nc	nc	M0	G8	G8	B0
Port F1	nc	nc	nc	M1	G9	G9	B1
Port F2	nc	nc	nc	M2	nc	G10	B2
Port F3	nc	nc	nc	M3	nc	G11	B3
Port F4	nc	nc	nc	M4	M8	M8	B4
Port F5	nc	nc	nc	M5	M9	M9	B5
Port F6	nc	nc	nc	M6	nc	M10	B6
Port F7	nc	nc	nc	M7	nc	M11	B7
Port G0	nc	nc	nc	nc	nc	nc	nc
Port G1	nc	nc	nc	nc	nc	nc	nc
Port G2	nc	nc	nc	nc	nc	nc	nc
Port G3	nc	nc	nc	nc	nc	nc	nc
Port G4	nc	nc	nc	nc	nc	nc	nc
Port G5	nc	nc	nc	nc	nc	nc	nc
Port G6	nc	nc	nc	nc	nc	nc	nc
Port G7	nc	nc	nc	nc	nc	nc	nc
Port H0	nc	nc	nc	nc	nc	nc	nc
Port H1	nc	nc	nc	nc	nc	nc	nc
Port H2	nc	nc	nc	nc	nc	nc	nc
Port H3	nc	nc	nc	nc	nc	nc	nc
Port H4	nc	nc	nc	nc	nc	nc	nc
Port H5	nc	nc	nc	nc	nc	nc	nc
Port H6	nc	nc	nc	nc	nc	nc	nc
Port H7	nc	nc	nc	nc	nc	nc	nc

Rx, Gx, Bx = Bit x, for color Red, Green or Blue.
Mx = Bit x for Monochrome or Nir

4 STANDARD CONFORMITY

The ELIIXA cameras have been tested using the following equipment:
• A shielded power supply cable
• A Camera Link data transfer cable ref. 14B26-SZLB-500-OLC (3M)

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 89/336/CEE (EN 50081-2, EN 61000-6-2).

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.

4.3 RoHs Conformity

ELIIXA cameras comply with the requirements of the RoHS directive

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.

5 SETTING UP THE CAMERA IN THE SYSTEM

Vocabulary:

w = size of the sensor line (40,96mm)
FOV = Field Of View (width of the web inspected by the sensor line) in mm.
L = Working distance (from the Lens to the Web) in mm.
f = focal distance of the lens in mm.
S = Speed of the web in mm/s

We have: w/FOV = f/L

The ratio M = w/FOV is called Magnification.
The FOV is grabbed by 4096 pixels in the width.
In order to get a ratio of 1 :1 in your image, at the web speed of S, your line rate has to be set:
Line Rate = (S/FOV) x 4096

Ex: if the FOV = 11 cm (110mm) and the speed of the web is S= 0,3 m/s (300mm/s) the line rate will be:
Line Rate = (300 /110) x 4096 = 11170 Lines/s.

The spatial correction has to be set to 2 because the spacing between two color lines in the sensor is 20µm center to center (2 lines of 10µm width).

If you use a 60mm lens, the working distance will be: L = (60 x 110) 40,96 = 161mm.
This will certainly require a macro lens.

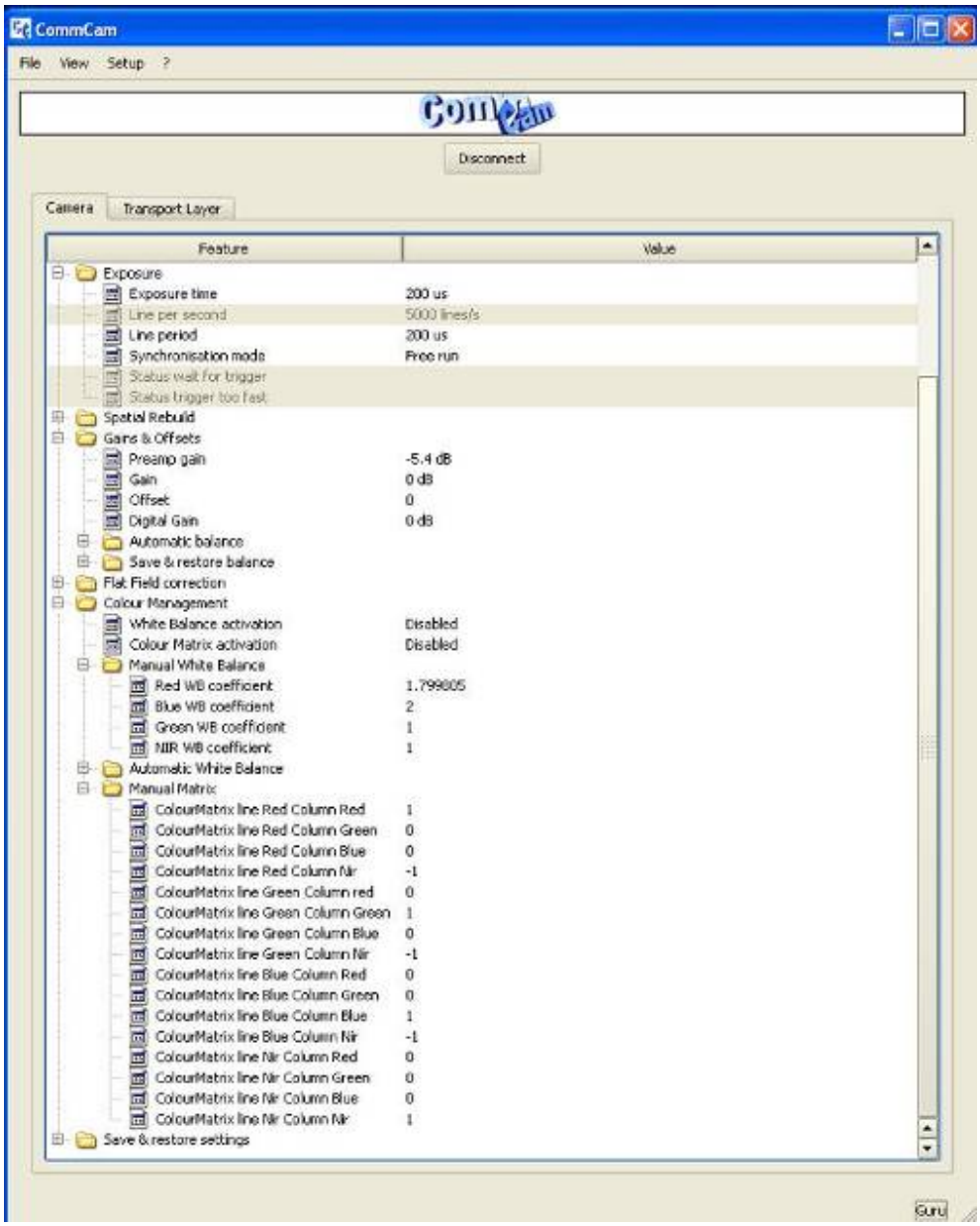
6 CAMERA SOFTWARE INTERFACE

6.1 Control and Interface

As all the e2v Cameras, the ELIIXA is delivered with the friendly interface control software COMMCAM.UCL (as “Ultimate Camera Link”) which is based on the GenICam standard

COMMCAM recognizes and detects automatically all the UCL Cameras connected on any transport layers (Camera Link or COM ports) of your system.

Once connected to the Camera you have an easy access to all its features. The visibility of these features can be associated to three types of users: Beginner, Expert or Guru. Then you can make life easy for simple users.



6.2 Serial Protocol and Command Format

The Camera Link interface provides two LVDS signal pairs for communication between the camera and the frame grabber. This is an asynchronous serial communication based on RS-232 protocol.
The serial line configuration is:

- Full duplex/without handshaking
- 9600 bauds (default), 8-bit data, no parity bit, 1 stop bit. The baud rate can be set up to 230,400

6.2.1 Syntax

Internal camera configurations are activated by write or readout commands.
The command syntax for write operation is:
w <command_name> <command_parameters><CR>
The command syntax for readout operation is:
r <command_name><CR>

6.2.2 Command Processing

Each command received by the camera is processed:

- The setting is implemented (if valid)
- The camera returns ">"<return code><CR>

We recommend to wait for the camera return code before sending a new command.

Table 5-1. Camera Returned Code

Returned code	meaning
>0	(or ">OK") : All right, the command will be implemented
>3	Error bad CRC in command
>16	Command Error (Command not recognize or doesn't exist)
>21	Invalid Command ID (the Command doesn't exist).
>33	Invalid Access (the receipt of the last command has failed).
>34	Parameter out of range (the parameter of the last command send is out of range).
>35	Access Failure (bad communication between two internal devices).

6.3 Camera Commands

Information, status and Communication
- Vendor Name / Model Name
- Camera ID / Customer ID
- Status
- Software version
- Dump
- Baud Rate

Chap 6.3.1

Output modes and spatial rebuild
- Signal Source
- Output Mode
- Scanning Direction
- Spatial Correction

Chap 6.3.2

Exposure and Synchronization
- Synchronization Modes
- Integration Time
- Line Period

Chap 6.3.3

Gain and Offset
- Preamp Gain
- Gain
- Digital Gain & Offset
- Tap Balance Management

Chap 6.3.4

Color Management
- White Balance Gains setting
- Auto White Balance Management
- Color Matrix Management & setting

Chap 6.3.5

Flat Field Correction
- FFC Management
- PRNU / DSNU reset
- PRNU / DSNU Manual setting
- FFC Save & Restore

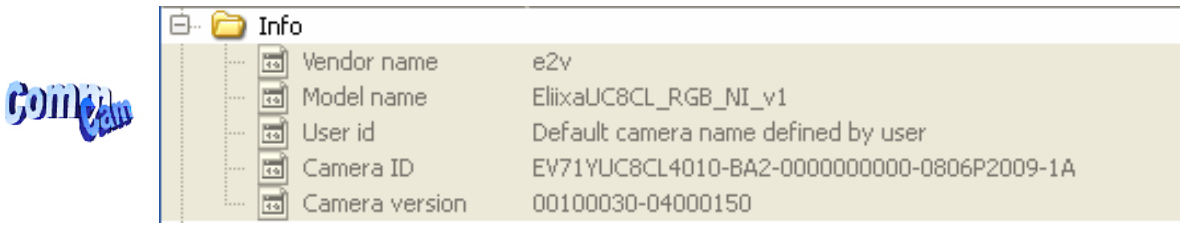
Chap 6.3.6

Save & Restore Settings
- Factory setting restore
- User settings Save & Restore

Chap 6.3.7

6.3.1 Information, Status and Communication

- **Information** : These values allow to identify the Camera. They can be accessed through the CommCam software in the "Info" section



All these values are fixed in factory except the Camera User ID which can be fixed by the Customer:

- o Vendor name: "e2v"
  Read function: "**r vdnm**";
  Return by the camera: "e2v" (string)
  Can not be written
- o Model Name: Internal name for GenICam :
  => Read function: "**r mdnm**";
  return by the camera (string) :
  - EliixaUC8CL_RGB_NI_v1
  - EliixaUC4CL_RGB_NI_v1
  - EliixaUC8CL_RGB_BW_v1
  - EliixaUC4CL_RGB_BW_v1
  - EliixaUC8CL_RGB_v1
  - EliixaUC4CL_RGB_v1

  => Can not be written
- o Camera ID : part number, serial number of the Camera
  => Read function : "**r idnb**";
  Return by the camera (string 50 bytes max) :
  ex : EV71YUC8CL4010-BA2-0000000000-0806P2009-1A
  with :
  - EV71YUC8CL4010-BA2 : Part number
  - 0000000000 : Batch number (not used for Cameras)
  - 0806P2009 : Serial number
    - "08" : Year of manufacturing
    - "06" : week in the year
    - "P" as Proto, "M" as Manual, "A" as automatic : type of testing
    - "2009" : Identification number
  - 1A: Fab indice.

