

IMPERX



Cheetah Python CMOS Cameras User Manual with CoaXPress® (CXP) Interface

The Cheetah C5180, C4181, C4180, C5190, C4191, and C4190 CMOS cameras provide exceptional video image quality with a CoaXPress® (CXP) output interface and GenICam™ compliant programming. The ruggedized cameras use advanced 25-, 16-, or 12-megapixel ON Semiconductor Python sensors, industrial grade components, and superior processing power to produce high-resolution images, a range of frame rates, low noise, and excellent near-infrared sensitivity. The cameras provide exceptional durability and performance in the most demanding applications.

Document Version 1.1

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IMPERX, Inc. is a leading designer and manufacturer of high performance, high quality digital cameras, frame grabbers, and accessories for industrial, commercial, military, and aerospace imaging applications including flat panel inspection, biometrics, aerial mapping, surveillance, traffic management, semiconductors and electronics, scientific & medical Imaging, printing, homeland security, space exploration, and other imaging and machine vision applications.

Fortune 100 companies, federal and state government agencies, domestic and foreign defense agencies, academic institutions, and other customers worldwide use IMPERX products.

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IMPERX warrants performance of its products and related software to the specifications applicable at the time of sale in accordance with IMPERX's standard warranty, which is 2 (two) years parts and labor. FOR GLASSLESS CAMERAS THE CCD OR CMOS IS NOT COVERED BY THE WARRANTY.

Do not open the housing of the camera. Warranty voids if the housing has been open or tampered.

IMPORTANT NOTICE

This camera has been tested and complies with the limits of Class A digital device, pursuant to part 15 of the FCC rules.

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REVISION HISTORY

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1.0	8/27/2019	R.Johnston I. Barabanova	Initial Release
1.1	1/03/2020	I. Barabanova	Removed logos

1 About the Cheetah Camera

1.1 General

The Cheetah Python series of cameras provide an imaging platform with the latest digital technology and industrial grade components. They use CMOS imaging sensors and offer a broad range of resolutions and frame rates. Cheetah cameras are available in both monochrome and color.

The cameras in this manual are compatible with the CoaXPress (CXP) output interface. Use your frame grabber's GeniCam™ compliant software to configure your cameras. The following table describes the C5180, C4181, C4180, C5190, C4191, and C4190 cameras covered in this manual.

Table 1: Cheetah Python cameras with CoaXPress (CXP) interface

Model	Resolution (HxV)	Resolution (MP)	Type	Frame Rate (max)	Optics	ON Semiconductor Sensor Model
2-channel CXP-6 CoaXPress cameras:						
CXP-C5180M	5120 x 5120	25	Mono	44	APS-H	NOIP1SN025KA
CXP-C5180C	5120 x 5120	25	Color	44	APS-H	NOIP1SE025KA
CXP-C5180N	5120 x 5120	25	ENIR	44	APS-H	NOIP1FN025KA
CXP-C4181M	4096 x 4096	16	Mono	68	APS-H	NOIP1SN016KA
CXP-C4181C	4096 x 4096	16	Color	68	APS-H	NOIP1SE016KA
CXP-C4181N	4096 x 4096	16	ENIR	68	APS-H	NOIP1FN016KA
CXP-C4180M	4096 x 3072	12	Mono	90	4/3"	NOIP1SN012KA
CXP-C4180C	4096 x 3072	12	Color	90	4/3"	NOIP1SE012KA
CXP-C4180N	4096 x 3072	12	ENIR	90	4/3"	NOIP1FN012KA
4-channel CXP-6 CoaXPress cameras:						
CXP-C5190M	5120 x 5120	25	Mono	80	APS-H	NOIP1SN025KA
CXP-C5190C	5120 x 5120	25	Color	80	APS-H	NOIP1SE025KA
CXP-C5190N	5120 x 5120	25	ENIR	80	APS-H	NOIP1FN025KA
CXP-C4191M	4096 x 4096	16	Mono	120	APS-H	NOIP1SN016KA
CXP-C4191C	4096 x 4096	16	Color	120	APS-H	NOIP1SE016KA
CXP-C4191N	4096 x 4096	16	ENIR	120	APS-H	NOIP1FN016KA
CXP-C4190M	4096 x 3072	12	Mono	160	4/3"	NOIP1SN012KA
CXP-C4190C	4096 x 3072	12	Color	160	4/3"	NOIP1SE012KA
CXP-C4190N	4096 x 3072	12	ENIR	160	4/3"	NOIP1FN012KA

Note: ENIR = Enhanced Near-Infrared

Cheetah CMOS cameras are advanced, high-resolution progressive scan cameras. They are fully programmable and field upgradeable. Programmable functions include exposure control, frame rate control, area of interest, subsampling, pixel averaging, gain, offset, triggering options, strobes, output control, bad pixel correction, and user-programmable look-up tables (LUT). The cameras use ON Semiconductor area scan Python CMOS image sensors and feature a built-in processing engine, low noise characteristics, and optimized thermal distribution.

The Cheetah C5180, C4181, C4180, C5190, C4191, and C4190 cameras use global shutter operation for exceptionally high frame rates and superior motion capture. The cameras can control exposure time using internal controls or an external pulse width. They support exposure times up to 1 second with 1 μ s increments. An Area of Interest (AOI) can be programmed for each acquisition frame, and subsampling or pixel averaging capabilities are also available. The cameras also support analog gain up to 10 dB (3.17x) and allow further expansion of the low-end signal with 24 dB (16x) of additional digital gain available.

Built-in gamma correction and user-defined look-up table (LUT) capabilities optimize the camera's dynamic range features. You can also apply defective pixel correction (DPC) and hot pixel correction (HPC) to correct for pixels that are over-responding or under-responding. Auto White Balance (AWB) is available in color cameras to correct for color temperature.

The cameras have a 2-channel (C5180, C4181, C4180) or 4-channel (C5190, C4191, C4190) CXP-6 CoaXPress output interface that includes 8-bit and 10-bit data transmission and camera control functionality in one cable. There is also support of active or passive Canon EF lenses.

The camera's ruggedized design and flexibility enable its use in a diverse range of applications including machine vision, metrology high-definition imaging and surveillance, medical and scientific imaging, intelligent transportation systems, aerial imaging, character recognition, document processing and many more.

1.1.1 Key Features

- Global shutter (GS)
- Monochrome or color
- Enhanced near infrared (ENIR) sensitivity version available upon request
- Fast frame rates
- Configurable pixel clock
- Pixel averaging (mono camera only)
- Subsampling
- Area of Interest
- Analog and digital gain controls
- Exposure and gain control: manual and automatic
- Offset control
- Four selectable trigger sources: external, pulse generator, software, trigger over CXP
- Built-in pulse generator
- Two programmable output strobes
- White balance: once, manual, or automatic
- Two 12-bit look-up tables (LUT)
- Defective and hot pixel correction (DPC/HPC), Fixed pattern noise (FPN) correction
- Two programmable external inputs (one opto-isolated) and two external outputs (one opto-isolated)
- Flat Field Correction (FFC), user-defined, and factory
- 2-channel or 4-channel CXP-6 CoaXPress interface
- Support for the Active Canon EOS lens
- Temperature monitor
- Field upgradeable firmware, LUT, DPC, HPC, FFC

1.1.2 Camera Link, GigE, 10GigE, and USB3 interfaces

The C5180, C4181, and C4180 cameras are also available with the following output interfaces:

- Camera Link[®],
- GigE Vision[®],
- 10 GigE Vision[®],
- USB3.

If you are adding a new C5180, C4181, and C4180 with an interface other than CoaXPress to your system, you can start configuring the camera right away as the key features (refer to [1.1.1 Key Features](#) and [1.2 Technical Specifications](#) sections) remain the same for all camera interfaces. Depending on the output interface, the following parameters may be different:

Table 2: Cheetah Python output interfaces

Feature		CoaXPress [®]	Camera Link [®]	GigE Vision [®]	10 GigE Vision [®]	USB3
Frame Rate (max)	C5180	44 / 80 (C5190)	32	4.3	40.6	13
	C4181	68 / 120 (C4191)	50	6.2	60.5	20
	C4180	90 / 160 (C4190)	67	8.3	80.4	27
Active Canon EOS Lens mount		Supported	Not Supported	Supported	Supported	Supported
Trigger Sources		External, Pulse generator, Software, Trigger over CoaXPress (CXP)	External, Pulse generator, Software, Computer	External, Pulse generator, Software	External, Pulse generator, Software	External, Pulse generator, Software
Dimensions (W x H x L, mm)		72.0 x 72.0 x 34.3 / 72.0 x 72.0 x 44.3 (C5190, C4191, C4190)	72.0 x 72.0 x 33.8	72.0 x 72.0 x 33.8	72.0 x 72.0 x 72.3	72.0 x 72.0 x 34.7
Operating temperatures		-40 °C to +70 °C	-40 °C to +85 °C	-40 °C to +85 °C	-40 °C to +75 °C	-40 °C to +85 °C
Weight		379 g	385 g	389 g	579.5 g	370 g
Power		Power over CXP	12 V (10 V to 33 V) or PoCL	12 V (5 V to 33 V)	12 V (5 V to 33 V)	12 V (5 V to 33 V)
¹ NOTE: Cheetah Python cameras with the CoaXPress [®] interface are available in two variations: <ol style="list-style-type: none"> 1) 2-channel CXP-6 CoaXPress[®] cameras (CXP-C5180, CXP-C4181, CXP-C4180) 2) 4-channel CXP-6 CoaXPress[®] cameras (CXP-C5190, CXP-C4191, CXP-C4190) 						

This User Manual provides information on cameras with CoaXPress[®] interface only.

For more information and technical documentation on cameras with other interfaces please visit our web site www.imperx.com.

1.2 Technical Specifications

The following table describes general features and specifications related to all Imperx Cheetah cameras.

Table 3: Cheetah cameras general specifications

Specifications	Cheetah Cameras
Shutter operation	Global only
Exposure time*	~44 μ s min, 1 second max in 1 micro-second steps
Area of Interest	One
Analog gain	Up to 10 dB (1x, 1.26x, 1.87x, 3.17x)
Digital gain	Up to 24 dB
Subsampling	Keep one, skip one
Pixel averaging (mono)	1x2, 2x1, and 2x2
Auto white balance	Yes
Test image	Static, dynamic
Defective pixel correction*	Static, dynamic, user DPM
Hot pixel correction*	Static, dynamic, user HPM
Inputs*	1-LVTTL / 1-Opto-coupled
Outputs*	1-TTL / 1-Opto-coupled
Triggers	Programmable rising/falling and de-bounce
Pulse generator	Yes
In-camera image processing*	2 LUTs
Camera housing	Aluminum
Supply voltage range*	5 V to 33 V DC; 6.5 V to 33 V DC with Canon Lens Control
Upgradeable firmware	Yes
Upgradeable LUT, DPM, FFC	Yes
Environmental – operating *	- 40 °C to + 85 °C
Environmental – storage*	- 50 °C to + 90 °C
Relative humidity	10% to 90% non-condensing

*The specifications may vary for the different Cheetah cameras with ON Semiconductor Python and Sony Pregius sensors.

1.2.1 C5180 and C5190 Cameras

The following table describes features and specifications of the C5180 and C5190 cameras with CoaXPress interface.

Table 4: Cheetah C5180 and C5190 specifications

Specifications	C5180 and C5190 (25 MP)
Active image resolution	5120 x 5120
Active image area (H x V)	23.0 mm x 23.0 mm 32.6 mm diagonal; APS-H optical format
Pixel size	4.5 μm
Video output	Digital, 8/10-bit
Interface	C5180: 2-channel CXP-6 C5190: 4-channel CXP-6
Camera connector	DIN 1.0/2.3 Push/Pull. Over molded miniature RF connector
Maximum frame rate	C5180: 35.6 fps (10-bit); 44 fps (8-bit) C5190: 70 fps (10-bit); 80 fps (8-bit)
Dynamic range	59 dB
Shutter speed	$\sim 50 \mu\text{s}$ to 1 s
Area of Interest	One
Analog gain	0 to 10 dB
Digital gain	0 to 24 dB
Black level offset	-512 to +511, 1/step
User LUT	2 LUTs: gamma and user LUT
Flat Field Correction (FFC)	Factory and User
Hardware trigger	Asynchronous; Fast trigger – exposure & readout overlap
Strobe modes	Programmable width, delay
Trigger sources	External, pulse generator, software, trigger over CXP
Trigger features	Rising/falling edge, de-glitch, delay, strobe
Size (W x H x L)	C5180: (72 x 72 x 34.3) mm C5190: (72 x 72 x 44.3) mm
Weight	379 g
Lens mount	F-Mount, M42, active or passive Canon EOS.
Power consumption	C5180: Typ.: 8.5 W; Max: 9.4 W (with Canon EOS) C5190: Typ.: 10 W; Max: 10.5 W (with Canon EOS)
Environmental – operating	- 40 °C to + 70 °C
Environmental – storage	- 50 °C to + 90 °C

1.2.2 C4181 and C4191 Cameras

The following table describes features and specifications of the C4181 and C4191 cameras with CoaXPress interface.

Table 5: Cheetah C4181 and C4191 specifications

Specifications	C4181 and C4191 (16 MP)
Active image resolution	4096 x 4096
Active image area (H, V)	18.4 mm x 18.4 mm 26.1 mm diagonal; APS-H optical format
Pixel size	4.5 μm
Video output	Digital, 8/10-bit
Interface	C4181: 2-channel CXP-6 C4191: 4-channel CXP-6
Camera connector	DIN 1.0/2.3 Push/Pull. Over molded miniature RF connector
Maximum frame rate	C4181: 54.8 fps (10-bit); 68 fps (8-bit) C4191: 107 fps (10-bit); 120 fps (8-bit)
Dynamic range	59 dB
Shutter speed	$\sim 50 \mu\text{s}$ to 1 s
Area of Interest	One
Analog gain	0 dB to 10 dB
Digital gain	0 dB to 24 dB
Black level offset	-512 to +511, 1/step
User LUT	2 LUTs: gamma and user LUT
Flat Field Correction (FFC)	Factory and User
Hardware trigger	Asynchronous, Fast Trigger – exposure & readout overlap
Strobe modes	Programmable width, delay
Trigger sources	External, pulse generator, software, trigger over CXP
Trigger features	Rising/falling edge, de-glitch, delay, strobe
Size (W x H x L)	C4181: (72 x 72 x 34.3) mm C4191: (72 x 72 x 44.3) mm
Weight	379 g
Lens mount	F-Mount, M42, Active or passive Canon EOS.
Power consumption	C4181: Typ.: 8.5 W; Max: 9.4 W (with Canon EOS) C4191: Typ.: 10 W; Max: 10.5 W (with Canon EOS)
Environmental – operating	- 40 °C to + 70 °C
Environmental – storage	- 50 °C to + 90 °C

1.2.3 C4180 and C4190 Cameras

The following table describes features and specifications of the C4180 and C4190 cameras with CoaXPress interface.

Table 6: Cheetah C4180 and C4190 specifications

Specifications	C4180 and C4190 (12 MP)
Active image resolution	4096 x 3072
Active image area (H, V)	18.4 mm x 13.8 mm 23.0 mm diagonal
Pixel size	4.5 μm
Video output	Digital, 8/10-bit
Interface	C4180: 2-channel CXP-6 C4190: 4-channel CXP-6
Camera connector	DIN 1.0/2.3 Push/Pull. Over molded miniature RF connector
Maximum frame rate	C4180: 72.9 fps (10-bit); 90 fps (8-bit) C4190: 132 fps (10-bit); 160 fps (8-bit)
Dynamic range	59 dB
Shutter speed	$\sim 50 \mu\text{s}$ to 1 s
Area of Interest	One
Analog gain	0 dB to 10 dB
Digital gain	0 dB to 24 dB
Black level offset	-512 to +511, 1/step
User LUT	2 LUTs: gamma and user LUT
Flat Field Correction (FFC)	Factory and User
Hardware trigger	Asynchronous, Fast Trigger – exposure & readout overlap
Strobe modes	Programmable width, delay
Trigger sources	External, pulse generator, software, trigger over CXP
Trigger features	Rising/falling edge, de-glitch, delay, strobe
Size (W x H x L)	C4180: (72 x 72 x 34.3) mm C4190: (72 x 72 x 44.3) mm
Weight	379 g
Lens mount	F-Mount, M42, Active or passive Canon EOS.
Power consumption	C4180: Typ.: 8.5 W; Max: 9.4 W (with Canon EOS) C4190: Typ.: 10 W; Max: 10.5 W (with Canon EOS)
Environmental – operating	- 40 °C to + 70 °C
Environmental – storage	- 50 °C to + 90 °C

1.3 Ordering Information

Table 7: Cheetah CoaXPress Camera Ordering Codes

Sample Codes: CXP-C5180M-RF000: Cheetah Monochrome 25MP camera with F-Mount and 2-channel CXP-6 interface without a filter/customization CXP-C4190C-RL000: Cheetah Color 12MP camera with Canon EF EOS Active Mount and 4-channel CXP-6 interface without a filter/customization					
Interface	Camera model	Sensor Type	Ruggedized	Lens Mount	Filter/Customization options
CXP = 2-channel CXP-6 CoaXPress or 4-channel CXP-6 CoaXPress (selectable)	<u>2-channel CXP-6 models:</u> C5180 – 5120 x 5120 C4180 – 4096 x 3072 C4181 – 4096 x 4096	C = Color M = monochrome N = Enhanced NIR	R = Ruggedized	F = F-Mount (default) M = M42 L = Canon EF EOS Active Mount E = Canon EF EOS Passive Mount	000 = none
					200 = Color w/out IR filters
					400 = Color w/out IR filter replace w/clear cover glass
					700 = Mono w/clear cover glass
	<u>4-channel CXP-6 models:</u> C5190 – 5120 x 5120 C4190 – 4096 x 3072 C4191 – 4096 x 4096				
Note: 000 (none) filter/customization option means that a color camera has IR filter, a monochrome camera does not have any filters.					

For any other custom camera configurations, contact Imperx, Inc. at:

Email: sales@imperx.com
 Tel. (+1) 561-989-0006
 Fax: (+1) 561-989-0045
 Visit our website: www.imperx.com

1.4 Technical Support

Imperx fully tests each camera before shipping. If the camera is not operational after power up, check the following:

1. Check coaxial and all I/O cables. Make sure that all the connectors are firmly attached.
2. Check the status LED and verify that it is steady ON. If it is not, refer to the section [2.3 LED Status Indicators](#).
3. Enable the test mode and verify that the communication between the computer and the camera is established. If the test pattern is not present, power off the camera, check all the cabling, software settings, and computer status.
4. If problems still exist, contact technical support at:

Email: techsupport@imperx.com
 Toll Free 1 (866) 849-1662 or (+1) 561-989-0006
 Fax: (+1) 561-989-0045
 Visit our website: www.imperx.com

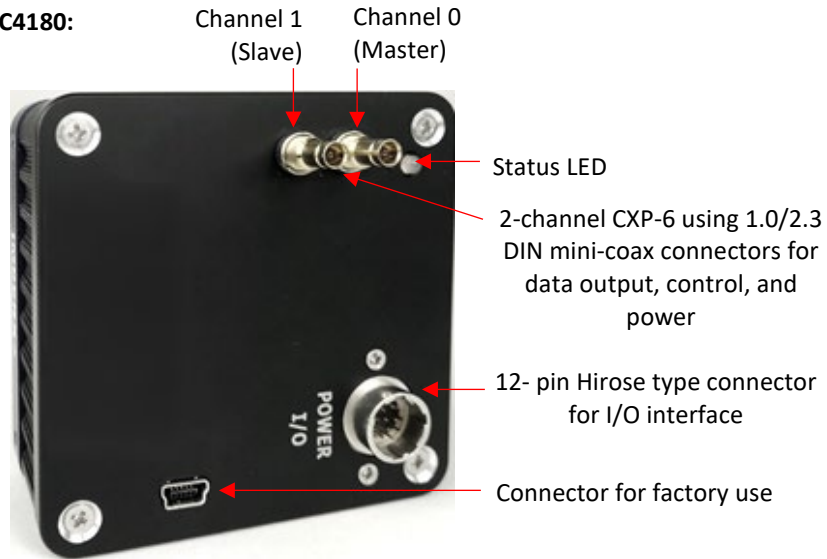
2 Hardware

2.1 Camera Back Panel

The Cheetah Python CXP cameras provide three connectors for outside equipment and one status indicator LED on the back panel. The panel includes:

1. Two 75-ohm, 1.0/2.3 DIN mini-coax receptacles (Amphenol P/N 282121-75) provide 2-channel data output, control data (including Canon lens control), trigger, and power over CXP.
2. Male 12-pin Hirose type miniature locking receptacle #HR10A-10R-12PB(71) provides the general purpose I/O interface.
3. USB type B programming/SPI connector.
4. Status LED indicates the status of the camera.
5. Serial Number shows camera model and serial number.

