IMPERX

Cheetah Python Cameras

User Manual

with USB3 Interface

The Cheetah C5180, C4181, and C4180 CMOS cameras offer 25, 16, and 12-megapixel options respectively with a USB3 compatible output interface and a GenICam™ compliant programming interface. The ruggedized cameras use advanced ON Semiconductor 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 1.0

IMPERX
Industrial Cameras & Imaging Systems

About Imperx, Inc.

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.

Imperx, Inc. | 6421 Congress Ave. | Boca Raton, FL, 33487
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Warranty

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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TABLE OF CONTENTS

REVISION HISTORY

Revision	Date	Reviser	Comments
1.0	12/5/2017	R.Johnston	Initial release

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 USB3 output interface. A GeniCam™ compliant programming graphical user interface ships with the camera. The following table describes the C5180, C4181, and C4180 model cameras covered in this manual.

Model	Resolution	Type	Optics	Sensor MFG	Model
C5180M	5120 x 5120	Mono	32.6 diag.	ON Semiconductor	NOIP1SN025KA
C5180C	5120 x 5120	Color	32.6 diag.	ON Semiconductor	NOIP1SE025KA
C5180N	5120 x 5120	ENIR	32.6 diag.	ON Semiconductor	NOIP1FN025KA
C4181M	4096 x 4096	Mono	26.1 diag.	ON Semiconductor	NOIP1SN016KA
C4181C	4096 x 4096	Color	26.1 diag.	ON Semiconductor	NOIP1SE016KA
C4181N	4096 x 4096	ENIR	26.1 diag.	ON Semiconductor	NOIP1FN016KA
C4180M	4096 x 3072	Mono	4/3”	ON Semiconductor	NOIP1SN012KA
C4180C	4096 x 3072	Color	4/3”	ON Semiconductor	NOIP1SE012KA
C4180N	4096 x 3072	ENIR	4/3”	ON Semiconductor	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, defective 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, and C4180 model cameras use global shutter operation for superior motion capture and exceptionally high frame rates for use in high throughput applications. The cameras can control exposure time using internal controls or an external pulse width. They support exposure times up to 1 second with 1µs increments. The cameras also support analog gains up to 10 dB (3.17x).

Built-in gamma correction and user-defined look-up table (LUT) capabilities optimize the camera's dynamic range features. Defective pixel correction (DPC) and hot pixel correction (HPC) 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 USB3 compatible interface that includes 8- and 10-bit data transmission, as well as camera control functionality in one cable. There is also support of active or passive Canon EOS lenses.

The camera's ruggedized design and flexibility enable its use in a wide and 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

1. Global shutter (GS)
2. Monochrome or color
3. Enhanced near infrared (ENIR) sensitivity version available
4. Fast frame rates: 14 fps (C5180), 22 fps (C4181), 30 fps (C4180)
5. Configurable pixel clock
6. Pixel averaging (mono camera only)
7. Subsampling
8. Area of Interest
9. Analog and digital gain controls
10. Offset control
11. Three selectable trigger sources: external, pulse generator, or software
12. Built-in pulse generator
13. Two programmable output strobes
14. White balance: once, manual, or auto
15. Two 12-bit look-up tables (LUT)
16. Defective pixel correction (DPC); hot pixel correction (HPC)
17. Two programmable external inputs (one opto-isolated) and two external outputs (one opto-isolated)
18. Flat Field Correction (FFC), user defined and factory
19. USB3 interface
20. Support for Active Canon EOS Lens mount
21. Temperature monitor
22. Field upgradeable firmware, LUT, DPC, HPC, FFC

1.2 General Specifications

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

Specifications	**C5180 / C4181 / C4180**
Shutter operation	Global only
Exposure time	40 µs min
Area of Interest	One
Analog gain	1x, 1.26x, 1.87x, 3.17x
Digital gain	Up to 24dB
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	5V to 33V DC; 6.5V to 33V 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

Table 1: Cheetah camera general specifications.

1.3 C5180, C4181, C4180 Specifications

The following table describes features and specifications related directly to the C5180, C4181, and C4180 Cheetah Python cameras.

Specifications	C5180	C4181	C4180
Active image resolution	5120 x 5120	4096 x 4096	4096 x 3072
Active image area (H, V)	23.0 mm x 23.0 mm 32.6 mm diagonal	18.4 mm x 18.4 mm 26.1 mm diagonal	18.4 mm x 13.8 mm 23.0 mm diagonal
Pixel size	4.5 µm	4.5 µm	4.5 µm
Video output	Digital, 8/10-bit	Digital, 8/10-bit	Digital, 8/10-bit
Interface	USB3 compatible	USB3 compatible	USB3 compatible
Camera connector	9-pin, screw-locking micro-B USB 3.0	9-pin, screw-locking micro-B USB 3.0	9-pin, screw-locking micro-B USB 3.0
Host connector	USB 3.0-A plug	USB 3.0-A plug	USB 3.0-A plug
Maximum frame rate	6 fps (10-bit) 13 fps (8-bit)	10 fps (10-bit) 20 fps (8-bit)	13 fps (10-bit) 27 fps (8-bit)
Dynamic range	59 dB	59 dB	59 dB
Shutter speed	40 µs to 1 sec	40 µs to 1 sec	40 µs to 1 sec
Area of Interest	One	One	One
Analog gain	0 to 10dB	0 to 10dB	0 to 10dB
Digital gain	0 to 24dB	0 to 24dB	0 to 24dB
Black level offset	0 to 1024, 1/step	0 to 1024, 1/step	0 to 1024, 1/step
User LUT	2 LUTs: gamma and user LUT	2 LUTs: gamma and user LUT	2 LUTs: gamma and user LUT
Flat Field Correction (FFC)	FFC, factory and User	FFC, factory and User	FFC, factory and User
Hardware trigger	Asynchronous	Asynchronous	Asynchronous
Strobe modes	Programmable width, delay	Programmable width, delay	Programmable width, delay
Trigger sources	External, pulse generator, software	External, pulse generator, software	External, pulse generator, software
Trigger features	Rising/falling edge, De-glitch, delay, strobe	Rising/falling edge, De-glitch, delay, strobe	Rising/falling edge, De-glitch, delay, strobe
Size (W x H x L)	(72 x 72 x 34.7) mm	(72 x 72 x 34.7) mm	(72 x 72 x 34.7) mm
Weight	370 g	370 g	370 g
Lens mount	F-Mount, APS-H, Active or passive Canon EOS.	F-Mount, APS-H, Active or passive Canon EOS.	F-Mount, APS-H, Active or passive Canon EOS.

Power	12V / 500mA. Canon EOS 12V/ 550mA.	12V / 500mA. Canon EOS 12V/ 550mA.	12V / 500mA. Canon EOS 12V/ 550mA.

Table 2: Cheetah C5180, C4181, and C4180 specifications.

1.4 Ordering Information

Cheetah C5180, C4181, and C4180 Camera Ordering Codes			Sample Code: U3V-C5180M-RF000		
Interface	Camera Number	Sensor Type	Ruggedized	Lens Mount	Filter Option
U3V	C5180 – 5120 x 5120	M – monochrome C – color N - ENIR		F Mount	000 - none
	C4180 – 4096 x 3072			L – Canon EF EOS Active Mount	200 – Color w/out IR filters
	C4181 – 4096 x 4096				400 – Color w/out IR filter replace w/clear cover glass
					700 – Mono w/clear cover glass

Part Number Example:
U3V-C4181M-RF000: Cheetah Monochrome 16MP camera with F-Mount and USB3 Interface

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

1.3.1 Technical Support

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

1. Check the power supply 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 LED section.
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, IPX Player 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 Web Site: www.imperx.com

2 Hardware

2.1 Camera Back Panel

The back panel of the camera provides connectors to the USB3 interface and other external equipment (Figure 1). The panel also provides a status LED indicator. The panel includes:

1. A standard USB 3.0 interface with Micro-B 3.0 connector (Mill-Max p/n: 897-10-010-00-300002) for data, and control. Imperx offers cables in various lengths. Contact Imperx for information.
2. A male Hirose type miniature locking receptacle #HR10A-10R-12PB (71) providing power and I/O interface.
3. A USB type B programming/SPI connector for factory use only.
4. A camera status LED indicator (2.16.1 Status LED).
5. The camera's model / serial number.

Figure 1: Cheetah Python USB3 Camera back panel.

2.2 Camera Power Connector

The 12-pin Hirose connector provides power and all external input/output signals supplied to the camera (Figure 2). The connector is a male HIROSE type miniature locking receptacle #HR10A-10R-12PB (71). The optionally purchased power supply ships with a power cable that terminates in a female HIROSE plug #HR10A-10P-12S (73). The following table shows power connector pin mapping.

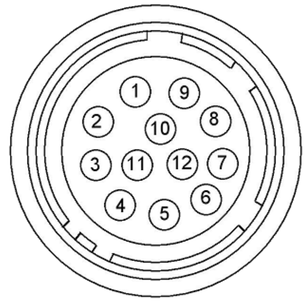


Figure 2: Camera Power Connector Pin-outs.

2.2.1 Power Connector Pins

Pin	Signal	Type	Description
1	12 VDC Return	Ground Return	12 VDC Main Power Return
2	+ 12 VDC	Power - Input	+ 12 VDC (nominal) Main Power
3	NC	–NC	Reserved
4	NC	NC	Reserved
5	GP OUT 2	Opto- Switch contact 2	General Purpose Output 2-
6	GP Out 1 RTN	TTL Ground Return	General Purpose Output 1 Return
7	GP OUT 1	TTL OUT 1	General Purpose Output 1
8	GP IN 1	Opto-isolated IN 1	General Purpose Input 1
9	GP IN 2	TTL/LVTTL IN 2	General Purpose Input 2
10	GP IN 1 Return	Ground Return IN1	General Purpose Input 1 Return
11	GP IN 2 Return	LVTTL Ground Return IN2	General Purpose Input 2 Return
12	GP OUT 2	Opto-Switch contact 1	General Purpose Output 2+

Table 3: Power connector pin mappings.

2.2.2 Power Supply – Camera Only

Cheetah Python cameras use the PS12V04 Standard Power Supply shown in the following figure. The PS12V04A supplies power to the camera and provides connectors for trigger input (black) and strobe output (white).

Figure 3: PS12V04A standard

PS12V04A Standard Power Supply:

Cable length:
Supplied AC power input cable (IEC): 1.8m (6') 100 - 240 Vac, 50 - 60Hz 1A
Power supply Output (+12V): 3m (10') ± 15cm (6") connector HIROSE #HR10A-10P-12S
Strobe & Trigger: 10cm (4") ± 1cm (0.5") connector BNC male

Electrical:
Over-Voltage Protective Installation
Short-circuit Protective Installation
Protection Type: Auto-Recovery
10 -15 VDC 12VDC nominal, 2 A.
Load regulation ± 5%
Ripple & Noise 1% Max.

Regulatory:
Class 1
Safety standards UL60950-1, EN60950-1, IEC60950-1
Safety (1) EMC UL/CUL, CE, TUV, DoIR+C-Tick, Semko, CCC, FCC
Safety (2) BSMI, FCC

2.2.3 Power Supply - Camera with Canon Lens Control

Use the PS12V07B power supply if using the Canon Lens Control with the camera. The PS12V07B supplies power to the camera and provides connectors for Canon lens control (grey), trigger input (black), and strobe output (white).

Figure 4: PS12V07A power supply with Canon lens control.

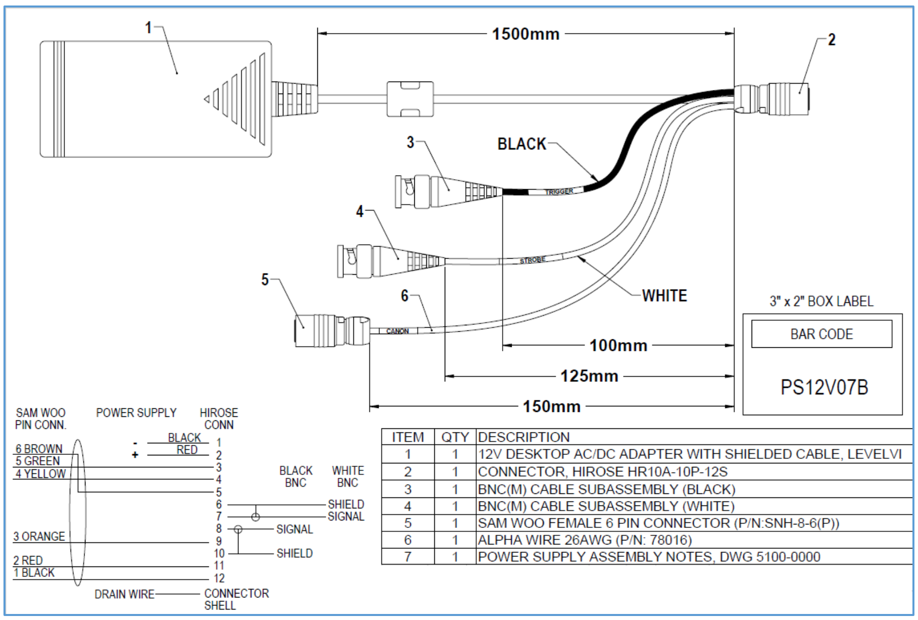


Figure 5: A Sam Woo connector enables Canon lens control.

2.2.4 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 5v TTL (5.0 Volts) 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 and 24 volts.

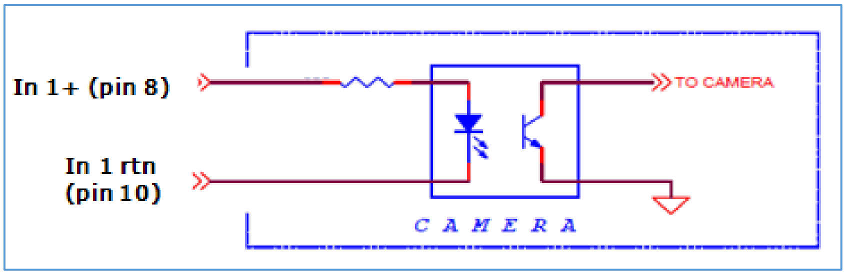


Figure 6: IN1 electrical connection

B. Input IN 2 LVTTL

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

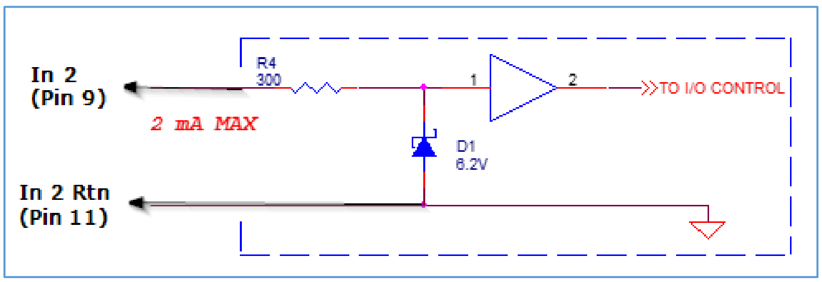


Figure 7: IN2 electrical connection.

C. Output OUT 1 LVTTL

Output OUT1 is a 5v TTL (5.0 Volts) compatible signal and the maximum output current must not exceed 8 mA.