  => Can not be written
- o User ID : Can be set by the Customer to identify the Camera
  ⇨ Read function : "**r cust**";
  Return by the camera (string 50 bytes max) :
  ⇨ Write function : "**w cust**" <string>;

o Firmware Version : Can be set by the Customer to identify the Camera

⇨ Read function : "**r vers**";

Return <id+ver #0>-<id+ver #1>

With <id+ver #N> = hexadecimal 32-bits long for id and version for module N

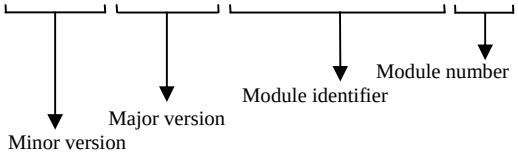
The format of a 32-bits value is:

- Bit 0 to 3 : 0
- Bit 4 to 7 : module number
- Bit 8 to 19 : module identifier
- Bit 20 to 25 : major version
- Bit 26 to 31 : minor version

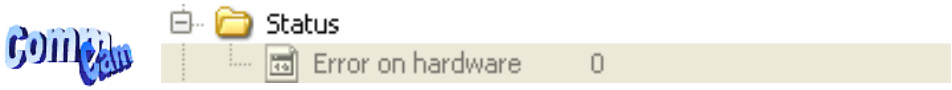
Ex :

0C100230 translated into binary :

0000 1100 0001 0000 0000 0010 0011 0000



- **Status** : Give the Camera Status. It can be accessed in CommCam software in the "Status" section :



⇨ Read function : "**r stat**";

Return by the camera : A 32 bits integer value composed as follows :

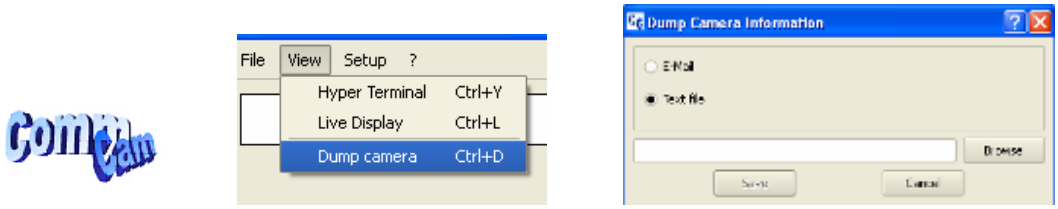
Statut Diagnostique Erreur						
31 22	21	20	19	18	17	16
0000 0000 00	**Err CommCam compatibility index**	**Err user camera settings**	**Err factory camera settings**	**Err user application settings**	**Err factory application settings**	**Err hardware init**

internal Task Status					
15 13	12	11	10	9	8
000	0	**Cal/App Enabled**	**Warn Udf**	**Warn Ovf**	

Processing Status					
7	6	5	4 2	1	0
Settings Modified	**Tap Balance Modified**	**FFC Modified**	000	*reserved*	**Wait for trigger**

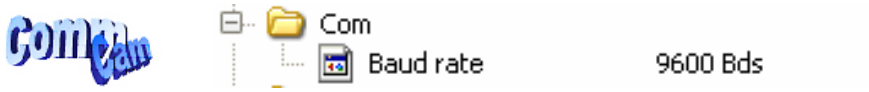
=> All these Values are explained in the APPENDIX A

- **Dump**: Allows to dump all the Camera info/settings in a text file. This command is available in the CommCam View Menu:



=> Read function : "**r dump**";

- **BaudRate**: Set the Camera BaudRate. This command is available in the CommCam "Com" section :



⇨ Read function : "**r baud**";
Return by the camera : Value of the Baud Rate
⇨ Write function : "**w baud**" <index> with the index as follows :

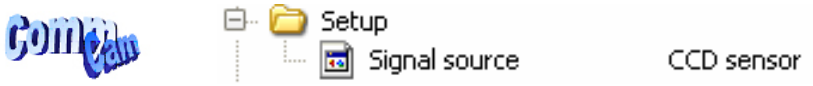
- 1 : 9600 Bauds (default value at power up)
- 2 : 19200Bds
- 6 : 57600Bds
- 12 : 115200Bds
- 24 : 230400Bds

After changing the communication rate, the communication with the Camera could be interrupted with the application (CommCam or whatever) it has made this change. The application has to reconnect. the baudrate will automatically switch to 9600 bds at the next power down/up

Title	Command	Features
VendorName	r vdnm	Get camera vendor name Return string e2v
ModelName	r mdnm	Get camera model name Return string
Camera ID	r idnb	Get camera ID. Return <idstr> Max 50 bytes
User ID	w cust <idstr>	Set customer ID to <idstr>. <idstr> format is : my camera …. Max 50 bytes
	r cust	Get customer ID. Return <idstr>
Firmware version	r vers	Get the camera software version Return <id+ver #0>-<id+ver #1> With <id+ver #N> = hexadecimal 32-bits long for id and version for module N
Status	r stat	Get camera status
Dump	r dump	Get camera configuration with the format: idnb AT71… fing 5 fga1 120
Baudrate	w baud 1	Set CL RS232 baudrate to 9600Bds (always boot with 9600bds)
	w baud 2	Set CL RS232 baudrate to 19200Bds
	w baud 6	Set CL RS232 baudrate to 57600Bds
	w baud 12	Set CL RS232 baudrate to 115200Bds
	w baud 24	Set CL RS232 baudrate to 230400Bds
	r baud	Get current baud rate

6.3.2 Output modes and Spatial Rebuild

- **Signal source :** Defines if the data comes from the Sensor or the FPGA (test Pattern). This command is available in the CommCam "Setup" section :

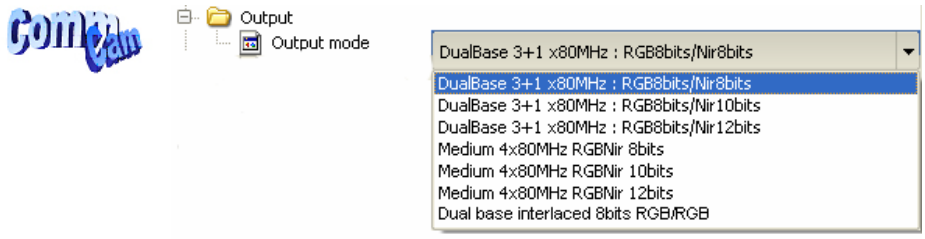


⇨ Read function : "**r srce**";
Return by the camera: "0" if Source from the Sensor and "1" if test pattern active
⇨ Write function : "**w srce**" <value> :
- "0" to switch to CCD sensor image
- "1" to switch to Test Pattern.
  The Test pattern is a single ramp. The detail of this test pattern is given in APPENDIX B.
  The test pattern is generated in the FPGA : It's used to point out any interface problem with the Frame Grabber.

The test pattern is generated by the FPGA. This is a 12bit width pattern identical for each line as following:

R	G	B	Nir
0	80	40	C0
1	81	41	C1
2	82	42	C2
3	83	84	C3
…	…	…	…
…	…	…	…
…	…	…	…
F00	F80	F40	FC0
F01	F81	F41	FC1
…	…	…	…
…	…	…	…
F3F	FBF	F7F	FFF
F40	FC0	F80	FFF
…	…	…	…
…	…	…	…
FFD	FFF	FFF	FFF
FFE	FFF	FFF	FFF
FFF	FFF	FFF	FFF

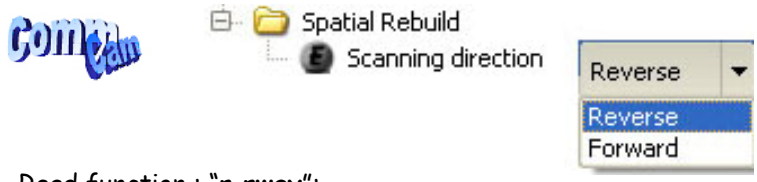
- **Output mode :** Set the Camera Link Output mode (refer to Chap 3.2.3 : Camera Link Output Configuration). This command is available in the CommCam "Output" section :



⇨ Read function : "**r mode**";
Return by the camera : Output mode from 0 to 9 (see below).
⇨ Write function : "**w mode**" <value> :

Value	Modes	
	Dual Base 3 + 1	
0	RGB 8bits + Nir/**Mono** 8bits	RBG 8bits for 3-Linear versions
1	RGB 8bits + Nir/**Mono** 10bits	
2	RGB 8bits + Nir/**Mono** 12bits	
	Dual Base 3 + 3	
7	RGB 8bits + RGNir/RG**Mono** 8bits	RBG 8bits for 3-Linear versions
8	RGB 8bits + RBNir/RB**Mono** 8bits	
9	RGB 8bits + GBNir/GB**Mono** 8bits	
	Medium	
3	RBGNir / RBG**Mono** 8bits	RBG 8bits for 3-Linear versions
4	RBGNir / RBG**Mono** 10bits	RBG 10bits for 3-Linear versions
5	RBGNir / RBG**Mono** 12bits	RBG 12bits for 3-Linear versions
	Dual Base Interlaced 8bits	RGB (BA0) versions only
13	RGB 8bits odd + RGB 8bits even	2 connectors interlaced odd/even

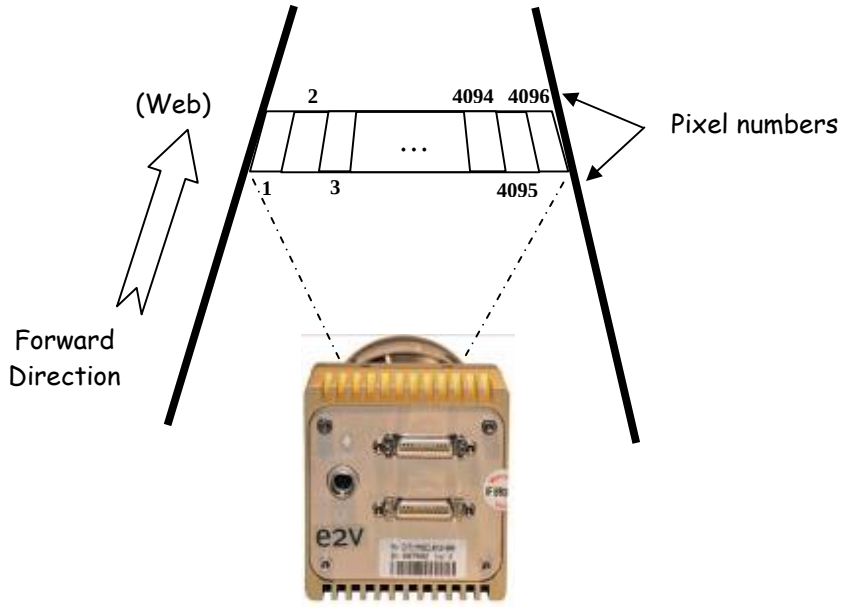
- **Scanning direction :** Set the scanning direction of the Camera. This command is available in the CommCam "Spatial Rebuild" section :



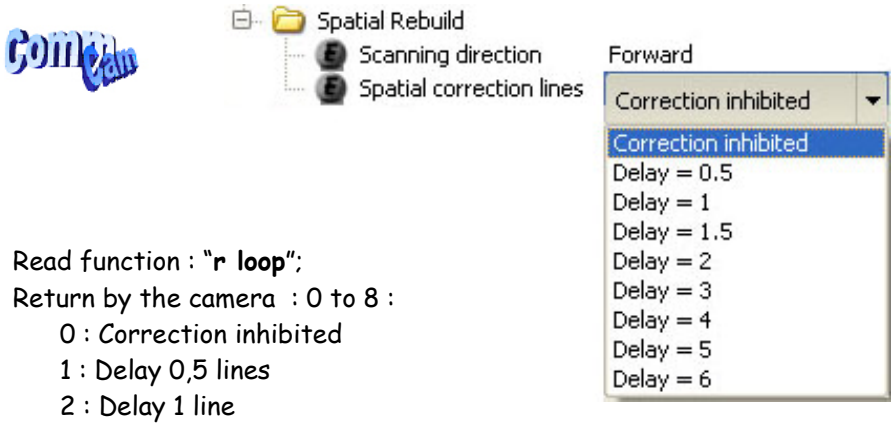
⇨ Read function : "**r rway**";
Return by the camera :
- 0 : Reverse
- 1 : Forward

⇨ Write function : "**w rway**" <value>

Definition of Forward / Reverse :



- **Spatial Correction :** Set the number of lines (0 up to 6) for the spatial correction (see explanation below). This command is available in the CommCam "Spatial Rebuild" section :



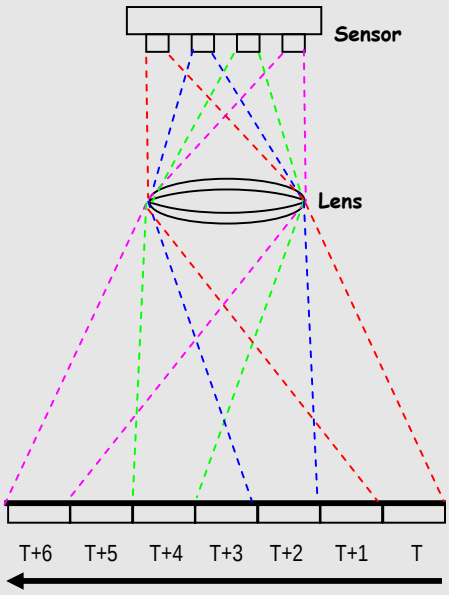
⇨ Read function : "**r loop**";
Return by the camera : 0 to 8 :
0 : Correction inhibited
1 : Delay 0,5 lines
2 : Delay 1 line
3 : Delay 1,5 lines
4 : Delay 2 lines
5 : Delay 3 lines
6 : Delay 4 lines
7 : Delay 5 lines
8 : Delay 6 lines

⇨ Write function : "**w loop**" <value>

The spatial correction has changed since the firmware version 3.0.0
On all previous versions, only the delays from 1 to 7 were available with the associated loop value.
For more information, please contact the Hotline : hotline-cam@e2v.com

What is the Spatial correction ?