C5180, C4181, C4180:



C5190, C4191, C4190:



Figure 1: Cheetah Python CXP Camera back panel

2.2 CXP Camera Connectors and Cables

The coaxial cable(s) connected to the camera provides power over CXP (PoCXP). The Camera’s video data output, control data, triggering, and general I/O’s are serialized and continuously transmitted over CoaXPress (CXP-6) using a standard 75-ohm mini-coaxial cable. Imperx offers two types of mini-coax cables: 1) a cable with a 1.0/2.3 DIN mini-coax push/pull plug on one end and a BNC connector on the opposing end; 2) a cable with a 1.0/2.3 DIN mini-coax push/pull plug on both ends. The interface provides a high-speed downlink up to 6.25 Gbps for video transport and a lower speed 20 Mbps uplink for communication and control.

NOTE *

The CXP output interface requires a CoaXPress frame grabber for collecting and storing the camera’s output. The frame grabber installs in the host computer and enables you to view images and configure the camera.

2.2.1 I/O Cable

The optionally purchased PWIO01 cable is used for transmitting external trigger and strobe signals. It terminates in a female HIROSE plug #HR10A-10P-12S(73) on one end and 12 loose wires on the opposing end (see Figure 2).

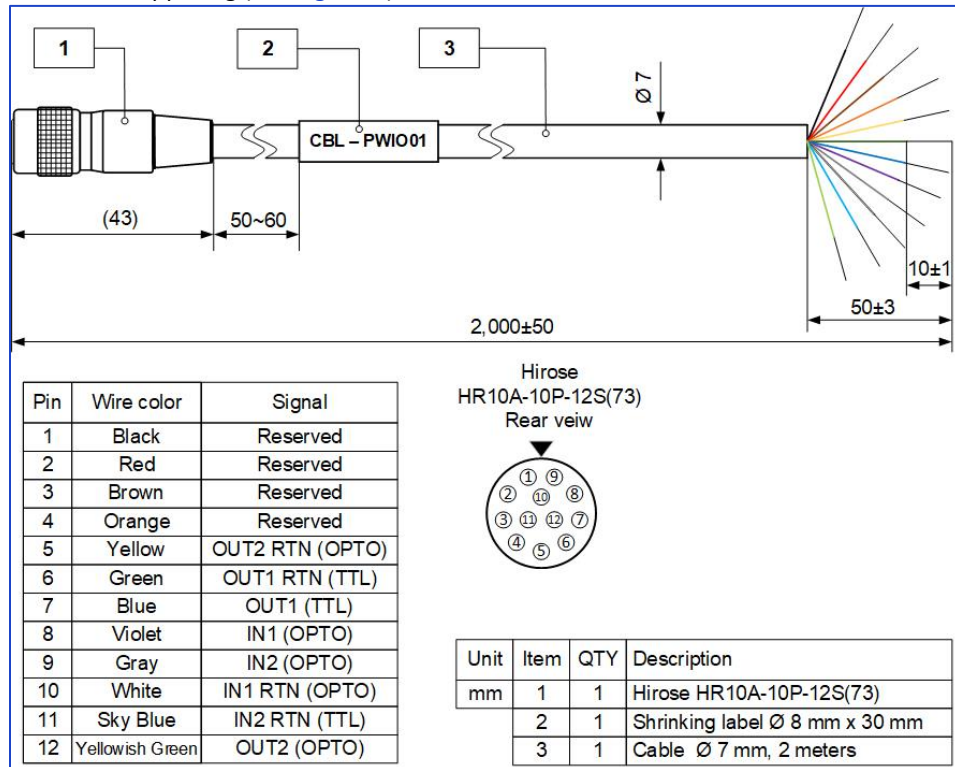


Figure 2: CBL-PWIO01 cable (ordered separately)

2.2.2 Cable for cameras with Canon Lens Control

If using Canon EOS active lens control with the camera, use CBL-IO12-0002 cable to connect lens to the camera. The CBL-IO12-0002 cable is sold separately and used for transmitting power, lens control, trigger input, and strobe output signals. It terminates in a female HIROSE plug #HR10A-10P-12S(73) on one end and on a female Sam Woo and two BNC connectors on opposing end (see [Figure 3](#)).

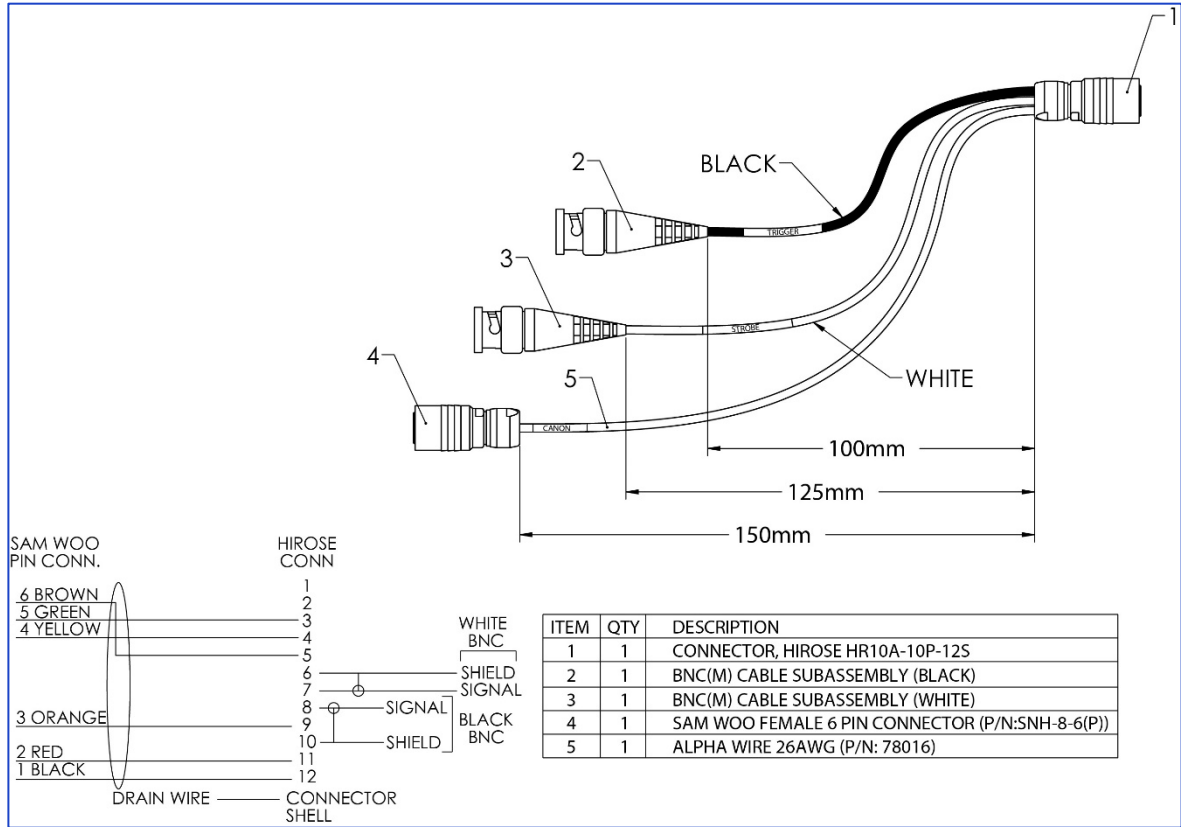


Figure 3: CBL-IO12-0002 cable (ordered separately)

2.2.3 I/O Connector

A 12-pin Hirose type connector on the back of the camera provides all external input/output signals supplied to the camera. The male Hirose connector is a miniature locking receptacle #HR10A-10R-12PB(71).

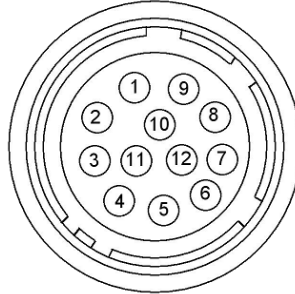


Figure 4: Camera I/O Connector Pin-outs

2.2.4 I/O Connector Pin Assignment

The following table provides the Hirose connector pin mappings:

Table 8: Hirose connector pin assignments

Pin	Signal Name	Use
1	Reserved	Reserved
2	Reserved	Reserved
3	Reserved	Reserved
4	Reserved	Reserved
5	OUT2 RTN	General Purpose Output 2, Contact 1 (Opto-isolated)
6	OUT1 RTN	General Purpose Output 1 Return (TTL)
7	OUT1	General Purpose Output 1 (TTL)
8	IN1	General Purpose Input 1 (Opto-isolated)
9	IN2	General Purpose Input 2 (TTL/LVTTL)
10	IN1 RTN	General Purpose Input 1 Return (Opto-isolated)
11	IN2 RTN	General Purpose Input 2 Return (TTL)
12	OUT2	General Purpose Output 2, Contact 2 (Opto-isolated)

2.2.5 Electrical Connectivity

Cheetah cameras have two external inputs: IN 1 and IN 2. Input IN1 is optically isolated while input IN2 accepts low voltage TTL (LVTTL). Cheetah cameras provide two general-purpose outputs. Output OUT1 is a 5 V TTL compatible signal and output OUT2 is opto-isolated. The following graphics show the external input electrical connections and the external output electrical connections.

A. Input IN 1 – Opto-Isolated

Input signals IN1 and IN1 Rtn are optically isolated, and the voltage difference between the two must be positive between 3.3 V and 24 V. The minimum input current is 3.3 mA.

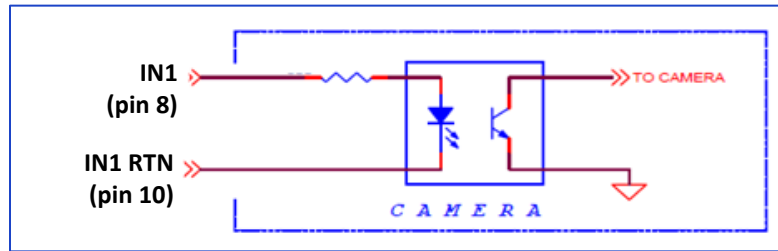


Figure 5: IN1 electrical connection

B. Input IN 2 – LVTTTL

Input signals IN2 and IN2 RTN provide interfaces to a TTL or LVTTTL input signal. The signal level (voltage difference between the inputs IN2 and IN2 RTN) **must be** LVTTTL (3.3 V) or TTL (5.0 V). The total maximum input current **must not** exceed 2.0 mA.

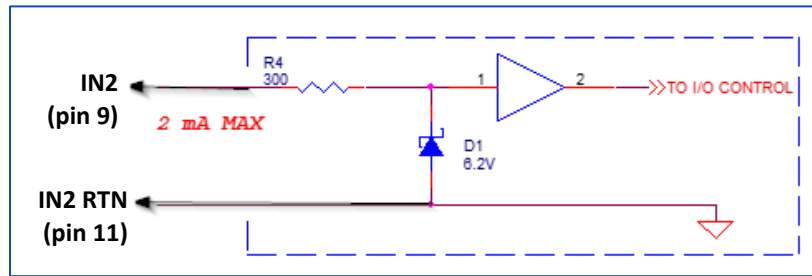


Figure 6: IN2 electrical connection

C. Output OUT 1 – TTL

Output OUT1 is a 5 V TTL compatible signal and the maximum output current **must not** exceed 8 mA.

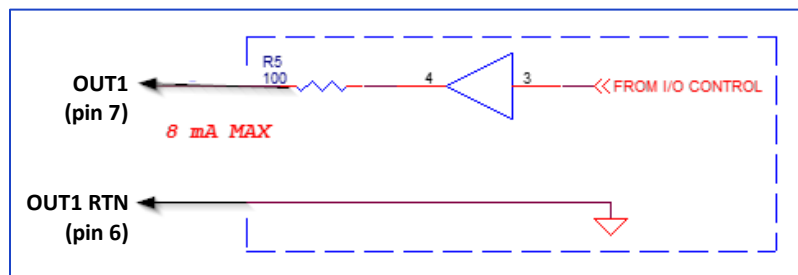


Figure 7: OUT1 LVTTTL electrical connection

D. Output OUT 2 – Solid state relay, optically isolated

Output OUT2 is an optically isolated switch. There is no pull-up voltage on either contact. External pull-up voltage of up to 25 volts is required for operation. Output is not polarity sensitive. AC or DC loads are possible. The voltage across OUT2 Contact 1 and OUT 2 Contact 2 **must not** exceed 25 V and the current through the switch **must not** exceed 50 mA. On resistance is less than 5 Ohms.

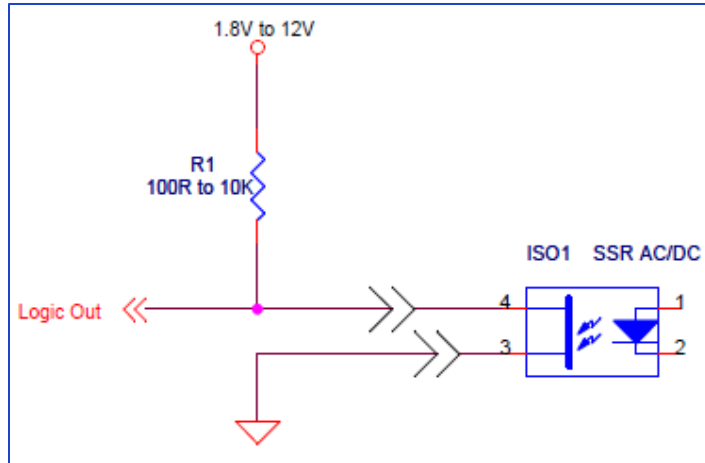


Figure 8: Open drain logic driver

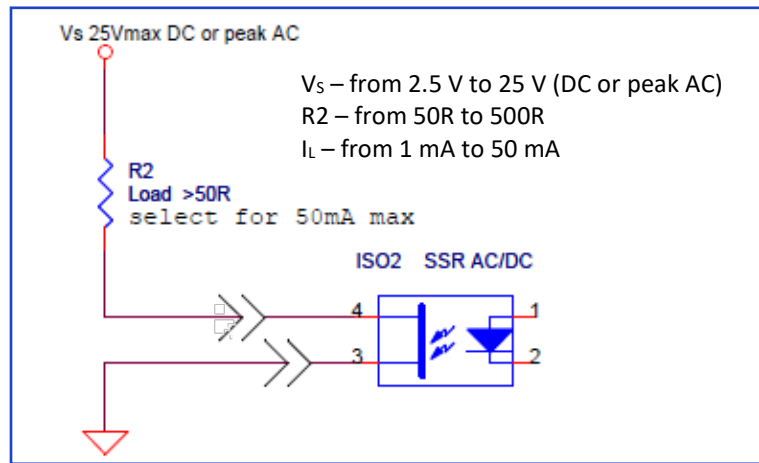


Figure 9: Low side load driver

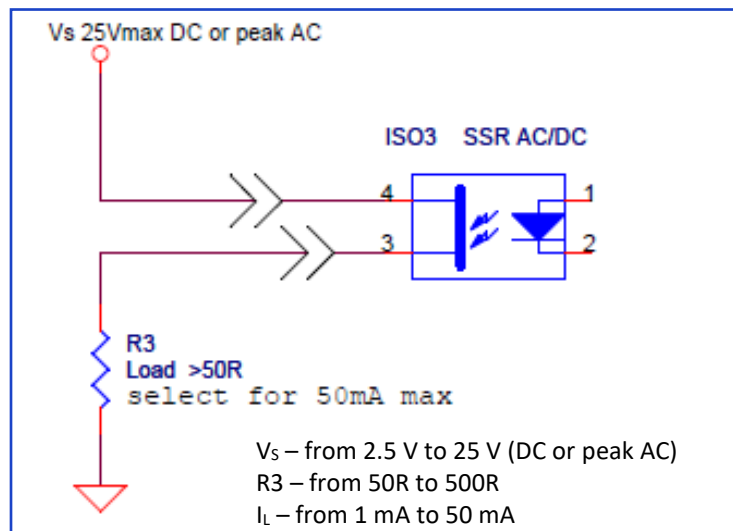





Figure 10: High side load driver

2.3 LED Status Indicators

An LED light on the back panel of the camera indicates camera status and mode of operation.

Table 9: Status LED

	LED Color	Status Description
	Green steady ON	Camera connected, but no data being transferred
	Green/Amber fast flash alternation	Connection detection in progress, PoCXP active (Shown for a minimum of 1 s even if the connection detection is faster)
	LED Off	No power

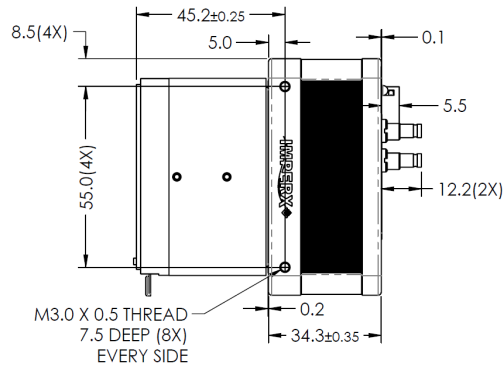
2.4 Mechanical, Optical, Environmental

2.4.1 Mechanical Drawings

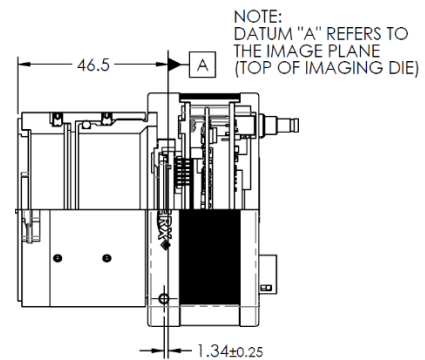
The camera housing consists of high quality series 6000 aluminum. For maximum usability, the camera has eight (8) M3X0.5mm mounting screws located towards the front and the back. Cameras ship with an additional plate with ¼-20 UNC tripod mount and hardware. All dimensions are in millimeters.