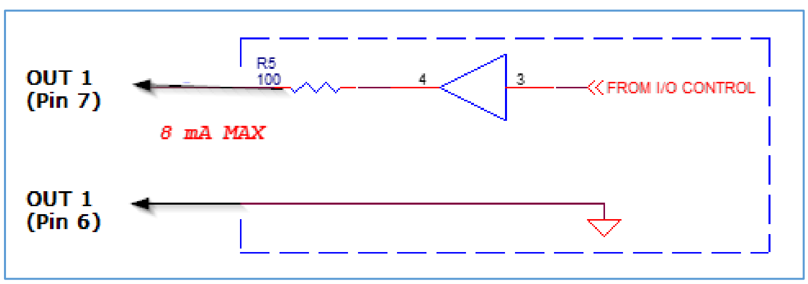


Figure 8: OUT1 LVTTL electrical connection.

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 OUT2 Contact 2 must not exceed 25 volts and the current through the switch must not exceed 50 mA. On resistance is less than 5 Ohms.

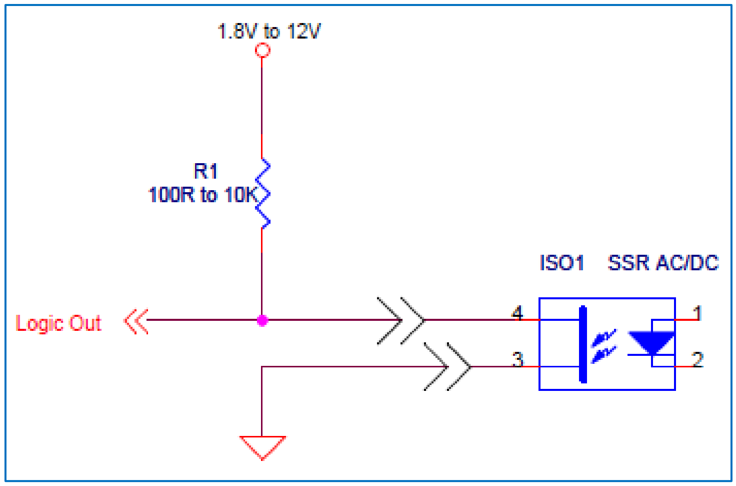


Figure 9: Open drain logic driver.

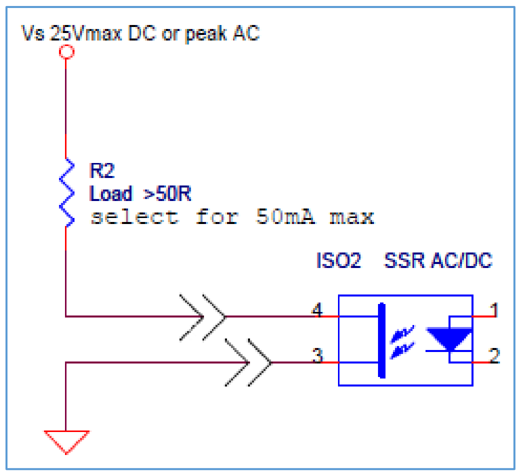


Figure 10: Low side load driver.

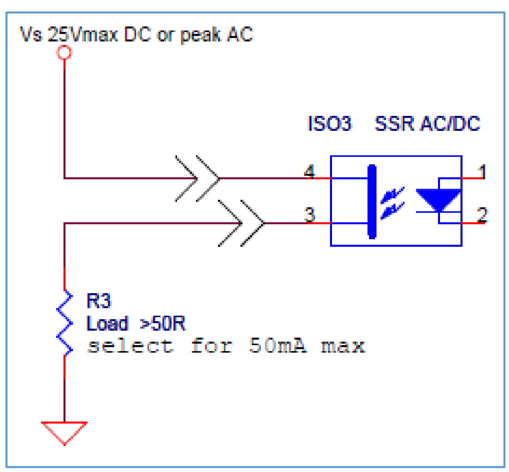


Figure 11: High side load driver.

2.2.5 Status LED

The camera has a dual red-green LED located on the back panel. The LED color and light pattern indicate the camera status and mode of operation.

	LED Color	Status Description
(green)	Green steady ON	Normal operation. You should see a normal image coming out of the camera.
(green)	Green blinking	Trigger enabled.
(yellow)	Yellow steady ON	Test mode enabled.
(red)	Red steady ON	Firmware load error.*
(black)	LED OFF	No power. Indicates power supply failure.**

Table 4: Status LED.

*Re-power the camera and load the factory settings. If the condition is still present, contact the factory

** A faulty external AC adapter could also cause this. To restore the camera operation, re-power the camera and load the factory settings. If the LED is still OFF, contact the factory.

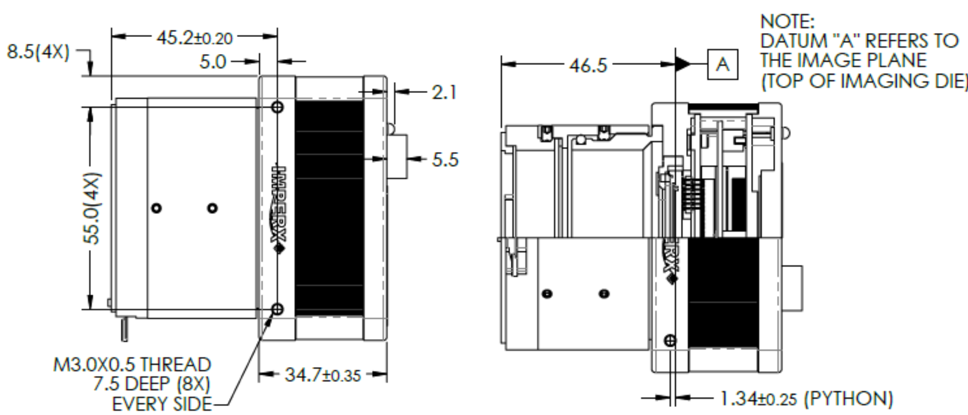
2.3 Mechanical, Optical, Environmental

2.3.1 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.

2.3.1.1 Mechanical Drawings, C5180, C4181, and C4180

Side Views:



Front and Back Views:

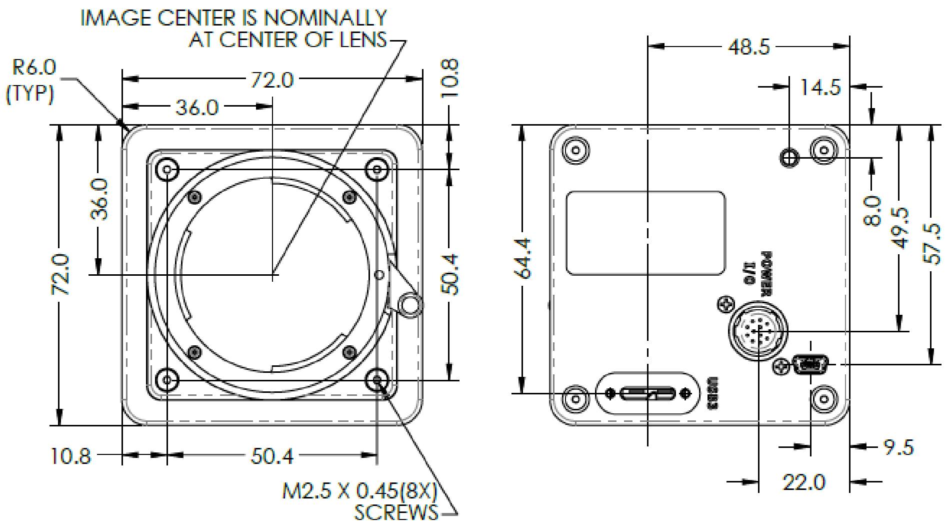


Figure 12: C5180, C4181, C4180 Mechanical Drawings.

2.3.2 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.

2.3.3 Environmental

The camera operating temperatures range from -40°C to +85°C in a dry environment. The relative humidity should not exceed 80% 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 GenICam API Module – Configuring the Camera

3.1 Overview

Cheetah cameras are programmable and flexible. You can control all of the camera's resources (internal registers, video amplifiers, and parameter flash) using a GenICam compliant USB3 compatible interface. The interface is bi-directional enabling you to issue commands to the camera, and for the camera to issue responses (either status or information). You can configure and monitor all of the camera's features and resources. The graphical user interface (GUI) configurator embedded within the Imperx IpxPlayer software enables setting the camera's parameters.

3.2 Camera Configuration

3.2.1 Configuration Memory – 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 Defective 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.

3.2.2 Camera Command Protocol

You can access Cheetah camera features and registers using the GenICam IpxPlayer, a graphical user interface (GUI) included with the camera.

There is latency for each command due to command execution and data transmission over the USB bus. This latency varies from command to command because of resource location and command response length.

3.3 Camera User Set Description

3.3.1 Startup Procedure

Upon power on 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 Cheetah XML nodes are listed below with a description of the camera configuration parameters, the interface type, the range of control values, and the access mode for the parameter (RW: Read/Write, RO: Read Only, WO: Write Only).

NOTE

Parameter names underlined in *italic and red color* are changeable only if image acquisition is turned **off**. These parameters cannot be changed if image acquisition is on.

3.4.1 Device Control

Parameter Name	Type	Value	Access	Description
DeviceSFNCVersionMajor	Integer		RW	Major version of SFNC used in XML.
DeviceSFNCVersionMinor	Integer		RW	Minor version of SFNC used in XML.
DeviceSFNCVersionSubMinor	Integer		RW	Subminor version of SFNC used in XML.
DeviceReset	Command		WO	Resets device to power-up state.
CameraHeadReset	Command		RW	Resets camera circuitry. USB3 does not reset. Note: After camera reset, issue a

Parameter Name	Type	Value	Access	Description
				UserSetLoad command.
CurrentSpeed	Enumeration	String Numeric HighSpeed 4 SuperSpeed 8	RO	Indicates the speed of the current USB connection.
CurrentTemperature	Integer		RW	Returns current camera temperature*****.

*****Current Temperature returns a two's complement number. The range is +127C to -128C. 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

The camera contains non-volatile memory that stores manufacturing related information. This factory programs this information during the manufacturing process.

Parameter Name	Type	Value	Access	Description
SensorType	Enumeration	String Numeric "Monochrome" 0 "Bayer" 1	RW	Returns the CMOS sensor type.
FirmwareImage	Integer		RW	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.
XmlVersion	Integer		RO	Returns the version of the XML file.

3.4.3 Image Format Control

Parameter Name	Type	Value	Access	Description
SensorWidth	Integer		RO	Effective width of sensor in pixels.

Parameter Name	Type	Value	Access	Description
SensorHeight	Integer		RO	Effective height of sensor in pixels.
WidthMax	Integer		RO	Max. width of image in pixels calculated after horizontal binning, decimation, or other function.
HeightMax	Integer		RO	Max. height of image in pixels calculated after vertical binning, decimation, or other function.
Width	Integer	Min: 256 Max: WidthMaxReg	RW	Represents actual image output width (in pixels).
Height	Integer	Min: 2 Max: HeightMaxReg	RW	Represents actual image output (in lines).
OffsetX	Integer	Min: 0 Max: OffsetX_MaxExpr	RW	Horizontal offset from origin to region (area) of interest (in pixels).
OffsetY	Integer	Min: 0 Max: 5120	RW	Vertical offset from origin to region (area) of interest (in pixels).
PixelFormat	Enumeration	String / Numeric "Mono8" 0x01080001 "Mono10" 0x01100003 "Mono10p" 0x010A0046 "BayerRG8" 0x01080009 "BayerRG10" 0x0110000D "BayerRG10p" 0x010A0058	RW	Indicates pixel format of the output data.
PixelSize	Enumeration	String "Bpp8" "Bpp10"	RO	Indicates bits per pixel.
AveragingMode	Enumeration	String / Numeric "Off" 0 "Horizontal" 1 "Vertical" 2 "BothDirections" 3	RW	Sets averaging mode.
SubsamplingMode	Enumeration	String / Numeric	RW	Sets subsampling mode.

Parameter Name	Type	Value	Access	Description
		"Off" 0 "Horizontal" 1 "Vertical" 2 "BothDirections" 3		
PixelClockInfo	Integer		RO	Current pixel clock frequency in MHz.
TestPattern	Enumeration	String "Off" "GreyHorizontalRamp" "GreyVerticalRamp" "GreyHorizontalRampMoving" "GreyVerticalRampMoving" "CrossHair"	RW	Selects type of test pattern generated by device as image source.

3.4.4 Acquisition Control

Parameter Name	Type	Value	Access	Description
AcquisitionStart	Command		WO	Starts device acquisition.
AcquisitionStop	Command		WO	Stops acquisition at end of the current frame.
AcquisitionAbort	Command		WO	Aborts acquisition immediately. Ends capture without completing current frame or waiting on trigger.
ExposureMode	Enumeration	String Numeric "Off" 0 "TriggerWidth" 1 "Timed" 2	RW	Sets operation mode of exposure. (Trigger must be enabled to use TriggerWidth).
ExposureTime	Float	Min: ExposureMinExpr Max: ExposureMaxExpr	RW	Sets exposure time in microseconds.
AcquisitionFrameRateEnable	Boolean		RW	Sets acquisition frame rate (in Hz).
AcquisitionFrameTime	Integer	Min: Frame_MinFrameTimeReg Max: 1000000	RW	Sets frame time in microseconds.
AcquisitionFrameRate	Float	Min: 0.9999999 Max: FrameRateMaxExpr	RW	Controls acquisition rate (in

Parameter Name	Type	Value	Access	Description
				Hz) of frames captured.
PixelClock	Integer	Min: 32 Max: PixelClockMaxReg	RW	Sets pixel clock in MHz.
CurrentExposureTime	Integer		RO	Returns current exposure time in microseconds.
CurrentFrameTime	Integer		RO	Returns current frame time in microseconds.
MinMaxExposureTime	Integer	40 µs min up to 1 frame time in 1µs increments	RO	Returns exposure min (1 byte)/max (3 bytes) time in microseconds (Hexadecimal).
TriggerMode	Enumeration	String Numeric "Off" 0 "On" 1	RW	Enables the trigger mode of operation.
TriggerSoftware	Command		WO	Generates internal trigger. TriggerSource must be set to Software.
TriggerSource	Enumeration	String Numeric "IN1" 0 "IN2" 1 "PulseGenerator" 4 "Software" 5	RW	Specifies internal signal or external input as trigger source. Selected trigger must have TriggerMode set to On.
TriggerActivation	Enumeration	String Numeric "RisingEdge" 0 "FallingEdge" 1	RW	Specifies activation edge of trigger.
TriggerDebounce	Enumeration	String Numeric "Disabled" 0 "TenMicroSeconds" 1 "FiftyMicroSeconds" 2 "OneHundredMicroSeconds" 3 "FiveHundredMicroSeconds" 4 "OneMilliSecond" 5 "FiveMilliSeconds" 6 "TenMilliSeconds" 7	RW	Specifies debounce period of the trigger signal.

Parameter Name	Type	Value	Access	Description
TriggerDelay	Integer	Min: 0 Max: 1000000	RW	Specifies the delay time in microseconds between the trigger pulse and start of exposure.

