IMPERX

Cheetah Pregius Cameras

User Manual

with Camera Link® Interface

The Imperx Cheetah C2020, C2420, C2420Z, C4020, and C4120 CMOS cameras provide exceptional video image quality in a remarkably compact and ruggedized design. The cameras use Sony Pregius CMOS sensors for their high sensitivity, image clarity, and high dynamic range. They achieve frame rates up to 148 frames per second with Camera Link® Full, PoCL output.

Revision 1.1

IMPERX
Industrial Cameras & Imaging Systems

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

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

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

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REVISION HISTORY

Revision	Date	Reviser	Comments
1.0	12/21/2017	R.Johnston	Initial release.
1.1	07/06/2018	R.Johnston	Added AEC/AGC speed control; added C2420 polarizer camera; updated Image Control GUI screen.

1 About the Camera

1.1 General

The Cheetah C2020, C2420, C2420Z, C4020, and C4120 CMOS cameras feature advanced Sony Pregius CMOS image sensors, global shutter technology, and Camera Link interface to produce high quality images with fast frame rates in a small form factor for industrial application. The cameras ship with Imperx CamConfig programming software featuring an easy-to-use graphical user interface (GUI).

The cameras in this manual support Camera Link Base, Medium, and Full connectivity for reliability and high frame rates. Power over Camera Link (PoCL) capability is provided to minimize cabling. Camera Link cameras require a frame grabber on the computer for capturing individual frames from the camera's video stream.

The manual describes the cameras listed in the following table.

Camera Model	Resolution (MP)	Resolution	Frame Rate (Max)	Type	Optics	CMOS	Sony Sensor Model
CLF-C2020M	3	2048 x 1536	148	Mono	1/1.8"	Sony	IMX-252LLR
CLF-C2020C	3	2048 x 1536	148	Color	1/1.8"	Sony	IMX-252LQR
CLF-C2420M	5	2448 x 2048	97	Mono	2/3"	Sony	IMX-250LLR
CLF-C2420C	5	2448 x 2048	97	Color	2/3"	Sony	IMX-250LQR
CLF-C2420Z	5	2462 x 2056	97	Mono	2/3"	Sony	IMX-250MZR
CLF-C4020M	9	4096 x 2160	57	Mono	1"	Sony	IMX-255LLR
CLF-C4020C	9	4096 x 2160	57	Color	1"	Sony	IMX-255LQR
CLF-C4120M	12	4096 x 3000	42	Mono	1.1"	Sony	IMX-253LLR
CLF-C4120C	12	4096 x 3000	42	Color	1.1"	Sony	IMX-253LQR

The C2020, C2420, C2420Z, C4020, and C4120 are small profile, progressive scan digital cameras. They are fully programmable and field upgradeable. The cameras feature a built-in image-processing engine, low power consumption, low noise, and high dynamic range (71 dB). The cameras provide several trigger modes and output strobes allowing you to synchronize the image capture of one or more cameras to an external event. They also provide Area of Interest (AOI) and programmable look-up tables (LUT).

The C2420Z camera features a micro-polarized CMOS sensor. The sensor has a 2x2 pixel sub-array where each pixel within the sub-array blocks a different polarization filter angle (0, 45, 90 or 135 degrees). The camera's 2462 x 2056 resolution provides resolution of 1232 x 1028 per polarization angle.

The cameras are suitable in a wide range of environmental conditions and applications, such as machine vision, industrial inspection, high-definition surveillance, aerospace, and more.

1.1.1 Key Features

- Global shutter
- High frame rates
- Internal, external exposure controls
- Automatic gain and exposure control (AEC/AGC)
- Two Areas of Interest (AOI)
- Camera Link interface
- Two strobe outputs
- Trigger inputs
- Automatic and manual white balance
- Binning and sub-sampling
- Dynamic transfer function and gamma corrections
- field upgradeable firmware