2.4.1.1 Mechanical Drawings of C5180, C4181, and C4180

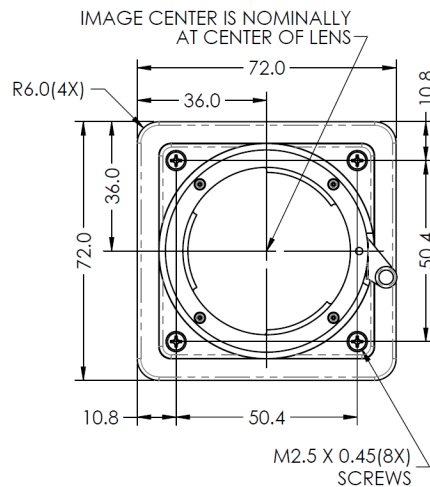
Top View:



Side View with Image Plane:



Front View:



Back View:

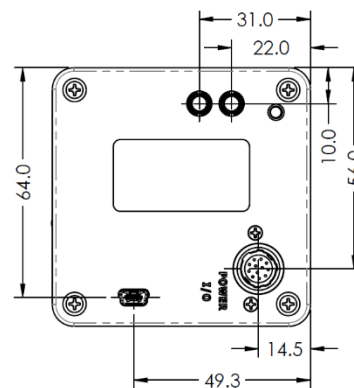
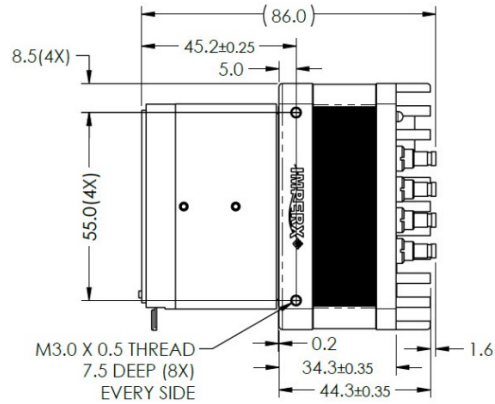


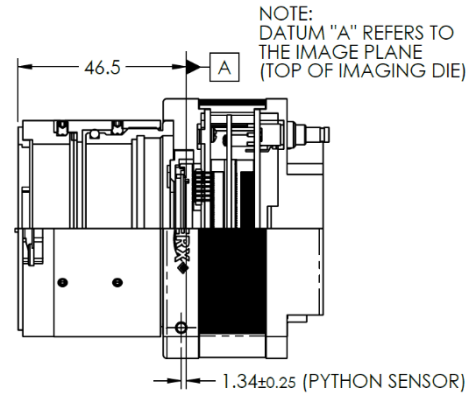
Figure 11: Mechanical drawings of C5180, C4181, C4180 cameras

2.4.2 Mechanical Drawings of C5190, C4191, and C4190

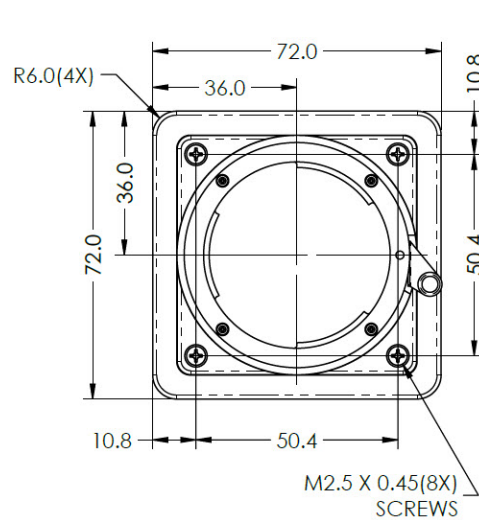
Top view:



Side View with Image Plane:



Front View:



Back View:

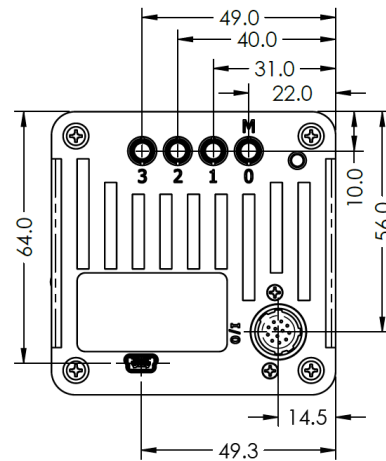


Figure 12: Mechanical drawings of C5190, C4191, C4190 cameras

2.4.3 Optical

The camera's 72 mm x 72 mm cross-section comes with an adapter for F-mount lenses, which have a 46.50 mm back focal distance.

Camera performance and signal-to-noise ratio (SNR) depend on the illumination (amount of light) reaching the sensor and the exposure time. Always try to balance these two factors. Unnecessarily long exposures increase the amount of noise, thus decreasing the SNR.

The cameras are very sensitive in the infrared (IR) spectral region. Color cameras have an IR cut-off filter installed; monochrome cameras come without an IR cut-off filter. The camera includes space under the front lens bezel for inserting an IR filter (1 mm thickness or less) if necessary.

CAUTION

1. Avoid direct exposure to a high intensity light source (such as a laser beam). This may damage the camera optical sensor!
2. Avoid foreign particles on the surface of the imager.

2.4.4 Environmental

The camera operating temperatures range from -40 °C to +70 °C in a dry environment. The relative humidity should not exceed 90% non-condensing. Always keep the camera as cool as possible. Always allow sufficient time for temperature equalization if the camera is stored below 0 °C.

The camera should be stored in a dry environment with the temperature ranging from -50 °C to +90 °C.

CAUTION

1. Avoid direct exposure to moisture and liquids. The camera housing is not hermetically sealed and any exposure to liquids may damage the camera electronics!
2. Avoid operating in an environment without any air circulation or in close proximity to an intensive heat source, strong magnetic fields, or electric fields.
3. Avoid touching or cleaning the front surface of the optical sensor. To clean the sensor, use only a soft lint-free cloth and an optical cleaning fluid.

Do not use methylated alcohol!

3 Configuring the Camera

3.1 Overview

Cheetah cameras are programmable and flexible. You can monitor and control all of the camera's resources, camera settings, internal registers, video amplifiers, parameter flash, and so on. You communicate with the camera from a simple GenICam compliant graphical user interface (GUI). The GUI is bi-directional allowing you to issue commands to the camera and enabling the camera to issue responses (either status or information).

The CXP camera contains an XML parameters file enabling you to configure your camera's features and functions. The frame grabber you use to view the camera's images should also provide a GenICam compliant programming interface for configuring the camera.

3.2 Camera Configuration Memory

3.2.1 Parameter Flash

The camera has a built-in configuration memory divided into four segments: Work Space, Factory Space, User Space #1, and User Space #2. The Work Space segment contains the current camera settings while the camera is powered up and operational. All camera registers are located in this space. You can program these registers and issue commands to retrieve data.

The Work Space is RAM based. All camera registers clear upon camera power-down. The Factory Space segment is ROM based, write protected, and contains the default camera settings. This space is available for read operations only. User Space #1 and User Space #2 are non-volatile, flash-based, and used to store two user-defined configurations or User Sets. Upon power up or software reset, the camera firmware loads the Work Space registers from the Factory Space, User Space #1, or User Space #2 as determined by a User Set Default Selector setting.

At any time, you can instruct the camera to load its Work Space with the contents of the Factory Space, User Space #1, or User Space #2 using the User Set Load command. Similarly, you can instruct the camera to save the current Work Space settings into either User Space #1 or User Space #2 using the User Set Save command.

The non-volatile parameter Flash memory also contains the Dead Pixel Map, Hot Pixel Map, LUT 1, and LUT 2, which can be loaded to the camera internal memory upon enabling the corresponding camera feature. You can create your own DPM, HPM, and LUT tables and upload them to the parameter Flash using the Imperx Upload Utility, which is a separate utility available from the Imperx website www.imperx.com.

3.3 Camera Startup

During camera power-up or receipt of a 'DeviceReset' command, the camera performs the following steps:

1. Boot loader checks program flash memory for a valid firmware image and loads it into the field-programmable gate array (FPGA).
2. The camera reads the "Boot From" register from the parameter Flash and loads a workspace from one of the configuration spaces as determined by the User Set Default Selector. The configuration spaces are: Factory Space, User Space #1, and User Space #2.
3. The camera completes startup and accepts user commands.

3.4 GenApi Camera Configuration

The following XML parameter nodes provide parameter names, descriptions, interface type, range of control values, and the access mode for the parameter (RW: Read/Write, RO: Read Only, WO: Write Only).

NOTE *

In the following tables, parameter names underlined in *red bold italic* letters indicate that you must turn image acquisition **off** in order to change the parameters. You cannot change these parameters if image acquisition is **on**. After making changes, you can turn the camera image acquisition back **on**.

3.4.1 Device Control

Device Control provides read-only information about the camera’s XML file and enables camera reset functionality.

DeviceControl	
DeviceVendorName	Imperx, inc.
DeviceModelName	CXP-C5180C-RF00
DeviceVersion	Version 1.0
DeviceFirmwareVersion	F002003;H005025;X70D0000
DeviceManufactureInfo	www.imperx.com
DeviceSerialNumber	860000
DeviceUserID	User def. name
DeviceScanType	Areascan
DeviceSFNCVersionMajor	2
DeviceSFNCVersionMinor	3
DeviceSFNCVersionSubMinor	0
AssemblyPartNumber	ASSY062800002RA01
SensorSerialNumber	00000000
DateOfManufacturing	08262018
DeviceReset	Execute
CameraHeadReset	Execute
CurrentTemperature	38

Figure 13: Sample Device Control GUI screen

Table 10: Device Control parameters

Parameter Name	Type	Value	Access	Description
DeviceScanType	Enumeration	String	RO	Specifies the scan type of the sensor.
		"Areascan"		
DeviceSFNCVersionMajor	Integer		RO	Major version of Standard Features Naming Convention (SFNC) used to create XML.
DeviceSFNCVersionMinor	Integer		RO	Minor version of SFNC used to create XML.
DeviceSFNCVersionSubMinor	Integer		RO	Subminor version of SFNC used to create XML.
DeviceReset	Command		WO	Resets device to power-up state.
CameraHeadReset	Command		WO	Resets camera circuitry. CXP does not reset. After camera reset, issue a UserSetLoad command.
CurrentTemperature ¹	Integer		RO	Returns current camera temperature.

¹Current Temperature returns a two’s complement number. The range is +127 °C to -127 °C. A value greater than 127 indicates negative temperature. To calculate negative temperature, subtract 255 from the value. For example, a value of 254 indicates a temperature of 254-255 = -1 degree C.

3.4.2 Version Information

Version Information provides read-only information identifying the camera’s firmware, hardware, software, image sensor, camera version, CXP support, and so on. This information is programmed during the manufacturing process and stored in non-volatile memory.

VersionInfo	
SensorType	Bayer
RgsID	24576
FpgaID	8
EpcsID	2
FirmwareImage	10
CameraHeadFirmwareVersion	5
CameraHeadFirmwareBuild	37
CustomerID	0
FamilyID	2
XmlVersion	261

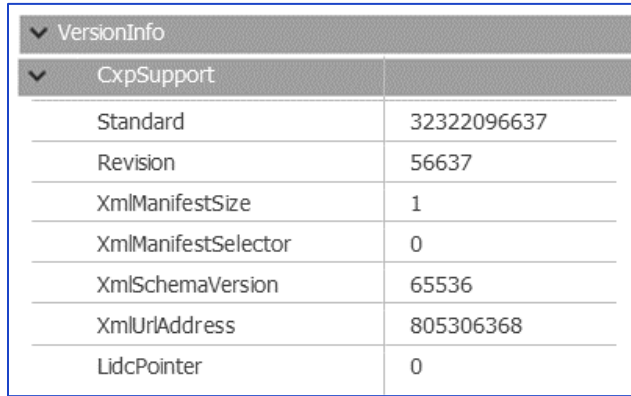
Figure 14: Sample Version Information screen

Table 11: Version Information parameters

Parameter Name	Type	Value	Access	Description
SensorType	Enumeration	String "Monochrome" "Bayer"	Num. 0 1	RO Returns the CMOS sensor type.
RgsID	Integer		RO	Returns the RGS ID register.
FpgaID	Integer		RO	Returns the FPGA ID (8 = 5AGXBA1D).
EpcsID	Integer		RO	This feature returns the EPCS ID (3 = 128MB-EPCQ).
FirmwareImage	Integer		RO	This feature returns the Firmware Image ID (F=Factory or A=Application).
CameraHeadFirmwareVersion	Integer		RO	Returns the CameraHead Firmware version number.
CameraHeadFirmwareBuild	Integer		RO	Returns the CameraHead Firmware build number.
CustomerID	Integer		RO	Returns the Customer ID for custom firmware (0=Imperx standard firmware).
FamilyID	Integer		RO	Returns the Family ID.
XmlVersion	Integer		RO	Returns version number of the XML file.

3.4.2.1 CXP Support

CXP Support includes registers, needed to support other standards, such as GenICam.



▼ VersionInfo	
▼ CxpSupport	
Standard	32322096637
Revision	56637
XmlManifestSize	1
XmlManifestSelector	0
XmlSchemaVersion	65536
XmlUrlAddress	805306368
LidcPointer	0

Figure 15: Sample CXP Support screen

Table 12: Version Information parameters

Parameter Name	Type	Value	Access	Description
Standard	Integer		RO	Returns CoaXPress “magic” number.
Revision	Integer		RO	Returns revision of CoaXPress specification implemented in the camera.
XmlManifestSize	Integer		RO	Returns number of XML manifests available in the camera.
XmlManifestSelector	Integer		RO	Returns number of the selected XML manifest.
XmlSchemaVersion	Integer		RO	Returns GenICam schema version of the XML.
XmlUrlAddress	Integer		RO	Returns address of start of the URL string that points to the XML file.
lidcPointer	Integer		RO	Returns address of the start of the IIDC register space.

3.4.3 Image Format Control

Image Format Control lets you change screen resolution, select camera bit depth, apply averaging and subsampling modes, and more.

ImageFormatControl	
SensorWidth	5120
SensorHeight	5120
WidthMax	5120
HeightMax	5120
Width	5120
Height	5120
OffsetX	0
OffsetY	0
PixelFormat	Mono8
PixelSize	Bpp8
PixelColorFilter	None
AveragingMode	Not Available
SubsamplingMode	Off
PixelClockInfo	195
TestPattern	Off

Figure 16: Sample Image Format screen

Table 13: Image Format parameters

Parameter Name	Type	Value	Access	Description
SensorWidth	Integer		RO	Returns effective width of sensor in pixels.
SensorHeight	Integer		RO	Returns effective height of sensor in pixels.
WidthMax	Integer		RO	Returns max. width of image in pixels calculated after horizontal binning, decimation, or other function.
HeightMax	Integer		RO	Returns max. height of image in pixels calculated after vertical binning, decimation, or other function.
Width	Integer	Min: 256 Max: WidthMaxExpr	RW	Represents actual image output width of master AOI (in pixels).
Height	Integer	Min: 2 Max: HeightMaxExpr	RW	Represents actual image output of master AOI (in lines).

Table 13: Image Format parameters (continued)

Parameter Name	Type	Value	Access	Description
OffsetX	Integer	Min: 0 Max: OffsetX_MaxExpr	RW	Horizontal offset from origin to region of interest (in pixels) (multiple of 8).
OffsetY	Integer	Min: 0 Max: OffsetY_MaxExpr	RW	Vertical offset from origin to region (area) of interest (in pixels) (multiple of 2)
PixelFormat	Enumeration	String "Mono8" "Mono10" "BayerRG8" "BayerRG10"	Num. 0x01080001 0x01100003 0x01080009 0x0110000D	RW Indicates pixel format of the output data.
PixelSize	Enumeration	String "Bpp8" "Bpp10"	Num. 0 1	RO Indicates total size (in bits) of a pixel in an image.
PixelColorFilter	Enumeration	String "None" "BayerRG" "BayerGB" "BayerGR" "BayerBG"	Num. 0 1 2 3 4	RO Indicates type of color filter applied to the image.
AveragingMode	Enumeration	String "Off" "Horizontal" "Vertical" "BothDirections"	Num. 0 1 2 3	RW Uses the average of several adjacent pixels in either horizontal, vertical, or both directions to reduce image resolution. You cannot apply averaging and subsampling simultaneously
SubsamplingMode	Enumeration	String "Off" "Horizontal" "Vertical" "BothDirections"	Num. 0 1 2 3	RW Sets the subsampling decimation with a "skip one, keep one" algorithm in either horizontal, vertical, or both directions.
PixelClockInfo	Integer			RO Indicates current pixel clock frequency in MHz.

Table 13: Image Format parameters (continued)

Parameter Name	Type	Value	Access	Description	
TestPattern ¹	Enumeration	String	Num.	RW	Selects type of test pattern generated by camera as image source.
		"Off"	0		
		"GreyHorizontalRamp"	1		
		"GreyVerticalRamp"	2		
		"GreyHorizontalRampMoving"	3		
		"GreyVerticalRampMoving"	4		
		"Crosshair"	5		

¹**Test Pattern** Values:

- **Off** – Image is coming from the sensor
- **GreyHorizontalRamp** – Image is filled horizontally with an image that goes from the darkest possible value to the brightest.
- **GreyVerticalRamp** – Image is filled vertically with an image that goes from the darkest possible value to the brightest
- **GreyHorizontalRampMoving** – Image is filled horizontally with an image that goes from the darkest possible value to the brightest and that moves horizontally from left to right at each frame.
- **GreyVerticalRampMoving** – Image is filled vertically with an image that goes from the darkest possible value to the brightest and that moves vertically from top to bottom at each frame.
- **Crosshair** – Displays a cross-hair in the absolute center of the image. A live image is superimposed under the cross-hair pattern. Cross-hair has a thickness of two pixels.

3.4.4 Acquisition Control

Acquisition Control lets you configure settings for image capture, exposure, frame rates, triggers, and so on. It also provides a variety of read-only information.

AcquisitionControl	
AcquisitionMode	Continuous
AcquisitionStart	Execute
AcquisitionStop	Execute
ExposureMode	Off
ExposureTime	Not Available
AcquisitionFrameRateEnable	False
AcquisitionFrameTime	1000000
AcquisitionFrameRate	9.999999999
ZeroROTEnable	True
PixelClock	195
PixelClockMax	195
CurrentExposureTime	22619
CurrentFrameTime	22950
MinMaxExposureTime	1375754331
TriggerMode	Off
TriggerSoftware	Execute
TriggerSource	Line1
TriggerActivation	RisingEdge
TriggerDebounce	Disabled
TriggerDelay	0

Figure 17: Sample Acquisition Control screen

Table 14: Acquisition Control parameters

Parameter Name	Type	Value	Access	Description
AcquisitionMode	Enumeration	String "Continuous"	RO	Sets the camera acquisition mode (mainly the number of frames to capture and the way acquisition stops).
AcquisitionStart	Command	Num. 0	WO	Starts image acquisition.
AcquisitionStop	Command		WO	Stops acquisition at end of the current frame.

Table 14: Acquisition Control parameters (continued)

Parameter Name	Type	Value	Access	Description
ExposureMode ¹	Enumeration	String "Off" 0 "TriggerWidth" 1 "Timed" 2	RW	Sets operation mode of exposure. (TriggerMode must be enabled to use TriggerWidth).
ExposureTime ²	Float	Min: ExposureMinExpr Max: ExposureMaxExpr	RW	Sets exposure time in microseconds when ExposureMode is Timed and ExposureAuto is Off .
AcquisitionFrameRateEnable	Boolean		RW	Enables AcquisitionFrameRate and AcquisitionFramePeriod features. If enabled, you can extend the actual frame time beyond the free-running frame time.
AcquisitionFrameTime	Integer	Min: MinFrameTimeReg Max: 1000000	RW	Sets frame time in microseconds. Changes to AcquisitionFrameTime affect the AcquisitionFrameRate setting.
AcquisitionFrameRate	Float	Min: 0.9999999 Max: FrameRateMaxExpr	RO	Controls acquisition rate of frame capture (in Hz). Changes to AcquisitionFrameRate affect the AcquisitionFrameTime setting.
ZeroROTEnable	Boolean		RW	Enables Zero Row Overhead Time (ROT) mode, allowing you extend the actual frame time beyond the free-running frame time. If disabled, the line readout time increases by one microsecond.

Table 14: Acquisition Control parameters (continued)

Parameter Name	Type	Value	Access	Description
PixelClock	Integer	Min: 48 Max: PixelClockMaxReg	RW	Sets pixel clock in MHz.
PixelClockMax	Integer	Min: 32 Max: 511	RO	Sets the imager's line time in units of clocks.
CurrentExposureTime	Integer		RO	Returns current exposure time in microseconds.
CurrentFrameTime	Integer		RO	Returns current frame time in microseconds.
MinMaxExposureTime	Integer	40 μ s min up to 1 frame time in 1 μ s increments	RO	Gets the exposure min and max time in microseconds.
TriggerMode	Enumeration	String "Off" "On"	Num. 0 1	RW Enables the trigger mode of operation. A trigger initiates an exposure then readout sequence – exposure and readout can overlap
TriggerSoftware	Command		WO	Instructs the camera to generate one short trigger pulse to capture and read out one frame. <u>TriggerSource</u> must be set to Software.
TriggerSource ³	Enumeration	String "Line1" "Line2" "CxpTrigger" "PulseGenerator" "Software"	Num. 0 1 2 4 5	RW Specifies internal signal or physical input line to use as the trigger source. Selected trigger must have <u>TriggerMode</u> set to On.
TriggerActivation	Enumeration	String "RisingEdge" "FallingEdge"	Num. 0 1	RW Specifies activation edge of trigger.

Table 14: Acquisition Control parameters (continued)

Parameter Name	Type	Value	Access	Description
TriggerDebounce	Enumeration	String "Disabled" "TenMicroSeconds" "FiftyMicroSeconds" "OneHundredMicroSeconds" "FiveHundredMicroSeconds" "OneMilliSecond" "FiveMilliSeconds" "TenMilliSeconds"	Num. 0 1 2 3 4 5 6 7	RW Specifies debounce period of the trigger signal. Subsequent trigger signals coming to the camera within the de-bounce time period are ignored
TriggerDelay	Integer	Min: 0 Max: 1000000	RW	Specifies delay time in microseconds between the trigger pulse and start of exposure.