Vocabulary :



w= Pixel Size : 10µm in the Eliixa
W = Size of the real object of the web seen by one pixel
M = Magnification : M = w/W
p = Color pitch or distance between to lines centers = 20µm in the Eliixa
S = Speed of the web.

For magnification of M, the line rate has to be adjusted at S/W (see Chapter 5). Then, due to the fact that the color pitch is 2x the pixel size, an area size of W which has been grabbed by the red line at T will be grabbed by the Blue at T+2, by the Green at T+4 …

The Camera memorizes each line for each color from T to T+6.
The spatial correction of "2" allows to associate :
Red (T) + Blue(T+2) + Green (T+4) + Nir/BW(T+6) to be outputted in the same time on the Camera Link connector.

Then the Spatial correction of "2" is for a pixel ratio (width/height) of 1/1 ("square pixels").
We define the "width" in the sensor direction and the "height" in the web direction : A web speed which is 2x times faster than the appropriate line rate to get square pixels will compress by 2 the pixels in the web direction : In this case the ratio will be defined as 1/2.
But if the ratio is different, in order to avoid color artifacts, you've to adjust your spatial correction in the following range :

Delay	Ratio
Inhibited	-
0,5	1/4
1	1/2
1,5	2/3
2	1/1
3	3/2
4	2/1
5	5/2
6	3/1

Example :
Sensor size = 40,96mm (pixel size = 10µm)
Web Speed = 2200mm/s
Web Width = 500mm
Focal length = 65mm
Magnification = 0,08192 : (sensor size/ Web width)
=> 10µ on the sensor ⇔ 0,12207mm on the Web
At 18000l/s, the actual web speed (2200mm/s) is covered : The spatial correction has to bet set to 2, the image ratio will be 1/1
Working distance => 793,5mm : (Focal length / Magnification)

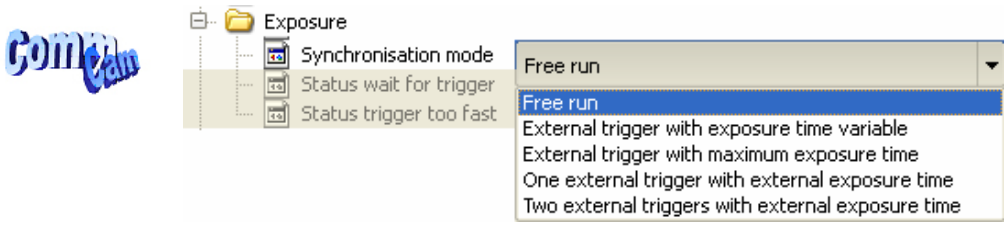
If the Web speed is set at 4400mm/s, the image ratio will be 1/2 and then the Spatial correction has to be set to 1 (line rates remains 18000l/s for the Camera : It's the max it can achieve.

Title	Command	Features
Signal Source	w srce 0	Set signal source to CCD sensor
	w srce 1	Set signal source to user pattern
	r srce	Get current signal source
Output Mode	w mode 0	set 3+1 outputs Dual Base 8/ 8bits (*)
	w mode 1	3+1 outputs Dual Base 8/10bits (*)
	w mode 2	3+1 outputs Dual Base 8/12bits (*)
	w mode 3	4 outputs Medium 8bits
	w mode 4	4 outputs Medium 10bits
	w mode 5	4 outputs Medium 12bits
	w mode 7	3+3 outputs dual base 8 bits RGB + RGNir/RGMono (*)
	w mode 8	3+3 outputs dual base 8 bits RGB + RBNir/RBMono (*)
	w mode 9	3+3 outputs dual base 8 bits RGB + BGNir/BGMono (*)
	w mode 13	Dual base interlaced 8bits RGB/RGB (**)
	r mode	Get current output mode
Scanning direction	w rway 0 w rway 1	set the scanning direction: 0: Reverse 1: Forward
	r rway	get the scanning direction
Spatial correction	w loop <val>	Set number of lines for spatial correction val :0 to 8 : 0 : Correction inhibited 1 : Delay 0,5 lines 2 : Delay 1 line 3 : Delay 1,5 lines 4 : Delay 2 lines 5 : Delay 3 lines 6 : Delay 4 lines 7 : Delay 5 lines 8 : Delay 6 lines
	r loop	get the number of lines for spatial correction

(*) for RGB models these modes are equivalent to RGB 8 bits 3x80 or 3x60MHz
(**) for RGB models (BA0) only

6.3.3 Exposure and Synchronization

- **Synchronisation Mode:** Timed or Triggered, it defines how the grabbing is synchronized. This command is available in the CommCam "Exposure" section :



⇨ Read function : "**r sync**";

Return by the camera:

- 0 : Free Run mode
- 1 : Ext Trig with Integration time set in the Camera
- 2 : Ext Trig with Integration time maximum in the line period
- 3 : Ext ITC (Integration Time Controlled) : The same Trig signal defines the line period and its low level defines the integration time
- 4 : Ext Trig with two trig signal : CC2 defines the start of the integration and CC2 defines the Stop of the integration.

⇨ Write function : "**w sync**" <value>

o **Timing Specifications**

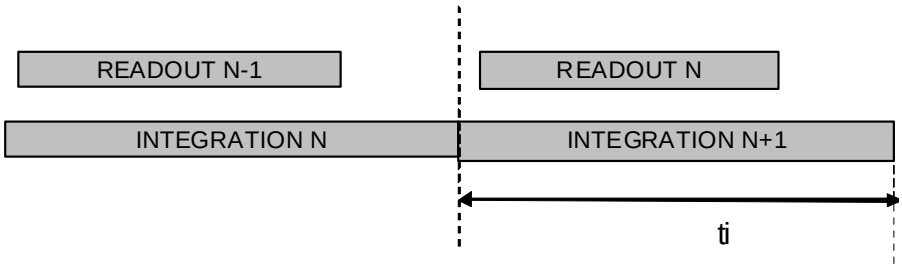
This table is for all the synchronization modes.

Label	Description	Min	Typ	Max
ti	Effective exposure time duration	1,5 µs	-	-
td	CC1 rising to integration period start delay	0.3 µs		
ts	Integration period stop to LINE1 rising set-up time	2.0 µs		
th	CC1 hold time (pulse high duration)	1 / 3 µs (*)		
td1	CC1/CC2 falling/rising to integration period start delay	0.3 µs		
td2	CC1/CC2 rising to integration period stop delay	0.3 µs		
tcc	CC1 Rising to integration stop delay	3µs		

(*) 3µs in ITC Trig Mode, 1µs for the other modes

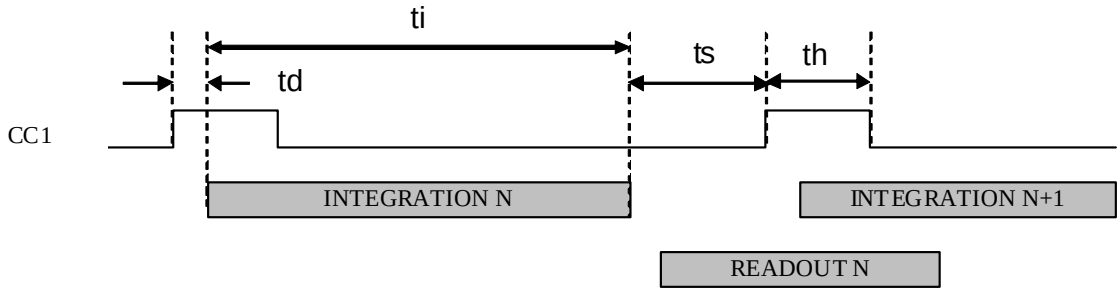
- **Exposure Mode Timed : Free Run**

  This mode doesn't require an external trigger.
  In this case, the line period (Lp) can be defined in the Camera (see below) but the real line period of the camera depends also on the exposure time (Texp) set:
  - If Texp > Lp, the line period is equal to Texp
  - If Lp > Texp, the line period is equal to Lp



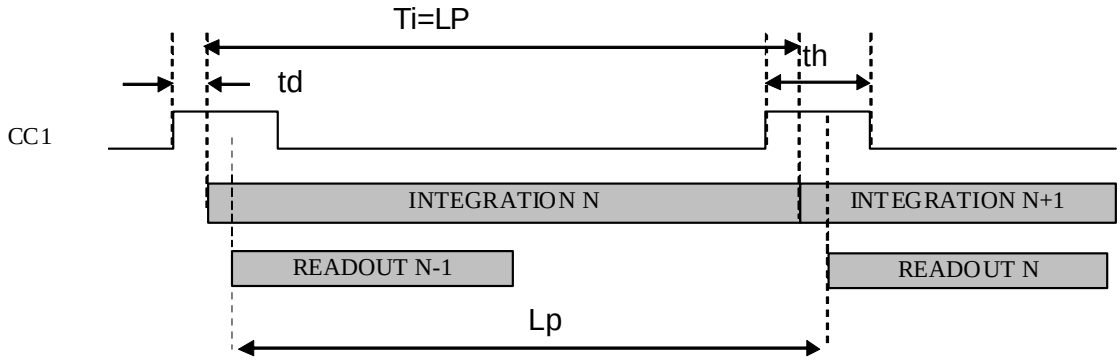
- **Ext Trig with integration time set in the camera**
  This mode requires an external trigger (via CC1) but the exposure time is the one defined in the Camera.

If the line period of the Trig signal provided to the camera is bigger than the exposure time set in the camera, the "short trig pulses" will be ignored : The exposure set in the camera defines the minimum line period possible.

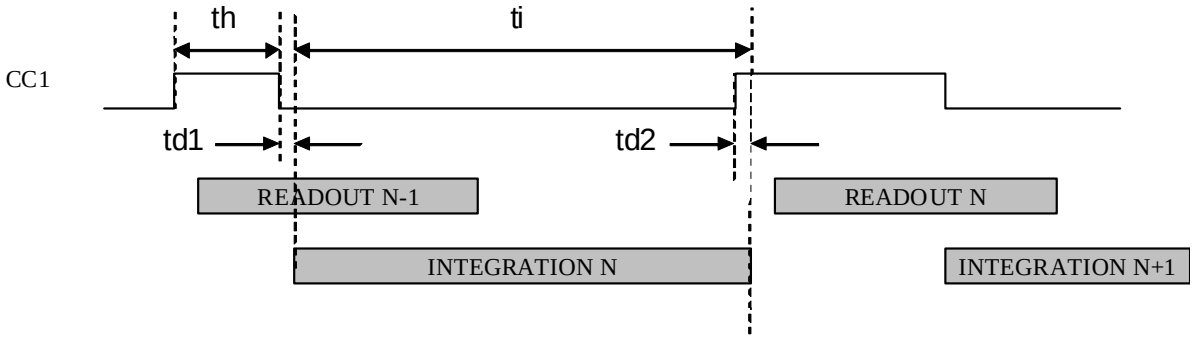


- **Ext Trig Full Integration time available**
  This mode requires an external trigger (via CC1). The exposure time is the maximum possible value between two Tri pulses.
  In this mode, the exposure time set in the camera is ignored.

Avoid this mode if your trigger is not stable (variable line period) : The exposure of each line could then be different.
If the period of the trig signal is less than the readout time, the Camera won't send any signal.