3.4.5 Transport Layer Information

USB3, SIRM

Parameter Name	Type	Value	Access	Description
PayloadSize	Integer		RO	Provides number of bytes transferred for each image on stream channel, including any end-of-line, end-of-frame statistics or other stamp data.
SI_Info	Integer		RO	SI_Info.
SI_Control	Integer		RO	SI_Control.
SI_Required_Payload_Size	Integer		RO	SI_Required_Payload_Size.
SI_Required_Leader_Size	Integer		RO	SI_Required_Leader_Size.
SI_Required_Trailer_Size	Integer		RO	SI_Required_Trailer_Size.
SI_Maximum_Leader_Size	Integer		RO	SI_Maximum_Leader_Size.
SI_Payload_Transfer_Size	Integer		RO	SI_Payload_Transfer_Size.
SI_Payload_Transfer_Count	Integer		RO	SI_Payload_Transfer_Count.
SI_Payload_FinalTransfer1_Size	Integer		RO	SI_Payload_FinalTransfer1_Size.
SI_Payload_FinalTransfer2_Size	Integer		RO	SI_Payload_FinalTransfer2_Size.
SI_Maximum_Trailer_Size	Integer		RO	SI_Maximum_Trailer_Size.

3.4.6 Gain Control

Parameter Name	Type	Value	Access	Description
AnalogGain	Enumeration	String — Numeric "Gain_1.0x" (0dB) — 0 "Gain_1.26x" (2 dB) — 1 "Gain_1.87x" (5.43dB) — 2 "Gain_3.17x" (10dB) — 3	RW	Controls analog gain.
BlackLevelAuto	Enumeration	String — Numeric "Off" — 0	RW	Enables automatic black level adjustment.

Parameter Name	Type	Value	Access	Description
		"Continuous" 1		
BlackLevel	Float	Min: -511 Max: 511	RW	Sets analog black level (DC offset) as an absolute physical value with BlackLevelAuto 'off.'
DigitalGain	Float	Min: 1.0 Max: 15.9	RW	Controls digital gain from 1x to 15.9x.
DigitalGainRaw	Integer	Digital gain from 1.0 to 15.9x in steps of 0.00097x.	RW	See Section 4.6.5.
DigitalOffset	Integer	Min: -512 Max: 511	RW	Applies a digital offset.

3.4.7 Auto Gain and Auto Exposure

AGC and AEC Controls

Parameter Name	Type	Value	Access	Description
GainAuto	Enumeration	**String** **Numeric** "Off" 0 "Continuous" 1	RW	Enables automatic gain control (AGC) mode.
AgcGainMin	Float	Min: 1.0 Max: AgcGainMax	RW	Sets min. digital gain value for AGC as a multiplication factor in increments of 0.01x.
AgcGainMinRaw	Integer	Gain increment is 0.00097x from 1.0 to 15.9x	RW	Sets min. digital gain value for AGC mode in RAW units. (See Section 4.6.5 Digital Gain Raw).
AgcGainMax	Float	Min: 1.0 Max: 15.9	RW	Sets max. digital gain value for AGC as a multiplication factor in increments of 0.01x.
AgcGainMaxRaw	Integer	Gain increment is 0.00097x from 1.0 to 15.9x	RW	Sets max. digital gain value for AGC mode in RAW units. See Section 4.6.5.
ExposureAuto	Enumeration	**String** **Numeric** "Off" 0	RW	Enables automatic exposure control (AEC) mode.

Parameter Name	Type	Value	Access	Description
		"Continuous" 1		
AecExposureMin	Integer		RW	Sets min. exposure time value for AEC in micro-seconds.
AecExposureMax	Integer		RW	Sets max. exposure time value for AEC in micro-seconds.
AgcAecLuminanceLevel	Integer		RW	Sets luminance level up to 4095 counts.
AgcAecLuminanceType	Enumeration	**String** **Numeric** "Average" 0 "Peek" 1	RW	Sets the luminance mode to be used during AGC or AEC.

Status

Parameter Name	Type	Value	Access	Description
AgcGainCurrentValue	Float		RO	Displays current value of digital gain in AGC mode as a multiplication factor of x times.
AgcGainCurrentValueRaw	Integer		RO	Displays max. digital gain value for AGC mode in RAW units.
AgcMinLimitReached	Integer		RO	Returns 1 if min. digital gain limit was reached or 0 if not reached during AGC operation.
AgcMaxLimitReached	Integer		RO	Returns 1 if max. digital gain limit was reached or 0 if not reached during AGC operation.
AecExposureCurrentValue	Integer		RO	Displays current value of exposure in microseconds in AEC mode.
AecMinLimitReached	Integer		RO	Returns 1 if min. exposure limit was reached or 0 if not reached during AEC operation.
AecMaxLimitReached	Integer		RO	Returns 1 if max. exposure limit was reached or 0 if not

				reached during AEC operation.
CurrentAvgOrPeakLuminance	Integer			Returns current average or peak luminance in counts.

3.4.8 Data Correction

Parameter Name	Type	Value	Access	Description
LUTSelector	Enumeration	String Numeric "LUT1" 0 "LUT2" 1	RW	Selects LUT to be used in processing image.
LUTEnable	Boolean		RW	Activates selected LUT.
FFCSelector	Enumeration	String Numeric "FFC1" 0 "FFC2" 1	RW	Selects FFC to be used in processing image.
FFCEnable	Boolean		RW	Activates selected FFC.
FixedPatternNoiseCorrection	Enumeration	String Numeric "Off" 0 "On" 1	RW	Enables Fixed Pattern Noise Correction.
DefectPixelCorrection	Enumeration	String Num "Off" 0 "Static" 1 "Dynamic" 2 "Both" 3	RW	Enables Defective Pixel Correction.
DefectPixelThreshold	Integer	Min: 0 Max: 4095	RW	Sets threshold for Defect Pixel Correction algorithm.
HotPixelCorrection	Enumeration	String Num "Off" 0 "Static" 1 "Dynamic" 2 "Both" 3	RW	Enables Hot Pixel Correction.
HotPixelThreshold	Integer	Min: 0 Max: 4095	RW	Sets threshold for Hot Pixel Correction algorithm.

3.4.9 White Balance

Parameter Name	Type	Value	Access	Description
BalanceWhiteAuto	Enumeration	String / Numeric "Off" 0 "Once" 1 "Continuous" 2 "Manual" 3	RW	Controls the camera white balance. Options 1 and 2 calculate color coefficients automatically.
RedCoefficient	Integer	Min: 0 Max: 4095	RW	Manually sets white balance coefficient for red channel.
GreenCoefficient	Integer	Min: 0 Max: 4095	RW	Manually sets white balance coefficient for green channel.
BlueCoefficient	Integer	Min: 0 Max: 4095	RW	Manually sets adjusted white balance coefficient for blue channel.
AutoTrackingSpeed	Enumeration	String / Numeric "x1" 0 "x2" 1 "x3" 2 "x4" 3 "x5" 4	RW	Controls speed of auto white balance update rate: x1=slowest x5=fastest.

3.4.10 Strobe

OUT1

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

OUT2

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

Strobe

Parameter Name	Type	Value		Access	Description
Strobe1Mode	Enumeration	String "Off" "On"	Numeric 0 1	RW	Enables/disables Strobe 1.
Strobe1Reference	Enumeration	String "ExposureStart" "ReadoutStart"	Numeric 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 Strobe 1 delay from reference in microseconds.
Strobe2Mode	Enumeration	String "Off" "On"	Numeric 0 1	RW	Enables/disables Strobe 2.
Strobe2Reference	Enumeration	String "ExposureStart" "ReadoutStart"	Numeric 0 1	RW	Sets reference point for Strobe 2.
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.

3.4.11 Pulse Generator

Parameter Name	Type	Value	Access	Description
PulseGenGranularity	Enumeration	String / Numeric "x1uS" 0 "x10uS" 1 "x100uS" 2 "x1000uS" 3	RW	Sets the multiplication factors of the Pulse Generator where x1 = 1µS, x10 = 10 µS, and so on.
PulseGenWidth	Integer	Min: PulseGenMin Max: PulseGenWidthMax	RW	Sets pulse width of Pulse Generator where each unit is equal to PulseGenGranularity.
PulseGenPeriod	Integer	Min: PulseGenMin Max: PulseGenPeriodMax	RW	Sets pulse period of Pulse Generator where each unit is equal to PulseGenGranularity.
PulseGenNumPulses	Integer	Min: 1 Max: 65535	RW	Sets number of pulses to be generated by Pulse Generator.
PulseGenMode	Enumeration	String / Numeric "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.

3.4.12 Canon Lens Control

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

Parameter Name	Type	Value		Access	Description
LensClockPolarity	Enumeration	String "Negative" "Positive"	Numeric 0 1	RW	Sets polarity of Lens Clock

3.4.13 Canon Lens Control - Focus

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 by amount defined in FocusStepValue feature.
NearStep	Command		WO	Drives focus one step toward Near 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.

3.4.14 Canon Lens Control - Iris

Parameter Name	Type	Value		Access	Description
CurrentIrisPosition	Enumeration	String "F0_7" "F0_8" "F0_9" "F1_0" "F1_1" "F1_2" "F1_4" "F1_6" "F1_8"	Numeric 0 1 2 3 4 5 6 7 8	RO	Returns current iris position.

Parameter Name	Type	Value		Access	Description
		"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		
		"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.
OpenIrisFull	Command			WO	Opens iris to fully opened position.
CloseIrisStep	Command			WO	Closes iris one step by amount defined in the IrisStepValue feature.
OpenIrisStep	Command			WO	Opens iris one step by 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.

Parameter Name	Type	Value	Access	Description
GetIrisRange	Command		WO	Get Iris Range and stores the values in IrisRange register.
IrisMin2	Integer		RW	Minimum value of iris for varifocal lens only. For fixed focal lens, Min1 = Min2. For varifocal lens, Min1=Min2 for lowest and highest value of the lens.
IrisMin1	Integer		RW	Minimum value of iris for fixed and varifocal lenses.
IrisMax	Integer		RW	Returns max. iris limit.
IrisRange	Integer		RO	Displays limit values of iris after GetIrisRange command issued.
GetLensStatus	Command		WO	Requests value of Lens Status register.
LensStatus	Integer		RO	Returns status of Lens after GetLensStatus runs. For test purposes and internal usage only.

3.4.15 Event Control

Parameter Name	Type	Value	Access	Description
EventTest	Integer		RO	Returns unique ID of test event.
EventTestTimestamp	Integer		RO	Returns timestamp of test event.
TriggerEventTest	Command		WO	Generates test event if event channel is enabled.
GP_INPUT_EventEnable	Integer		RW	Enables general purpose IN1/IN2 events.
GP_OUTPUT_EventEnable	Integer		RW	Enables general purpose OUT1/OUT2 events.
Image_ACQ_EventEnable	Integer		RW	Enables image acquisition events.

3.4.16 User Set Control

Parameter Name	Type	Value	Access	Description
UserSetSelector	Enumeration	String / Numeric "Default" 0 "UserSet0" 1 "UserSet1" 2	RW	Selects User Set to load or save.
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 / Numeric "Default" 0 "UserSet0" 1 "UserSet1" 2	RW	Selects User Set to load and activate when device is powered on or reset.

4 Software GUI

4.1 Overview

The IpxPlayer configurator software application provides a graphical user interface (GUI) with functionality for controlling Imperx camera parameters, acquiring video, showing acquired video, and saving acquired images or video on the host computer.

The application also collects and displays statistical information on acquired images and generates a log of data transfers between the camera and the host computer.

4.1.1 Supported Operating Systems

The IpxPlayer is compatible with the following operating systems:

- Windows 7, 32-bit and 64-bit
- Windows 8, 32-bit and 64-bit
- Windows 10, 32-bit and 64-bit
- Linux

4.1.2 Compatibility

The IpxPlayer is compatible with Imperx USB3 cameras.

4.1.3 User Interface and Functionality

The IpxPlayer provides the following functionalities:

- Detects camera.
- Connects to the camera and will run multiple instances of applications.
- Controls camera parameters (gain, exposure, trigger, white balance, and so on) using the GenICam node tree GUI.
- Logs all protocol-related data (commands, images, events, and so on) transferred between the camera and host computer.
- Shows live video from the selected camera.
- Saves acquired video images or series of images to files.
- Saves and loads camera configuration files.

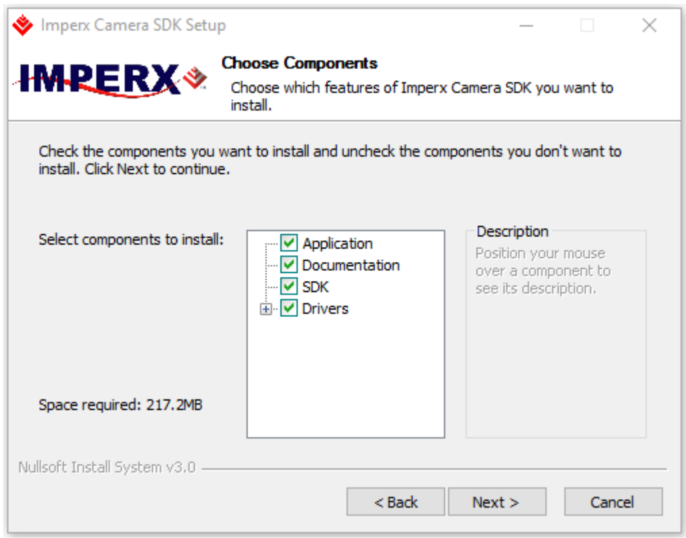
4.2 Software Installation

The Imperx Camera SDK installer ships with the camera. Locate the executable file (IpxCameraSdk_x_x_x_xxxx.exe) and copy it to your computer before installing the application.

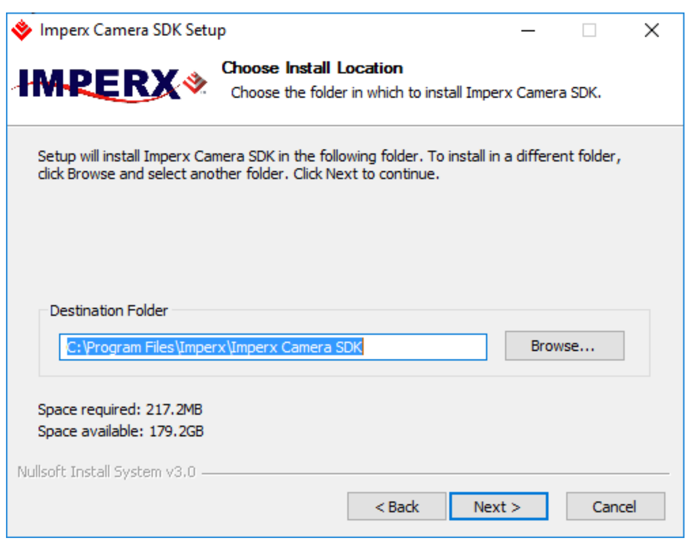
4.2.1 Installing the Imperx Camera SDK Software

Prior to installation, close any software applications and files currently open on your computer. The installation process requires rebooting your computer to complete.

1. Locate the Imperx Camera SDK executable file (IpxCameraSdk_x_x_x_xxxx.exe) that you copied to your computer.
2. Double click the file to begin installation.
3. When the Open File screen appears, click **Run**.
4. After the Welcome screen appears, click **Next**.
5. Read the license agreement and click **I Agree** to accept the terms. The Choose Components screen appears.



1. Select all components to install and click **Next**. The Choose Install Location screen appears.



2. Accept the destination folder or browse for a different location, then click **Next**.

3. Click **Install**. The installer will offer to restart your computer to complete the installation.

4.3 Camera SDK

The installation process places the Imperx Camera SDK files on your computer's hard drive using following structure:

<InstallationFolder> - root SDK folder (usually, on the Windows OS, it is C:\Program Files\Imperx\Imperx Camera SDK\).