¹**ExposureMode** values:

- **Off** – Disables the Exposure and let the shutter open.
- **TriggerWidth** – Uses the width of the current Frame or Line trigger signal(s) pulse to control the exposure duration. Note that if the Frame or Line TriggerActivation is RisingEdge or LevelHigh, the exposure duration will be the time the trigger stays High. If TriggerActivation is FallingEdge or LevelLow, the exposure time will last as long as the trigger stays Low.
- **Timed** – Timed exposure. The exposure duration time is set using the ExposureTime or ExposureAuto features and the exposure starts with the FrameStart or LineStart.

²**ExposureTime** - The maximum exposure time is equal to the frame period. For longer exposure times, increase the frame period using the Acquisition Frame Time feature or the Acquisition Frame Rate feature.

³**TriggerSource** values:

- **Line 1** – Specifies that the Hardware Input Line GP IN 1 (TRIGGER 1) will be used as external source for the trigger signal.
- **Line 2** – Specifies that the Hardware Input Line GP IN 2 (TRIGGER 2) will be used as external source for the trigger signal.
- **CxpTrigger** – Specifies that the trigger source will be generated by CXP framegrabber.
- **PulseGenerator** – Specifies that the trigger source will be generated by camera's internal Pulse Generator.
- **Software** – Specifies that the trigger source will be generated by software using the TriggerSoftware command.

3.4.5 Gain Control

Gain Control provides parameters for setting analog gain, black level raw, and digital gain.

GainControl	
AnalogGain	Gain_1x26
BlackLevelAuto	Continuous
BlackLevel	-511
DigitalGain	1.0
DigitalGainRaw	1024
DigitalOffset	0

Figure 18: Sample Gain Control screen

Table 15: Gain Control parameters

Parameter Name	Type	Value	Access	Description
AnalogGain	Enumeration	String "Gain_1x0" "Gain_1x26" "Gain_1x87" "Gain_3x17"	Num. 0 1 2 3	RW Controls analog gain for all taps. Always apply analog gain before digital gain. You can select from 1.0x (0 dB), 1.26x (2 dB), 1.87x (5.4 dB) and 3.17x (10 dB) gain
BlackLevelAuto	Enumeration	String "Off" "Continuous"	Num. 0 1	RW Controls the mode for automatic black level adjustment. When set to Continuous, this automatically adjusts the black level based on measurements of the dark reference lines at the start of each frame
BlackLevel	Float	Min: -511 Max: 511	RW	Controls the analog black level as an absolute physical value. This represents a DC offset applied to the video signal.
DigitalGain	Float	Min: 1.0 Max: 15.999	RW	Controls digital gain for all taps.
DigitalGainRaw	Integer	Min: 1024 Max: 16383	RW	Controls the raw value of Digital Gain from 1024 (1x) to 16383 (15.9x).
DigitalOffset	Integer	Min: -512 Max: 511	RW	Controls the Digital Offset for all taps.

3.4.6 Auto Gain and Auto Exposure

You can set the camera to automatic exposure control (AEC) to keep the same image brightness during changing light conditions. You can enable both AEC and automatic gain control (AGC) independently or together. Auto gain and auto exposure controls let you control the range of exposure times and gain values used by placing minimum and maximum limits on these parameters. When both AEC and AGC are enabled together, exposure times are varied until the maximum exposure time limit is reached, then gain is applied.

3.4.6.1 AGC and AEC Controls

AutoGainAndAutoExposure	
Control	
GainAuto	Off
AgcGainMin	1.0
AgcGainMinRaw	1024
AgcGainMax	7.9999989061
AgcGainMaxRaw	8192
ExposureAuto	OffContinuous
AecExposureMin	95
AecExposureMax	20000
AgcAecLuminanceLevel	1400
AgcAecLuminanceType	Average
AgcAecSpeed	x4

Figure 19: Sample Auto Gain and Auto Exposure screen

Table 16: Auto Gain and Auto Exposure parameters

Parameter Name	Type	Value	Access	Description
GainAuto	Enumeration	String "Off" "Continuous"	Num. 0 1	RW Enables automatic gain control (AGC) mode.
AgcGainMin	Float	Min: 1.0 Max: AgcGainMaxRegConv	RO	Sets min. digital gain value for the AGC mode.
AgcGainMinRaw	Integer	Min: 1024 Max: AgcGainMaxReg	RW	Sets min. digital gain value for AGC mode in RAW units.
AgcGainMax	Float	Min: AgcGainMinRegConv Max: 15.999	RO	Sets maximum Digital Gain value for the AGC mode.
AgcGainMaxRaw	Integer	Min: AgcGainMinReg Max: 16383	RW	Sets max. digital gain value for AGC mode in RAW units.
ExposureAuto	Enumeration	String "Off" "Continuous"	Num. 0 1	RW Enables automatic exposure control (AEC) mode.

Table 16: Auto Gain and Auto Exposure parameters (continued)

Parameter Name	Type	Value	Access	Description
AecExposureMin	Integer	Min: IntExposureMinExpr Max: AecExposureMaxReg	RW	Sets min. exposure time value for AEC in microseconds.
AecExposureMax	Integer	Min: AecExposureMinReg Max: IntExposureMaxExpr	RW	Sets max. exposure time value for AEC in microseconds.
AgcAecLuminanceLevel	Integer	Min: 1 Max: 4095	RW	Sets the desired luminance level to be maintained during AGC or AEC.
AgcAecLuminanceType	Enumeration	String "Average" "Peak"	Num. 0 1	RW Sets the luminance mode to be used during AGC or AEC.
AgcAecSpeed	Enumeration	String "x1" "x2" "x3" "x4"	Num. 0 1 2 3	RW Controls the exposure and gain correction speed during AGC or AEC where x1=slowest and x4=fastest. The AGC and AEC processes can set the algorithm convergence speed, i.e. how long it takes to reach the desired exposure or gain

3.4.6.2 Status

Status	
AgcGainCurrentValue	1.0
AgcGainCurrentValueRaw	1024
AgcMinLimitReached	0
AgcMaxLimitReached	0
AecExposureCurrentValue	12251
AecMinLimitReached	0
AecMaxLimitReached	0
CurrentAvgOrPeakLuminance	1128
AgcAecStatus	73925632

Figure 20: Sample Status screen

Table 17: Status parameters

Parameter Name	Type	Value	Access	Description
AgcGainCurrentValue	Float	Min: 1.0 Max:15.999	RO	Displays the current value of Digital Gain, calculated by the camera in AGC mode.
AgcGainCurrentValueRaw	Integer		RO	Displays the current Digital Gain value for the AGC mode in RAW units.
AgcMinLimitReached	Integer		Ro	Returns whether or not the minimum digital gain limit was reached during AGC operation.
AgcMaxLimitReached	Integer		RO	Returns whether or not the maximum digital gain limit was reached during AGC operation.
AecExposureCurrentValue	Integer		RO	Displays the current value of Exposure in microseconds, calculated by the camera in AGC mode.
AecMinLimitReached	Integer		RO	Returns whether or not the minimum exposure limit was reached during AEC operation.
AecMaxLimitReached	Integer		RO	Returns whether or not the maximum exposure limit was reached during AEC operation.
CurrentAvgOrPeakLuminance	Integer		RO	Returns the current average or peak luminance depending on the AgcAecLuminanceType mode.
AgcAecStatus	Integer		RO	Displays the value of AgcAecStatus register.

3.4.7 Data Correction

Data Correction parameters enable you to implement tables and other techniques to improve image sensor performance.

DataCorrection	
LUTSelector	LUT1
LUTEnable	False
FFCSelector	FFC1
FFCEnable	False
FixedPatternNoiseCorrection	On
DefectPixelCorrection	Off
DeectPixelThreshold	1500
HotPixelCorrection	Off
HotPixelThreshold	1500

Figure 21: Sample Data Correction screen

Table 18: Data Correction parameters

Parameter Name	Type	Value	Access	Description
LUTSelector	Enumeration	String "LUT1" "LUT2"	Num. 0 1	RW Selects which LUT is to be controlled when enabled.
LUTEnable	Boolean			RW Activates the selected LUT.
FFCSelector	Enumeration	String "FFC1" "FFC2"	Num. 0 1	RW Selects which FFC is to use when FFC is enabled.
FFCEnable	Boolean			RW Activates the selected FFC.
FixedPatternNoiseCorrection	Enumeration	String "Off" "On"	Num. 0 1	RW Enables column Fixed Pattern Noise Correction.
DefectPixelCorrection	Enumeration	String "Off" "Static" "Dynamic" "Both"	Num. 0 1 2 3	RW Enables Defective Pixel Correction. ("Dynamic" and "Both" modes available only in C5180, C4181, C4180)
DefectPixelThreshold ¹	Integer	Min: 0 Max: 4095		RW Sets threshold for dynamic Defect Pixel Correction algorithm. (Available only in C5180, C4181, C4180)

Table 18: Data Correction parameters (continued)

Parameter Name	Type	Value	Access	Description
HotPixelCorrection	Enumeration	String Num. "Off" 0 "Static" 1 "Dynamic" 2 "Both" 3	RW	Enables Hot Pixel Correction. ("Dynamic" and "Both" modes available only in C5180, C4181, C4180)
HotPixelThreshold ²	Integer	Min: 0 Max: 4095	RW	Sets threshold for Hot Pixel Correction algorithm. (Available only in C5180, C4181, C4180)

¹**DefectPixelThreshold** – Sets the threshold value for dynamic defective pixel correction. The sensitivity increases as the value decreases. Defective Pixel Threshold should be set with the image data output level at about 75% of maximum.

²**HotPixelThreshold** – Sets the threshold value for dynamic hot pixel correction. The sensitivity of the correction increases as the value decreases. You should set the hot pixel threshold using the longest expected exposure time with the longest expected frame time at the maximum expected ambient temperature. The camera should be warmed up for 10 minutes prior to determining the desired threshold.

3.4.7.1 FFC Sequencer

This feature is available only for the 4-channel CXP-6 cameras (C5190, C4191, and C4190) and is enabled by default. FFC Sequencer is required to apply appropriate FFC table (refer to the section [4.15 Flat Field and Noise Correction](#)).

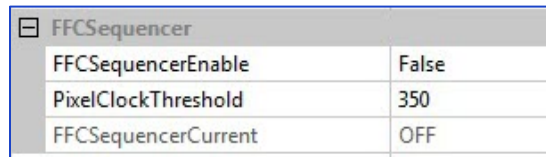


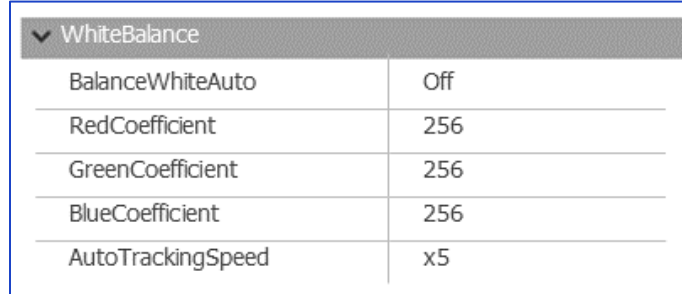
Figure 22: Sample FFC Sequencer screen

Table 19: FFC Sequencer parameters

Parameter Name	Type	Value	Access	Description
FFCSequencerEnable	Boolean		RW	Enables the FFC Sequencer. It applies appropriate FFC table for given PixelClockThreshold
PixelClockThreshold	Integer	Min: 48 Max: 360	RW	Defines the Threshold of Pixel Clock, used by FFC Sequencer to switch the current FFC table
FFCSequencerCurrent	Enumeration	String Num. "OFF" 0 "FFC1" 1 "FFC2" 2	RW	Displays the current FFC table applied by FFC Sequencer

3.4.8 White Balance

White Balance parameters give you control over the individual red, green, and blue colors produced by the sensor in color cameras.



WhiteBalance	
BalanceWhiteAuto	Off
RedCoefficient	256
GreenCoefficient	256
BlueCoefficient	256
AutoTrackingSpeed	x5

Figure 23: Sample White Balance screen

Table 20: White Balance parameters

Parameter Name	Type	Value	Access	Description
BalanceWhiteAuto ¹	Enumeration	String "Off" 0 "Once" 1 "Continuous" 2 "Manual" 3	RW	Controls the mode for automatic white balancing between the color channels. The white balancing ratios are automatically adjusted.
RedCoefficient	Integer	Min: 0 Max: 4095	RW	Sets white balance coefficient for red channel when <u>WhiteBalanceAuto</u> is set to Manual.
GreenCoefficient	Integer	Min: 0 Max: 4095	RW	Sets white balance coefficient for green channel when <u>WhiteBalanceAuto</u> is set to Manual.
BlueCoefficient	Integer	Min: 0 Max: 4095	RW	Sets adjusted white balance coefficient for blue channel when <u>WhiteBalanceAuto</u> is set to Manual.
AutoTrackingSpeed	Enumeration	String Num. "x1" 0 "x2" 1 "x3" 2 "x4" 3 "x5" 4	RW	Controls the speed of the auto white balance loop when <u>BalanceWhiteAuto</u> = Continuous, where x1 is slowest and x5 is fastest.

¹BalanceWhiteAuto values:

- **Off** – No white balance is performed.
- **Once** – The camera analyzes one image frame, calculates one set of correction coefficients, and corrects all subsequent frames using this set of coefficients.
- **Continuous** – The camera analyzes every frame, derives a set of correction coefficients for each frame, and applies them to the next frame.
- **Manual** – The camera uses the correction coefficients as entered from the user. The range is from 0 to 4095 (0 is equal to 0.0x, 256 is equal to 1.0x, 4095 is equal 15.995x gain).

3.4.9 Strobe

Use strobe XML parameters to configure strobe settings, performance, and outputs.

▼ Strobe	
Strobe1Mode	On
Strobe1Reference	ExposureStart
Strobe1Width	1000
Strobe1Delay	0
Strobe2Mode	On
Strobe2Reference	ExposureStart
Strobe2Width	1000
Strobe2Delay	0
▼ Out1	
OUT1Polarity	ActiveHigh
OUT1Selector	PulseGenerator
▼ Out2	
OUT2Polarity	ActiveHigh
OUT2Selector	PulseGenerator

Figure 24: Sample Strobe screen

Table 21: Strobe parameters

Parameter Name	Type	Value	Access	Description
Strobe1Mode	Enumeration	String "Off" "On"	Num. 0 1	RW Sets Strobe 1 mode of operation.
Strobe1Reference	Enumeration	String "ExposureStart" "ReadoutStart"	Num. 0 1	RW Sets reference point for Strobe 1.
Strobe1Width	Integer	Min: 1 Max: 1000000	RW	Sets Strobe 1 pulse duration in microseconds.
Strobe1Delay	Integer	Min: 0 Max: 1000000	RW	Sets delay from the reference for Strobe 1 in microseconds.
Strobe2Mode	Enumeration	String "Off" "On"	Num. 0 1	RW Sets the Strobe #2 mode of operation.
Strobe2Reference	Enumeration	String "ExposureStart" "ReadoutStart"	Num. 0 1	RW Sets reference point for Strobe 2.

Table 21: Strobe parameters (continued)

Parameter Name	Type	Value	Access	Description
Strobe2Width	Integer	Min: 0 Max: 1000000	RW	Sets Strobe 2 pulse duration in microseconds.
Strobe2Delay	Integer	Min: 0 Max: 1000000	RW	Sets Strobe 2 delay in microseconds.

3.4.9.1 OUT1

Table 22: OUT1 parameters

Parameter Name	Type	Value	Access	Description
OUT1Polarity	Enumeration	String "ActiveLow" "ActiveHigh"	Num. 0 1	RW Sets active logic level of OUT1 output.
OUT1Selector ¹	Enumeration	String "None" "Trigger" "PulseGenerator" "Strobe1" "Strobe2"	Num. 0 1 2 3 4	RW Maps various internal signals to OUT1 output.

3.4.9.2 OUT2

Table 23: OUT2 parameters

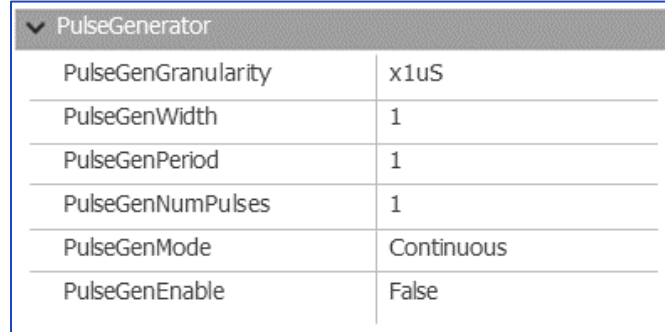
Parameter Name	Type	Value	Access	Description
OUT2Polarity	Enumeration	String "ActiveLow" "ActiveHigh"	Num. 0 1	RW Sets active logic level of OUT2 output.
OUT2Selector ¹	Enumeration	String "None" "Trigger" "PulseGenerator" "Strobe1" "Strobe2"	Num. 0 1 2 3 4	RW Maps various internal signals to OUT2 output.

¹OUT1 and OUT2 Selector values:

- **Trigger** – Maps the input trigger pulse to the output with no delay (as is).
- **PulseGenerator** – Maps the internal pulse generator waveform to the output
- **Strobe1** – Maps the Strobe 1 signal to the corresponding external output.
- **Strobe2** – Maps the Strobe 2 signal to the corresponding external output.

3.4.10 Pulse Generator

The camera provides an internal pulse generator for generating a trigger signal. You can program it to generate a discrete sequence or a continuous trail of pulse signals.



PulseGenerator	
PulseGenGranularity	x1uS
PulseGenWidth	1
PulseGenPeriod	1
PulseGenNumPulses	1
PulseGenMode	Continuous
PulseGenEnable	False

Figure 25: Sample Pulse Generator screen

Table 24: Pulse Generator parameters

Parameter Name	Type	Value	Access	Description
PulseGenGranularity	Enumeration	String Num. "x1uS" 0 "x10uS" 1 "x100uS" 2 "x1000uS" 3	RW	Sets the multiplication factors of the Pulse Generator where x1 = 1 μ S; x10 = 10 μ S; and so on.
PulseGenWidth	Integer	Min: PulseGenMin Max: PulseGenWidthMax	RW	Sets pulse width of Pulse Generator in microseconds.
PulseGenPeriod	Integer	Min: PulseGenMin Max: PulseGenPeriodMax	RW	Sets the pulse period of the Pulse Generator in microseconds
PulseGenNumPulses	Integer	Min: 1 Max: 65535	RW	Sets the number of pulses to be generated by the Pulse Generator when <u>NumPulses</u> mode is selected.
PulseGenMode	Enumeration	String Num. "Continuous" 0 "NumPulses" 1	RW	Sets mode of Pulse Generator.
PulseGenEnable	Boolean		RW	Enables Pulse Generator. Pulse generator output can map to OUT1 or OUT2 output signals.

3.4.11 Canon Lens Control

If using Canon lens control, the following parameters provide options for controlling the lens or checking its status.

▼ CanonLensControl	
GetLensStatus	Execute
LensStatus	0x0

Figure 26: Sample Canon Lens Control screen

Table 25: Canon Lens Control parameters

Parameter Name	Type	Value	Access	Description
GetLensStatus	Command		WO	Requests value of Lens Status register.
LensStatus	Integer		RO	Returns status of Lens after GetLensStatus runs.