1.2 Technical Specifications

1.2.1 C2020 and C2420 Cameras

Specifications	C2020 – 3.1 MP	C2420 – 5 MP
Active image resolution	2064 (H) x 1544 (V)	2464 (H) x 2056 (V)
Pixel size	3.45 µm	3.45 µm
Optical format	1/1.8 inch	2/3 inch
Shutter	Global	Global
Frame rate (max)	148 (8-bit), 121 (10-bit), 54 (12-bit)	97 (8-bit), 79 (10-bit), 35 (12-bit)
Digitization	8-bit, 10-bit, 12-bit	8-bit, 10-bit, 12-bit
Pixel Clock rate	37.125MHz	37.125MHz
Dynamic range	71 dB	71 dB
Shutter speed	1 µs/step, 14 µs to 16.0 sec	1 µs/step, 14 µs to 16.0 sec
Analog / Digital gain	0-48 dB (0.1 dB step)	0-48 dB (0.1 dB step)
Auto gain/exposure	Yes	Yes
Black level offset	Yes	Yes
Binning	1x2, 2x1 and 2x2	1x2, 2x1 and 2x2
Sub-sampling	1x2, 2x1 and 2x2	1x2, 2x1 and 2x2
White balance	Once, Manual, Auto	Once, Manual, Auto
Trigger inputs	External, pulse generator, software, computer	External, pulse generator, software, computer
Trigger options	Edge, Overlap	Edge, Overlap
Trigger modes	Standard, Fast	Standard, Fast

I/O control	2 IN (OPTO, LVTTL) / 2 OUT (OPTO, TTL)	2 IN (OPTO, LVTTL) / 2 OUT (OPTO, TTL)
Strobe output	2 strobes, programmable position and duration	2 strobes, programmable position and duration
Pulse generator	Yes, programmable	Yes, programmable
Minimum illumination	0.2 lux, f=1.4	0.2 lux, f=1.4
Lens mount	C-mount (default)	C-mount (default)
Test image patterns	Yes	Yes
In-camera processing	Yes	Yes
Camera housing	6000 series aluminum	6000 series aluminum
Upgradeable firmware	Yes	Yes
Data correction	4 LUTs, 1 LUT pre-programmed with Gamma 0.45, bad pixel correction	4 LUTs, 1 LUT pre-programmed with Gamma 0.45, bad pixel correction
Supply voltage range	12VDC (5V – 30V), 1.5 A inrush	12VDC (5V – 30V), 1.5 A inrush
Power	Typical: 200mA/12V	Typical: 200mA/12V
Camera size (W x H x L)	37mm (W), 37mm (H), 48.6mm (L)	37mm (W), 37mm (H), 48.6mm (L)
Weight	91.8 grams	91.8 grams
Vibration, shock	TBD	TBD
Environmental	-40°C to +85°C Operating; -50°C to +90°C Storage	-40°C to +85°C Operating; -50°C to +90°C Storage
Relative humidity	10% to 90% non-condensing	10% to 90% non-condensing
Regulatory	FCC 15 part A, CE, RoHS	FCC part 15, CE, RoHS

1.2.2 C2420Z Camera with Micro-Polarizer

Specifications	**C2420Z – 5 MP Monochrome**
Active image resolution	2464 (H) x 2056 (V); 1232 (H) x 1028 (V) per polarization angle
Pixel size	3.45 µm
Optical format	2/3 inch
Shutter	Global
Frame rate (max)	97 (8-bit), 79 (10-bit), 35 (12-bit)
Digitization	8-bit, 10-bit, 12-bit
Pixel Clock rate	37.125MHz
Dynamic range	71 dB
Shutter speed	1 µs/step, 14 µs to 16.0 sec
Analog / Digital gain	0-48 dB (0.1 dB step)
Auto gain/exposure	Yes
Black level offset	Yes
Binning	Not supported
Sub-sampling	Not supported

White balance	Once, Manual, Auto
Trigger inputs	External, pulse generator, software, computer
Trigger options	Edge, Overlap
Trigger modes	Standard, Fast
I/O control	2 IN (OPTO, LVTTL) / 2 OUT (OPTO, TTL)
Strobe output	2 strobes, programmable position and duration
Pulse generator	Yes, programmable
Minimum illumination	0.2 lux, f=1.4
Lens mount	C-mount (default)
Test image patterns	Yes
In-camera processing	Yes
Camera housing	6000 series aluminum
Upgradeable firmware	Yes
Data correction	4 LUTs, 1 LUT pre-programmed with Gamma 0.45, bad pixel correction
Supply voltage range	12VDC (5V – 30V), 1.5 A inrush
Power	Typical: 200mA/12V
Camera size (W x H x L)	37mm (W), 37mm (H), 48.6mm (L)
Weight	91.8 grams
Vibration, shock	TBD
Environmental	-40°C to +85°C Operating; -50°C to +90°C Storage
Relative humidity	10% to 90% non-condensing
Regulatory	FCC part 15, CE, RoHS