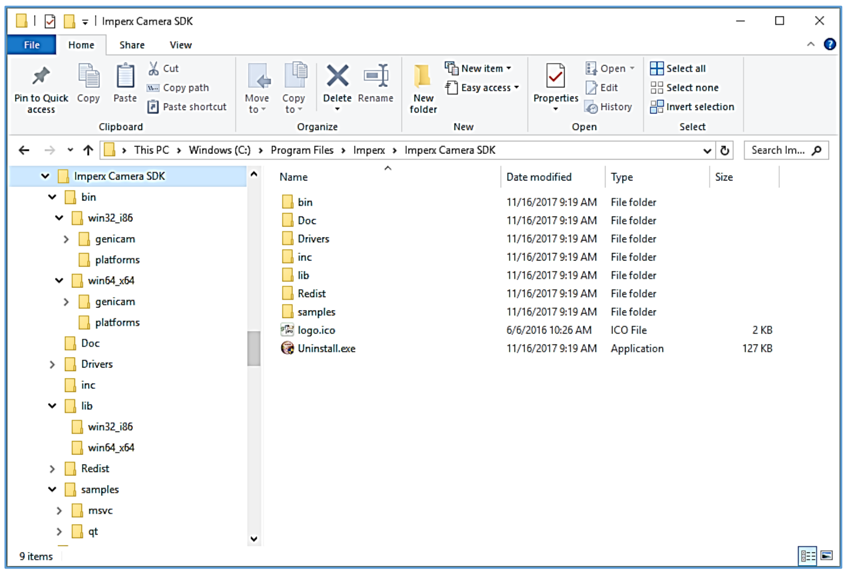


Figure 13: Imperx Camera SDK file locations on your computer.

<InstallationFolder> **bin**\ – contains SDK binary executable files, including SDK dynamic libraries and IpxPlayer application executable
<InstallationFolder> **Doc**\ - contains SDK user manual files
<InstallationFolder> **inc**\ - contains SDK C++ header files
<InstallationFolder> **lib**\ - contains SDK C++ library files
<InstallationFolder> **samples**\ - contains SDK C++ samples
<InstallationFolder> **Drivers**\ - contains kernel drivers for Imperx USB3 cameras

4.4 Connecting to Cameras

The installation process places a shortcut to the IpxPlayer application on your computer desktop. Launch the application by double clicking the shortcut. The first task is to connect to a camera.

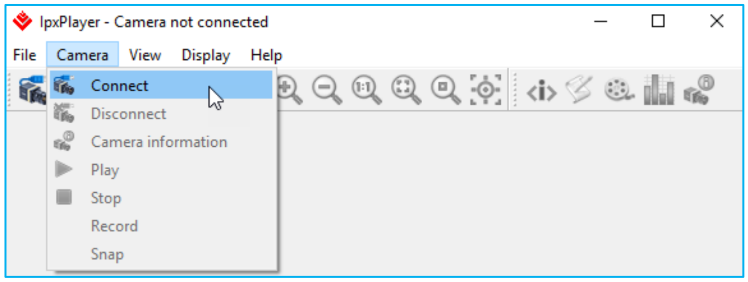


Figure 14: Connecting to a camera.

To connect to a camera:

1. Locate and open the IpxPlayer from the shortcut on your desktop.
2. Click the camera **icon**. Alternatively, click **Camera** menu and select **Connect**.
    a. The Select Camera dialog appears.
    b. The dialog lists all connected cameras.
    c. The version number refers to the installed Imperx GUI driver.
3. Select a camera listed on the dialog. Camera information appears in the Device info section of the dialog.

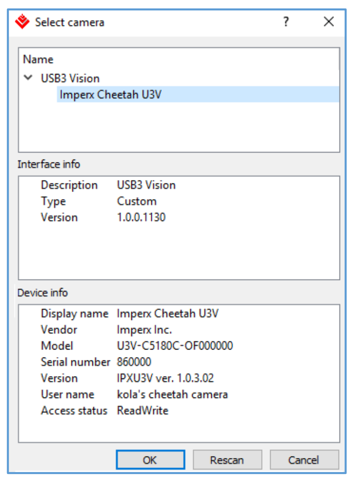


Figure 15: Select Camera dialogue.

4. Click **OK**. If needed, click **Rescan** to update the list of cameras.

After connecting a camera, click the play icon ▶ on the IpxPlayer to begin capturing and displaying images.

4.5 Using the IpxPlayer

The IpxPlayer displays and controls camera features and attributes based on an XML file stored in Flash memory inside the camera. The main window provides access to menus, shortcut icons, camera parameters, live images, capture options, a log, and camera statistics. You can customize the screen by closing, resizing, or hiding certain sections. Click **Log** at the bottom of the screen to see recent data transfers to or from the connected camera.

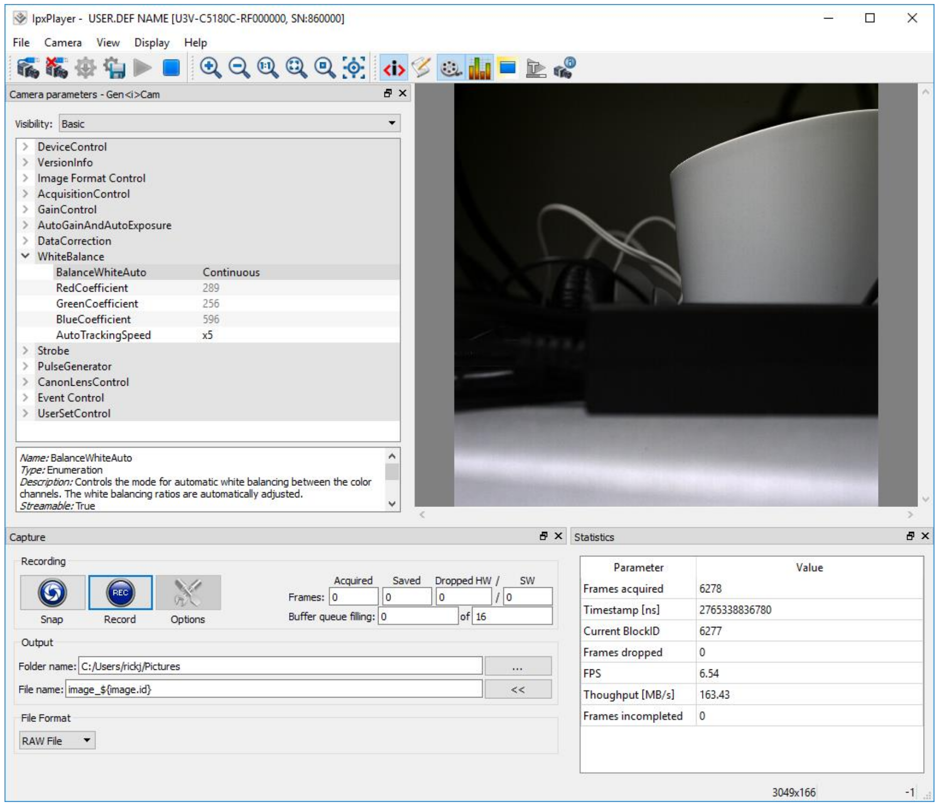


Figure 16: IpxPlayer main window.

4.5.1 Menu Bar

The menu bar provides File, Camera, View, and Display options. Icons below the menu bar provide quick access to many of the menu bar functions. You can display an icon's function by rolling the computer cursor over it.

4.5.1.1 File Menu

Load Configuration		Opens the Open File dialog for loading a Camera Configuration file.
Save Configuration		Saves changes to an opened configuration file.
Save Configuration As		Opens the Save File dialog for saving the Camera Configuration file with a user-specified file name.
Exit		Closes the application.

4.5.1.2 Camera Menu

Connect		Opens the Connection dialog for connecting to a camera.
Disconnect		Disconnects the camera.

Camera Information		Displays Camera Information including model, version, sensor type, firmware version, XML version, and so on.
Play		Starts live video.
Bandwidth testing		Finds the optimal PixelClock value for a given interface bandwidth.
Stop		Stops live video.
Record		Toggles video recording using two states: blue is inactive recording, red is active recording.
Snap		Captures one image and saves it to the computer's hard drive.

4.5.1.3 View Menu Functions

GenICam Tree		Shows/hides the camera control GenICam tree panel.
Log		Shows/hides the camera control Log panel (Control, Stream, Events).
Capture		Shows/hides the Capture panel.
Statistics		Shows/hides the Statistics panel.

4.5.1.4 Display Menu Functions

Zoom IN		Increases the zoom by 25 percent around the center of the image when clicked.
Zoom OUT		Decreases the zoom by 25 percent around the center of the image when clicked.
Actual Size (100%)		Sets zoom to 1:1 in the center of the image.
Fit to Window		Scales the image to fit within the window height while maintaining aspect ratio.
Spread to Window		Scales the image width to fit across the display window while maintaining the image aspect ratio.
Center Image		Moves the center of the image to the center of display window.

4.6 Saving / Loading Configurations

The File menu provides a Save As function for configuration changes made in the camera parameters section of the screen. Saved configurations on the host computer have the `.iccf` file extension.

You can share these files with other users by email and other file transfer methods. You can load saved configurations into the IpxPlayer at any time.

To save a configuration:

1. Select the **File** menu.
2. Select Save Configuration as.
3. Navigate to location on your host computer.
4. Create a file name.
5. Click **Save**.

To load a configuration:

1. Select the **File** menu.
2. Select Load Configuration.
3. Navigate to the folder containing the file.
4. Click **Open**.

4.7 Camera Parameters Panel

The GenICam node tree displays the camera's available configuration parameters. Use Visibility drop-down to select an access level of Basic, Expert, or Guru.

4.7.1 Device Controls

This node provides information about the camera:

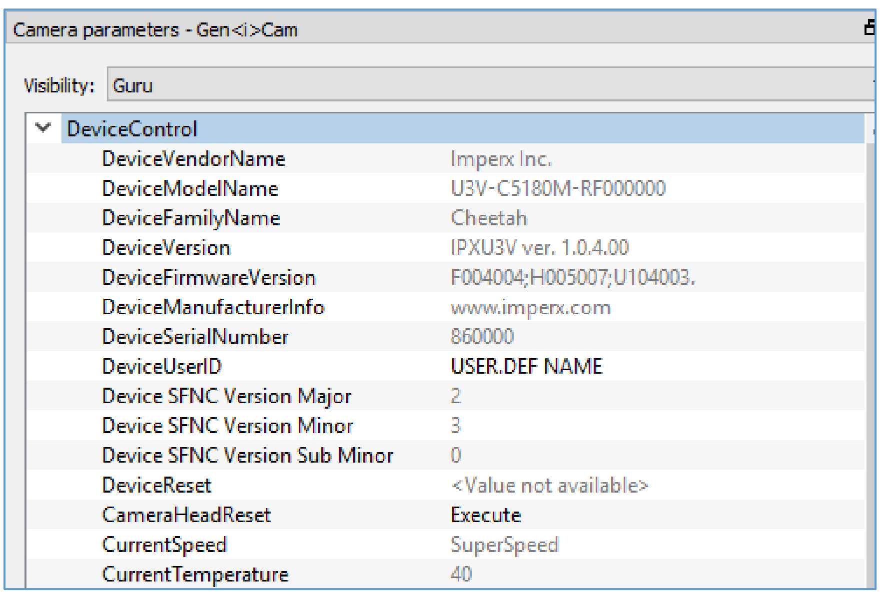


Figure 17: Device control parameters.

DeviceVendorName: Imperx, Inc.

DeviceModelName: Full camera part number.

DeviceFamilyName: Camera Family category, e.g. Cheetah.

DeviceVersion: Camera Hardware version.

DeviceFirmwareVersion: Firmware version loaded in camera.

DeviceManufactureInfo: Imperx website.

DeviceSerialNumber: Camera serial number.

DeviceUserID: User-defined camera name.

Device SFNC Version Major: The major version number of the GenICam Standard Features Naming Convention.

Device SFNC Version Minor: The minor version number of the GenICam Standard Features Naming Convention.

Device SFNC Version Sub Minor: The sub major version number of the GenICam Standard Features Naming Convention.

DeviceReset: Resets the entire camera, including communications.

CameraHeadReset: Resets only the image sensor to default. The USB3 interface does not reset.

Current Speed: Indicates speed of current USB connection.

Current Termperature: Returns the current camera temperature.

4.7.2 Version Info Controls

The camera contains non-volatile memory that stores manufacturing related information. The factory programs this information during the manufacturing process.

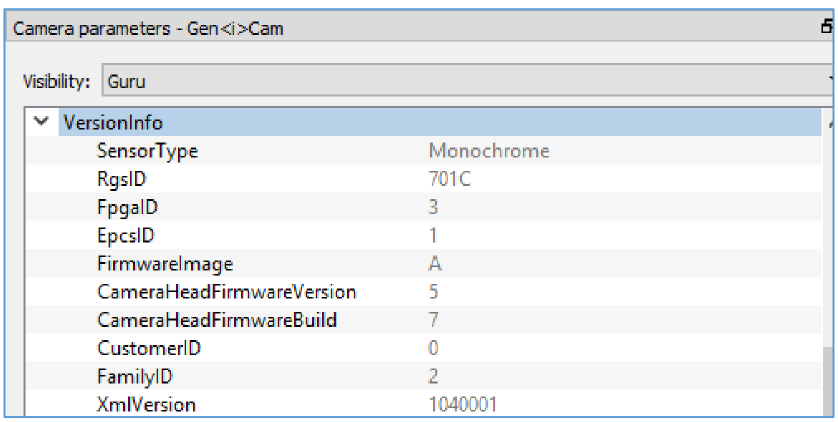


Figure 18: Version info parameters.

SensorType: Returns the CMOS sensor type: Bayer Color, Monochrome or Monochrome Enhanced NIR.

RgsID: The camera's register ID number.

FpgaID: Shows the field-programmable gate array (FPGA) ID (0=EP4C25, 1=EP4C40, 3=5CEFA4).

EpcsID: Shows the EPCS ID (0=EPCS16, 1=EPCS64, 2=EPCS128).

FirmwareImage: The Firmware Image ID (F=Factory or A=Application).

CameraHeadFirmwareVersion: The Firmware version number.

CameraheadFirmwareBuild: The Firmware build number.

CustomerID: The Customer ID for custom firmware (0=Imperx standard firmware).

FamilyID: The Family ID.

XmlVersion: The version of the XML file.

4.7.3 Image Format Controls

Provides information on the camera base resolution and output resolution.

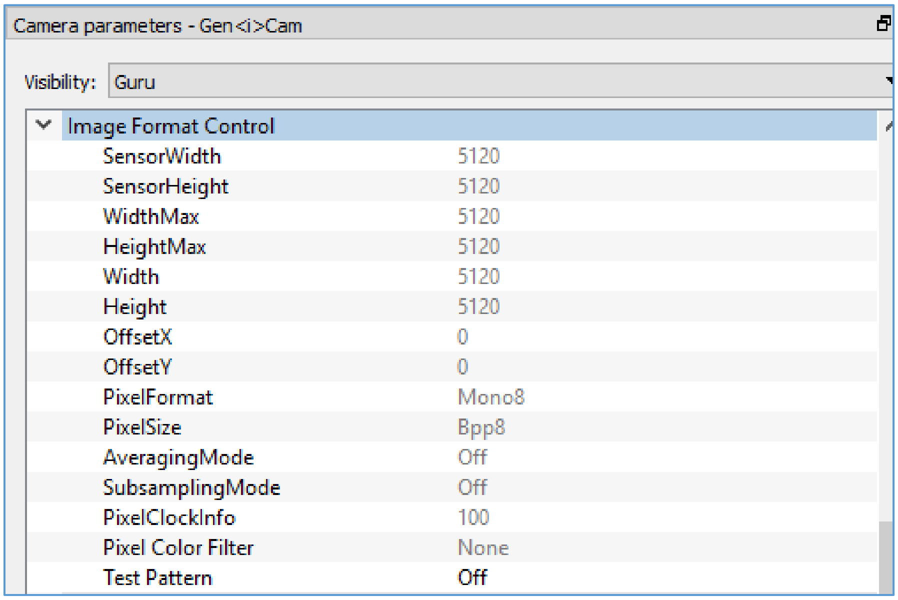


Figure 19: Image format control parameters.