3.4.11.1 Controller Settings

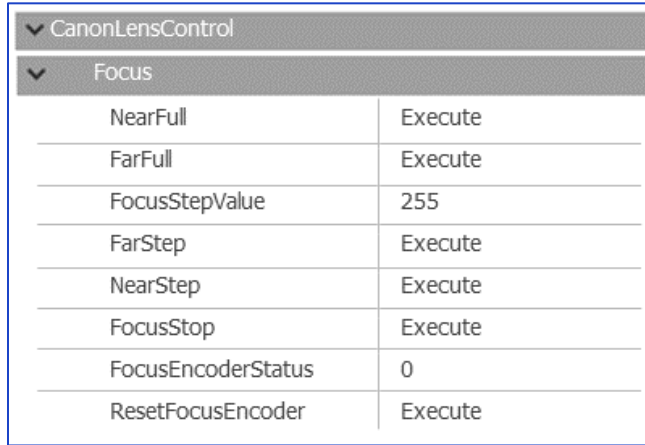
▼ CanonLensControl	
▼ ControllerSettings	
InitLens	Execute
IrisRangeCheck	On
LensPresenceCheck	On
LensClockPolarity	Negative

Figure 27: Sample Controller Settings screen

Table 26: Controller Settings parameters

Parameter Name	Type	Value	Access	Description
InitLens	Command		WO	Initializes Canon Lens. Always initialize lens after power-up.
LensControllerStatus	Enumeration	String "InitLens_Failed" "InitLens_Done"	Num. 0 8 RO	Shows status of Canon Lens initialization.
IrisRangeCheck	Enumeration	String "Off" "On"	Num. 0 1 RW	Enables internal checkout of Iris Position and Step.
LensPresenceCheck	Enumeration	String "Off" "On"	Num. 0 1 RW	Enables or disables check of lens presence.
LensClockPolarity	Enumeration	String "Negative" "Positive"	Num. 0 1 RW	Sets polarity of Lens Clock.

3.4.11.2 Focus



Focus	
NearFull	Execute
FarFull	Execute
FocusStepValue	255
FarStep	Execute
NearStep	Execute
FocusStop	Execute
FocusEncoderStatus	0
ResetFocusEncoder	Execute

Figure 28: Sample Focus screen

Table 27: Focus parameters

Parameter Name	Type	Value	Access	Description
NearFull	Command		WO	Drives focus to fully Near position.
FarFull	Command		WO	Drives focus to fully Far position.
FocusStepValue	Integer	Min: 1 Max: 255	RW	Sets focus step to be moved with NearStep and FarStep commands.
FarStep	Command		WO	Drives focus one step toward Far position by amount defined in FocusStepValue feature.
NearStep	Command		WO	Drives focus one step toward Near position by the amount defined in FocusStepValue feature.
FocusStop	Command		WO	Stops focus movement immediately.
FocusEncoderStatus	Integer		RO	Returns current focus encoder value after GetFocusEncoderStatus command issued.
ResetFocusEncoder	Command		WO	Resets Focus encoder.

3.4.11.3 Iris

▼ CanonLensControl	
▼ Iris	
CurrentIrisPosition	0.0
CloseIrisFull	Execute
OpenIrisFull	Execute
CloseIrisStep	Execute
OpenIrisStep	Execute
StopIris	Execute
IrisStepValue	127
GetIrisRange	Execute
IrisMin2	255
IrisMin1	255
IrisMax	255
IrisRange	255

Figure 29: Sample Iris screen

Table 28: Iris parameters

Parameter Name	Type	Value	Access	Description	
CurrentIrisPosition	Enumeration	String	Enum.	RO	Returns current iris position.
		"F0_7"	0		
		"F0_8"	1		
		"F0_9"	2		
		"F1_0"	3		
		"F1_1"	4		
		"F1_2"	5		
		"F1_4"	6		
		"F1_6"	7		
		"F1_8"	8		
		"F2_0"	9		
		"F2_2"	10		
		"F2_5"	11		
		"F2_8"	12		
		"F3_2"	13		
		"F3_6"	14		
		"F4_0"	15		
		"F4_5"	16		
"F5_0"	17				

Table 28: Iris parameters (continued)

Parameter Name	Type	Value	Access	Description
		"F5_6"	18	
		"F6_3"	19	
		"F7_1"	20	
		"F8_0"	21	
		"F9_0"	22	
		"F10_0"	23	
		"F11_0"	24	
		"F13_0"	25	
		"F14_0"	26	
		"F16_0"	27	
		"F18_0"	28	
		"F20_0"	29	
		"F22_0"	30	
		"Unknown"	255	
CloseIrisFull	Command		WO	Closes iris to fully closed position.
CloseIrisFull	Command		WO	Closes iris to fully closed position.
OpenIrisFull	Command		WO	Opens iris to the fully opened position.
CloseIrisStep	Command		WO	Closes iris by the amount defined in the IrisStepValue feature
OpenIrisStep	Command		WO	Opens iris by the amount defined in the IrisStepValue feature.
StopIris	Command		WO	Stops iris movement immediately.
IrisStepValue	Integer	Min: 1 Max: 127	RW	Sets iris step to move with OpenStep and CloseStep commands.
GetIrisRange	Command		WO	Sends "Get Iris Range" command to the camera
IrisMin2	Integer		RO	Returns the minimum2 iris limit.
IrisMin1	Integer		RO	Returns the minimum1 iris limit.
IrisMax	Integer		RO	Returns the maximum iris limit.
IrisRange	Integer		RO	Displays limit values of iris after the GetIrisRange command is issued.

3.4.12 Transport Layer Control

The Transport Layer control provides a variety of configuration settings and read-only information for configuring communications between the camera with the CoaXPress interface.



Figure 30: Sample Transport Layer Control screen

Table 29: Transport Layer parameters

Parameter Name	Type	Value	Access	Description	
DeviceTapGeometry	Enumeration	String "Geometry_1X_1Y"	Num. 0	RO	Describes the geometrical properties characterizing the taps of a camera as presented at the output of the device

3.4.12.1 CoaXPress

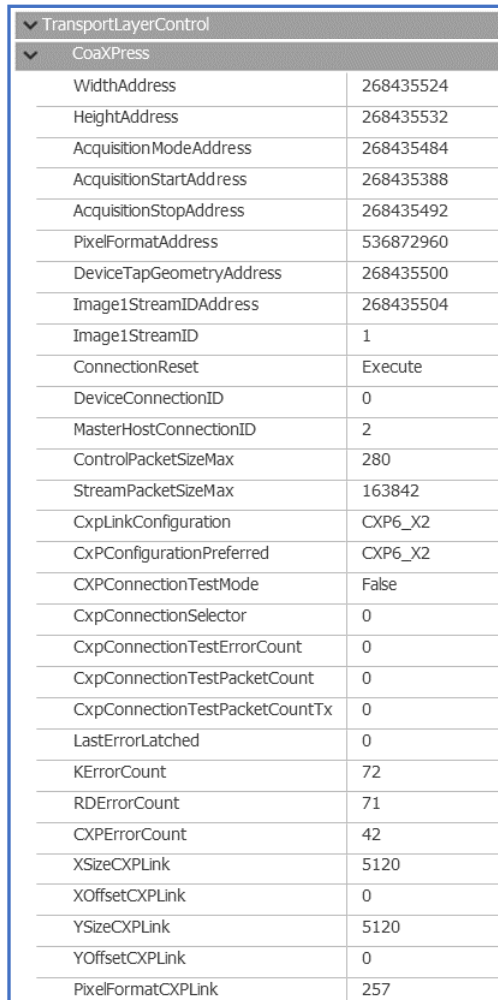


Figure 31: Sample CoaXPress screen

Table 30: CoaXPress parameters

Parameter Name	Type	Value	Access	Description
WidthAddress	Integer		RO	Returns address of the width information register.
HeightAddress	Integer		RO	Returns the address of the Height information register.
AcquisitionModeAddress	Integer		RO	Returns the address of the AcquisitionMode information register.
AcquistionStartAddress	Integer		RO	Returns the address of the AcquistionStart command register.
AcquistionStopAddress	Integer		RO	Returns the address of the AcquistionStop command register.
PixelFormatAddress	Integer		RO	Returns the address of the PixelFormat information register.
DeviceTapGeometryAddress	Integer		RO	Returns the address of the DeviceTapGeometry information register.
Image1StreamIDAddress	Integer		RO	Returns the address Image1StreamIDAddress
Image1StreamID	Integer		RO	Returns the STREAM ID for the primary image stream from the device.
ConnectionReset	Command		RW	Activates the Link Reset procedure.
DeviceConnectionID	Integer		RO	Returns the ID of the device link.
MasterHostConnectionID	Integer		RO	Returns the host link ID connected to this device's master link.
ControlPacketSizeMax	Integer		RO	Returns the maximum control packet data size that the device can accept.
StreamPacketSizeMax	Integer		RW	Returns the maximum stream packet data size that the host can accept.

Table 30: CoaXPress parameters (continued)

Parameter Name	Type	Value	Access	Description	
CxpLinkConfiguration	Enumeration	String	Num.	RW	Allows specifying the Link configuration for communication between Receiver and Transmitter Device. In most cases, this feature does not need to be written because automatic discovery will set the configuration correctly to the value returned by CxpLinkConfigurationPreferred. The currently active configuration of the Link can be read using CxpLinkConfigurationStatus.
		"CXP1_X1"	0x00010028		
		"CXP2_X1"	0x00010030		
		"CXP3_X1"	0x00010038		
		"CXP5_X1"	0x00010040		
		"CXP6_X1"	0x00010048		
		"CXP1_X2"	0x00020028		
		"CXP2_X2"	0x00020030		
		"CXP3_X2"	0x00020038		
CxpLinkConfigurationPreferred	Enumeration	String	Num.	RO	Provides the Link configuration that allows the Transmitter Device to operate in its default mode.
		"CXP1_X1"	0x00010028		
		"CXP2_X1"	0x00010030		
		"CXP3_X1"	0x00010038		
		"CXP5_X1"	0x00010040		
		"CXP6_X1"	0x00010048		
		"CXP1_X2"	0x00020028		
		"CXP2_X2"	0x00020030		
		"CXP3_X2"	0x00020038		
CxpConnectionTestMode	Boolean			RW	Enables the test mode for an individual physical connection of the Device.
CxpConnectionSelector	Integer	Min: 0 Max: CxpMaxConnectionsExpr		RW	Selects the CoaXPress physical connection to control.
CxpConnectionTestErrorCount	Integer			RW	Reports the current connection error count for test packets received by the device on the connection selected by CxpConnectionSelector.
CxpConnectionTestPacketCount	Integer			RW	Reports current count for test packets received by the device on the connection selected by CxpConnectionSelector.

Table 30: CoaXPress parameters (continued)

Parameter Name	Type	Value	Access	Description
CxpConnectionTestPacketCountTx	Integer		RW	Reports current count for test packets sent by the device on the connection selected by CxpConnectionSelector.
LastErrorLatched	Integer		RO	Returns the low-speed link's last CXP error that occurred.
KErrorCount	Integer		RW	Returns the low-speed link's current 8B10B K-Code error count. Writing a 0x0 clears the error counter.
RDErrorCount	Integer		RW	Returns the low-speed link's current 8B10B Running-Disparity error count. Writing a 0x0 clears the error counter.
CXPErrorCount	Integer		RW	Returns the low-speed link's current CXP protocol error count. Writing a 0x0 clears the error counter.
XSizeCXPLink	Integer		RO	Returns the horizontal image size in the CXP link.
XOffsetCXPLink	Integer		RO	Returns the horizontal image offset in the CXP link.
YSizeCXPLink	Integer		RO	Returns the vertical image size in the CXP link.
YOffsetCXPLink	Integer		RO	Returns the vertical image offset in the CXP link.
PixelFormatCXPLink	Integer		RO	Returns the pixel format in the CXP link.

3.4.12.2 CoaXPress Customization

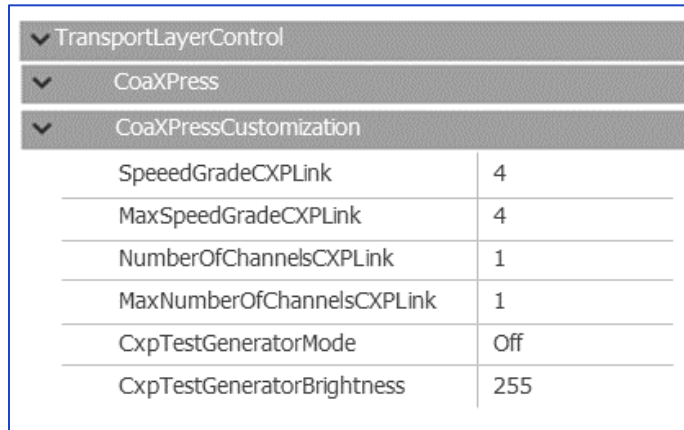


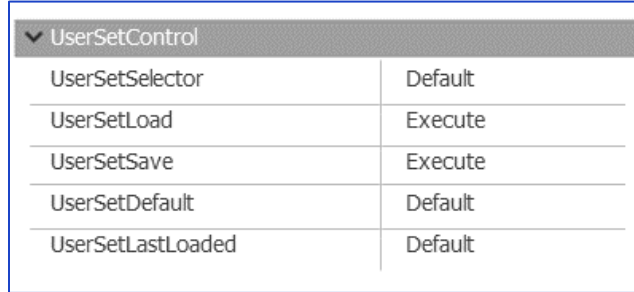
Figure 32: CoaXPress Customization screen

Table 31: CoaXPress Customization parameters

Parameter Name	Type	Value	Access	Description
SpeedGradeCXPLink	Integer	Min: 2 Max: MaxSpeedGradeCXPLinkReg	RW	Sets the speed grade of the CXP link. 2 - CXP3, 3 - CXP5, 4 - CXP6. Changes take effect after a power cycle or after running the DeviceReset command.
MaxSpeedGradeCXPLink	Integer		RO	Returns the Maximum speed grade of the CXP link.
NumberOfChannelsCXPLink	Integer	Min: 0 Max: MaxNumberOfChannelsCXPLinkReg	RW	Sets the number of channels of the CXP link. 0 - X1, 1 - X2. Changes take effect after a power cycle or after running the DeviceReset command.
MaxNumberOfChannelsCXPLink	Integer		RO	Returns the Maximum number of channels of the CXP link.
CxpTestGeneratorMode	Enumeration	String Num. "Off" 0 "Mode_0" 1 "Mode_1" 2 "Mode_2" 3	RW	Represents the operation mode of CXP engine test image generator.
CxpTestGeneratorBrightness	Integer	Min: 0 Max: 4095	RW	Represents the brightness of CXP engine test image generator.

3.4.13 User Set Control

User Set Control allows you to save custom settings and reload them into the camera as needed.



UserSetControl	
UserSetSelector	Default
UserSetLoad	Execute
UserSetSave	Execute
UserSetDefault	Default
UserSetLastLoaded	Default

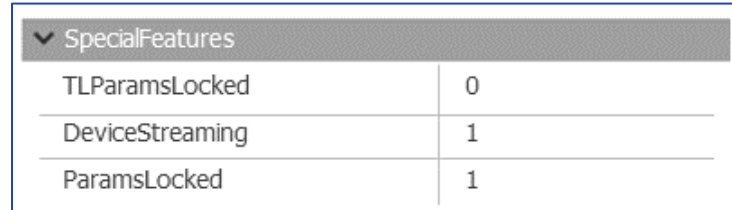
Figure 33: Sample User Set Control screen

Table 32: User Set Control parameters

Parameter Name	Type	Value	Access	Description
UserSetSelector	Enumeration	String "Default" 0 "UserSet0" 1 "UserSet1" 2	Num. RW	Enables selection of User Set to load, save, or configure.
UserSetLoad	Command		WO	Loads User Set specified by UserSetSelector to camera and makes it active.
UserSetSave	Command		WO	Saves User Set specified by UserSetSelector to non-volatile memory.
UserSetDefault	Enumeration	String "Default" 0 "UserSet0" 1 "UserSet1" 2	Num. RW	Selects User Set to load and activate when camera is reset.
UserSetLastLoaded	Enumeration	String "Default" 0 "UserSet0" 1 "UserSet1" 2 "UserSet2" 3 "UserSet3" 4	Num. RO	Reports the currently loaded User Set (from the last UserSetLoad command or device reset).

3.4.14 Special Features

The Special Features parameters provide status information on the camera and on GenICam transport layer streaming.



SpecialFeatures	
TLParamsLocked	0
DeviceStreaming	1
ParamsLocked	1

Figure 34: Sample Special Features screen

Table 33: Special Features parameters

Parameter Name	Type	Value	Access	Description
DeviceStreaming	Integer		RO	Returns the state of the Camera streaming interface: 1 when grabbing, 0 when not.
ParamsLocked	Integer		RO	Returns the state of the GenTL or Camera streaming interface: 1 when grabbing, 0 when not.

4 Camera Features

4.1 Exposure Control

4.1.1 Internal Exposure Control - Electronic Shutter

In global shutter mode, all pixels in the array reset at the same time, then collect signal during the exposure time, then transfer the image to a non-photosensitive region within each pixel. After transferring the image to the non-photosensitive region, the readout of the array begins. In this way, all pixels capture the image during the same period, which reduces any image artifacts due to motion within the scene. The maximum exposure is frame-time dependent, and the minimum exposure is about 40 microseconds.

The camera normally overlaps the exposure and read-out times as shown in below.

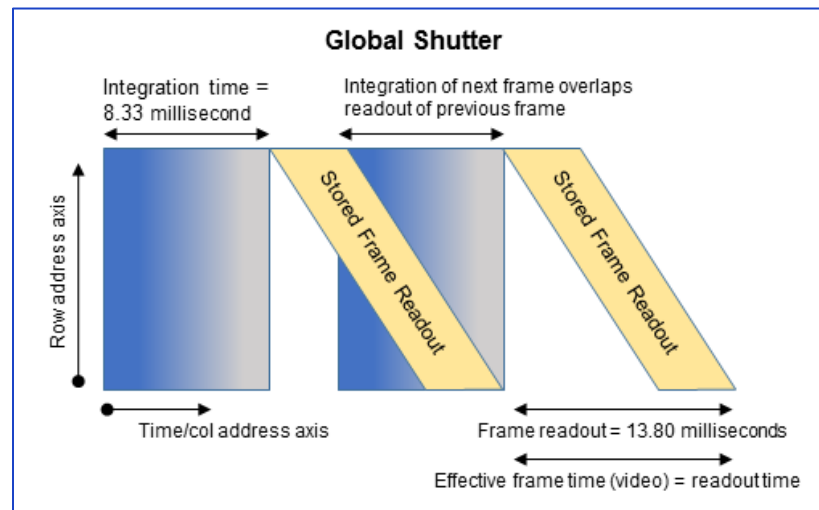


Figure 35: Global Shutter with 8.33 ms exposure time.

4.1.2 External Exposure Control

The camera can use an external pulse to control exposure. The pulse duration determines the exposure. In global shutter mode, the minimum exposure time is about 40 microseconds. Refer to section [4.5 Camera Triggering](#) and [4.10 Input / Output Control](#).

4.2 Frame Time Control

4.2.1 Internal Line and Frame Time Control

The camera speed (frame rate) depends on the CMOS read-out time (frame time). Frame time is the time it takes to read out all of the pixels on the CMOS imager. The following formula (1.1) calculates the frame rate:

$$\text{Frame rate [fps]} = 1 / \text{read-out time [sec]} \quad (1.1)$$

4.2.1.1 Pixel Clock Rate Control

The camera read-out speed exceeds the CoaXPress (CXP) interface output rate. You can use the Pixel Clock Rate function to program the camera's speed to match the CXP image capture rate. Decreasing the pixel clock rate decreases a camera output rate.

You should never use Pixel Clock to control camera frame rate; for best image quality, you should always set the Pixel Clock to the maximum rate possible without the CXP interface missing or skipping data. This minimizes the dark current generated within the pixel and the dark current noise.

Changing Pixel Clock for the C5190, C4191, and C4190 cameras is not recommended.

4.2.1.2 Programmable Frame Time Control

After adjusting the Pixel Clock Rate to minimize the line read-out time, you can increase the frame time using the programmable Frame Time function. When enabled, the sensor reads out the frame, then idles and inserts a vertical blanking period at the end of the frame readout to provide the desired frame rate.

In this way, you can match the camera's frame rate to application requirements. You can reduce the frame time to about one second with a precision of one microsecond. Using Frame Time control, you can achieve exposure times longer than the time needed to read out the image sensor.

4.2.2 Zero Row-Overhead Time (ROT) Control

A Row-Overhead time (ROT) control is provided and the control is called: "Zero-Row Overhead Time" (Zero-ROT). Disabling Zero-ROT adds one microsecond of blanking time at the end of each row to further reduce the line rate. Zero-ROT should only be used as a last resort and only when decreasing Pixel Clock line rate control to the minimum value still results in frame grabber overruns. Zero-ROT must always be disabled and is not supported when pixel averaging is used.