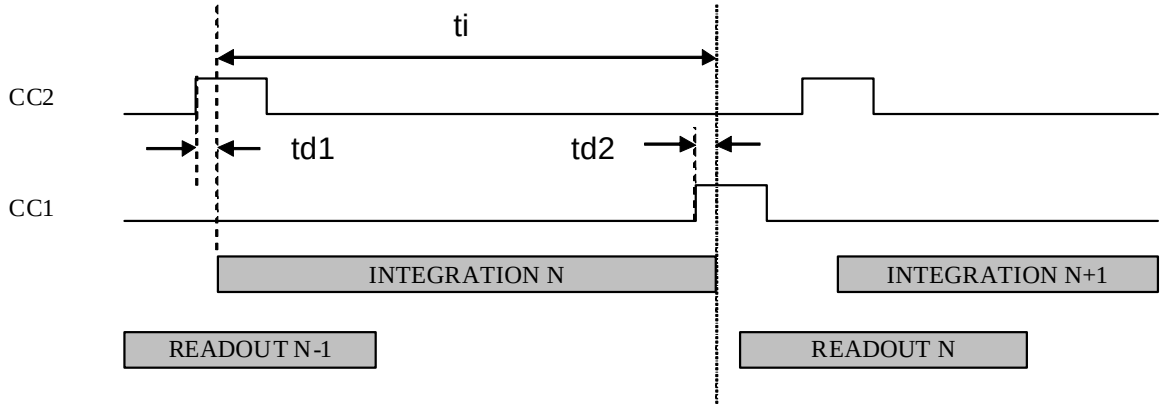


- **Ext Trig with Integration Time Controlled (ITC) with one Trig**
  This mode requires an external trigger (via CC1). Both exposure time and line period are defined by this Trig signal :
  - The exposure time during the low level of the Trig Signal
  - The line period between two rising edges of the Trig Signal

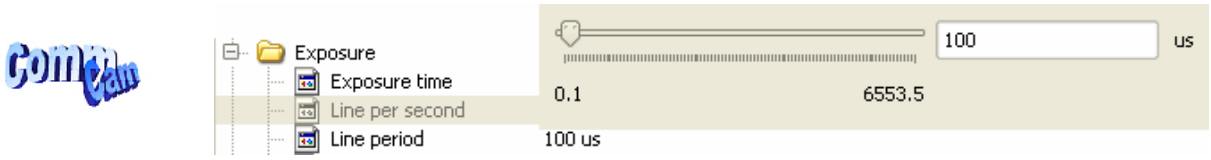


- **Ext Trig with Integration Time Controlled (ITC) with two Trigs**
  This mode requires two external triggers (via CC1 and CC2):
  - CC2 controls the starting of the exposure time
  - CC1 controls the end of the exposure time.

  The line period is defined by the one of the CC2 Trig signal.



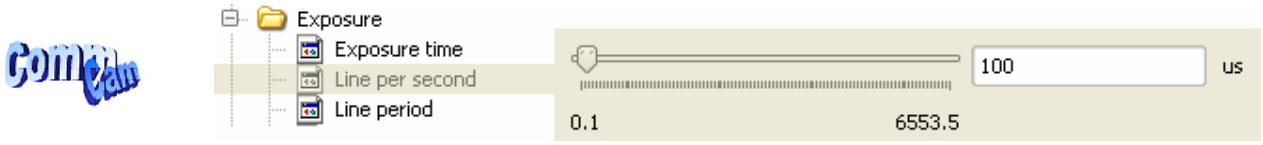
- **Exposure time:** Defines the integration time when set in the Camera. This command is available in the CommCam "Exposure" section :



⇨ Read function : "**r tint**";
Return by the camera : Integer from 1 to 65535 (=0,1µs to 6,5535ms)
⇨ Write function : "**w tint**" <value> ;

This value of integration time is taken in account only when the synchronisation mode is "free run" (0) or "Ext Trig with Integration time set" (1). Otherwise it's ignored.

- **Line Period:** Defines the Line Period of the Camera in Timed mode. This command is available in the CommCam "Exposure" section :



⇨ Read function : "**r tper**";
Return by the camera : Integer from 1 to 65535 (=0,1µs to 6,5535ms)
⇨ Write function : "**w tper**" <value> ;

The line period is active only in Free Run mode. It's also disabled if in this mode, the Integration time is set higher than the Line Period.
The Line frequency indication (line per second) is calculated as : 1/Line Period.

Title	Command	Features
Synchronisation Mode	w sync 0	Set free run mode, with integration time and line period programmable
	w sync 1	Set line period synchronisation with integration time programmable
	w sync 2	Set line period synchronisation (start and period) with integration time to its maximum
	w sync 3	Set line period synchronisation (start and period) and integration time controlled by 1 signal (ITC)
	w sync 4	Set line period synchronisation (start and period) and integration time controlled by 2 signals
	r sync	Get current synchronisation mode
Integration time	w tint <val>	Set integration time to <val> x100ns, from 1 to 65535
	r tint	Get current integration time
Line Period	w tper <val>	Set line period to <val> x100ns, from 1 to 65535 Disabled if tper < tint
	r tper	Get current line period

6.3.4 Gain and Offset

Ultimate Concept: A different way to set the Gain in order to improve the Tap balance

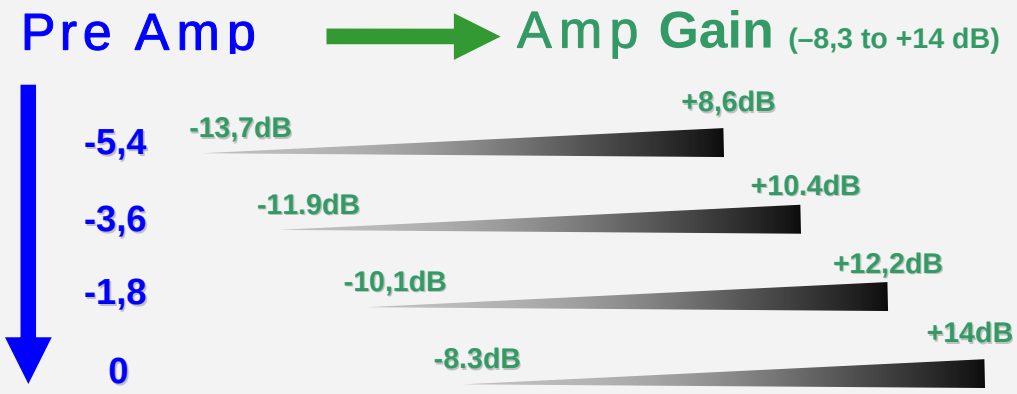
The "U" Concept has been developed to get a real improvement in term of tuning for the multi-Tap sensors :
As each sensor tap is driven by a different analog Chain, for an increasing of the global gain of the Camera, each tap can have a different behavior on its own Gain and offset.
This means that to be perfectly adjusted, a balance of the taps should be performed ideally after each change of the Gain.
The Ultimate Concept offers a solution as following:

The Global analog Gain of the Camera is divided in 2 parts :

- A preamp-Gain which is composed of several steps (4 x steps of 1,8dB on the ELIIXA)
- An amplification Gain with a continuous tuning (from -8,3dB to +14dB on the ELIIXA)

At each step of Preamp Gain, a Tap balance has been performed in factory for both Gains and Offsets and saved in ROM memory. When a new value of Preamp Gain is set, the factory settings of the both Gain and offset balance is automatically reloaded.
The user might also perform his own balance (automatically or manually) and can save it in one of the four dedicated memory banks.

After the Preamp Gain level, the user can add more gain by using the Amplification Gain:

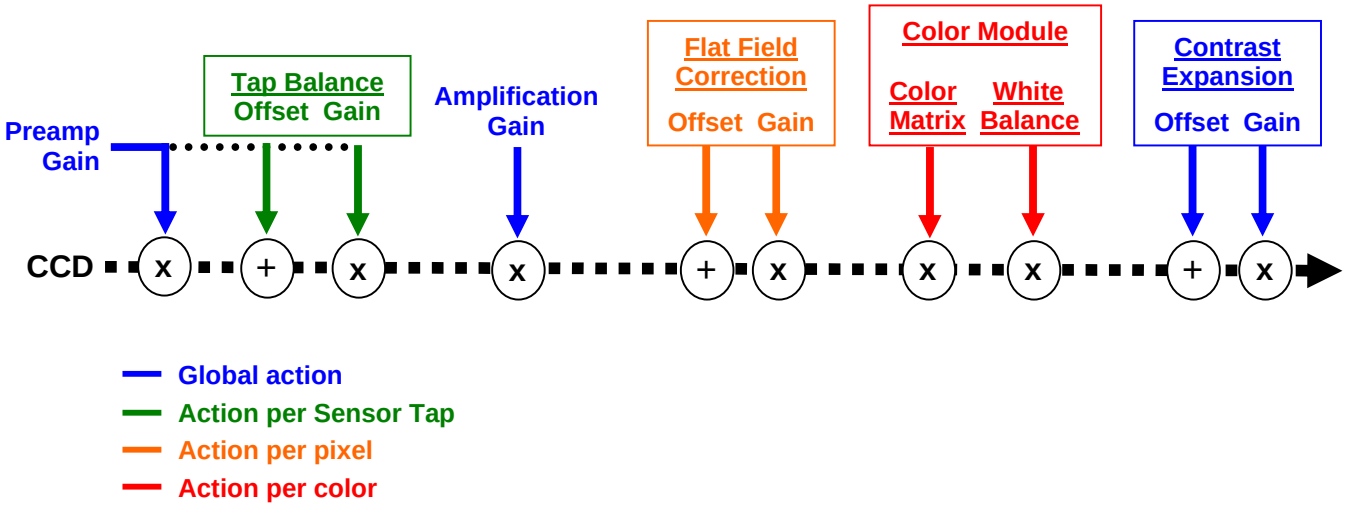


⇨ The best tuning is when the Amplification Gain is at its minimum possible

⇨ Each change of Preamp Gain value loads automatically the associated values of the Tap balance (Gain and offset for each sensor tap).

This action takes more time than simply changing the Amplification Gain

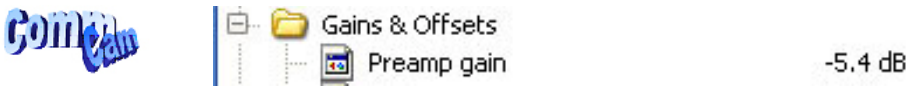
The Global Chain of Gain is described as follows:



The Flat Field correction and the Color Modules will be detailed in a following chapter.

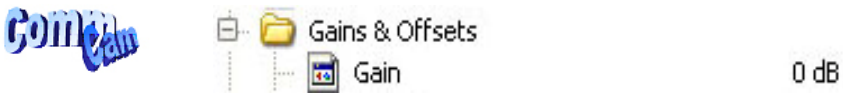
Analog Gain

- **Preamp Gain:** Set the Pre-amplification Gain. This command is available in the CommCam "Gain & Offset" section :



⇨ Read function : "**r pamp**";
Return by the camera: Integer corresponding to one of the different step values:
0 (-5.4dB), 1 (-3.6dB), 2 (-1.8dB) or 3 (0dB)
⇨ Write function : "**w pamp**" <int> ;

- **Gain:** Set the Amplification Gain. This command is available in the CommCam "Gain & Offset" section :



⇨ Read function : "**r gain**";
Return by the camera: Value from -237 to 416 corresponding to a Gain range of -8,32dB to 14,6dB by step of 0,0351dB
⇨ Write function : "**w gain**" <int> ;

Tap Balance

How to perform a Tap Balance ?

Why and when performing a Tap Balance?

Each output of the sensor (Tap) has its own analog Chain and behavior. There could have some discrepancies between these outputs in extreme conditions of Gain or temperature

The Tap balance is already performed in factory for each level of Preamp-Gain. If necessary, the Tap balance can be performed again by the User on both Offsets and Gains

The Procedure is the following :

Tap Balance by Offsets

- Cover the Lens of the camera to get a dark uniform target. This is not recommended to perform an Offset balance under light conditions.
- Launch the Tap Offset Balance
- The process takes a few seconds and can be interrupted when you want

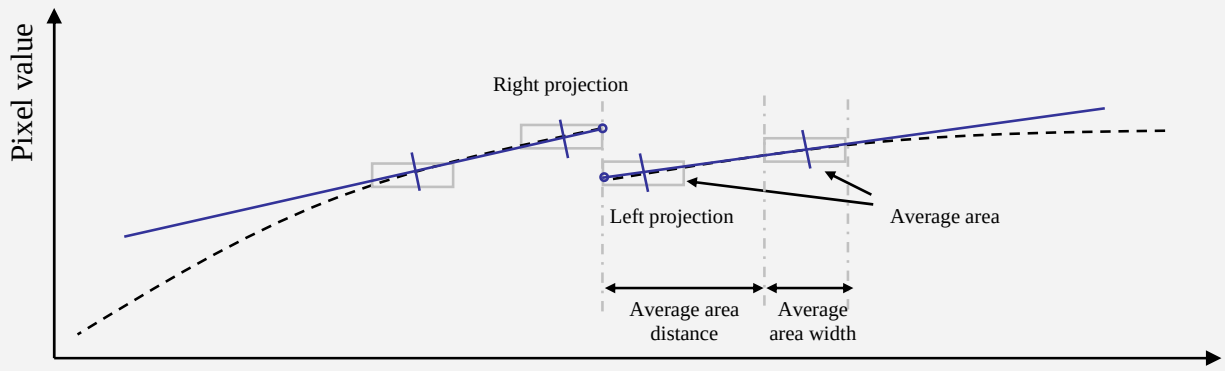
Tap Balance by Gains

- Choose the color line on which you'll perform the Gain balance
- Provide an uniform light target to the camera: This is recommended to have a global level of around at least 70% of the saturation, otherwise, with a low light level (< 30% of the Saturation) the Gain has less effect than the Offset and your balancing won't be efficient.
- Launch the Tap Gain Balance
- The process takes a few seconds and can be interrupted when you want

- You can save the result in memory (result for both Gains and offsets).