1.2.3 C4020 and C4120 Cameras

Specifications	**C4020 – 9 MP**	**C4120 – 12 MP**
Active image resolution	4112 (H) x 2176 (V)	4112 (H) x 3008 (V)
Pixel size	3.45 µm	3.45 µm
Optical format	1 inch	1.1 inch
Shutter	Global	Global
Frame rate (max)	57 (8-bit), 47 (10-bit), 20 (12-bit)	42 (8-bit), 34 (10-bit), 14 (12-bit)
Digitization	8-bit, 10-bit, 12-bit	8-bit, 10-bit, 12-bit
Pixel Clock rate	37.125MHz	37.125MHz
Dynamic range	71 dB	71 dB
Shutter speed	1 µs/step, 14 µs to 16.0 sec	1 µs/step, 14 µs to 16.0 sec.
Analog / Digital gain	0-48 dB (0.1 dB step)	0-48 dB (0.1 dB step)
Auto gain/exposure	Yes	Yes
Black level offset	Yes	Yes
Binning	1x2, 2x1 and 2x2	1x2, 2x1 and 2x2

Sub-sampling	1x2, 2x1 and 2x2	1x2, 2x1 and 2x2
White balance	Once, Manual, Auto	Once, Manual, Auto
Trigger Inputs	External, pulse generator, software, computer	External, pulse generator, software, computer
Trigger options	Edge, Overlap	Edge, Overlap
Trigger modes	Standard, Fast	Standard, Fast
I/O control	2 IN (OPTO, LVTTL) / 2 OUT (OPTO, TTL)	2 IN (OPTO, LVTTL) / 2 OUT (OPTO, TTL)
Strobe output	2 strobes, programmable position and duration	2 strobes, programmable position and duration
Pulse generator	Yes, programmable	Yes, programmable
Minimum illumination	0.2 lux, f=1.4	0.2 lux, f=1.4
Lens mount	C-mount (default)	C-mount (default)
Test image patterns	Yes	Yes
In-camera processing	Yes	Yes
Camera housing	6000 series aluminum	6000 series aluminum
Upgradeable firmware	Yes	Yes
Data correction	4 LUTs, 1 LUT pre-programmed with Gamma 0.45, bad pixel correction	4 LUTs, 1 LUT pre-programmed with Gamma 0.45, bad pixel correction
Supply voltage range	12VDC (5V – 30V), 1.5 A inrush	12VDC (5V – 30V), 1.5 A inrush
Power	Typical: 200mA/12V	Typical: 200mA/12V
Camera size (W x H x L)	37mm (W), 37mm (H), 48.6mm (L)	37mm (W), 37mm (H), 48.6mm (L)
Weight	91.8 grams	91.8 grams
Vibration, shock	TBD	TBD
Environmental	-40°C to +85°C Operating; -50°C to +90°C Storage	-40°C to +85°C Operating; -50°C to +90°C Storage
Relative humidity	10% to 90% non-condensing	10% to 90% non-condensing
Regulatory	FCC part 15, CE, RoHS	FCC part 15, CE, RoHS

1.3 Ordering Information

Cheetah Camera Ordering Codes Sample codes: CLF-C2420C-RC000; CLF-C2020C-RC000					
Interface	Camera model	Sensor Type	Ruggedized	Lens Mount	Filter/ customization options
CLF- Camera Link	C2020 C2420* C4020 C4120	M – monochrome C – color Z – monochrome polarized	Ruggedized	C - Mount	000 – none
* C2420 camera available in monochrome unpolarized, color unpolarized, and monochrome polarized. Note: PS12V04A Power Supply sold separately.					

1.4 Technical Support

Each camera is fully tested before shipping. If for some reason 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 not – refer to the LED section.
3. Enable the test mode and verify that the communication between the frame grabber and the camera is established. If the test pattern is not present, power off the camera, check all the cabling, frame grabber settings, and computer status.