TIP

If the exposure time is greater than 50 ms, keep camera vibration to a minimum to keep a motion induced smear from appearing on the image.

4.2.3 Camera Output Control

The table below describes CXP full frame rates.

Table 34: CXP Typical maximum frame rates verses bit depth

Camera	Bit Depth	Frame Rates at Full Resolution	Camera	Bit Depth	Frame Rates at Full Resolution
C5180	8	44.0 fps	C5190	8	80.0 fps
	10	35.6 fps		10	70.0 fps
C4181	8	68.0 fps	C4191	8	120.0 fps
	10	54.89 fps		10	107.0 fps
C4180	8	90.0 fps	C4190	8	160.0 fps
	10	72.9 fps		10	132.0 fps

NOTE *

Frame rates depend on camera configurations and several factors external to the camera, such as the host computer performance (host controller card speed, PCIe interface bandwidth, motherboard, etc.), cable length, and cable type ([4.3.3 Factors Impacting Frame Rate](#)).

4.3 Area of Interest

4.3.1 Overview

For some applications, you might not need the entire image, but only a portion of it. To accommodate this requirement, Cheetah cameras provide one Area of Interest (AOI), also known as a region of interest. An AOI is a unique field of view created within the camera's maximum field of view. This limitation is based on the structure of the camera's sensor. When creating an AOI, you will specify its horizontal and vertical dimensions and location (using horizontal and vertical offsets).

4.3.2 Creating an AOI Window

Set the starting and ending point for each AOI independently in the horizontal direction (Horizontal Window) and the vertical direction (Vertical Window) by setting the window (H & V) offset and (H & V) size, as shown in the following figure. The minimum window size is 320 (H) x 2 (V) pixel/line and the horizontal dimension is limited to multiples of 8 pixels. In normal operation, the AOI defines the number of columns and rows output. However, you can apply subsampling and averaging modes to the AOI to reduce the number of rows and columns output even further. Using the AOI function and subsampling/averaging modes effectively increases the camera frame rate. The maximum horizontal window size (H) and the vertical window size (V) are determined by the camera's image full resolution, for example, 5120 x 5120 if using the C5180 camera.

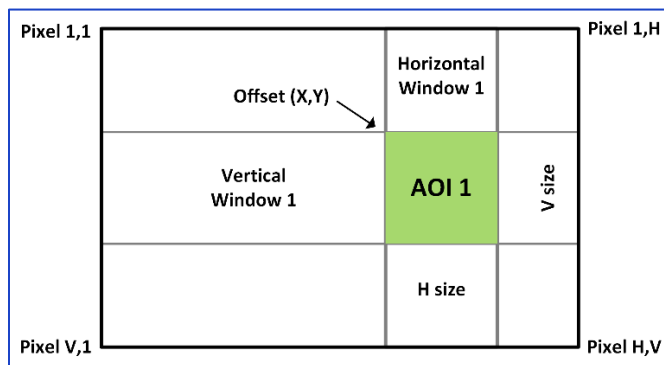


Figure 36: Horizontal and vertical window positioning

NOTE *

For color version use with AOI enabled, use an even number for Offset X and Offset Y to achieve proper color reconstruction and white balance.

4.3.3 Factors Impacting Frame Rate

The camera frame rate depends upon a number of variables including the exposure time, number of rows and columns in the AOI, the amount of decimation within the image, and the bandwidth of the output interface.

AOI size – Camera frame rate increases by decreasing either the number of columns or number of rows to read out. Decreasing the number of rows to read out causes the largest increase in frame rate.

Exposure Time – In free-running mode, the camera overlaps the exposure time and image readout. In trigger mode, the exposure and readout time do not overlap, and long exposure times will decrease frame rate.

Decimation – The camera supports both subsampling and pixel averaging to reduce the output resolution. Subsampling and pixel averaging increase the sensor frame rate. However, subsampling decimation offers the largest frame rate improvement by reducing the number of rows and columns read out from the image sensor. Subsampling and pixel averaging decimation provide about a 2x to 3x increase in frame rate.

Output Interface Bandwidth – The bandwidth of the output interface can impact the maximum achievable frame rate.

4.3.3.1 AOI Frame Rate Examples

The following table provides examples of frame rate from various AOI's using the CXP output with a Cheetah C5180 camera. The camera will calculate and display actual frame rates from any horizontal and vertical window you choose to implement. The hardware and speed of your output interface might impact your results.

Table 35: Frame Rates for various AOIs

C5180 Resolution	Max. CXP Frame Rates
Full Resolution	44 fps
3840 x 2160	137
1920 x 1080	466
1280 x 720	687

4.4 Subsampling

4.4.1 Pixel Averaging

The principal objective of pixel averaging is to reduce the image resolution with better final image quality than using a subsampling function. Pixel averaging reduces the output resolution by averaging several pixels together and has the advantage of reducing aliasing and noise, which increases the signal-to-noise ratio (SNR). Subsampling — as opposed to averaging — has the advantage of increasing the output frame rate by reducing the number of rows read out, but also introduces aliasing in the final image. Subsampling, however, increases the output frame rate more than pixel averaging.

You cannot apply both averaging and subsampling decimation simultaneously. The camera does not support Zero ROT when averaging is enabled. Color cameras do not support pixel averaging.

The following graphic illustrates the concept of 4:1 averaging for a monochrome image sensor. The values of pixels P1, P2, P3 and P4 are summed together and the result is divided by 4 to achieve an average of the 4 adjacent pixels.

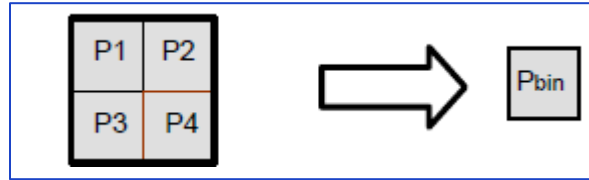


Figure 37: Monochrome pixel averaging

The averaging feature is usable on the full resolution image or within any area of interest. For example, if the area of interest is defined as quad full HD (3840 x 2160) and 4:1 averaging is selected, the output is 1080P (1920 x 1080).

4.4.2 Subsampling Decimation

Subsampling reduces the number of pixels output by reducing the output frame size while maintaining the full field of view. Selecting an Area of Interest (AOI) maintains the AOI field of view.

The cameras employ a “keep one pixel, skip one pixel” sequence. When enabled in both x and y coordinates, every other pixel within a line is retained and every other line within the image is retained.

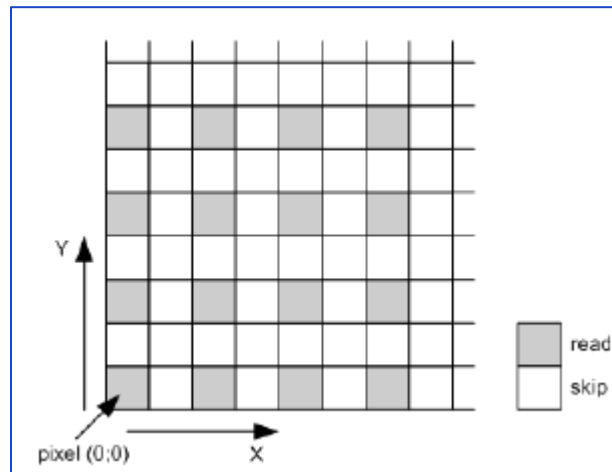


Figure 38: Monochrome subsampling.

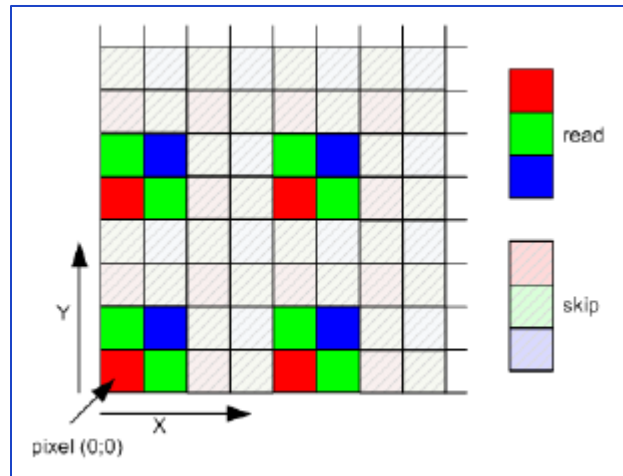


Figure 39: Color subsampling

4.5 Camera Triggering

4.5.1 Triggering Inputs

In the normal mode of operation, the camera is free running, which means the camera continually reads out the sensor. If using a trigger to initiate readout, trigger mode enables synchronizing the camera to a timing pulse.

The camera offers four input modes for external triggering: external, internal (pulse generator), software, and CXP trigger. You must map the trigger input to a corresponding camera input.

- **External** – the camera receives the trigger signal coming from the Hirose connector on the back of the camera.
- **Internal** – the camera has a built-in programmable pulse generator (refer to [4.9 Pulse Generator](#) section). In Internal triggering mode, the camera receives the trigger signal from the internal pulse generator.
- **Software** – the camera expects a computer to send a command to the camera for generating one short trigger pulse. You can trigger the camera by clicking the GUI Software Trigger button or by sending the GenICam™ Trigger Software command. The trigger exposure is internal register controlled. Pulse duration exposure is not supported
- **CXP Trigger** – the camera receives the trigger signal coming from a CXP frame grabber through the DIN connector on the back of the camera.

4.5.2 Acquisition and Exposure Control

For each trigger input, set the trigger edge and de-bounce (de-glitch) time.

- **Triggering Edge** – select one of the following to activate triggering edge:
 - **Rising** – uses the rising edge for triggering.
 - **Falling** – uses the falling edge for triggering.
- **De-bounce** – de-bouncing trigger inputs prevents multiple triggering from ringing triggering pulses. De-bounce provides eight choices of de-bounce intervals:
 - **Off** – no de-bounce (default)

- **10 μs, 50 μs, 100 μs, or 500 μs** de-bounce interval.
- **1.0 ms, 5.0 ms, 10.0 ms** de-bounce interval.
- **Exposure Time** – the exposure for all frames can be set in two ways:
 - **Pulse Width** – the trigger pulse width (duration) determines the exposure subject to limitations.
 - **Internal** – the camera internal exposure register determines the exposure.

CAUTION

1. The de-bounce interval MUST be smaller than the trigger pulse duration. Adjust the interval accordingly.
2. When Triggering Pulse Width is enabled, Internal Exposure timing is not active.

4.5.3 Triggering Modes

Exposure Control

With trigger mode enabled, you can set the exposure time using either the internal exposure timer or the trigger pulse width.

In trigger mode, the camera idles and waits for a trigger signal. Upon receiving the trigger signal, the camera starts integration for the frame, then completes the integration, and reads out the image. If the next trigger occurs prior to completion of the readout, the camera will overlap the exposure and readout (Figure 40 and Figure 41). You can set the exposure time manually using either the internal exposure register setting or the duration of the trigger pulse. Upon completing the readout, the camera idles while awaiting the next trigger pulse.

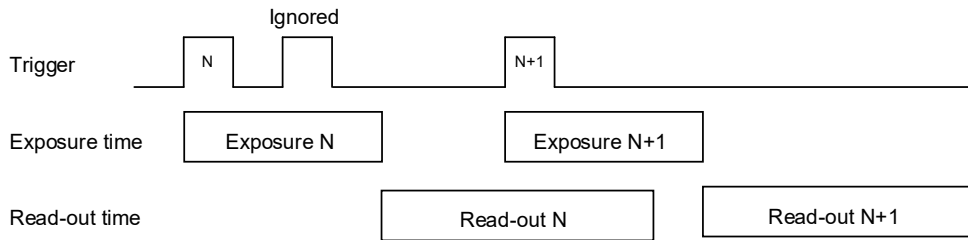


Figure 40: “Fast” Trigger Mode (Internal Exposure Control)

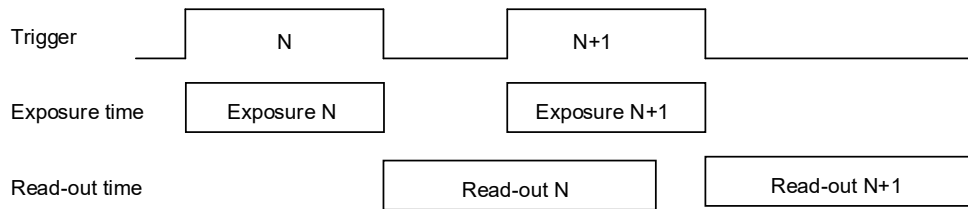


Figure 41: “Fast” Trigger Mode (Pulse Width Exposure Control)

CAUTION

When using the internal exposure timer, if the next trigger activates prior to the completion of the previous exposure, the camera ignores it.

4.6 Strobes

The camera can provide up to two strobe pulses for synchronization with an external light source, additional cameras, or other peripheral devices. You can set each strobe's pulse delay and duration with respect to the start of the exposure period or the start of the readout period. You can set the maximum pulse duration and the maximum delay up to 1 second with 1.0 μ s of precision. You can assign the strobe pulse to either of the external outputs. The following graphic shows strobe signals positioned with respect to the start of exposure.

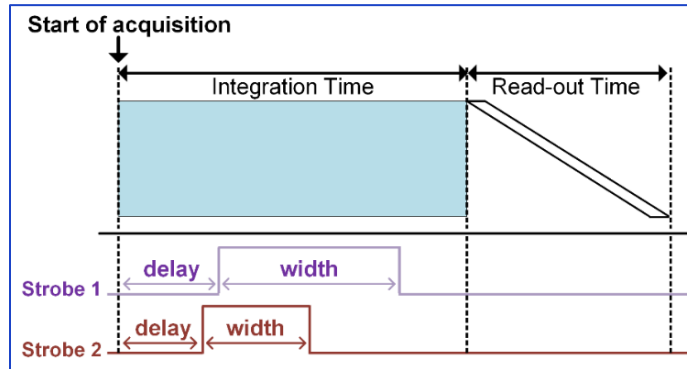


Figure 42: Strobe positioning with respect to exposure start

4.7 Video Amplifier Gain and Offset

4.7.1 Analog Gain

The cameras provide 1x (0 dB), 1.26x (2.0 dB), 1.87x (5.43 dB), and 3.17 (10.0 dB) analog gain. Always apply analog gain before applying digital gain.

4.7.2 Digital Gain

Digital gain can be varied from 1x (0 dB) to 15.9x (24 dB) with a precision of ~ 0.00097 x using the raw (fine) gain control. There are 15,360 gain steps from 1x gain to 15.9x gain. Each step increases the gain by 0.000969932x or 1/1031 from 1024 (1.0x gain) to 16384 (15.9x gain). Digital Gain does not provide any improved contrast and should be used cautiously.

To determine the gain step when the gain value is known, use the following steps:

1. Subtract 1.0 from the desired gain multiplier (e.g. 2.54x gain).
2. Multiply the result by 1031.
3. Add 1024.

Or use this formula:

$$\text{Gain coefficient} = [(\text{Desired gain} - 1) * 1031] + 1024.$$

If the desired gain is in dB, use the following formula:

$$\text{Gain coefficient} = [([\text{anti-log}_{10}(\text{Desired gain (dB)}/20)] - 1) * 1031] + 1024.$$

EXAMPLES:

- 1) Desired gain is 7.9x (17.95 dB): $[(7.9 - 1.0) * 1031] + 1024 = 8137$.
Set coefficient to 8137.
- 2) Desired gain is 6 dB, then the code is 2050.
Minimum setting is 1024 corresponding to 1x gain.

Below are other examples:

Gain (dB)	Multiplier	Coefficient
0 dB	1x	1024
3 dB	1.41254x	1449
6 dB	1.99526x	2050
12 dB	3.98107x	4097

4.7.3 Digital Offset

Digital offset is a digital count added or subtracted from each pixel. The range is +/- 512 counts.

4.7.4 Black Level Auto-calibration and Offset

The camera automatically adjusts black level based on measurements of the dark reference lines at the start of each frame. Imperx recommends leaving the black level auto-calibration engaged. If auto-calibration is disabled, you can set the Black Level Offset and adjust it by +/- 511 counts. Black level will vary with temperature and gain settings.

4.8 Data Output Format

4.8.1 Pixel Format

The image sensor digitization level is fixed at 10-bits, which enables 8-bit or 10-bit data format output. With 8-bit output, the camera uses the standard bit reduction process and truncates the least significant bits.

10-bit digitization

- If the camera is set to output 10-bit data, sensor data bits map directly to D0 (LSB) to D9 (MSB).
- If the camera is set to output 8-bit data, sensor most significant data bits (D2 to D9) map to D0 (LSB) to D7 (MSB).

Camera Output – 10 bits									
MSB					LSB				
D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
P9	P8	P7	P6	P5	P4	P3	P2	P1	P0

Camera Output – 8 bits									
MSB				LSB					
D7	D6	D5	D4	D3	D2	D1	D0	-	-
P9	P8	P7	P6	P5	P4	P3	P2	P1	P0

Figure 43: 10-bit internal Digitization with 10-bit and 8-bit outputs

4.9 Pulse Generator

The camera has a built-in pulse generator that you can program to generate a discrete sequence of pulses or a continuous sequence (Figure 44). You can use the pulse generator as a trigger signal or map it to one of the outputs (refer to 4.10.1 Input / Output Mapping). Set the discrete number of pulses from 1 to 65535 with a step of 1.

You can also set the following options:

- **Granularity** – Indicates the number of clock cycles used for each increment of the width and the period. Four possible options are available: x1, x10, x100, and x 1000.
- **Width** – Specifies the amount of time (determined by the granularity) the pulse remains at a high level before falling to a low level. Minimum value is 1, maximum is 524,287.
- **Period** – Indicates the amount of time (also determined by the granularity) between consecutive pulses. Minimum value is 1; maximum is 1,048,575.

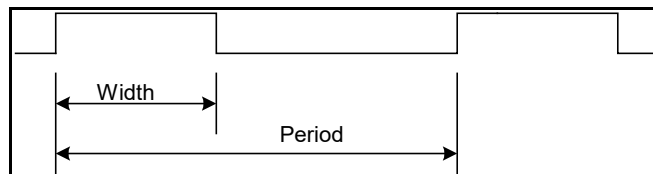


Figure 44: Internal pulse generator

4.10 Input / Output Control

4.10.1 Input / Output Mapping

The camera has two external inputs (1 TTL input and 1 opto-coupled input) and two external outputs (1 TTL output and 1 opto-coupled switch) wired to the 12-pin HIROSE connector on the back of the camera. In addition to these inputs and outputs, a CoaXPress input (Trigger over CXP, Master channel) is also available. You can map CoaXPress input (Trigger over CXP) or either external input to the Trigger input. You can map camera outputs to: Trigger, Pulse Generator, Strobe One, or Strobe Two. For each mapped signal, select either active High or active Low. The following tables show all possible mapping options for the camera inputs and outputs:

Table 36: Cheetah Input Mapping

Input Signal	IN1	IN2	CoaXPress input (Master)
Trigger	✓	✓	✓

Table 37: Cheetah Output Mapping

Output Signal	OUT1	OUT2
Trigger	✓	✓
Pulse Generator	✓	✓
Strobe One	✓	✓
Strobe Two	✓	✓

4.11 Test Image Patterns

4.11.1 Test Image Patterns

The camera can output several test images to verify the camera's general performance and connectivity to the computer. This ensures that all the major modules in the hardware are working properly and the connection between the computer and camera is synchronized, that is, the image framing, output mode, communication rate, and so on are properly configured. Note that the test image patterns do not exercise and verify the image sensor functionality.

Table 38: Test patterns

Patterns	Description
H Ramp Still	Displays a stationary horizontal ramp image.
V Ramp Still	Displays a stationary vertical ramp image.
H Ramp Move	Displays a moving horizontal ramp image.
V Ramp Move	Displays a moving vertical ramp image.
Cross-hairs	Displays cross-hair pattern in center of image over a superimposed live image (cross-hair thickness is 2 pixels).