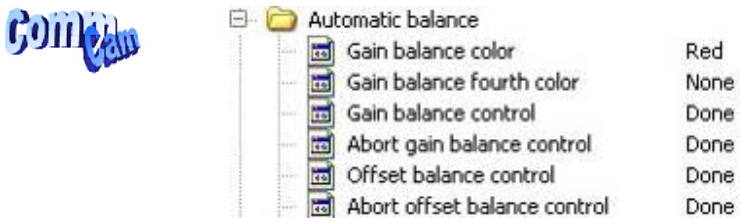
Internal Process

During the calibration process, the Camera calculates averages on some strategic ROIs (around the junction between taps) and then estimates the slope of the tangents and then the projections on each side of the junction.



The adjustment between these two neighbor taps is calculated to cancel the difference between the two projections (right and left).

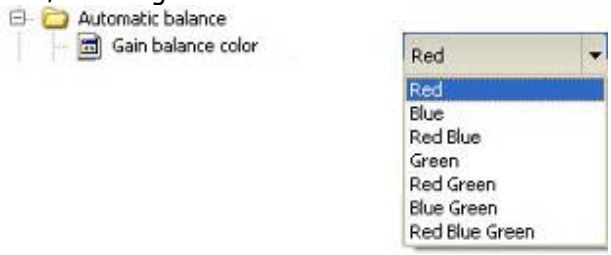
- **Offsets and Gain Taps Balance:** All the commands are available in the CommCam "Gain & Offset" section :



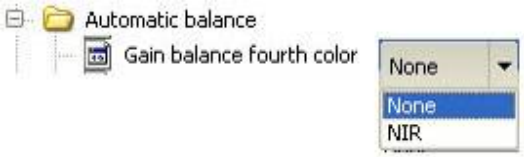
- **Offsets Balance:**
  - ⇨ Read function: "**r balo**";
    Returns the Offset Balance status: 1 for running and 0 for stopped.
  - ⇨ Write function :
    - "**w balo 1**" : Starts the offset balance. The value switches back to 0 automatically when the balance process is finished ("Offset Balance control" in CommCam)
    - "**w balo 0**" : Stops the offset balance. No action if the process is already finished ("Abort Offset balance Control" in CommCam).

- **Gains Balance:**
  - o **Choice of the color line**
    In CommCam, the Choice of the line(s) is done through two different commands :

    Red, blue or green or a combination of these 3 colors.



    Choice of the Fourth line:



    Each of these commands is followed by the reading of the Gain Balance Status.
    The final combination of choice will be taken in account in the launching of the Gain balance

  - o **Tap Gains balance Control**
    - ⇨ Read function : "**r balg**";
      Returns the Tap Balance status: 0 if finished.
    - ⇨ Write function :
      - "**w balg <val>**": Starts the offset balance.
        <Val> is a combination (Xor or Sum) of the different color lines on which the balance will be performed:
        <val>=1: Red =1; Blue = 2; Green = 4; Nir/Mono = 8.

For example val = 14 means that the lines Blue + Green + Nir (or Mono) will be processed.

The value switches back to 0 automatically when the balance process is finished ("Gain Balance control" in CommCam)

- "**w balg 0**" : Stops the Gain balance. No action is the process is already finished ("Abort Gain balance Control" in CommCam).

- **Tap Balance Bank Management:** The new-processed Tap balance can be saved in 4 x User banks (both Gains and Offsets in the same time).

  ⇨ Read function
  - "**r rbal**" : Get the current Tap Bank used (0: Factory or 1 to 4)
  - "**w rbal <val>**" : Load Tap Bank from bank <val> (0: Factory or 1 to 4)

  ⇨ Write function :
  - "**w sbal <val>**" : Save the current Tap Balance in the User bank <val> (1 to 4)

Contrast Expansion

- **Digital Gain:** Set the global Digital Gain. This command is available in the CommCam "Gain & Offset" section :

⇨ Read function : "**r gdig**";
Returned by the camera : Value from 0 to 255. The corresponding Gain is calculated as 20log(1+val/64) in dB
⇨ Write function : "**w gdig**" <int> ;

- **Digital Offset:** Set the global Digital Offset. This command is available in the CommCam "Gain & Offset" section :

⇨ Read function : "**r offs**";
Returned by the camera : Value from –4096 to +4095 in LSB
⇨ Write function : "**w offs**" <int> ;

Title	Command	Features
Preamp gain	w pamp <val>	Set pre amplifier gain to: 0 (-5.4dB), 1 (-3.6dB), 2 (-1.8dB), 3 (0dB) (analog gain) Change Tap balance settings to factory default
	r pamp	Get current pre amplifier
Gain	w gain <val>	Set gain form –8.32dB (-237) to +14.60dB (+416) step of 0.0351dB
	r gain	Get current gain
Tap Balance	w balo 1	Start offset tap balance; OnePush button (auto disable once finished)
	w balo 0	Stop offset tap balance
	r balo	Get the offset tap balance status
	w balg <val>	Start gain tap balance; OnePush button (auto disable once finished) • <val>=1: Red • <val>=2: Blue • <val>=4: Green • <val>=8: NIR <val> can be Combined with different values
	w balg 0	Stop gain tap balance
	r balg	Get the gain tap balance status (1 for running, 0 for finished).
Balance Tap bank	w sbal <val>	Save current Balance tap into bank number <val>. <val> between 1 and 4
	w rbal 0	Load current Balance tap from factory bank (0)
	w rbal <val>	Load current Balance tap from bank number <val>. <val> between 1 and 4
	r rbal	Get the current Balance tap bank used (saved or loaded)
Digital Gain	w gdig <val>	Set digital gain from 0 to 255 (20log(1+val/64) dB)
	r gdig	Get digital gain
Digital Offset	w offs <val>	Set global offset from –4096 to +4095 in 12bits LSB (numeric offset)
	r offs	Get global offset

6.3.5 Color Management

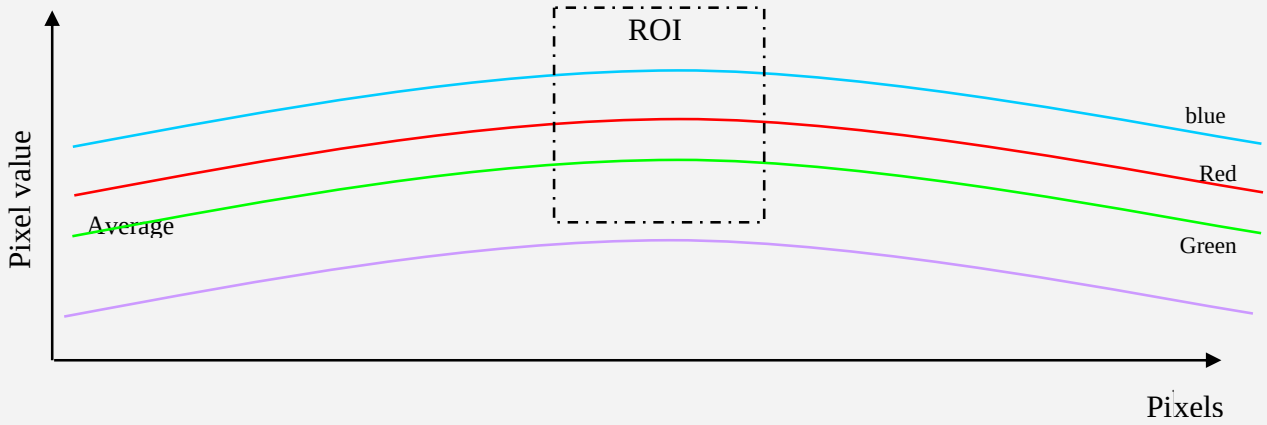
White Balance

How is performed the White Balance ?

Automatic White Balance Calculation

The User can access to one dedicated Gain per color line (R, G, B and eventually Mono or NIR).
The Red, Green and Blue Gain are used to perform the "White Balance".
The ELIIXA embeds an automatic function to calculate the appropriate Gains for a perfect white balance.
This Auto white balance affects only the Red, Green and Blue Gains (not the Mono or Nir of the 4x Lines versions).

When this function is launched, the Camera calculates the average value for each color line in a ROI of 512 pixels located in the centre of the CCD :



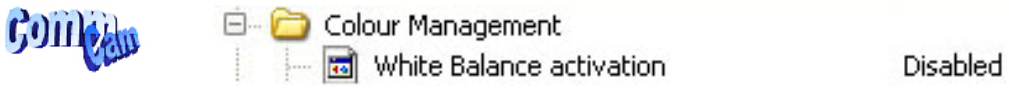
Each gain is then calculated to reach the level of the color which has the highest sensitivity.
Note: After an automatic White Balance with CommCam, the 3 colors gains values are not refreshed in the CommCam Interface.

How to perform the White Balance?

The User has to propose a white target to the Camera.
The Global Gain of the Camera has to be set to avoid saturation in any of the 3 x RGB colors.
The Color Matrix must be enabled if you're using a RGB+Nir Camera version.
The White Balance can be enabled before: During the calculation process it is disabled automatically.

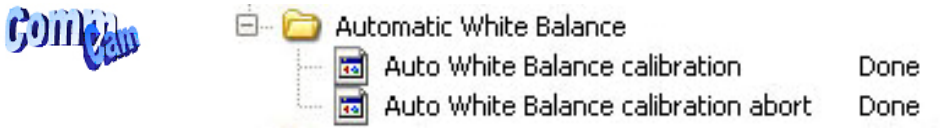
- The User has to propose a white target to the Camera.
- Set the global Gain to avoid saturation and disable the color Matrix.
- Launch the auto WB calibration
- Enable the White Balance : The new coefficients are now active
- Adjust the Gain of the fourth line (Mono or Nir) if present
- Save the result in one of the 4 x user banks dedicated to the color management.

- **Auto White Balance Activation:** Activate the White balance. This command is available in the CommCam "Color Management" section :



  - ⇨ Read function : "**r wben**" : Returns the White balance Status (0 if disabled, 1 if enabled)
  - ⇨ Write function :
    - "**w wben 1**": Enable the white Balance : The Color Gains are now activated.
    - "**w wben 0**" : Disable the white Balance

- **Auto White Balance Calibration:** Launch the Auto WB calculation process. This command is available in the CommCam "Color Management" section :



  - ⇨ Read function : "**r sawb**" : Returns the Auto White balance process Status (0 if off, 1 if active)
  - ⇨ Write function :
    - "**w sawb 1**" : Launch the Auto white Balance calibration process.
    - "**w sawb 0**" : Abort the Auto white Balance calibration process. No effect if already stopped.

- **Manual White Balance:** Access to the RGB +Mono or Nir Gains. These commands are available in the CommCam "Color Management" section :

  - o **White Balance Red Gain**
    - ⇨ Read function : "**r wbar <val>**" : Returns the White balance Red Gain value.
    - ⇨ Write function : "**w wbar <val>**" : Sets the White balance Red Gain value.
      <val> is a Q13.10 unsigned value (from 0 to 7,999…).
      The Red Gain is calculated and displayed as follow : WBr = 1 + <val>

  - o **White Balance Green Gain**
    - ⇨ Read function : "**r wbag <val>**" : Returns the White balance Green Gain value.
    - ⇨ Write function : "**w wbag <val>**" : Sets the White balance Green Gain value.
      <val> is a Q13.10 unsigned value (from 0 to 7,999…).
      The Green Gain is calculated and displayed as follow : WBg = 1 + <val>

- **White Balance Blue Gain**
  - ⇨ Read function : "**r wbab <val>**" : Returns the White balance Blue Gain value.
  - ⇨ Write function : "**w wbab <val>**" : Sets the White balance Blue Gain value.
    <val> is a Q13.10 unsigned value (from 0 to 7,999…).
    The Blue Gain is calculated and displayed as follow : WBb = 1 + <val>

- **White Balance Nir or Mono Gain** (non available on RGB versions)
  - ⇨ Read function : "**r wbai <val>**" : Returns the White balance Nir/Mono Gain value.
  - ⇨ Write function : "**w wbai <val>**" : Sets the White balance Nir/Mono Gain value.
    <val> is a Q13.10 unsigned value (from 0 to 7,999…).
    The Nir/Mono Gain is calculated and displayed as follow : WBi = 1 + <val>

Color Matrix

What is the interest of the Color Matrix ?