SensorWidth: Horizontal resolution of the image sensor in pixels.

SensorHeight: Vertical resolution of the image sensor in pixels.

WidthMax: Maximum width of the image in pixels calculated after horizontal averaging, decimation, or any other functions change horizontal dimension of image.

HeightMax: Maximum height of image in pixels calculated after vertical averaging, or decimation, or any other functions change vertical dimension of image.

Width: Allows you to set the output image width in number of pixels (multiples of 8 and minimum width is 320).

Height: Allows you to set the output image height in number of lines (multiples of 2 and minimum height is 2 rows).

OffsetX: Enter a number of pixels to offset the image output from the edge of the image sensor. The number must be a multiple of 8.

OffsetY: Enter a number of pixels to offset the image output from the top of the image sensor.

PixelFormat: Options are: Mono8, Mono10, Mono10p, BayerRG8, BayerRG10, and BayerRG10p. The Mono10P (10-bit packed) option enables efficient USB communications and increased frame rates.

PixelSize: Pixel bit depth. For example, 10 bits unpacked requires 16 bits per pixel whereas 10 bits packed requires 10 bits per pixel.

AveragingMode: Uses the average of several adjacent pixels to reduce image resolution. You cannot apply averaging and subsampling simultaneously.

SubsamplingMode: Sets the Subsampling decimation with a “skip one, keep one” algorithm in either horizontal, vertical, or both directions. Options are Off, Horizontal, Vertical, and Both Directions (5.4 Subsampling).

PixelClockInfo: Reports the current pixel clock frequency in MHz.

PixelColorFilter: Indicates type of color filter pattern applied to the image. The default for Python cameras is RG (read-green).

TestPattern: Enables the following test patterns: GreyHorizontalRamp, GreyVerticalRamp, GreyHorizontalRampMoving, GreyVerticalRampMoving, and CrossHair.

4.7.4 Acquisition Control

Acquisition Control determines the data flow between the camera and the computer. After starting acquisition, data moves through the USB3 interface from the camera to the computer. After acquisition stops or aborts, the transfer across the USB3 interface stops. There is currently only one acquisition mode supported.

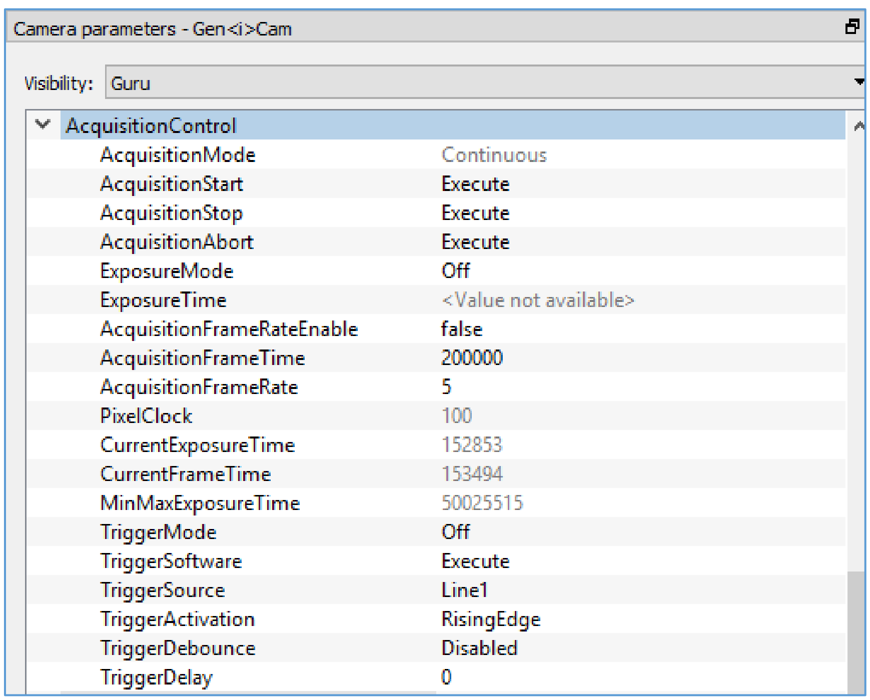


Figure 20Acquisition control parameters.

AcquisitionMode: USB3 supports only the Continuous mode.

AcquisitionStart: Starts the acquisition of the device.

AcquisitionStop: Stops the acquisition of the device at the end of the current frame.

AcquisitionAbort: Aborts acquisition immediately without completing the current frame or waiting on a trigger. If acquisition is not in progress, command is ignored.

ExposureMode: Sets the operation mode of the exposure. Options are:

- Off – the exposure is free running.
- Triggerwidth – uses an external pulse to control exposure. The trigger pulse width (duration) determines the exposure subject to limitations. (TriggerMode must be set to “ON.”)
- Timed - uses the value specified in the ExposureTime parameter field to determine exposure.

ExposureTime: Sets the exposure time in microseconds when Exposure Control is set to Timed. The maximum exposure time is equal to the frame period. For longer exposure times, increase the frame period using the Acquisition Frame Time feature.

AcquisitionFrameRateEnable: Controls the acquisition frame rate. If this mode is On, you can extend frame time beyond the free-running frame time lowering the frame rate.

AcquisitionFrameTime: Allows you to set the actual frame time in microseconds. Changes to Acquisition Frame Time affect the Acquisition Frame Rate setting (5.2.1.2 Frame Time Control).

AcquisitionFrameRate: Allows you to set the acquisition frame rate (in Hz with a precision of 0.01 Hz) (5.2.1 Internal Line and Frame Time Control and 5.3.3 Factors Impacting Frame Rate). Changes to Acquisition Frame Rate affect the Acquisition Frame Time setting.

PixelClock: Defines how fast the camera outputs pixel data. Decreasing the pixel clock rate allows you to match the camera USB3 output rate to the computer capture rate. Increasing the pixel clock rate increases the camera output rate (5.2.1.1 Pixel Clock Rate Control).

CurrentExposureTime: This is a read-only feature providing a real-time monitor of the camera exposure time in micoseconds.

CurrentFrameTime: This is a read-only feature providing a real-time monitor of the camera output period in mico-seconds.

MinMaxExposureTime: Describes the minimum allowable (first byte) and maximum allowable (last 3 bytes) exposure times for Timed exposures.

TriggerMode: Enables or disables the triggering operation.

TriggerSoftware: The Start SW Trigger command instructs the camera to generate one short trigger pulse to capture and read out one frame.

TriggerSource: Specifies the internal signal or physical input line to use as trigger source. Options are External Input Line1, External Input Line2, PulseGenerator, and Software (Software is a single frame capture using internal exposure setting). (5.5 Camera Triggering).

TriggerActivation: Selects the triggering edge to Rising or Falling (5.5.2 Acquisition and Exposure Control).

TriggerDebounce: Selects the trigger signal de-bounce time. Subsequent trigger signals coming to the camera within the de-bounce time interval are ignored (5.5.2 Acquisition and Exposure Control).

4.7.5 Gain Controls

These parameters define analog and digital gain controls.

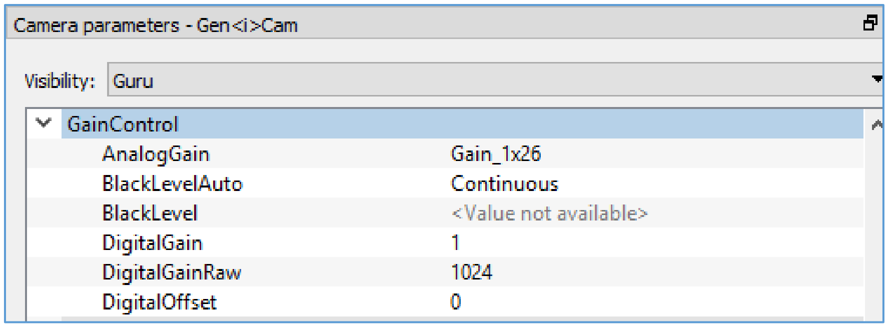


Figure 21: Gain Control.

AnalogGain: Sets the Analog Gain. You can select from 1.0x (0 dB), 1.26x (2 dB), 1.87x (5.4dB) and 3.17x (10dB) gain. Always apply analog gain before digital gain (5.7.1 Analog Gain).

BlackLevelAuto: When set to Continuous, this automatically adjusts the black level based on measurements of the dark reference lines at the start of each frame (5.7.4 Black Level Auto-calibration and Offset).

BlackLevel: Controls the analog black level as an absolute physical value. This represents a DC offset applied to the video signal.

DigitalGain: This feature sets the Digital Gain from 1x to 15.9x in steps of 0.00097x.

DigitalGainRaw: Controls the raw value of digital gain with inputs ranging from 1024 (1x) to 16384 (15.9x). You can control the gain by ~0.00097x per step from 1.0x to 15.9x. To determine the raw value, take the desired gain multiplier, subtract 1.0 then divide by 0.00097 and add 1024 or use the following formula:

1. Raw Value = [(Desired gain – 1)/0.00097]+1024.

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

2. Raw Value = [[[anti-log10(Desired gain/20)]-1]/0.00097]+1024.

For example, desired gain is 7.9x

Raw Value = (17.95 dB). [(7.9 – 1.0)/0.00097] +1024 = 8137 if the desired gain is 6dB, then the code is 2050. Minimum setting is 1024 corresponding to 1x gain.

DigitalOffset: This controls the digital offset for all taps. The offset is a digital count added or subtracted from each pixel. The range is +/- 512 counts.

4.7.6 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 place minimum and maximum limits on auto gain/exposure.

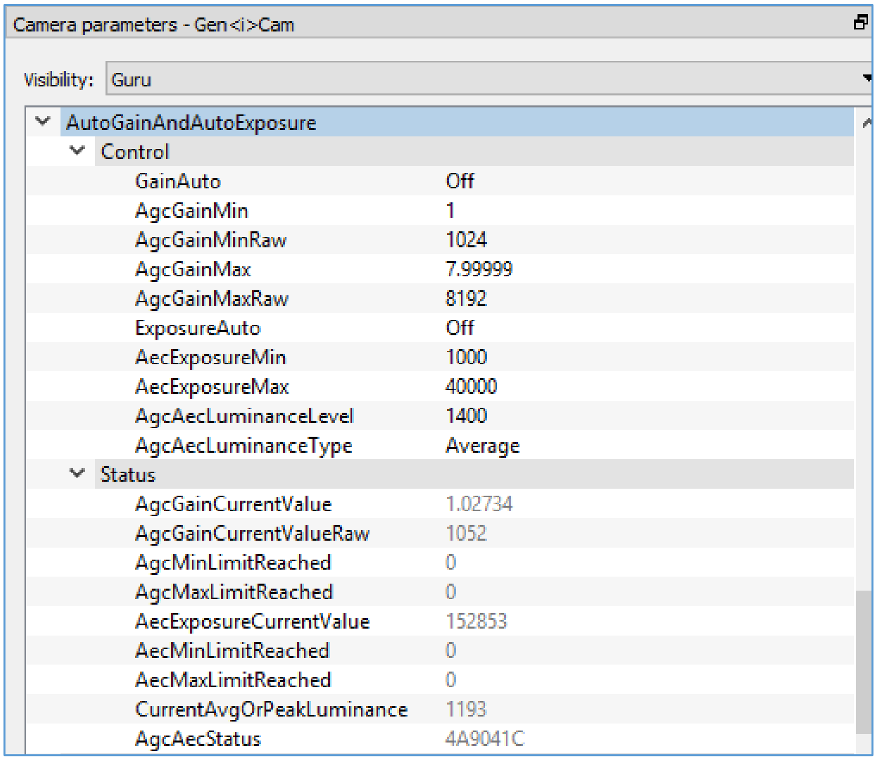


Figure 22: Auto Gain and Auto Exposure.

GainAuto: Enables automatic gain control. When enabled, the camera constantly adjusts gain to achieve the luminance target level.

AgcGainMin: Sets the minimum digital gain (1x to 15.9x).

AgcGainMinRaw: Sets the minimum digital gain in RAW units.

AgcGainMax: Sets the maximum digital gain (1x to 15.9x).

AgcGainMaxRaw: Sets the maximum digital gain in RAW units.

ExposureAuto: Enables automatic exposure control. When enabled, the camera constantly adjusts the exposure to achieve the luminance target.

AecExposureMin: Sets the minimum exposure time value in microseconds

AecExposureMax: Sets the maximum exposure time value in microseconds

AgcAecLuminanceLevel: Sets the desired luminance level to be maintained during AGC or AEC.

AgcAecLuminanceType: Sets how the luminance target is calculated in AGC or AEC. Options are Average or Peak.

AgcGainCurrentValue: Displays current digital gain value calculated in AGC mode.

AgcGainCurrentValueRaw: Displays current digital gain value calculated in AGC mode in RAW units.

AgcMinLimitReached: Returns a value ‘1’ if the minimum digital gain limit was reached while in AGC mode. Otherwise, the value is ‘0.’

AgcMaxLimitReached: Returns a value ‘1’ if the maximum digital gain limit was reached while in AGC mode. Otherwise, the value is zero.

AecExposureCurrentValue: Displays exposure value in microseconds, calculated by the camera in AEC mode.

AecMinLimitReached: Returns a value of ‘1’ if the minimum exposure limit was reached during AEC mode. Otherwise, the value is zero.

AecMaxLimitReached: Returns a value of ‘1’ if the maximum exposure limit was reached during AEC mode. Othersie, the value is zero.

CurrentAvgOrPeakLuminance: Returns the current average or peak luminance.

AgcAecStatus: Internal use only.

4.7.7 Data Correction Controls

These parameters enable data correction and image improvements with Look-up tables and file corrections.

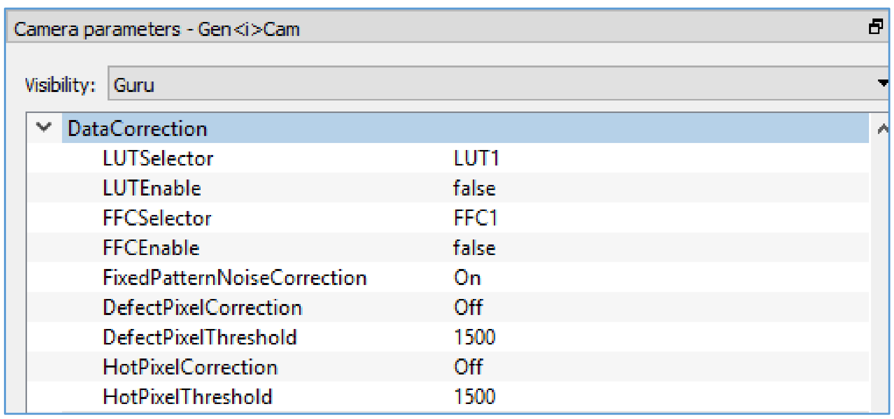


Figure 23: Data correction parameters.