4.12 White Balance and Color Conversion

4.12.1 White Balance Correction

The color representation in the image depends on the spectral content of the light source. Cheetah cameras have a built-in algorithm to compensate for this effect. With white balance correction enabled, the camera collects the data for all of the image sensor's red (R), green (G), and blue (B) pixels, analyzes the data, and adjusts the color gain coefficients for each color pixel to properly proportion the colors and make white objects appear white. The algorithm collects data from the entire image and can work in the following modes:

Table 39: Automatic white balance (AWB) modes

AWB Mode	Description
Off	No white balance correction performed.
Once	Camera analyzes one image frame, calculates only one set of coefficients, and corrects all subsequent frames with this set of coefficients.
Continuous	Camera analyzes every frame, derives a set of correction coefficients for each frame, and applies them to the next frame. You can select five tracking speeds.
Manual	Camera uses the correction coefficients you enter (see TIP below)

TIP

To get the best white balance for the R, G, and B coefficients when the spectral source is constant:

1. Image a grey or white target over the camera's entire field of view using the intended lighting source.
2. Select **Once** mode for the **White Balance**. The R, G, and B coefficients appear in the RedCoefficient, GreenCoefficient, and BlueCoefficient areas respectively.
3. Change **Once** mode to **Manual** mode. The camera will now apply these coefficients to every frame captured.

4.13 Transfer Function Correction

The user-defined Lookup Table (LUT) feature allows you to transform the original video data into any arbitrary value. The LUT is designed to transform any 12-bit value into any other 12-bit value. For the 10-bit Python sensor, the camera multiplies the 10-bit pixel data by 4 to get 12-bit pixel data for input into the 12-bit LUT. After the 12-bit LUT transforms the data, the camera divides the 12-bit data by 4 to get 10-bit pixel values for output to the camera interface (refer to the following figure). The camera supports two separate lookup tables, each consisting of 4096 entries, with each entry being 12 bits wide. Both LUTs are factory programmed with a standard Gamma 0.45 and available for modifications. You can generate and upload a custom LUT using the Imperx Upload Utility application.

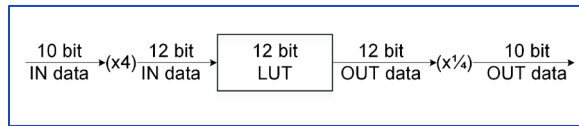


Figure 45: Look up table

4.13.1 Standard Gamma Correction

The image generated by the camera is normally viewed on a monitor and does not have a linear transfer function, that is, the display brightness is not linearly proportional to the scene brightness (as captured by the camera). As the object brightness is lowered, the brightness of the display correspondingly lowers. At a certain brightness level, the scene brightness decrease does not lead to a corresponding display brightness decrease. The same is valid if the brightness is increased. This is because the display has a nonlinear transfer function and a brightness dynamic range much lower than the camera.

The camera has a built-in transfer function to compensate for this non-linearity called gamma correction. Gamma correction can also help map the camera’s wider dynamic range to the limited dynamic range of the display. If enabled, the video signal is transformed by a non-linear function close to the square root function (0.45 power) as shown the following formula. In the digital domain, this is a nonlinear conversion from 12-bit to 12-bit.

$$\text{Output signal [V]} = (\text{input signal [V]})^{0.45} \tag{1.4}$$

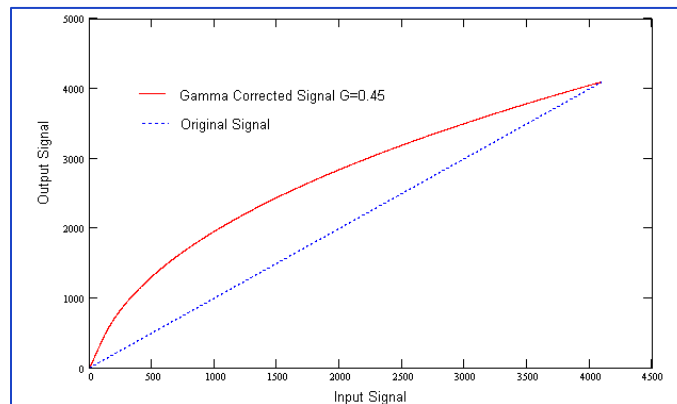


Figure 46: Gamma corrected video signal

4.13.2 User Defined LUT

You can define any 12-bit to 12-bit transformation as a user Look-up Table (LUT) and upload it to the camera using the Upload Utility. You can specify a transfer function to match the camera's dynamic range to the scene's dynamic range. There are no limitations to the profile of the function. The LUT must include all possible input values (0 to 4095) (refer to the chapter [6 Creating Look-up Tables](#))

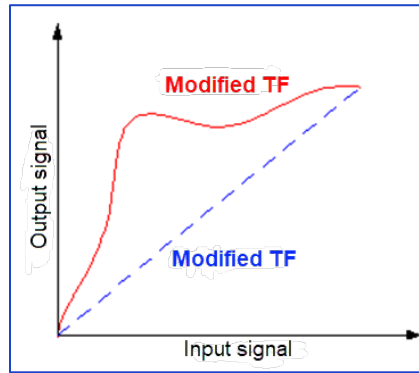


Figure 47: Custom LUT

4.14 Defective Pixel Correction

A CMOS imager is composed of a two-dimensional array of light sensitive pixels. In general, the majority of the pixels have similar sensitivity. However, some pixels deviate from the average pixel sensitivity and are called “defective pixels.” In most cases, defective pixels are responsive to light, and rarely is a pixel totally dark or totally bright. There are two major types of pixel defects: defective and hot.

Defective – these are pixels whose sensitivity deviates due to fluctuations in the CMOS manufacturing process and materials. At the factory, final testing identifies and corrects up to 1024 defective pixels using defective pixel correction. Two types of defective pixels are possible:

- **Dark** – a pixel whose sensitivity is lower than the sensitivity of the adjacent pixels. In some cases, this pixel will have no response (completely dark).
- **Bright** – a pixel whose sensitivity is higher than the sensitivity of the adjacent pixels. In some cases, this pixel will have full response (completely bright).

Hot – these are pixels that in normal camera operation behave as normal pixels (sensitivity equal to one of the adjacent pixels). But during long exposures or at elevated temperatures, the pixel becomes far brighter than the average of the pixels surrounding it. In some cases, the pixel becomes so bright that it saturates. Final camera testing at the factory identifies and automatically corrects up to 8192 hot pixels.

4.14.1 Static Pixel Correction

Static pixel maps provide one method of correcting defective and hot pixels. During factory testing, engineers identify the coordinates of defective and hot pixels. They create a map file listing the pixel coordinates of these bad pixels by row and column, and the camera corrects the defective and hot pixels found at these coordinates. The map file downloads into the camera's non-volatile memory.

When DPM is enabled, the camera compares each pixel's coordinates with entries in the DPM. If a match is found, the camera corrects the defective pixel. The same methodology is used to correct hot pixels.

You can create your own Defective Pixel Map (DPM) and Hot Pixel Map (HPM) files (see chapter [7 Creating DPC / HPC Tables](#)) and upload them using the Imperx Upload Utility application.

4.14.2 Dynamic Pixel Correction

Dynamic pixel correction provides another method of correcting defective and hot pixels. Dynamic correction works without preloaded pixel maps. Instead, you set a dynamic threshold value between zero and 4096 (12-bit) counts. The threshold determines how much a pixel's luminance can deviate from neighboring pixels. If the deviation between bright or dark is too great, the camera corrects the pixel.

Dynamic and Static corrections can be enabled independently or simultaneously.

NOTE *

Dynamic pixel correction is available only in C5180, C4181, and C4180 models.

4.15 Flat Field and Noise Correction

The C5180, C4181, and C4180 cameras use a factory installed flat field correction (located in FFC1) algorithm to correct some of the image sensor's non-uniformity and employs an algorithm to correct the fixed pattern noise (FPN) within the image sensor. You can upload your own FFC table to FFC2. While not recommended, you can disable both the FFC1 and FPN corrections. If two FFC correction tables are needed, you can also overwrite the factory installed FFC located in FFC1.

In the C5190, C4191, C4190 cameras, high Pixel Clock frequencies lead to the additional fixed pattern noise (FPN). The camera employs FFC Sequencer feature to correct FPN. As the FPN varies for the different Pixel Clock frequencies, FFC Sequencer applies either FFC1 or FFC2 tables (both are factory installed) for the correction (refer to the [3.4.7.1 FFC Sequencer](#) section).

The FFC Sequencer switches FFC tables based on the difference between the Pixel Clock and Pixel Clock Threshold values. If Pixel Clock is greater than Pixel Clock Threshold, FFC Sequencer applies FFC1 table for the correction. Otherwise, FFC2 table is applied.

While not recommended, you can change Pixel Clock Threshold and create your own FFC tables to use with this threshold.

In C5180, C4181, and C4180 cameras, there is no additional FPN and FFC Sequencer is not required.

4.16 Camera Interface

4.16.1 Temperature Monitor

The camera has a built-in temperature sensor that monitors the internal camera temperature at the image sensor. The sensor is placed on the hottest spot in the camera. The camera configuration software should display the temperature.

4.16.2 Exposure Time Monitor

The camera has a built-in exposure time monitor. In any mode of operation (normal, AOI, and so on), you can query the camera for the current exposure time. The camera will return the current integration time in units of microseconds (refer to the [Table 14: Acquisition Control parameters](#)).

4.16.3 Frame Time Monitor

The camera has a built-in frame time monitor. In any mode of operation (normal, AOI, and so on), you can query the camera for the current frame time. The camera will return the current camera speed in units of microseconds (refer to the [Table 14: Acquisition Control parameters](#)).

4.16.4 Current Image Size

The camera image size can change based on a camera feature selected. In any mode of operation (normal, AOI, and so on) you can query the camera for the current image size by issuing a command. The camera will return current camera image size in (pixels x lines) (refer to the [Table 13: Image Format parameters](#)).

4.16.5 Auto Gain and Auto Exposure Control (AGC/AEC)

Automatic Exposure (and Gain) Control keeps the same image brightness in spite of changing light conditions. You can enable both Automatic Exposure Control (AEC) and Automatic Gain Control (AGC) simultaneously. In either mode, you set the image brightness (luminance) target level in counts, and the camera adjusts the exposure or gain accordingly. The target luminance can be an average luminance or peak brightness within the entire image or within a defined Area of Interest (AOI).

If both AEC and AGC are enabled, the camera adjusts the exposure first within the preset minimum/maximum limits you set. If the exposure reaches the maximum limit, the camera indicates the limit has been reached and begins increasing the gain.

The camera displays the current values for AGC/AEC luminance, current exposure, and current gain.

CAUTION

In some rapidly changing bright light conditions, an image brightness oscillation (image intensity flipping from bright to dark) could occur. To prevent this situation, increase the minimum exposure limit, decrease the AEC speed, or use an AOI for the luminance target to control the intensity variability.

5 Image Sensor Technology

5.1 General Information

A CMOS camera is an electronic device for converting light into an electrical signal. The C5180, C4181, C4180, C5190, C4191, and C4190 Python cameras contain ON Semiconductor CMOS (Complementary Metal-Oxide Semiconductor) image sensors.

The sensor consists of a two-dimensional array of silicon photodiodes, also known as pixels. The photons falling on the CMOS surface create photoelectrons within the pixels, and the number of photoelectrons is linearly proportional to the light level. Although the number of electrons collected in each pixel is linearly proportional to the light intensity and exposure time, the number of electrons varies with the wavelength of the incident light.

In general operation, when the desired exposure time is reached, the photo-electrons collected within each photodiode move onto a storage register within the pixel. The pixels are then read out one row at a time, processed in the analog domain, and digitized to 10 bits. Frame time, or read-out time, is the time interval required for all the pixels from the entire imager to read out of the image sensor. While reading out the image from the storage registers within each pixel, the camera captures the next image overlapping the exposure of the next image with the readout of the current image. The exposure is timed to end just as the readout of the previous frame ends and the readout of the next frame begins.

Unlike traditional CCD image sensors, the CMOS image sensor digitizes each pixel within a row simultaneously. This allows for more settling time, which lowers the overall noise floor and provides improved sensitivity. The low noise floor, combined with a reasonably large pixel charge capacity, translates into a dynamic range of 59 dB.

A set of color filters (red, green, and blue) arranged in a Bayer pattern over the pixels generates color images.

5.1.1 A/D Architecture and Frame Rate Controls

The C5180, C4181, C4180, C5190, C4191, and C4190 image sensors multiplex 80 (C5180, C5190) and 64 (C4181, C4180, C4191, and C4190) columns respectively into an array of 64 A/D converters. The camera takes care of all the details of re-ordering the lines so they are sequentially deposited in computer memory. Unlike a CCD sensor where digitization occurs within one pixel-time, these cameras perform digitization at $1/64^{\text{th}}$ the pixel rate (64 A/D converters), and the digitization has a depth of 10 bits.

The image sensor provides up to 32 Low-Voltage Differential Signaling (LVDS) outputs so the time to read out one line from the image sensor is far less than the time necessary to capture the data using the CXP interface. The camera compensates for this mismatch in data output rate versus data capture rate using two methods: a variable pixel clock for line readout and the ability to add 1 microsecond of delay (row overhead) time at the end of each line output by the camera. Slowing down the pixel line clock and adding delay (dead time) at the end of each line allow the CoaXPress frame grabber to keep pace with the camera output.

The following figure shows a typical CMOS image sensor architecture.

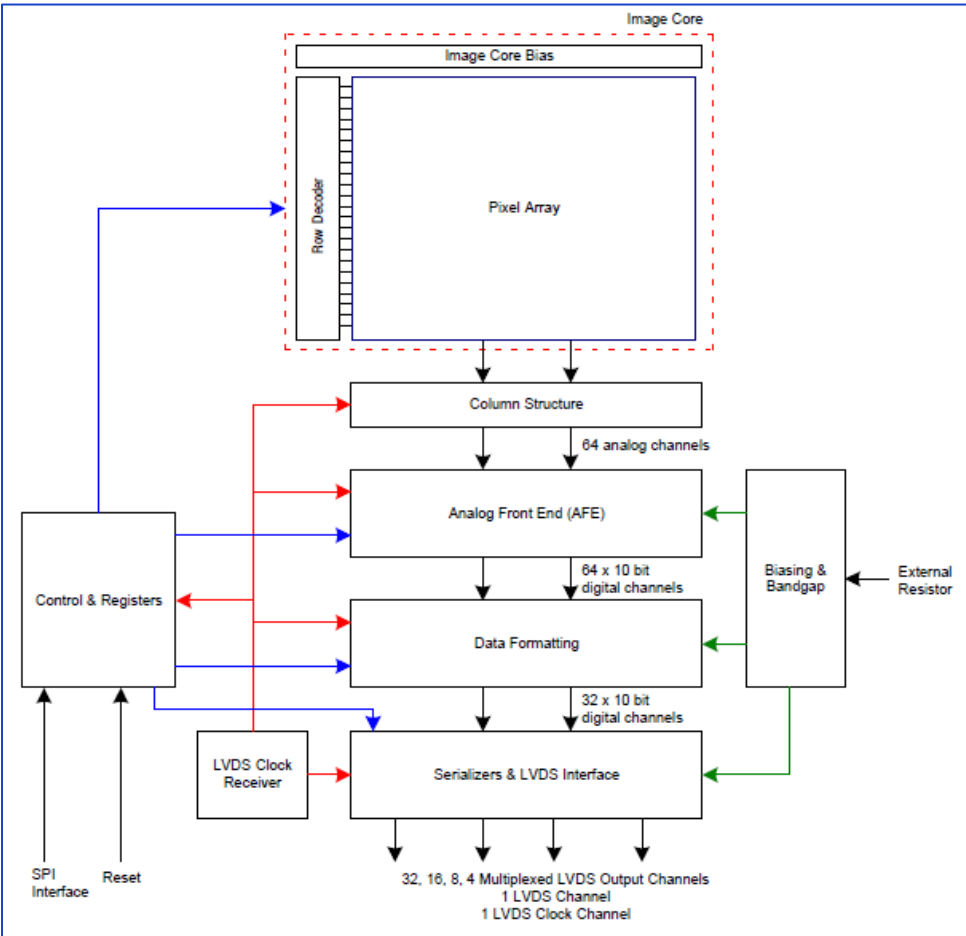


Figure 48: Typical CMOS image sensor architecture

5.1.2 Spectral Sensitivity

The camera’s spectral response is shown in the following two figures.

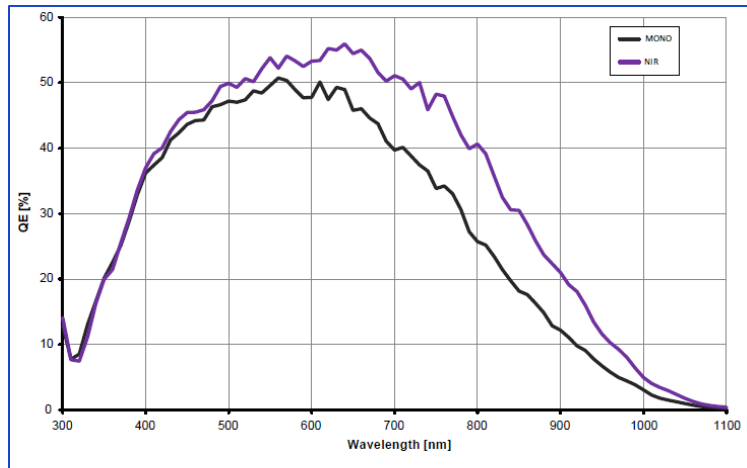


Figure 49: Python CMOS mono spectral response (monochrome, cover glass)

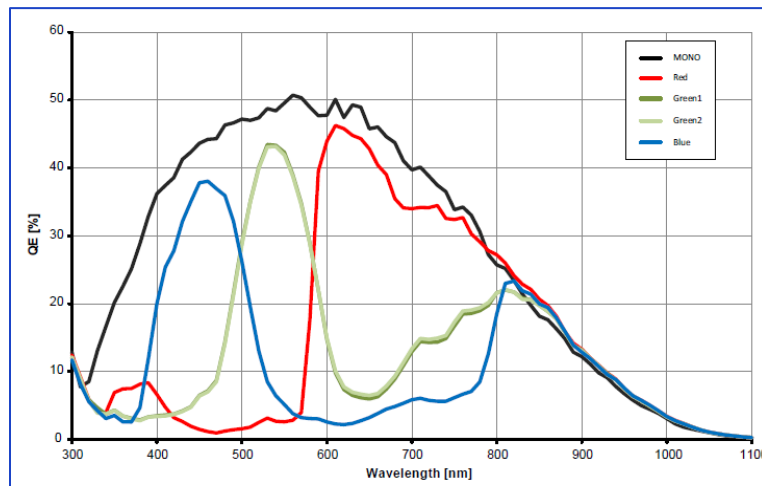


Figure 50: Python CMOS typical color spectral response (micro lens, cover glass)

5.1.3 Bayer Pattern Information

Cheetah Python cameras are available with a Monochrome or Color CMOS imager. Color filters (red, green, and blue) arranged in a Bayer pattern and placed over the pixels generate color images. The starting color is red.

6 Creating Look-up Tables

6.1 Overview

A Look-up Table (LUT) is provided with each camera. You can create your own LUT file using any standard ASCII text editor, Microsoft Notepad, or Microsoft Excel. Additionally, you can use any spreadsheet or mathematical program capable of generating a comma delimited (.csv) file.

6.2 Using an ASCII Text Editor

A custom LUT can be prepared using any ASCII text editor, such as “Notepad” or similar. Alternatively, any spreadsheet program (i.e. Microsoft Excel) can be used by converting the spreadsheet into a comma delimited (.csv) file. In either case, the file must be renamed to include the .lut file extension.

The .lut file has two main sections: a header and a table. The header section is a free text area of up to 256 ASCII characters. Each line of the header section must be terminated in a comma. The table section of the file contains an array of 4096 lines with each line containing an input value followed by a comma and an output value. The input values represent incoming pixels and the output values represent what each incoming pixel should be converted into as an output pixel.