If you still have problems with the camera operation, 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 Connectivity

The back panel of the camera provides all the connectors needed to operate and control the camera. The back panel also provides an LED status indicator.

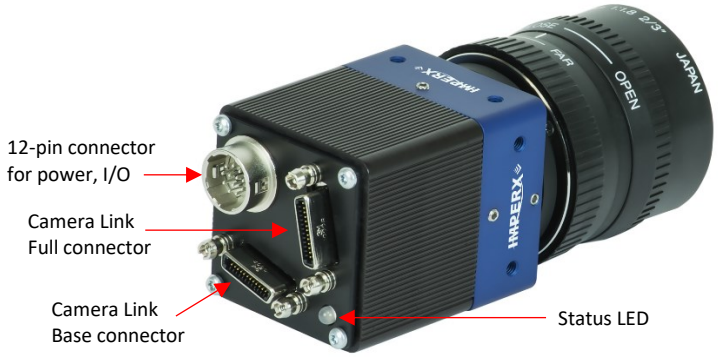


Figure 1: CLF camera back panel connectors.

The camera provides the following connectors:

1. Two camera outputs. These are standard Mini-Camera Link connectors providing data, sync, control, and serial interface.
2. Male 12-pin Hirose miniature locking receptacle #HR10A-10R-12PB (71) providing power and I/O interface.
3. Status LED indicating the status of the camera (2.1.2. Camera LED Status).
4. Model / Serial Number showing the camera model and serial number.

2.1.1 Pin Assignments

The Hirose connector on the camera's back panel is a male type miniature locking receptacle #HR10A-10R-12PB(71). The Imperx power supply (sold separately) terminates in a female HIROSE type miniature locking receptacle #HR10A-10P-12S(73) and has two small BNC pig-tail cables for the external trigger input (black) and strobe output (white) (Table 1).

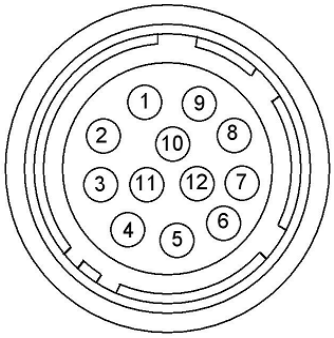


Figure 2: Connector Pin-outs.

Pin	Signal Name	Use
1	+12 VDC Return	12 VDC Main Power Return
2	+12 VDC	12 VDC Main Power
3	Reserved	Reserved
4	Reserved	Reserved
5	OUT2 C1	General Purpose Output 2, Contact 1 (OPTO-isolated)
6	OUT1 RTN	General Purpose Output 1 Return (TTL)
7	OUT1	General Purpose Output 1 (TTL)
8	IN1	General Purpose Input 1 (Opto-isolated)
9	IN2	General Purpose Input 2 (TTL)
10	IN1 RTN	General Purpose Input 1 Return (Opto-isolated)
11	IN2 TTL RTN	General Purpose Input 2 Return (TTL)
12	OUT2 C2	General Purpose Output 2, Contact 2 (OPTO-isolated)

Table 1: Power Connector Pin Mapping.

2.1.2. Camera LED Status Indicators

The camera has a red-green-yellow LED on the back panel of the camera. The following LED colors and light patterns indicate the camera status and mode of operation:

LED Condition	Status Indication
Green steady ON	Normal operation. You should see a normal image coming out of the camera.
Green blinks at ~ 2.0 Hz	Programmable Frame Time enabled.
Amber steady ON	Test mode. You should see one of the test patterns.
Amber blinks at ~ 0.5 Hz	Camera is in AGC/AEC mode or trigger mode. In this AGC/AEC mode, changing the shutter slider does not affect image luminance.
Red steady ON	RS-232 communication error or firmware load error. Re-power the camera and load the factory settings. If the condition is still present, contact the factory for support.
LED OFF	Power not present. Possible power supply failure or faulty external AC adapter. Re-power camera and load factory settings. If the LED is still OFF, contact the factory for RMA.

Table 2: LED status indicators on camera.