LUTSelector: Selects the lookup table, either LUT1 or LUT2, to use.

LUTEnable: Enables the selected LUT.

FFCSelector: Select either Flat Field Correction, either FFC1 or FFC2.

FFCEnable: Enables Flat Field Correction. Normally, FFC1 should be enabled to minimize Fixed Pattern Noise.

FixedPatternNoiseCorrection: Determines Fixed Pattern Noise Correction allowing you to implement a custom Fixed Pattern Noise (FPN) solution, if desired. Normally, you should enable FPN.

DefectPixelCorrection: Provides the following three modes of correction (5.14 Defective Pixel Correction):

- **Static**: corrects defective pixels using a factory or user-supplied table of defective pixel locations.
- **Dynamic**: corrects defective pixels on the fly (dynamically) based on a user-defined threshold.
- **Both**: applies both Static and Dynamic defective pixel correction (DPC).

DefectPixelThreshold: Sets the threshold for dynamic defective pixel correction. The sensitivity increases as the value decreases.

HotPixelCorrection: Provides the following modes of correction:

- **Static**: corrects hot pixels using a factory or user-supplied table of hot pixel locations.
- **Dynamic**: corrects hot pixels on the fly (dynamically) based on a user-defined threshold.
- **Both**: applies both Static and dynamic hot pixel correction.

HotPixelThreshold: Sets the threshold for dynamic hot pixel correction. The sensitivity of the correction increases as the value decreases.

4.7.8 White Balance Controls

White balance compensates for differences in the color temperature of light sources. The IpxPlayer enables color adjustments that preserve the original color and make white objects appear white (5.12.1 White Balance Correction).

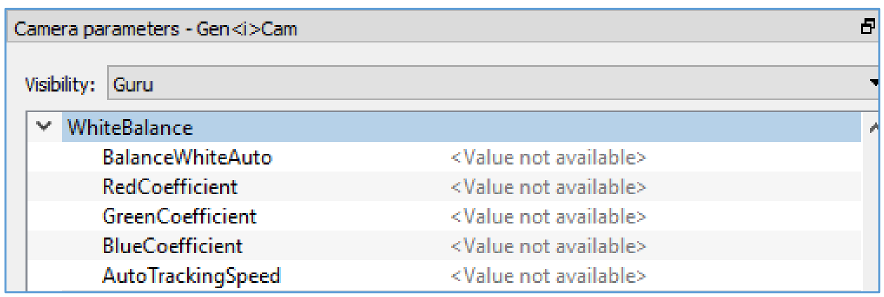


Figure 24: White balance parameter.

BalanceWhiteAuto: Enables selecting the white balance mode and the following options: Off, Once, Auto, or Continuous. In Continuous mode, the camera automatically computes the red, green, and blue coefficients to achieve good color reproduction. In manual mode, you define the coefficients.

RedCoefficient: This register contains the white balance correction coefficients for Red used in manual mode. In manual mode, you enter the value. In Once or Auto modes, the camera returns the actual (calculated) coefficient. Coefficient values range from 0.000 (0 Hex) to +15.996 (FFF Hex) in steps of 0.004 (4096 steps).

GreenCoefficient: This register contains the white balance correction coefficients for Green in manual mode. In manual mode, you enter the value. In Once or Auto modes, the camera returns the actual (calculated) coefficient. Coefficient values range from 0.000 (0 Hex) to +15.996 (FFF Hex) in steps of 0.004 (4096 steps).

BlueCoefficient: This register contains the white balance correction coefficients for Blue in manual mode. In manual mode, you enter the value. In Once or Auto modes, the camera returns the actual (calculated) coefficient. Coefficient values range from 0.000 (0 Hex) to +15.996 (FFF Hex) in steps of 0.004 (4096 steps).

AutoTrackingSpeed: The camera will automatically track the scene and adjust white balance according to five different tracking rates, x1 – x5 (x1 is slowest; x5 is fastest update rate).

4.7.9 Strobe Controls

These registers enable and control the two available strobes. Strobe signals map to one or both of the available strobe outputs (5.6 Strobes).

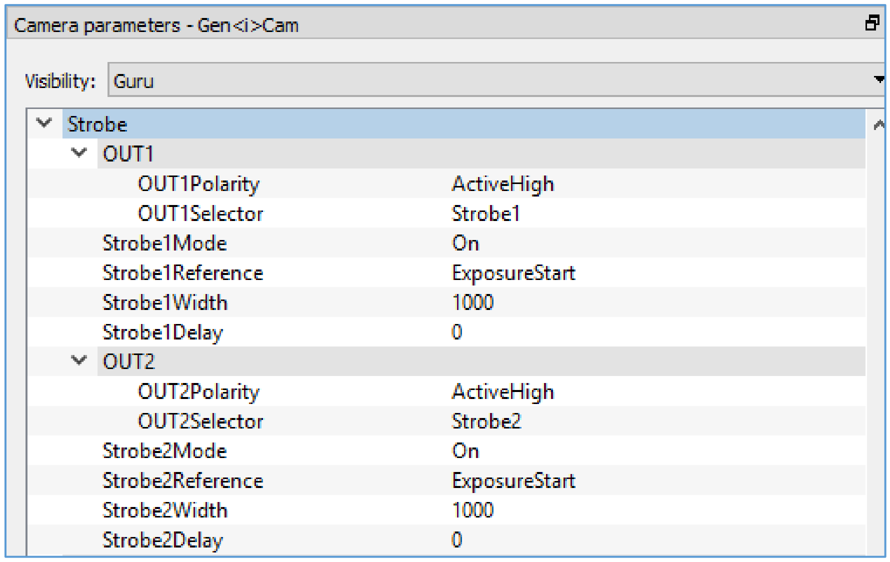


Figure 25: Strobe parameters.

The following descriptions apply equally to Output 1 (OUT1) and Output 2 (OUT2) and Strobe1 and Strobe2.

OUT1Polarity / OUT2Polarity: Sets the OUT1 or OUT2 active logic level to either Active Low or Active High.

OUT1Selector / OUT2Selector: Maps the camera's internal signals: Trigger, Pulse Generator, Strobe 1 or Strobe 2 to OUT1 or OUT2 camera output.

Strobe1Mode / Strobe2Mode: Enables or disables the strobe.

Strobe1Reference / Strobe2Reference: Sets the reference for the strobe to either the start of exposure or start of image readout.

Strobe1Width / Strobe2Width: Sets the strobe pulse duration in microseconds.

Strobe1Delay / Strobe2Delay: Sets the strobe delay from the selected Reference in microseconds.

4.7.10 Pulse Generator Controls

The Pulse Generator provides control over the camera's internal pulse for generating trigger or output signals (5.9 Pulse Generator).

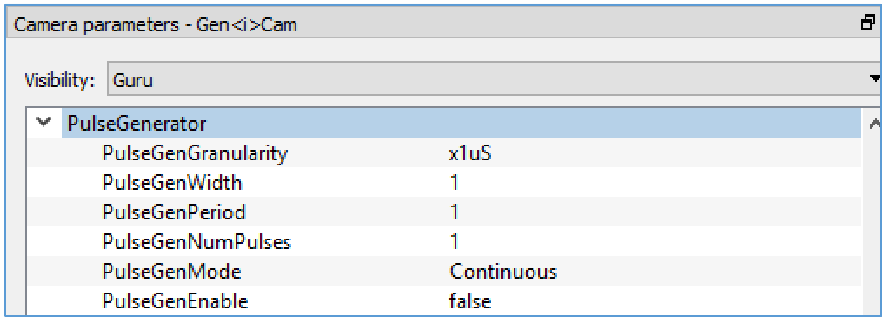


Figure 26: Pulse generator parameters.

PulseGenGranularity: Sets the pulse generator main timing resolution. The x1 resolution is in microseconds. The following four granularity steps are possible: x1, x10, x100, x1000 (x1000 is equal to 1ms timing resolution).

PulseGenWidth: Sets the value of the pulse width in microseconds.

PulseGenPeriod: Sets the value of the pulse period in microseconds.

PulseGenNumPulses: Sets the number of pulses generated by the Pulse Generator.

PulseGenMode: Sets the Pulse Generator to generate either a continuous sequence (Continuous) or a discrete number of pulses (NumPulses).

PulseGenEnable: Enables the pulse generator.

4.7.11 Transport Layer Control

The Transport Layer Control provides read-only status information on each Streaming Interface Register Map (SIRM). The SIRM registers describe the transfers expected from the host side software.

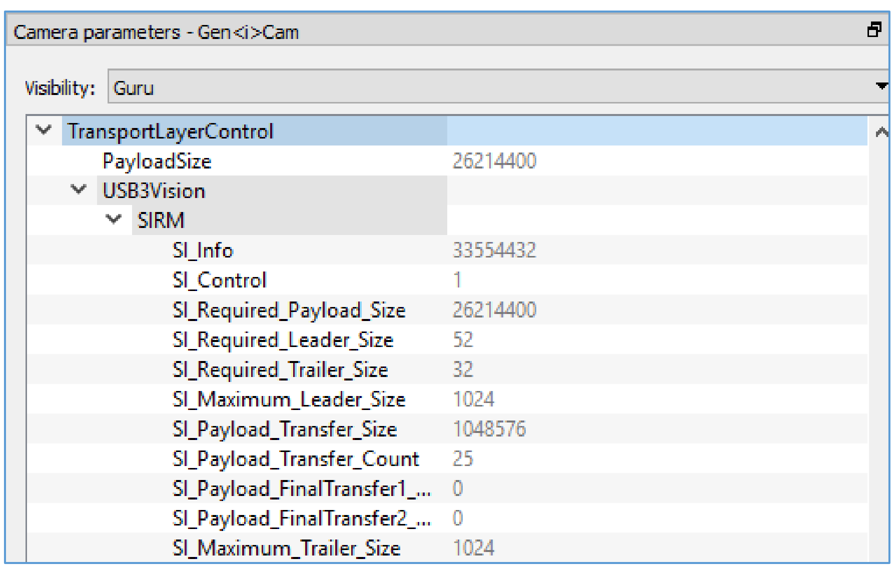


Figure 27: Transport layer control.

PayloadSize: Provides the number of bytes transferred for each image on the stream channel, including any end-of-line, end-of-frame statistics, or other stamp data.

SI_Info: Reports information about stream interface.

SI_Control: Controls streaming operations.

SI_Required_Payload_Size: Reports minimum required payload size.

SI_Required_Leader_Size: Reports minimum required size in bytes needed for the leader transfer.

SI_Required_Trailer_Size: Reports minimum required size in bytes needed for the trailer transfer.

SI_Maximum_Leader_size: Defines the maximum size of the leader the device may use.

SI_Payload_Transfer_Size: Expected size of a single payload transfer.

SI_Payload_Transfer_Count: Contains the number of regular payload data bulk transfers.

SI_Payload_FinalTranser1_Size: Contains the size of the Final Transfer 1 payload bulk transfer.

SI_Payload_FinalTranser2_Size: Contains the size of the Final Transfer 2 payload bulk transfer.

SI_Maximum_Trailer_Size: Defines the maximum size of the trailer the device may use.

4.7.12 Event Controls

Event parameters notify the host computer software about certain events occurring on the camera side, for example, a trigger event or an output that turns on a strobe light.

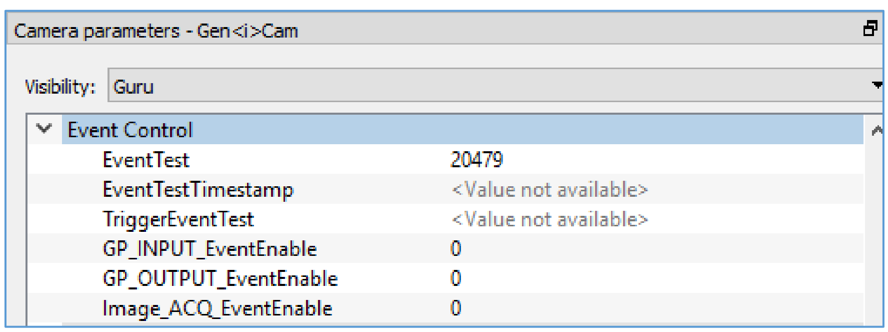


Figure 28: Event Controls.

EventTest: Returns the unique ID of the test event.

EventTestTimestamp: Returns the timestamp of the Test event.

TriggerEventTest: Generates the Test event if the event channel is enabled.

GP_INPUT_EventEnable: Enables General Purpose IN1/IN2 events.

GP_OUTPUT_EventEnable: Enables General Purpose OUT1/OUT2 events.

Image_ACO_EventEnable: Enables Image Acquisition events.

4.7.13 User Set Controls

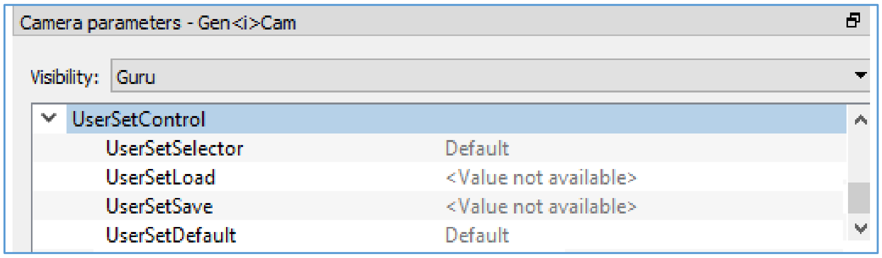


Figure 29: User set parameters.

UserSetSelector: Selects the User Configuration Set (Factory, User Set 1 or User Set 2) to load or save.

UserSetLoad: Loads the User Set specified by UserSetSelector into the camera workspace (volatile).

UserSetSave: Saves the User Configuration Set specified by UserSetSelector to the non-volatile memory.

UserSetDefault: Selects User Configuration Set to load and make active when the device is reset or after power is applied.

UserGetLastLoaded: Reports the User Set currently loaded (from the last UserSetLoad command or device reset).

4.8 Capture Panel

The Capture panel provides options for recording images and video and saving them to the computer hard drive. Click the Capture tab at the bottom of the IpxPlayer screen to access the panel.

4.8.1 Recording Acquired Images

Use the Recording section of the Capture screen to record snapped images or video images. The screen displays real-time capture information during recording.

- **Snap**. Saves the current image to the hard drive.
- **Record**. Starts or stops saving video to the hard drive.
- **Frames**. Shows the number of frames acquired, saved, and dropped during the current capture session. Dropped frames are frames received from the camera but not transferred due to a lack of host buffers.
- **Buffer Queue Filling**. Shows the current filling status of the capture frames queue.