After white balancing, the color space correction shall be done to improve the color response. This correction consists in a linear operation to convert the RGB triplet form the camera color space to the RGB triplet of the final color space. The final color space can be a monitor, a printer or others application specific color space. For some specific applications where "absolute" color value is not mandatory the color space correction can be bypassed.

$$\begin{pmatrix} R'' \\ B'' \\ G'' \\ N'' \end{pmatrix} = \begin{pmatrix} cm11 & cm12 & cm13 & cm14 \\ cm21 & cm22 & cm23 & cm24 \\ cm31 & cm32 & cm33 & cm34 \\ cm41 & cm4é & cm43 & cm44 \end{pmatrix} \times \begin{pmatrix} R' \\ B' \\ G' \\ N' \end{pmatrix}$$

Each coefficient can be set in the following limits : -4 to +3,999
The last line and column are valid only for the RGB + Nir Version.
They are available for the RGB + Mono but have no signification for the color space tuning.

Attention = This Matrix is shown here in the real order of the CCD color lines : Red, Blue and Green + 4th and not the usual order: R,G,B.
Then for Commcam:

- the "cm1x" define the first line or the "Red Line", "cm2x" the Blue line, cm3x the Green line and cm4x the Nir Line.
- "cmx1" define the Red column, cmx2 the Blue column, cmx3 the Green column and cmx4 the Nir column.

The default Matrix are the following :

- For the RGB+Nir Versions:

$$\begin{bmatrix} 1 & 0 & 0 & -1 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

To remove the Nir Infra Red component of each color and which has been measured with the Nir Line

Some values of the RGB Matrix will be proposed in Appendix C for different type of light source.

The Sum of the 3 parameters of the RGB Matrix on the same line must be equal to 1 in order to avoid changing the White Balance.

- For the RGB or RGB+Mono Versions:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

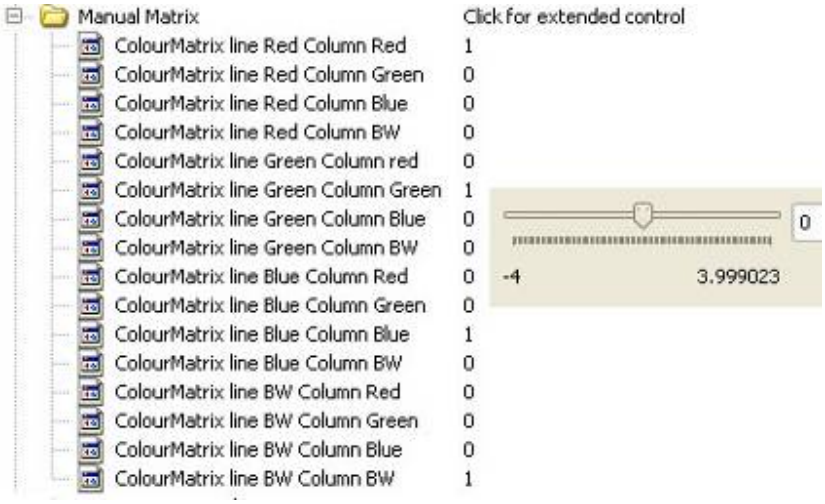
Not Available for the RGB Version.

Some values of the RGB Matrix will be proposed in Appendix C for different type of light source.

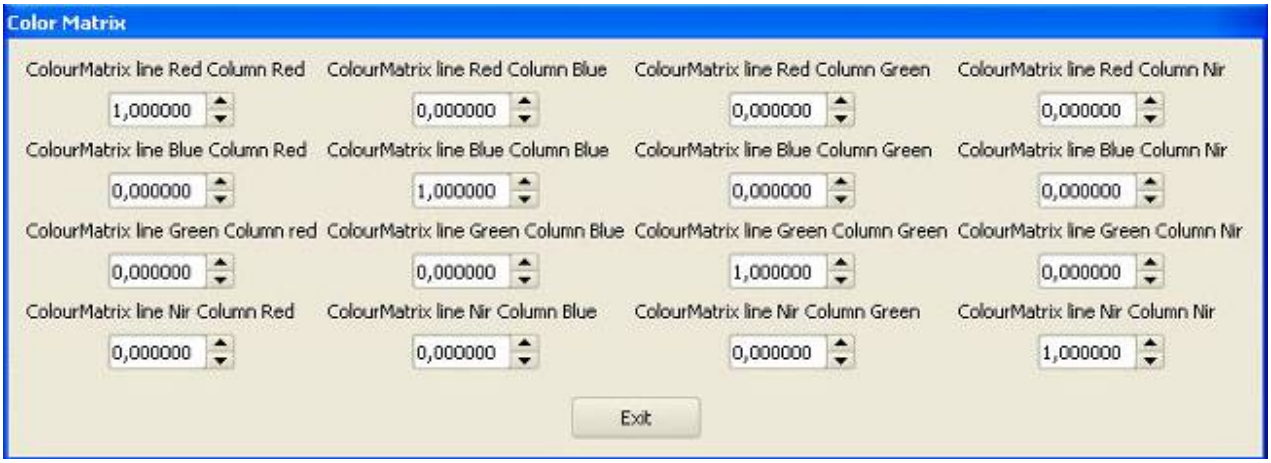
- **Color Matrix Enable :** Activates the color Matrix. This command is available in the CommCam "Color Management" section :

  - ⇨ Read function : "**r come**" : Returns the Color matrix Status (0 if disabled, 1 if enabled)
  - ⇨ Write function :
    - "**w come 1**" : Enable the color Matrix.
    - "**w come 0**" : Disable the color Matrix

- **Color Matrix coefficients :** To set each of the Color Matrix coefficients. This command is available in the CommCam "Color Management / Manual Matrix" section :



By clicking on "Click for extended control" we can get a global view of the Matrix :



- ⇨ Read function : "**r cm<line><column>**" : Returns the value of the designed coefficient.
  <line> and <column> are defined as follow : 1=Red, 2=Blue, 3=Green, 4=Nir or Mono (if exists)
- ⇨ Write function : "**w cm<line><column> <val>**" : sets the coefficient of the matrix.
  - <line> and <column> are defined as follow : 1=Red, 2=Blue, 3=Green, 4=Nir or Mono (if exists)
  - <val> is is from –4096 to +4095. (gain format Q13.10 signed)
    The coefficient associated to <val> is calculated as follow : cm = <val>/1024

- **Save & restore color settings:** Allows saving or restoring all the colors settings: White balance gains and colors matrix coefficients. This command is available in the CommCam "Color Management" section :

  - ⇨ Read function
    - "**r rcol**" : Get the current Tap Bank used (0: Factory , 1 to 4 for User, 5 for Integrator)
    - "**w rcol <val>**" : Load Tap Bank from bank <val> (0: Factory , 1 to 4 for User, 5 for Integrator)
  - ⇨ Write function :
    - "**w scol <val>**" : Save the current Tap Balance in the User bank <val> (1 to 4 for User, 5 for Integrator)

Title	Command	Features
Auto White balance calibration	w sawb 1	start auto white balance
	w sawb 0	stop auto white balance
	r sawb	auto white balance state
White balance activation	w wben 0 w wben 1	white balance disable white balance enable
	r wben	Get white balance state
White Balance Red	w wbar <val>	Set red white balance coefficient <val> from 0 to 8191. Red gain format 1+<val> (representation <val>: Q13.10 unsigned)
	r wbar	get red white balance coefficient
White Balance Blue	w wbab <val>	Set blue white balance coefficient (same representation as wbar)
	r wbab	get blue white balance coefficient
White Balance Green	w wbag <val>	Set green white balance coefficient (same representation as wbar)
	r wbag	get green white balance coefficient
White Balance IR	w wbai <val>	Set NIR white balance coefficient (same representation as wbar)
	r wbai	get NIR white balance coefficient
Color matrix enable	w come 1 w come 0	Enable color matrix Disable color matrix
	r come	read state of color matrix
Color Matrix	w cm<l><c> <val>	Color matrix coefficient: its representation is: cm11 cm12 cm13 cm14 cm21 cm22 cm23 cm24 cm31 cm32 cm33 cm34 cm41 cm42 cm43 cm44 <val> is from –4096 to +4095. (gain format Q13.10 signed) l/c : 1=Red, 2=Blue, 3=Green, 4=Nir or Mono (if exists)
	r cm<l><c>	read color matrix coefficient
Color settings bank	w scol <val>	Save current Color settings into bank number <val>. <val> between 1 and 4 for User and 5 for Integrator
	w rcol <val>	Load current Color settings from bank number <val>. <val> between 1 and 4 for User, O for factory default and 5 for Integrator
	r rcol	Get the current Color settings bank used (saved or loaded)

6.3.6 Flat Field Correction

Automatic Flat Field Correction

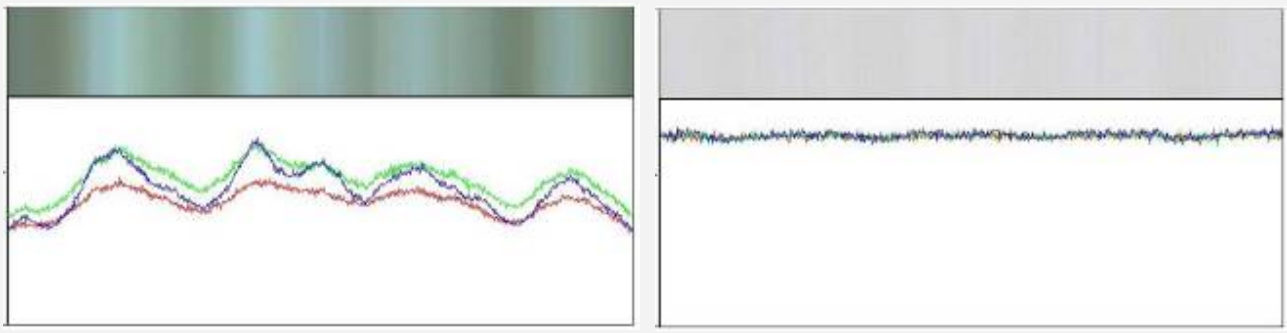
How is performed the Flat Field Correction?

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 : The FFC on color is also specially efficient when your Light source is non uniform in color (ex : LED source with some LEDs more blue and others more red) :

Before **After**

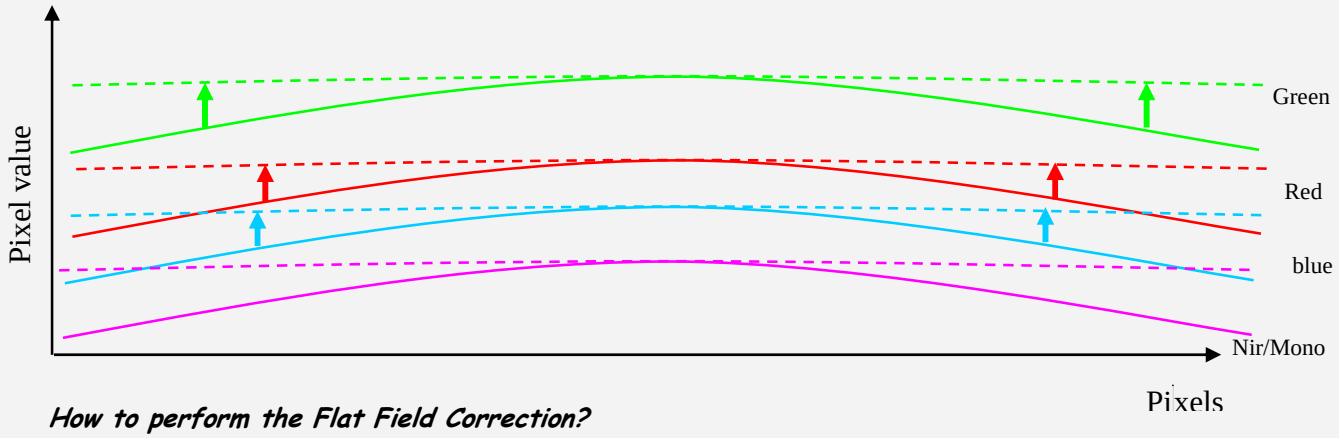


How is calculated/Applied the FFC?