2.1.3 Power Supply

The camera can use an external power supply providing +12VDC, ± 10% and up to 2.5A DC current. Imperx offers the PS12V04A universal power supply adapter for use with all Camera Link cameras. The PS12V04A power supply ships with a power cable that

terminates in a female HIROSE plug #HR10A-10P-12S (73). The PS12V04A includes connectors for trigger (black wire) and strobe (white wire).

Figure 3: PS12V04A power supply (ordered separately).

PS12V04A Power Supply Specs:

Cable length:

Supplied AC power input cable (IEC): 1.8m (6') 100 - 240 Vac, 50 - 60Hz 1A
Power supply Output (+12V): 1.5m (5') ± 15cm (6") connector HIROSE #HR10A-10P-12S
Strobe & Trigger: 15cm (6") ± 1cm (0.5") connector BNC male
Auto Iris Option: 15cm (6") ± 1cm (0.5") Video type 4 Pin MINI plug connector E4-191J

Electrical:

Over-Voltage Protective Installation
Short-circuit Protective Installation
Protection Type: Auto-Recovery
12V to 13 VDC, 12.6VDC 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

CAUTION ⚠

It is strongly recommended that you use the PS12V04A power adapter from Imperx!

2.2 Electrical Connectivity

The Cheetah camera has two external inputs, IN 1 and IN 2. Input IN1 is optically isolated while input IN2 accepts low voltage TTL (LVTTL). The camera provides two general-purpose outputs. Output OUT1 is a 5v TTL (5.0 Volts) compatible signal and output OUT2 is opto-isolated. The following figures 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.

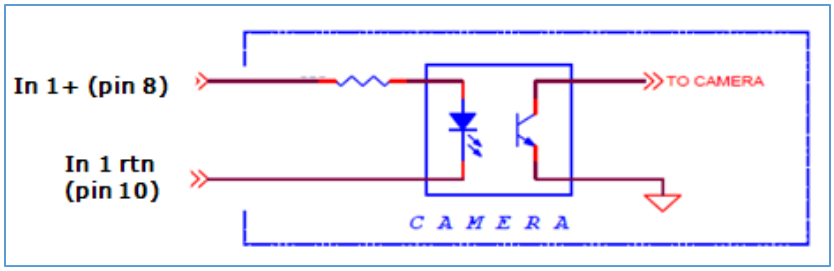


Figure 4: IN1 electrical connection.

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.

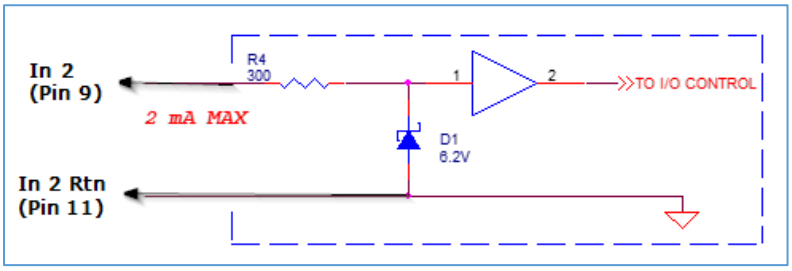


Figure 5: IN2 electrical connection.

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.

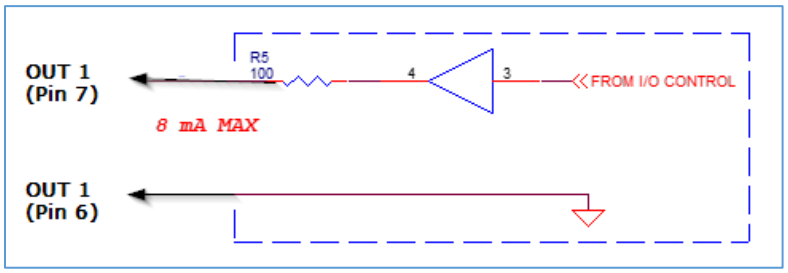


Figure 6: OUT1 LVTTL electrical connection.

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.