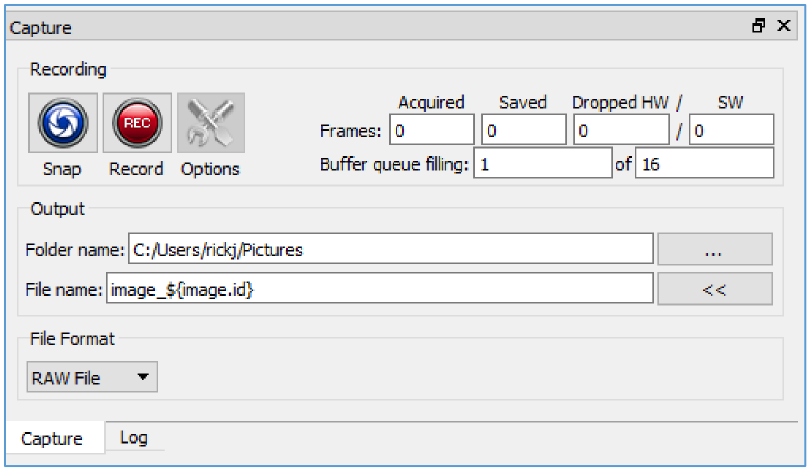


Figure 30: The Capture panel saves images and video.

4.8.2 Saving Image Output

The Output section of the Capture screen lets you configure the location and format of saved images in the computer.

- **Output Folder**. You determine where to save files on the computer.
- **File Name**. Defines the file name template.
- **File Format**. Allows you to specify the output file format from a drop-down list.
  - RAW File. This is an unprocessed file format.
  - BMP Image. (8bpp BMP for grayscale, 24bpp for Color images)
  - JPG Image. You can adjust the image quality. Default is 85%.
  - TIFF Image. Normalized option affects pixel intensity values.
  - AVI Movie. Options are – you can set the frames per second or get the current frames per second from the camera.

4.9 Log Panel

The Log panel shows data transfers to or from the connected camera. Log information provides a numeric identifier assigned by the application, the transfer time, the control channel, and the message. Click the Log tab at the bottom of the IpxPlayer screen to access the panel.

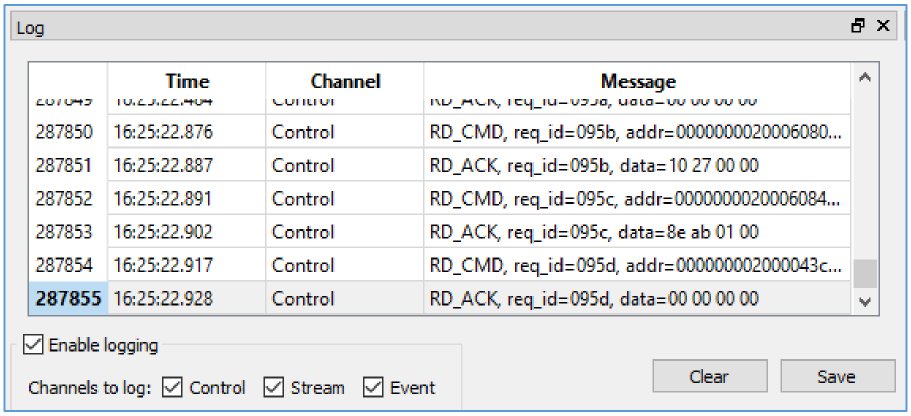


Figure 31: The Log panel records data transfers.

4.9.1 Channels to Log

The Enable Logging check box initiates logging. You can save current log data to a TXT file (.txt) with space-separated fields.

You must select a channel to log. Channels are USB3 device channels linked to an appropriate camera interface. The following options are available:

Control Channel. This is a data interface linked to the camera's Device Control Interface (DCI). The DCI is dedicated to camera parameters control. It sends and receives the data displayed on the Camera Parameters panel. DCI is bi-directional, enabling data transfers from the host computer to the camera or from the camera to the host computer.

Stream Channel. This links to the camera's Device Stream Interface (DSI). The DSI is dedicated to transferring video data from the camera to the host computer.

Event Channel. This links to the camera's Device Event Interface (DEI). The DEI notifies the host computer software about any events on the camera side. For example, the camera can notify the software that it received the trigger signal.

4.10 Statistics Panel

The Statistics panel displays camera performance and other information based on settings and parameters.

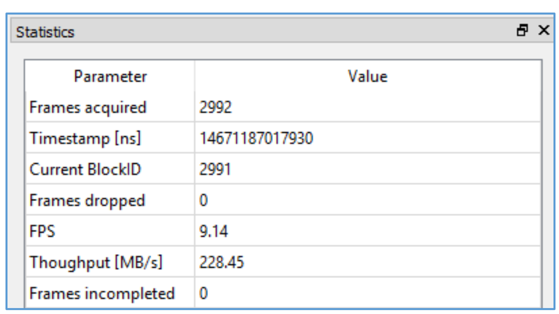


Figure 32: Statistics panel.

Frames acquired. The number of frames acquired after you click the Play button.

Timestamp [ns]. The current value of the timestamp in the acquired image in nanoseconds.

Current block ID. The current value of the block ID in the acquired image.

Frames dropped. The number of frames dropped by the camera (calculated from consequence block IDs).

FPS. The number of frames per second.

Throughput [MB/s]. The average throughput value of the camera interface in megabytes per second.

Frames incomplete. The number of frames transferred partially; usually caused when video acquisition is faster than the rate of data transfer.

5 Camera Features

5.1 Exposure Control

5.1.1 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, and finally 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 ~ 40 microseconds.

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

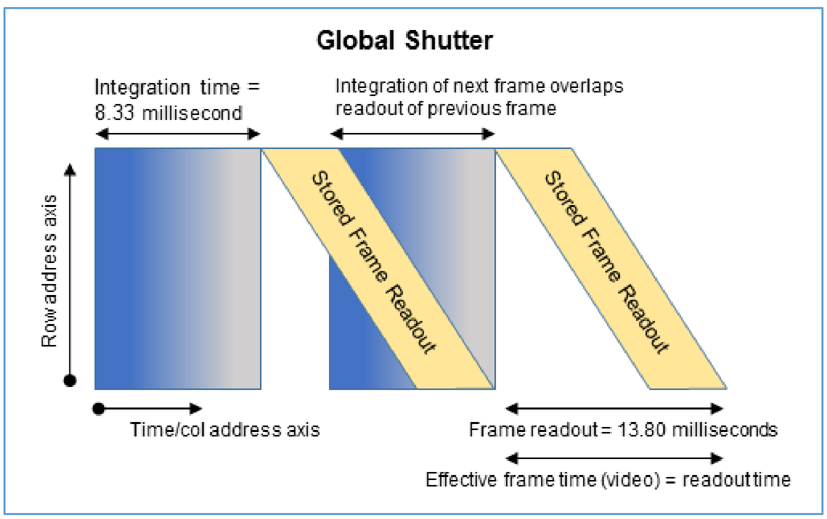


Figure 33: Global Shutter with 8.33mS exposure time.

5.1.2 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.

5.2 Frame Time Control

5.2.1 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:

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

5.2.1.1 Pixel Clock Rate Control

The camera read-out speed exceeds the USB3 compatible interface output rate. You can use the Pixel Clock Rate function to program the camera's speed to match the USB3 image capture rate.

Always adjust the Pixel Clock to the maximum rate possible without the USB3 interface missing or skipping data. This minimizes the dark current generated within the pixel and the dark current noise.

5.2.1.2 Frame Time Control

After adjusting the Pixel Clock 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. You might need to adjust frame time to control the amount of throughput if connecting more than one USB device to the same host computer.

TIP i

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

5.2.2 Camera Output Control

The USB3 compatible interface transfers data at 5.0Gbps, but uses 8b/10b encoding to achieve DC-Balance and allow reasonable clock recovery. This means the maximum theoretical data rate is 4Gbps. However, hardware and drivers vary considerably between manufacturers and with firmware overhead, the practical data bit rates range between 2.6Gbps and 3.2Gbps depending upon the hardware and drivers in the receiving computer. Note: if the camera output rate exceeds the USB3 compatible interface bandwidth, adjust the camera line rate using the Pixel Clock control to match the camera output rate to the USB3 transfer rate.

The table below describes tested USB3 compatible full frame rates.

Camera	Bit Depth	Data Rate (Gbps)	Full Resolution USB3 Interface (fps max)
C5180	8	2.8	13
	10	2.8	6
	10 packed	2.8	10
C4181	8	2.8	20
	10	2.8	10
	10 packed	2.8	16
C4180	8	2.8	27
	10	2.8	13
	10 packed	2.8	21

Figure 34: USB3 Typical maximum frame rates verses bit depth.

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, and so on), USB3 cable length, and cable type (5.3.3 Factors Impacting Frame Rate).

5.3 Area of Interest

5.3.1 Overview

For some applications, you might not need the entire image, but only a portion of it. To accommodate this requirement, Cheetah allows you to create one Region of Interest (ROI), also known as Area of Interest (AOI).

5.3.2 Horizontal and Vertical 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.

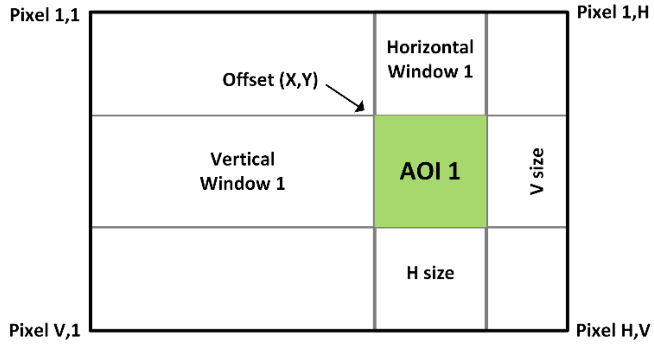


Figure 35: Horizontal and vertical window positioning.

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.

5.3.3 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. For example, the USB3 compatible interface bandwidth of approximately 3.0 Gbps limits the frame rate.

5.3.3.1 AOI Frame Rate Examples

The table below provides frame rate examples for various AOIs using USB3 output. The USB3 compatible interface hardware and drivers speed impact results, and results may vary. The camera calculates and displays the actual frame rate at any horizontal and vertical window selection.

The following table provides examples of C5180 frame rate performance at full resolution and within selected AOIs,

C5180 Frame Rates (fps)	USB3 (FPS)
Full Resolution	15
3840 x 2160	40
1920 x 1080	142
1280 x 720	323

Table 5: Frame Rates for Various AOIs.

5.4 Subsampling

5.4.1 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.

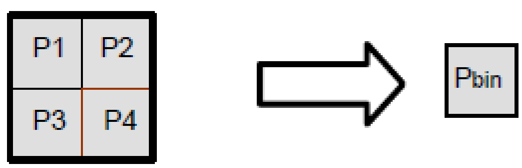


Figure 36: Monochrome pixel averaging.

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)

5.4.2 Subsampling Decimation

Subsampling reduces the number of pixels output by reducing the output frame size, but maintains the full field of view. Selecting an area of interest (AOI) maintains the AOI field of view.

The C5180, C4181, and C4180 employ a "keep one pixel, skip one pixel" sequence. When enabled in both x and y, every other pixel within a line is retained and every other line within the image is retained.

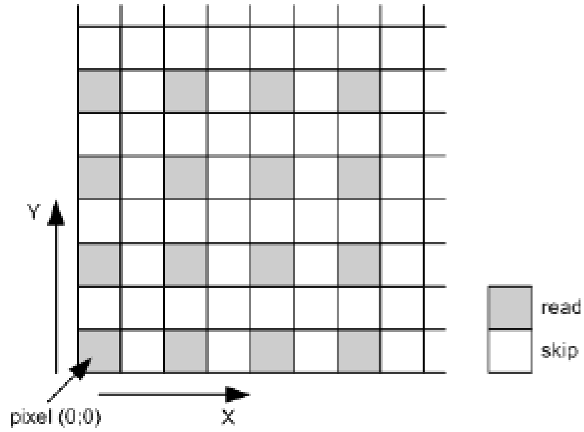


Figure 37: Monochrome subsampling.

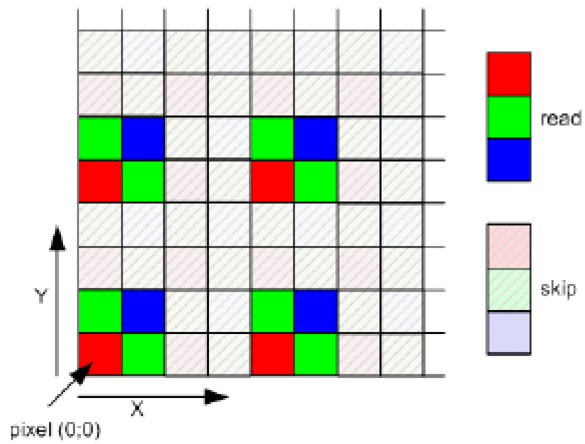


Figure 38: Color subsampling.

5.5 Camera Triggering

5.5.1 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 three input modes for external triggering: external, internal (pulse generator), and software. You must map the trigger input to a corresponding camera input (5.10.1 Input / Output Mapping).

- **External** – the camera receives the trigger signal coming from the connector located on the back of the camera.
- **Internal** – the camera has a built-in programmable pulse generator (refer to Pulse Generator section). In Internal triggering mode, the camera receives the trigger signal from the internal pulse generator.

- **Software** – the camera expects a single trigger (one clock cycle). You can trigger the camera by sending the GenICam™ Trigger Software command.

5.5.2 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.

5.5.3 Triggering Modes

A. 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 ignores the trigger and will complete the camera readout before accepting the next trigger (Figure 39 and Figure 40). The exposure time can be set manually using the internal exposure register setting or by the duration of the trigger pulse. Upon completing the readout, the camera idles while awaiting the next trigger pulse.

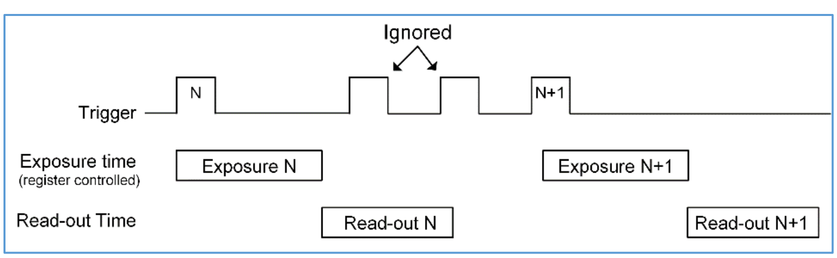


Figure 39: Trigger Mode (Internal Exposure Control).

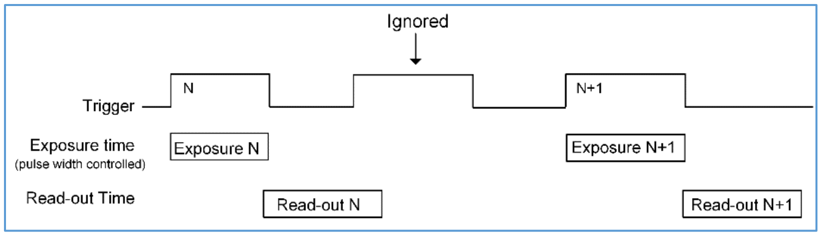


Figure 40: Trigger Mode (Pulse Width Exposure Control).

CAUTION ⚠

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

5.6 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 1.0µs 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 (5.10.1 Input / Output Mapping):

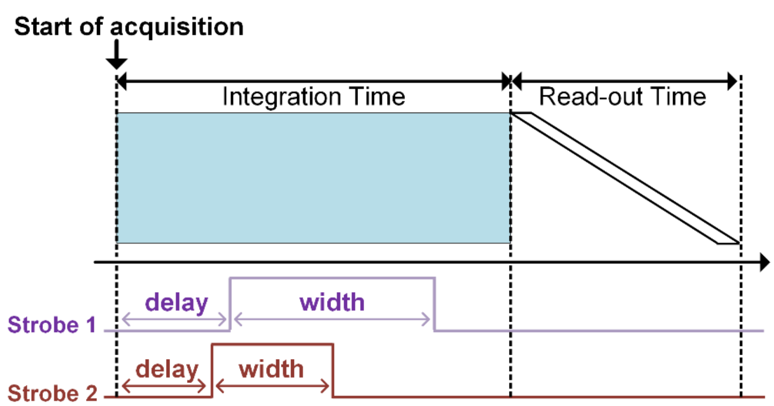


Figure 41: Strobe positioning with respect to exposure start.