The format of the .lut file is as follows:

```
-- Look Up Table input file example,  
-- lines beginning with two dashes are comments,  
-- and are ignored by parser,  
:Header,  
-- this is the text that will get displayed with a 'glh'  
command,  
Function is 'Negative Image',  
Created by John Doe,  
Date 1/14/09,  
:Table,  
-- input output,  
    0,4095  
    1,4094  
    2,4093  
    3,4092  
    4,4091  
    :  
    4095,0
```

6.3 Using Microsoft Excel

The LUT file can be created in Excel as follows:

1. Create the spreadsheet as shown below (note that 4096 rows are required in the table).
2. Add the necessary equations into the output cells to generate the transfer function required.
3. Save the file as a .csv (comma delimited format).
4. Rename the .csv file to an extension of .lut.

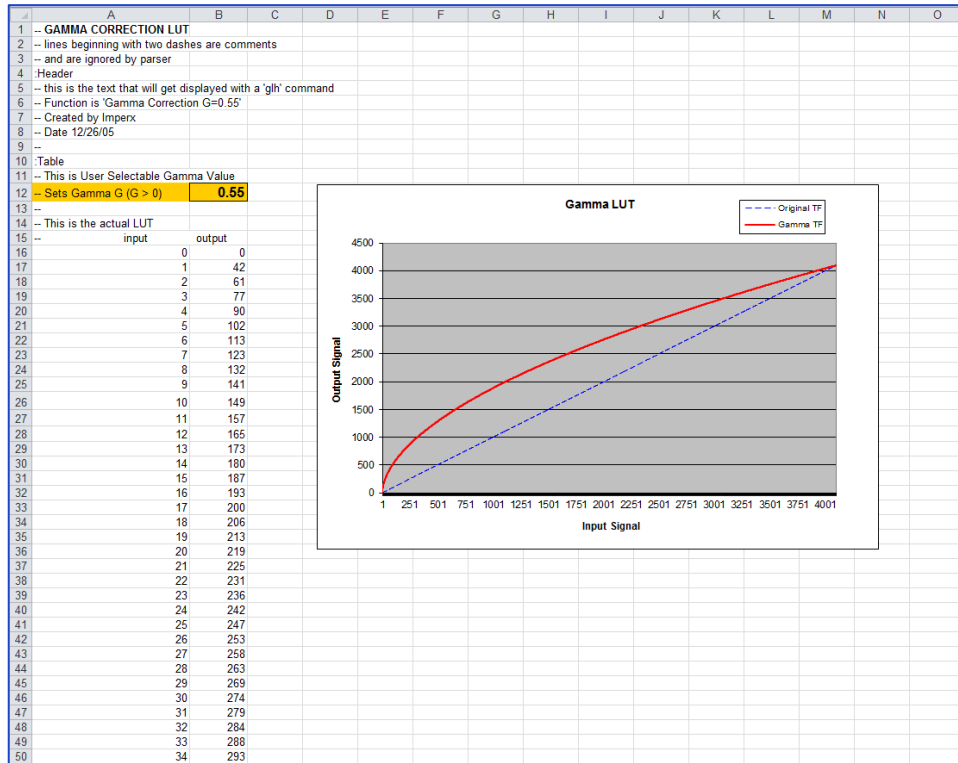


Figure 51: Sample spreadsheet

7 Creating DPC / HPC Tables

7.1 Overview

Defective Pixel Correction and Hot Pixel Correction work with predetermined and preloaded Defective and Hot pixel maps. The Defective Pixel Map (DPM) and Hot Pixel Map (HPM) are downloaded into the camera's non-volatile memory.

You can edit the original DPM / HPM file, create your own file and upload it to fit the unique requirements of your operating environment or camera use.

NOTE *

To get the original DPM and HPM files please contact technical support at:

Email: techsupport@imperx.com

Toll Free 1 (866) 849-1662 or (+1) 561-989-0006

Fax: (+1) 561-989-0045

Visit our website: www.imperx.com

7.2 Editing DMP / HPM Files

You can edit DPM and HPM files in Microsoft Notepad or any other editing software. The files look like this:

```
-- Defective Pixel Map,  
-- Date: 2.23.2018,  
-- Model#: CXP-C5180M-RF,  
-- Serial#: LAC001,  
:Table,  
-- Column (X) , Row (Y)  
    5683,155  
    3091,332  
    3532,893  
    650,1017  
    701,1017  
    1712,1053  
    914,1067
```

Pixel maps have two main sections: a header and a table. The header section is a free text area of up to 256 ASCII characters. Each line of the header section must be terminated with a comma. The table section of the file contains an array of lines with each line containing an X (column number) value followed by a comma and a Y (row number) value.

All pixels are listed in the DPM or HPM in order of increasing Y (row) location. If the Y location is identical, the listing is in order of increasing X (column) location.

The maximum number of pixels in the DPM list is 512 and in HPM list is 4096.

To edit original DPM or HPM file, you need to identify defective or hot pixels, locate and adjust their coordinates, and accurately place pixels' coordinates into the pixel map.

7.2.1 Finding defective pixels

To find all of the defective pixels you need to add to the map, it is recommended that you take an image with a uniform light source illuminating the sensor at about 50% ADU capacity (~2000 for 12-bit, ~500 for 10-bit, ~130 for 8-bit modes). Ensure that the **DefectPixelCorrection** and **HotPixelCorrection** are set to “Static” on the “Data Correction” screen of the Software GUI, so the camera will correct the known pixel defects. You can then identify any visible pixel defects and add them to the defective pixel maps.

7.2.2 Finding hot pixels

To identify all hot pixels that need to be added to the map, put the lens cap on the camera and capture an image after the camera has reached the normal operating temperature. Use the longest expected exposure time at the normal frame rate. If the camera will operate with variable frame rates, set the camera to the slowest frame rate expected. Ensure that the **HotPixelCorrection** is set to “Static” on the “Data Correction” screen of the software GUI, so the camera will correct the known hot pixels automatically. From this image, you can then identify all of the hot pixels not in the factory map and add them to the hot pixel map.

7.2.3 Locating and adding pixel coordinates

Follow the steps below to find first pixel coordinates, locate and adjust defective pixel coordinates, and accurately place defective pixel coordinates into the pixel map.

STEP 1: Find the First Pixel Coordinates

Your frame grabber’s first pixel coordinates can affect the location accuracy of defective pixel coordinates. So, you must find the image sensor’s first pixel coordinates and potentially adjust the defective pixel coordinates based on your findings.

Click the first pixel at the upper most left corner of the screen to find your frame grabber’s first pixel X, Y coordinates (Figure 52). The coordinates will be either 0, 0 or 1, 1:

- If your frame grabber’s first pixel coordinates are 0,0, you must add 1 to both the X and Y coordinates of the bad pixel.
- If the first pixel coordinates are 1, 1, do not add 1 to either coordinate.

STEP 2: Find Defective Pixel Coordinates

Click the defective pixel to find its X, Y coordinates (Figure 53).

The Figure 53 shows a pixel defect at location 593, 4816 — where X (Column) = 593 and Y (Row) = 4816.

IMPORTANT: Frame grabbers from different manufacturers may display pixel location coordinates in different order, for example:

X (Column), Y (Row) or,
X (Row), Y (Column).

You must put defective pixel coordinates into the pixel correction map file in this order:
X (Column), Y (Row).

If your frame grabber identifies pixel coordinates by X (**Row**), Y (**Column**), you must transpose the coordinates to X (**Column**), Y (**Row**) before entering them into the pixel map files. For example, if the 593, 4816 coordinates in the screen below (Figure 53) had been

displayed in this order, where X:593 is row and Y:4816 is column, you would have had to transpose the coordinates to 4816, 593.

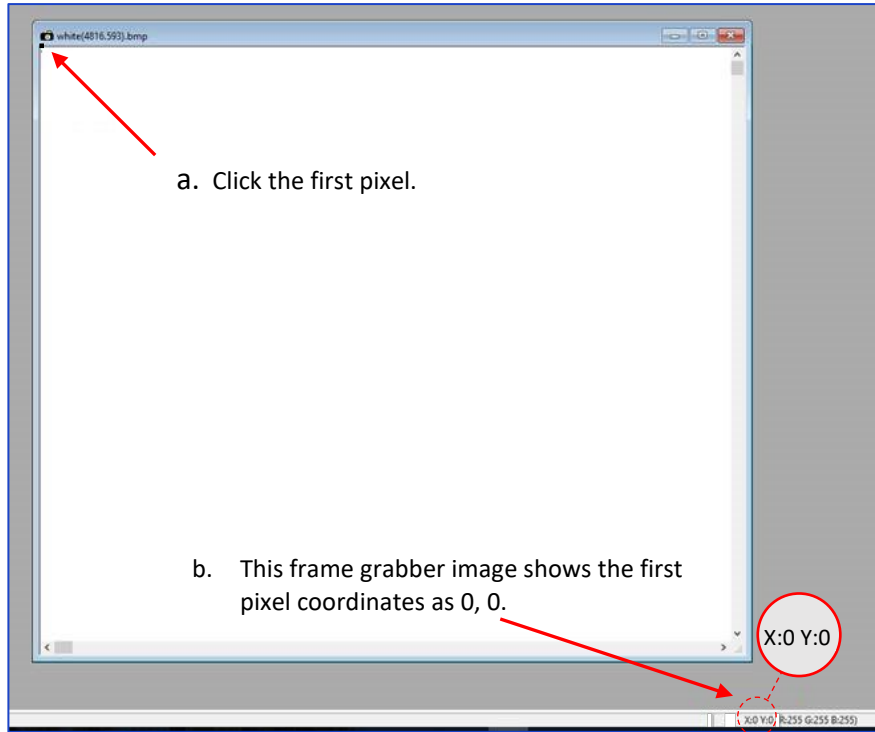


Figure 52: Frame grabber's first pixel

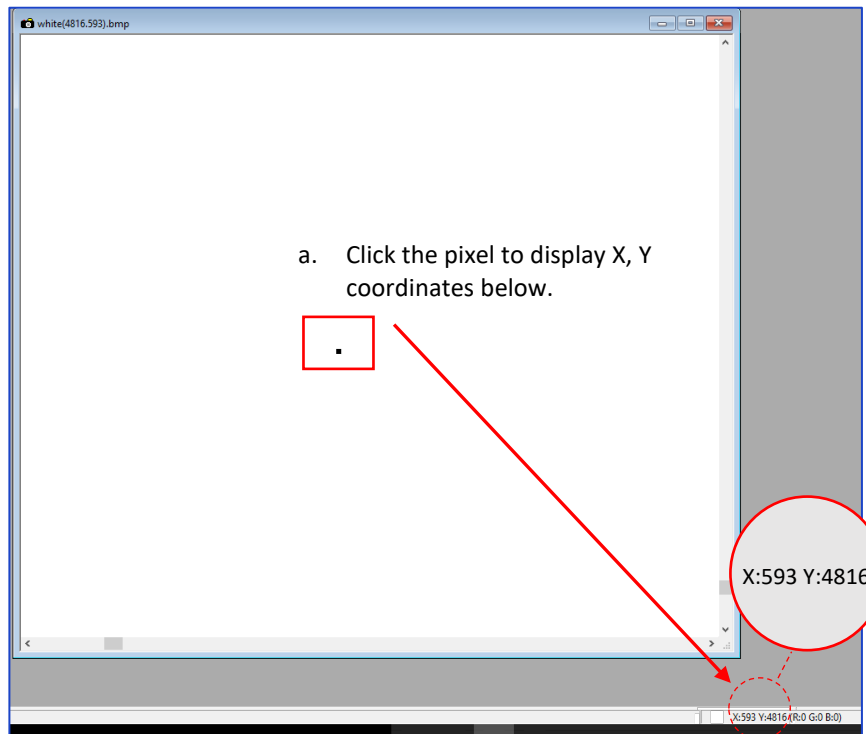


Figure 53: Locating defective pixel

STEP 3: Adjust Defective Pixel Coordinates

As described in **STEP 1**, if the first pixel coordinates are 0, 0, you must adjust the defective pixel coordinates by adding 1 to both coordinates as shown in the following:

$$593 (+1), 4816 (+1) = 594, 4817$$

- If the frame grabber pixel coordinates are Column (X), Row (Y), then go to **STEP 4**.
- If the frame grabber pixel coordinates are Row (X), Column (Y), then transpose the coordinates to the form Column, Row and then go to **STEP 4**.

STEP 4: Add Defective Pixel Coordinates to Defective Pixel Map

Place the defective pixel coordinates in the Defective Pixel Map file in ascending (increasing) numerical order of the Y (row) coordinate. The value of all Y coordinates should progressively increase as you look down the list of X, Y coordinates.

Example 1: Different Y coordinates	Example 2: Identical Y coordinates
<pre> -- Defective Pixel Map, -- Date: 4.12.2018, -- Model#: CXP-C5180M-RF, -- Serial#: LAC001, :Table, -- Column (X) , Row (Y) 701,1017 100,1018 4325,1019 2241,1020 458,1021 1712,1053 914,1067 3954,1546 2516,1670 3451,3331 1111,4149 95,4364 594,4817 433,4828 205,4899 </pre> <p style="border: 1px solid red; padding: 5px; display: inline-block;">Row coordinates are in ascending order (increasing Y values).</p>	<pre> -- Defective Pixel Map, -- Date: 4.12.2018, -- Model#: CXP-C5180M-RF, -- Serial#: LAC001, :Table, -- Column (X) , Row (Y) 650,1017 698,1017 701,1017 100,1018 4325,1019 2241,1020 458,1021 1712,1053 914,1067 3954,1546 2516,1670 3451,3331 1111,4149 95,4364 433,4828 205,4899 </pre> <p style="border: 1px solid red; padding: 5px; display: inline-block;">Column coordinates are in ascending order (increasing X values).</p>

As shown in the **Example 1** above, the Y coordinate of **594, 4817** is higher than **4364** and lower than **4828**. Do not add defective pixel coordinates at the end of the list unless the Y coordinate is the highest of all Y values.

NOTE *

If adding a defective pixel with a Y location identical to one or more other defective pixels, insert its coordinates based on the order of increasing X location.

As shown in the **Example 2** above, the Y coordinate of **698, 1017** is identical to two other defective pixels. Place its coordinates between **650, 1017** and **701, 1017** because its X location (698) is higher than 650 but lower than 701.

STEP 5: Save your DPM/HPM

- Save your Defective Pixel Map with the file extension .dpm.
- Save your Hot Pixel Map with file extension .hpm.

7.3 Creating new DPM / HPM Files

You can create your own DPM and HPM files using any ASCII text editor, such as “Notepad” or similar. Alternatively, any spreadsheet program (i.e. Microsoft Excel) can be used by converting the spreadsheet into a comma delimited (.csv) file. In either case, the file must be renamed to include the .dpm or .hpm file extension. The files look like this:

```
-- Defective Pixel Map,
-- Date: 2.23.2018,
-- Model#: CXP-C5180M-RF,
-- Serial#: LAC001,
:Table,
-- Column (X) , Row (Y)
    5683,155
    3091,332
    3532,893
    650,1017
    701,1017
    1712,1053
    914,1067
```

Pixel maps have two main sections: a header and a table. The header section is a free text area of up to 256 ASCII characters. Each line of the header section must be terminated with a comma. The table section of the file contains an array of lines with each line containing an X (column number) value followed by a comma and a Y (row number) value.

All pixels are listed in the DPM or HPM in order of increasing Y (row) location. If the Y location is identical, the listing is in order of increasing X (column) location.

The maximum number of pixels in the DMP list is 512 and in HPM list is 4096.

To create a DPM or HPM file:

1. Identify defective or hot pixels (refer to the sections [7.2.1 Finding defective pixels](#) and [7.2.2 Finding hot pixels](#)).

IMPORTANT: When creating a new pixel map, you need to get all defective pixel visible. Ensure that the **DefectivePixelCorrection** and **HotPixelCorrection** are set to “Off” on the “Data Correction” screen of the software GUI, so the camera will not correct the known pixel defects.

2. Locate and adjust defective pixels’ coordinates (refer to the section [7.2.3 Locating and adding pixel coordinates, STEP1 – STEP3](#)).
3. Place pixels’ coordinates into the pixel map and save the file (refer to the section [7.2.3 Locating and adding pixel coordinates STEP4, STEP5](#)).

EXAMPLE

In this example, the first table entry is pixel 4 from row 1, the next entry is pixel 588 from row 1, and the next entry is pixel 78 from row 5, and so on. The file looks like this:

```
:Table,
-- Column (X) , Row (Y)
    4,1
    588,1
    78,5
    82,27
    405,300
```

7.4 Uploading DPM / HPM Files

After saving the maps, you can upload them to the camera using the Imperx **Upload Utility**. The Upload Utility ships with your camera and enables uploads of DPM, HPM, and other files to your camera.

To upload DPM and HPM files:

1. Connect and power up your camera.
2. Start the Imperx **Upload Utility** and wait for the Utility to detect the camera (Figure 54). If the utility does not detect the camera, click **Refresh** to restart the device collection.

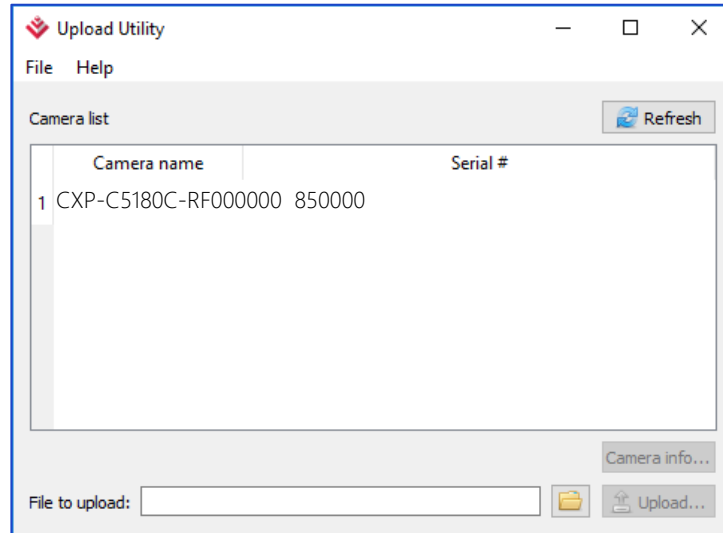


Figure 54: Detect a camera

3. Select the camera to update if more than one appears.

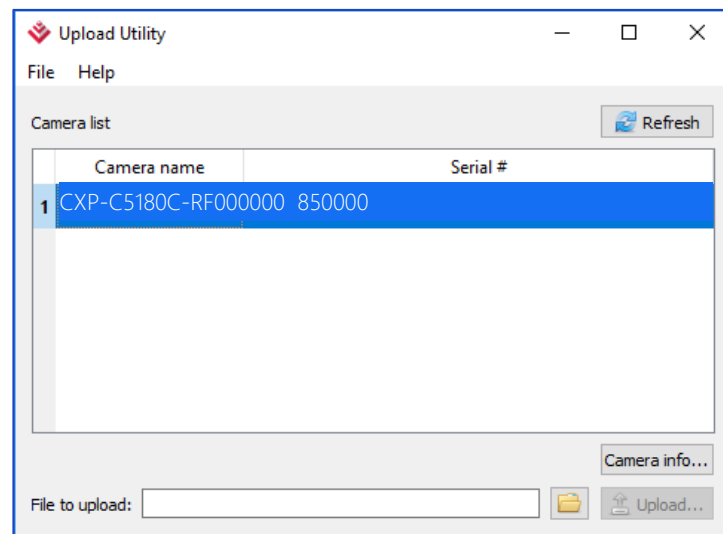


Figure 55: Select detected camera.

4. Browse for either the edited .dpm file or .hpm file, select it, and click the **Upload** button. Wait for the upload to finish.

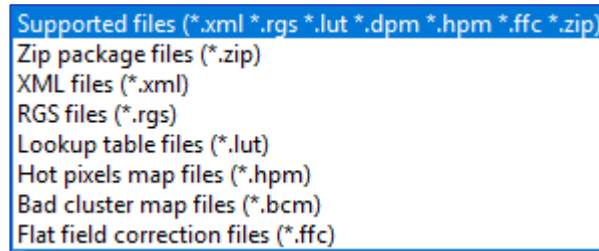


Figure 56: Supported upload files

5. After the upload is completed, do a power cycle on the camera.
6. After the camera re-starts, start your software GUI and select **Data Correction**.
7. Ensure that DPC and HPC are set to **Static** so that the camera uses the maps you loaded.
8. Retake images as described in sections [7.2.1 Finding defective pixels](#) and [7.2.2 Finding hot pixels](#) to ensure all defective and hot pixels are now corrected.