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

- Each Pixel is corrected with :
  - An Offset on 8 bits (Signed Int 5.3). They cover a dynamic of ±16LSB in 12bits with a resolution of 1/8 LSB 12bits.
  - A Gain on 14 bits (Unsigned Int 14) with a max gain value of x3
  - The calculation of the new pixel value is : **P' = (P + Off).(1 + Gain/8192)**

- Each color line has its own independent FFC Calculation :
  - For the offset, the average dark of each pixel is calculated to be subtracted as an offset correction
  - For the Gain, the Maximum of the color line is the reference and each pixel Gain is calculated to reach this maximum: The Maximum correction possible is x3.



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

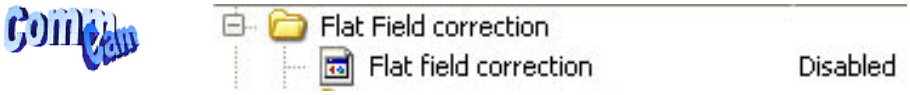
The User must propose a white uniform target to the Camera (not a fixed paper).
The Gain/Light conditions must give a non saturated image in any color.
The Camera must be set in the final conditions of Light/ Gain and in the final position in the System.
The White Balance and color Matrix can be enabled: They don't affect the result. but after the FFC calibration, the User will have to perform a new White Balance

- White uniform (moving) target
- 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.

Advices

The ELIIXA has 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 it's looking for different targets: You can perform one FFC per condition of Gain/setting of the Camera (4 Max) and recall one of the four global settings (Camera Configuration + FFC + Color management) when required.

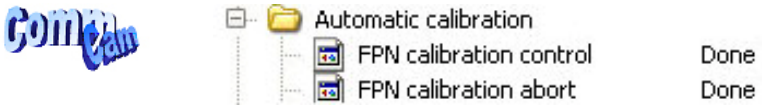
- **FFC Activation:** Enable/disable the Flat Field Correction. This command is available in the CommCam "Flat Field Correction" section :



  - ⇨ Read function : "**r ffcp**" : Returns the FFC Status (0 if disabled, 1 if enabled)
  - ⇨ Write function :
    - "**w ffcp 1**": Enable the FFC.

- "**w ffcp 0**": Disabled the FFC

- **FPN/DSNU Calibration:** Launches the FFC process for the Offsets calculation. This command is available in the CommCam "Flat Field Correction/Automatic Calibration " section:



⇨ Read function : "**r calo**": Returns the FPN Calculation Process Status (0 if finished, 1 if processing)

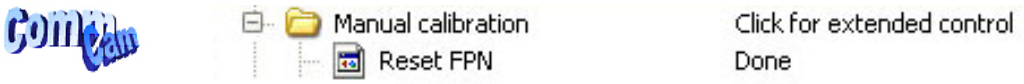
⇨ Write function :

- "**w calo 1**" : Launch the FPN Calibration Process.
- "**w calo 0**": Abort the FPN Calibration Process.

Some Warnings can be issued from the FPN Calibration Process as "pixel underflow" because some pixel have been detected at "0" level. The Calculation result will be proposed anyway as it's just a warning message.
This will change the Status Register which is displayed in CommCam :

The warning messages possible are detailed in the Appendix 6 (Table 2, §6.2).

- **FPN coefficient Reset :** Reset the FPN (Offsets) coefficient in Memory. This command is available in the CommCam "Flat Field Correction / Manual Calibration " section :



⇨ Write function : "**w rsto 0**" : Reset (set to 0) the FPN coefficients in memory. This doesn't affect the FFC User Memory Bank but only the active coefficients in Memory.

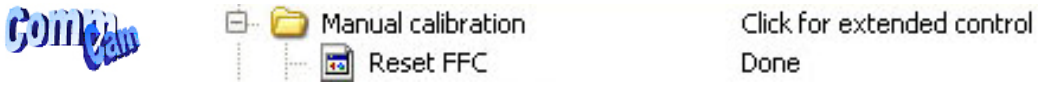
- **PRNU Calibration :** Launches the PRNU process for the Gains calculation. This command is available in the CommCam "Flat Field Correction / Automatic Calibration " section :

⇨ Read function : "**r calg**": Returns the PRNU Calculation Process Status (0 if finished, 1 if processing)

⇨ Write function :

- "**w calg 1**": Launch the PRNU Calibration Process.
- "**w calg 0**": Abort the PRNU Calibration Process.

- **DSNU coefficient Reset :** Reset the **DSNU** (Gains) coefficient in Memory. This command is available in the CommCam "Flat Field Correction / Manual Calibration " section :



⇨ Write function : "**w rstg 0**" : Reset (set to 0) the FPN coefficients in memory. This doesn't affect the FFC User Memory Bank but only the active coefficients in Memory.

Some Warnings can be issued from the FPN Calibration Process as "pixel Overflow" because some saturated pixel have been detected. The Calculation result will be proposed anyway as it's just a warning message.
This will change the Status Register which is displayed in CommCam :

The warning messages possible are detailed in the Appendix 6 (Table 2, §6.2).

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.

In CommCam, the User can access to a specific interface by clicking on "click for extended control" in the Manual FFC section :

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

It is recommended to setup the baud rate at the maximum value possible (115000 for example) otherwise the transfer can take a long time.

- **FPN coefficients modification :** Direct access to the FPN coefficients for reading or writing. This command is available in the CommCam "Flat Field Correction / Manual Calibration " section :

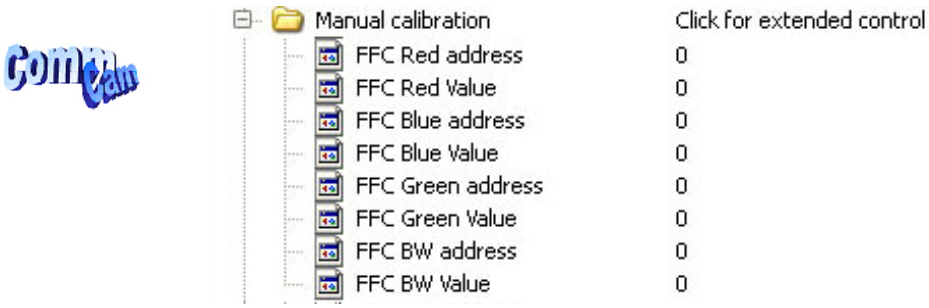
⇒ Read function : "**r ffco <addr> <nbrval> [crcreq]**": Read **<nbrval>** FPN user coefficients starting from **<addr>** address. If **[crcreq]** is equal to 1, the crc will be calculated on the outputted value.
<nbrval> is between 1 and 10
<addr> starts from
- 1 for Red coefficients
- 5001 for Blue Coefficients
- 10001 for Green coefficients
- 15001 for NIR Coefficients

Output is:
<val> …[crcval]

⇒ Write function :" **w ffco <addr> <nbrval> <val> … [crcval]**" : Write **<nbrval>** FPN user coefficients starting from the **<addr>** address. If **[crcval]** is added, the crc value is computed on the all the **<val>. <val>** is signed.
<addr> starts from
- 1 for Red coefficients
- 5001 for Blue Coefficients
- 10001 for Green coefficients
- 15001 for NIR Coefficients

<nbrval> is between 1 and 10
<val> is between **–128 et +127**

- **PRNU coefficients modification :** Direct access to the PRNU coefficients for reading or writing. This command is available in the CommCam "Flat Field Correction / Manual Calibration " section :



⇒ Read function : "**r ffcg <addr> <nbrval> [crcreq]**" : Read **<nbrval>** FPN user coefficients starting from **<addr>** address. If **[crcreq]** is equal to 1, the crc will be calculated on the outputted value.
<nbrval> is between 1 and 10
<addr> starts from
- 1 for Red coefficients
- 5001 for Blue Coefficients
- 10001 for Green coefficients
- 15001 for NIR Coefficients

Output is:
<val> …[crcval]

⇒ Write function :" **w ffcg <addr> <nbrval> <val> … [crcval]**" : Write **<nbrval>** FPN user coefficients starting from the **<addr>** address. If **[crcval]** is added, the crc value is computed on the all the **<val>. <val>** is signed.
<addr> starts from
- 1 for Red coefficients
- 5001 for Blue Coefficients
- 10001 for Green coefficients
- 15001 for NIR Coefficients

<nbrval> is between 1 and 10
<val> is between **0 and 16383**

- **FFC User Bank Management:** The new-processed FFC can be saved in 4 x User banks (both Gains and Offsets in the same time).

⇨ Read function
- "**r rffc**" : Get the current Tap Bank used (0: Factory or 1 to 4)
- "**w rffc <val>**" : Load Tap Bank from bank <val> (0: Factory or 1 to 4)

⇨ Write function :
- "**w rffc <val>**" : Save the current Tap Balance in the User bank <val> (1 to 4)

Title	Command	Features
FFCorrection	w ffcp 0	Disable Flat Field Correction processing
	w ffcp 1	Enable Flat Field Correction processing
	r ffcp	Get Flat Field Correction processing status
FPN User Calibration	w calo 1	Start FPN user calibration; OnePush button (auto disable once finished)
	w calo 0	Stop FPN user calibration
	r calo	Get the FPN user calibration status
PRNU User Calibration	w calg 1	Start PRNU user calibration for all colors; OnePush button (auto disable once finished)
	W calg 0	Stop PRNU user calibration
	r calg	Get the PRNU user calibration status
FPN Reset	w rsto 0	Clear FPN coefficients to 0
PRNU Reset	w rstg 0	Set PRNU coefficients to 1
FFC user bank	w sffc <val>	Save current user FFC (FPN & PRNU) into FFC bank number <val>. <val> between 1 and 4
	w rffc <val>	Load current user FFC from FFC bank number <val>. <val> between 0 and 4 0 is a virtual bank that reset ffc coefficients
	r rffc	Get the current user FFC bank used (saved or loaded)

Title	Command	Features
FPN user coefficients	w ffco <addr> <nbrval> <val> … [crcval]	Write <nbrval> FPN user coefficients starting from the <addr> address. If [crcval] is added, the crc value is computed on the all the <val>. <val> is signed. <addr> starts from • 1 for Red coefficients • 5001 for Blue Coefficients • 10001 for Green coefficients • 15001 for NIR Coefficients <nbrval> is between 1 and 10 <val> is between –128 et +127
	r ffco <addr> <nbrval> [crcreq]	Read <nbrval> FPN user coefficients starting from <addr> address. If [crcreq] is equal to 1, the crc will be calculated on the outputted value. <addr> starts from • 1 for Red coefficients • 5001 for Blue Coefficients • 10001 for Green coefficients • 15001 for NIR Coefficients <nbrval> is between 1 and 10 Output is: <val> …[crcval]
PRNU user coefficients	w ffcg <addr> <nbrval> <val> … [crcval]	Write <nbrval> PRNU user coefficients starting from the <addr> address. If [crcval] is added, the crc value is computed on the all the <val>. <addr> starts from • 1 for Red coefficients • 5001 for Blue Coefficients • 10001 for Green coefficients • 15001 for NIR Coefficients <nbrval> is between 1 and 10 <val> is between 0 and 16383
	r ffcg <addr> <nbrval> [crcreq]	Read <nbrval> PRNU user coefficients starting from <addr> address. If [crcreq] is equal to 1, the crc will be calculate on the outputted value. <addr> starts from • 1 for Red coefficients • 5001 for Blue Coefficients • 10001 for Green coefficients • 15001 for NIR Coefficients <nbrval> is between 1 and 10 Output is: <val> …[crcval]

6.3.7 Save & Restore Settings

The settings (or Main configuration) of the Camera can be saved in 4 x different User banks.

- These settings don't include neither the Color settings (White balance and Color Matrix) nor the Tap Balance (Gains and offsets) nor the FFC which have each their own 4 User banks.
- These settings include user bank in use for each category: Tap Balance, Color Management, FFC. This allow, by loading one Camera configuration at the startup to load also automatically the associated FFC and color settings.