5.7 Video Amplifier Gain and Offset

5.7.1 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. You should always apply analog gain before applying digital gain.

5.7.2 Digital Gain

The camera enables digital gain from 1x (0 dB) to 15.9x (24 dB) with a precision of 0.001x. There are 15,360 gain steps from 1x gain to 15.9x gain. Each step increases the gain by 0.00097x. Digital Gain does provide any improved contrast and should be used cautiously.

5.7.3 Digital Offset

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

5.7.4 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 +/- 512 counts. Black level will vary with temperature and gain settings.

5.8 Data Output Format

5.8.1 Bit Depth

The sensor digitization level is 10 bits. The Cheetah Python cameras can output 10- or 8-bit data formats. In 8-bit output, a standard bit reduction process 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 data most significant data bits (D2 to D9) map to D0 (LSB) to D7 (MSB).

MSB Camera Output – 10 bits LSB

D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
P10	P9	P8	P7	P6	P5	P4	P3	P2	P1

MSB Camera Output – 8 bits LSB

D7	D6	D5	D4	D3	D2	D1	D0
P10	P9	P8	P7	P6	P5	P4	P3

Figure 42: 10-bit internal Digitization with 8 and 10-bit outputs.

5.9 Pulse Generator

The camera has a built-in pulse generator. You can program the camera to generate a discrete sequence of pulses or a continuous sequence (Figure 43). You can use the pulse generator as a trigger signal or map it to one of the outputs (refer to the I/O Control section for more information). 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.

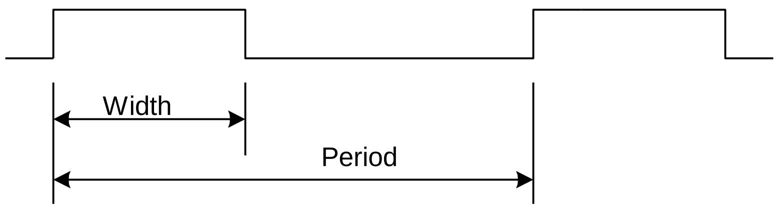


Figure 43: Internal pulse generator.

5.10 Input / Output Control

5.10.1 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. You can map either one of the two external inputs to the Trigger input to the camera. 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:

Input Signal	**IN1**	**IN2**
Trigger	✓	✓

Table 6: Cheetah Input Mapping.

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

Table 7: Cheetah Output Mapping.

5.11 Test Image Patterns

5.11.1 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. The following test images are available:

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).

Table 8: Test patterns.

5.12 White Balance and Color Conversion

5.12.1 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 sensors R, G, and B pixels, analyzes it, 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: Off, Once, AWB Tracking, and Manual.

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. **TIP** ⓘ Image a grey or white target over the entire field of view of the camera using the intended illumination source for best white balance coefficients.
AWB Tracking	Camera analyzes every frame, derives a set of correction coefficients for each frame, and applies them to the next frame.
Manual	Camera uses the correction coefficients you enter.

Table 9: Automatic white balance modes.

When Auto-White Balance (AWB) Tracking mode is selected, you can select five tracking speeds from slow to fastest.

5.13 Transfer Function Correction

The user-defined LUT (Lookup Table) feature allows you to modify and transform the original video data into any arbitrary value. The LUT enables transforming 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 to 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. The first LUT is factory programmed with a standard Gamma 0.45. The second LUT is not pre-programmed in the factory. Both LUT's are available for modifications, and you can generate and upload a custom LUT using the Imperx Upload Utility application.

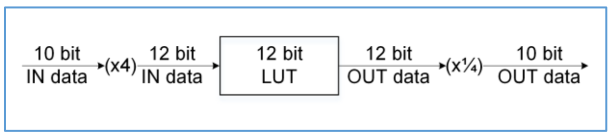


Figure 44: Look up table.

5.13.1 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). 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:

Formula: Output signal [V] = (input signal [V]) $^{0.45}$

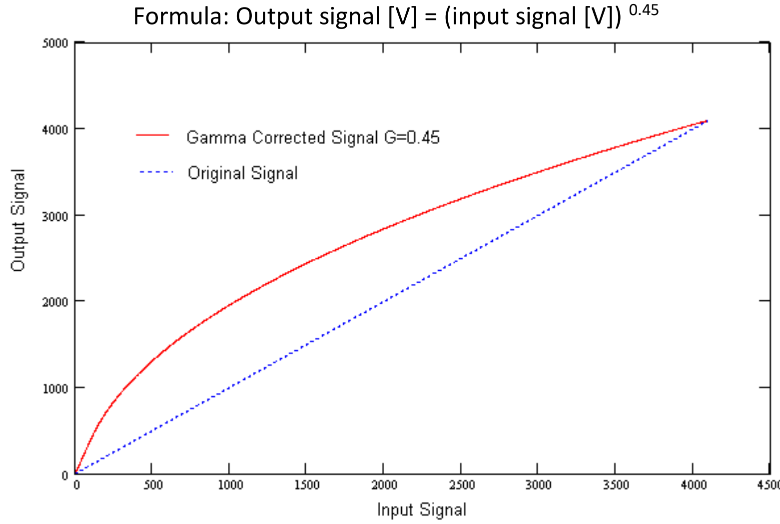


Figure 45: Gamma corrected video signal.

5.13.2 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 configuration utility software. 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).

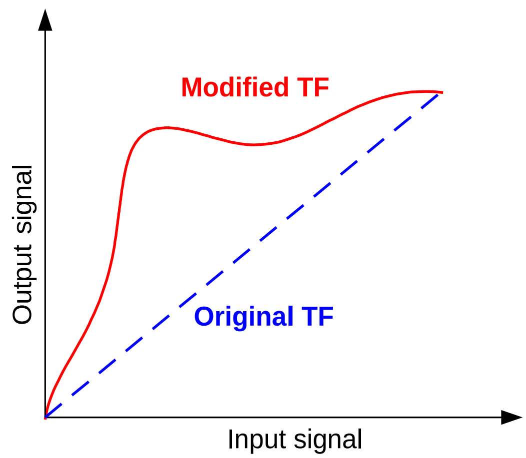


Figure 46: Custom LUT.

5.14 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.

1. **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:
   a. **Dark** - a pixel whose sensitivity is lower than the sensitivity of the adjacent pixels.
   b. **Bright** - a pixel whose sensitivity is higher than the sensitivity of the adjacent pixels.
2. **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 much, much brighter than the average of the pixels surrounding it. In some cases, the pixel becomes so bright that the pixel saturates. Final camera testing at the factory identifies and automatically corrects up to 8192 hot pixels.

5.14.1 Static Pixel Correction

Static defective and hot pixel correction work with predetermined and preloaded defective and hot pixel maps. During factory final testing, test programs identify defective and hot pixels and create a map file that lists the coordinates (row and column) of every defective pixel. This file, called the Defect Pixel Map (DPM), downloads into the camera's non-volatile memory. Since your operating environment or imaging requirements might be different from the Imperx test conditions, you can create and upload your own DPM and HPM file. When using Defective Pixel Correction, the camera corrects the defective pixel according to the pixel's coordinates provided in the DPM and when using Hot Pixel Correction, the camera corrects the Hot pixels according to the coordinates provided in the HPM.

5.14.2 Dynamic Pixel Correction

Dynamic pixel correction works without preloaded pixel maps. With this option enabled, the camera determines which pixel needs correction and performs the correction automatically. You can enable Static, Dynamic Defective Pixel Correction, and Dynamic Hot Pixel Correction independently or simultaneously. You can set the Dynamic Threshold value between 0 and 4096 (12-bit) counts. This threshold determines how much a pixel can deviate from neighboring pixels (either brighter or darker) before the camera recognizes the pixel as defective and applies correction. Dynamic pixel correction can be used with defective and hot pixels.

5.15 Flat Field and Noise Correction

The camera provides 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

5.16 Camera Interface

5.16.1 Temperature Monitor

The camera has a built-in temperature sensor that monitors the internal camera temperature in the image sensor location within the camera. The internal camera temperature is displayed on the Imperx IpxPlayer screen and you can query it at any time (refer to 3.4.1 Device Control).

5.16.2 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 by issuing a command (refer to 5.5.2 Acquisition and Exposure Control). The camera will return the current camera integration time in units of microseconds.

5.16.3 Frame Time Monitor

The camera has a built-in frame rate monitor. In any mode of operation (normal, AOI, and so on) you can query the camera for the current frame time by issuing a command (refer 4.7.4 Acquisition Control). The camera will return the current camera speed in units of frames per second.

5.16.4 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 (refer to 4.7.3 Image Format Controls). The camera will return current camera image size in (pixels x lines).

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

Automatic exposure (and gain) control keep the same image brightness despite changing light conditions. Both modes – automatic exposure and automatic gain – can be enabled simultaneously. In these modes, you set the image brightness (luminance) target level in counts, and the camera adjusts the exposure and/or gain accordingly. The target luminance can be the average luminance or peak brightness within the entire image or within the defined AOI.

If AEC and AGC are both enabled, the camera first adjusts the exposure within the preset min-max limits you set. If the maximum exposure limit is reached, 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.

6 Image Sensor Technology

6.1 General Information

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

The sensor consists of a two-dimensional array of silicon photodiodes. 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 are moved 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 59dB.

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

6.1.1 A/D Architecture and Frame Rate Controls

The C5180, C4181, and C4180 image sensors multiplex 80 (C5180) and 64 (C4181 and C4180) 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 1/64th 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 USB3 interface. The camera compensates for this mismatch in data output rate versus data capture rate by decreasing the pixel clock rate to match the computer's capture rate.

The following figure shows a typical CMOS image sensor architecture.

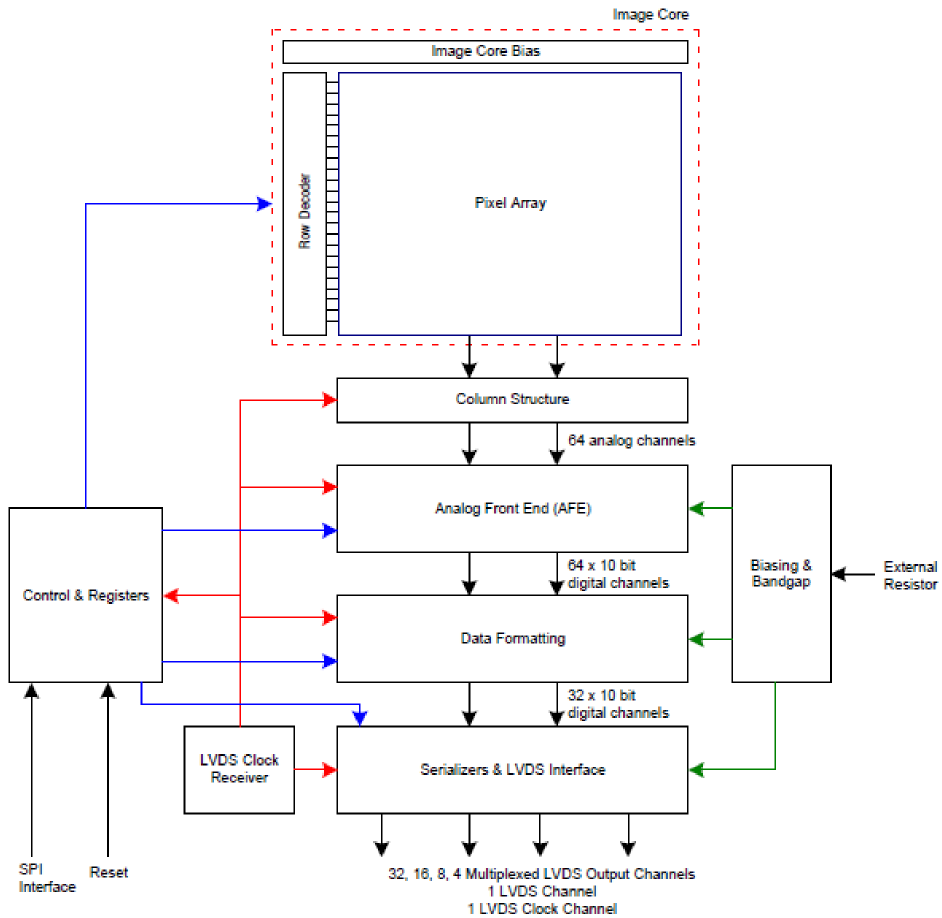


Figure 47: Typical CMOS image sensor architecture.

6.1.2 Spectral Sensitivity

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

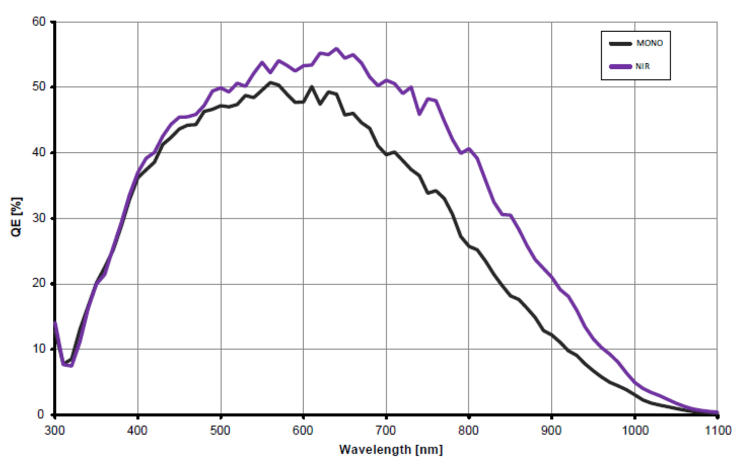


Figure 48: Python CMOS mono spectral response (monochrome, cover glass).

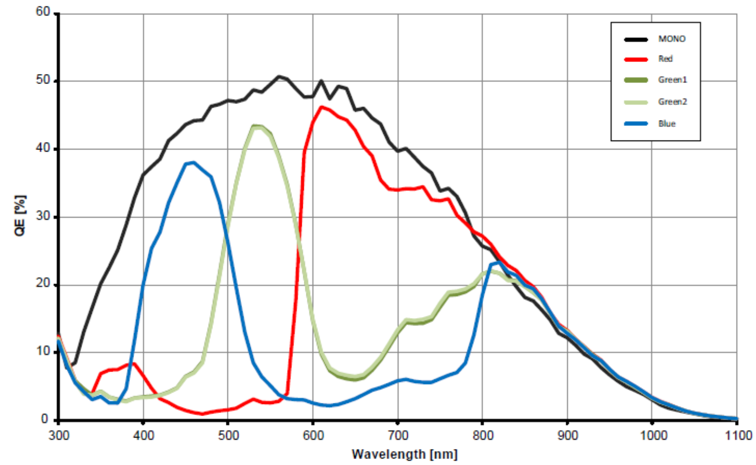


Figure 49: Python CMOS typical color spectral response (micro lens, cover glass).

6.1.3 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.