- **Save & restore settings :** Allows to save or restore all the Camera settings : This command is available in the CommCam "Save & Restore settings" section :

⇨ Read function
- "**r rcfg**" : Get the current Bank used (0: Factory , 1 to 4 for User, 5 for Integrator)
- "**w rcfg <val>**" : Load settings from bank <val> (0: Factory , 1 to 4 for User, 5 for Integrator)

⇨ Write function :
- "**w scfg <val>**" : Save the current Settings in the User bank <val> (1 to 4 for User, 5 for Integrator)

Title	Command	Features
Configuration	w scfg 0	Save current configuration into factory bank (0) PAS DISPO
	w scfg <val>	Save current configuration into bank number <val>. <val> between 1 and 4
	w scfg 5	Save current configuration into integrator bank (5)
	w rcfg 0	Load current configuration from factory bank (0)
	w rcfg <val>	Load current configuration from bank number <val>. <val> between 1 and 4
	w rcfg 5	Load current configuration from integrator bank (5).
	r rcfg	Get the current configuration bank used (saved or loaded)

7 APPENDIX A: Camera Status Details

7.1 Table 1 : Processing Status

	Name	Init Value	Update	Description
Processing Status	**Wait for trigger**	0	Set to 1 when Camera in triggered mode and no trigger is received. Otherwise, value set to 0	No trigger received since the last scan (1Hz).
	Settings Modified	0	Set to 1 after any valid change of a configuration parameter. Set to 0 after each save or restore action on a config memory bank	Notify any change in the Camera parameters. Saving in configuration User bank is necessary to keep the new settings after the reboot of the Camera
	Tap Balance Modified	0	Set to 1 after a valid change of the Tap balance Set to 0 after each save or restore action on a tap balance memory bank	Notify any change in the current Camera tap balance. Saving in tap balance User bank is necessary to keep the new settings after the reboot of the Camera
	FFC Modified	0	Set to 1 after a valid change of a FPN or PRNU coefficient Set to 0 after each save or restore action on a FFC memory bank	Notify any change in the current Camera FFC parameters. Saving in FFC User bank is necessary to keep the new settings after the reboot of the Camera

7.2 Table 2 : Internal Task Status

	Name	Init Value	Update	Description
Internal Task Status	**Warn Ovf**	0	At each end of calibration / Tap balance / White balance	Notify that an Overflow occurred during a calibration (FFC, Tap Balance, White Balance) : Logical OR of all the FPGA flags The result of the calibration is nevertheless available
	Warn Udf	0	At each end of calibration / Tap balance / White balance	Notify that an Underflow occurred during a calibration (FFC, Tap Balance, White Balance) : Logical OR of all the FPGA flags The result of the calibration is nevertheless available
	Cal/App Enabled	0	At each start and end of calibration / Tap balance / White balance	Notify that the Calibration (FFC, Tap Balance, White Balance) is : Active (1) Or terminated (0)

7.3 Table 3 : Error Diagnostic Status

	Name	Init Value	Update	Description
diagnostic error Status	**Err hardware init**	0	At each camera start or when the FPGA restart	Notify that an error has occurred during the hardware init of the camera : Mainly the loading of the FPGA with a invalid or corrupted dataflash contains.
	Err factory application settings	0	At the Camera startup	Notify that an error is detected in one parameters of the "Factory Application Settings" EEPROM area
	Err user application settings	0	At the Camera startup	Notify that an error is detected in one parameters of the "User Application Settings" EEPROM area
	Err factory camera settings	0	At the Camera startup or each factory default settings reload action	Notify that an error is detected in one parameters of the "Factory Camera Settings" EEPROM area
	Err user camera settings	0	At the Camera startup or each User settings reload action	Notify that an error is detected in one parameters of the "User Camera Settings" EEPROM area
	Err CommCam compatibility index	0	At each read / write of the Camera hardware ID	Notify that an error is detected in the "CommCam compatibility index" EEPROM area

8 APPENDIX C : Thermal Management

The most important source of heat in the camera is around the sensor. The fastest version dissipates around 14W with 8 taps at 40MHz on the sensor.
The Camera has been designed to dissipate the maximum of the internal heat through its front face: The packaging of the sensor is larger to increase the surface in contact with the front face and then improves the dissipation.

In the system, the camera has to be fixed by its front face with the largest contact possible with a metallic part.
Without any specific cooling system, a simple air flow around the camera will improve roughly the dissipation.

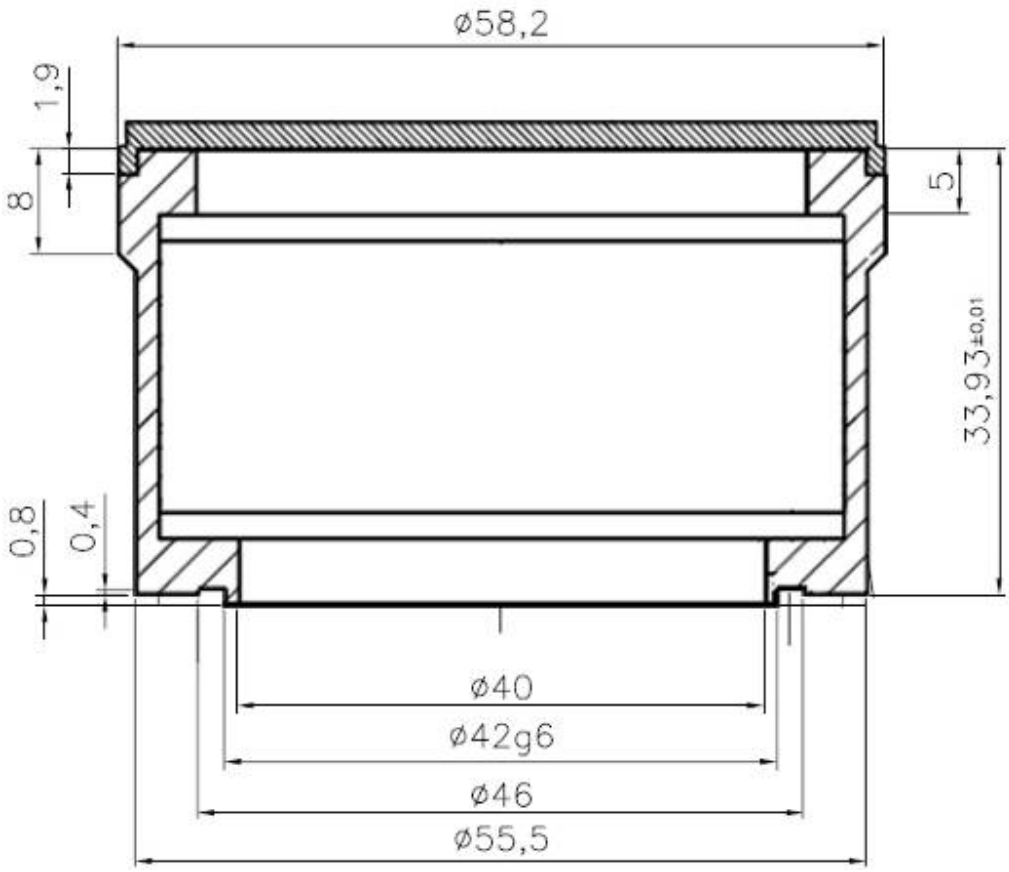
If necessary, additional heat sinks are available (reference below) and they can be fixed on any side of the front face:

Set of 2 x Heat Sinks: Part number AT71KFPAVIVA-CAA

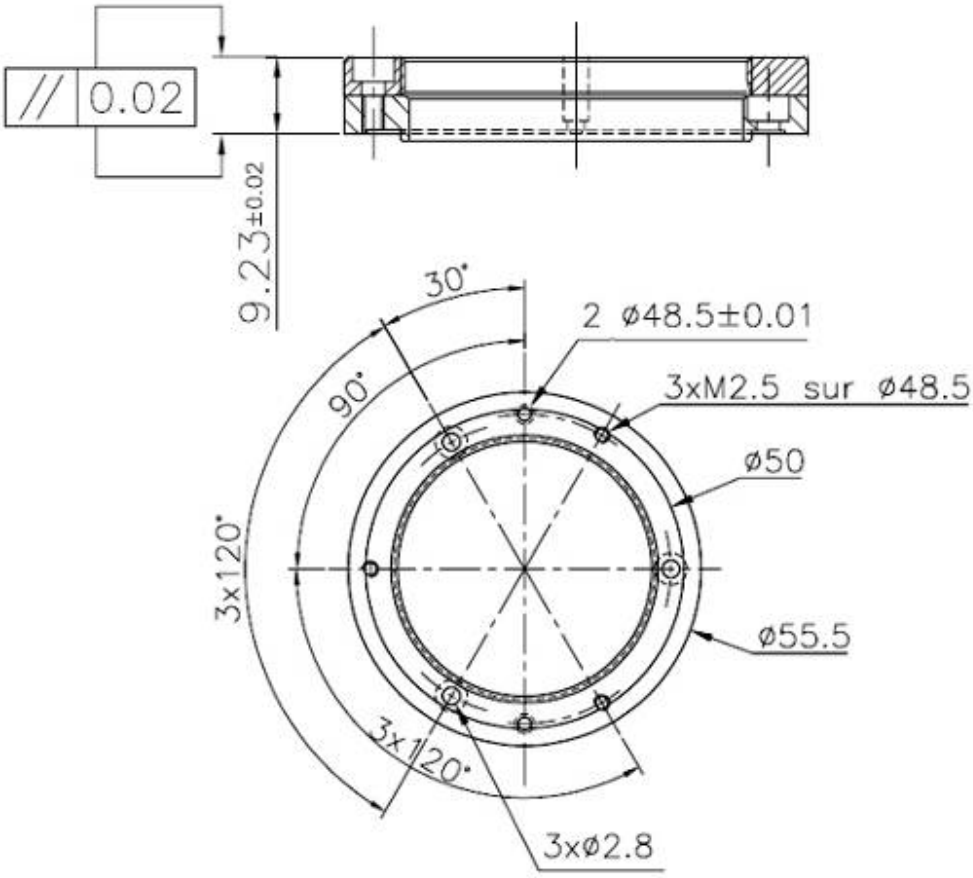
One heat sink can decrease the temperature of the front face of about 5°C down.

9 APPENDIX E: Optical Mounts available

F Mount: Kit10 (Part number AT71KFPAVIVA-ABA)



M42x0,75 (T2 Mount): Kit30 (Part number AT71KFPAVIVA-AKA)
M42x1 Mount: Kit40 (Part number AT71KFPAVIVA-ADA)



APPENDIX F: Color Matrix Examples

Please, contact the Camera hotline : hotline-cam@e2v.com for more information

10 APPENDIX G: Revision History

Revision	Comments / Details	Camera Ref
Rev A	Preliminary release	Firmware 2.0.0
Rev D	Spatial correction extended to 0,5 and 1,5 values + inhibition Mechanical drawing detailed Reverse/forward = 0/1 and explanation drawing	Firmware 3.0.0
Rev E	Status command Mechanical drawing detailed for Mounts Baud Rate change warning	Firmware 3.0.0
Rev F	Dual Base Interlaced 8bits output mode for BA0 only	Firmware 3.0.2

How to reach us

Home page: www.e2v.com

Sales Office:

Northern Europe
e2v ltd
106 Waterhouse Lane
Chelmsford
Essex CM1 2QU
England
Tel: +44 (0)1245 493493
Fax: +44 (0)1245 492492
E-Mail: enquiries@e2v.com

Southern Europe
e2v sas
16 Burospace
F-91572 Bièvres
Cedex
France
Tel: +33 (0) 1 60 19 55 00
Fax:+33 (0) 1 60 19 55 29
E-Mail: enquiries-fr@e2v.com

Germany and Austria
e2v gmbh
Industriestraße 29
82194 Gröbenzell
Germany
Tel: +49 (0) 842 410 570
Fax:: +49 (0) 842 284 547
E-Mail: enquiries-de@e2v.com

Americas
e2v inc.
4 Westchester Plaza
Elmsford
NY 10523-1482
USA
Tel: +1 (914) 592 6050
Fax:: +1 (914) 592-5148
E-Mail: enquiries-na@e2v.com

Asia Pacific
e2v ltd
11/F.,
Onfem Tower,
29 Wyndham Street,Central,
Hong Kong

Tel: +852 3679 364 8/9
Fax: +852 3583 1084
E-Mail: enquiries-ap@e2v.com

Product Contact:
e2v
Avenue de Rochepleine
BP 123 - 38521 Saint-Egrève Cedex
France
Tel: +33 (0)4 76 58 30 00
Hotline:
hotline-cam@e2v.com