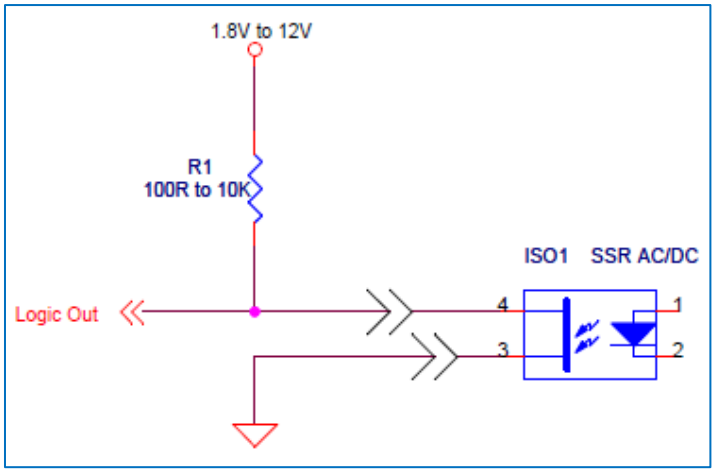


Figure 7: Open drain logic driver.

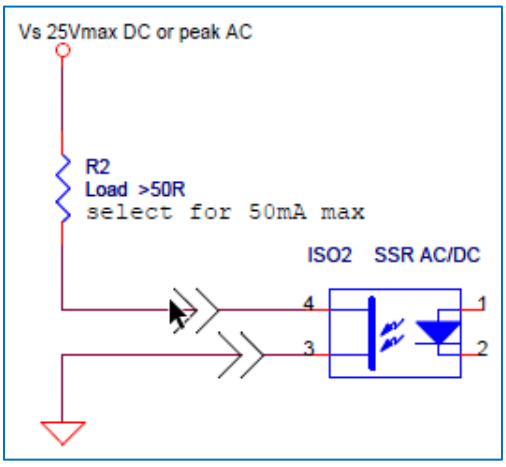


Figure 8: Low side load driver.

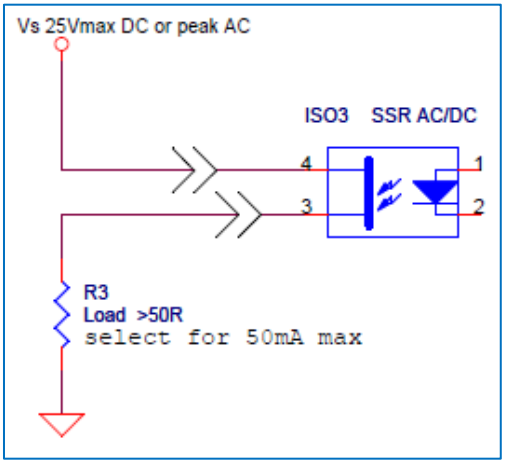


Figure 9: High side load driver.

2.3 Mechanicals

The camera housing is made of precision-machined aluminum. For maximum flexibility, the camera has eight M3X0.5mm mounting holes located towards the front of the camera on all four sides. An additional plate with ¼-20 UNC (tripod mount) and hardware ship with each camera.

Figure 10: C2020, C2420, C2420Z, C4020, C4120 camera.

The following mechanical drawings show side, front, and back views of the C2020, C2420, C2420Z, C4020, C4120 cameras.

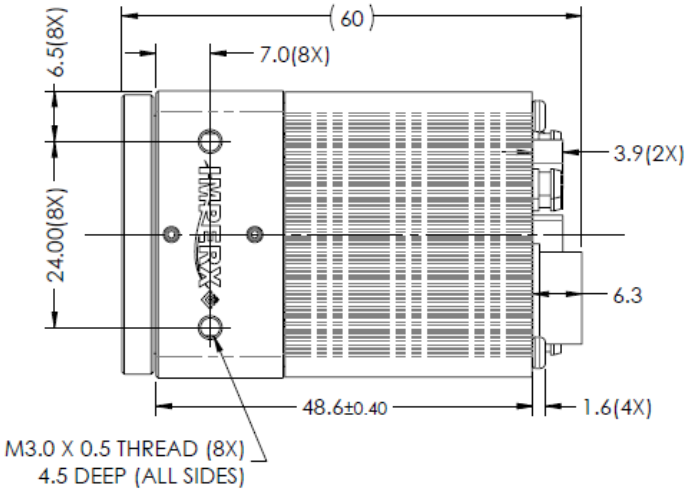


Figure 11: Mechanical drawing, side view.

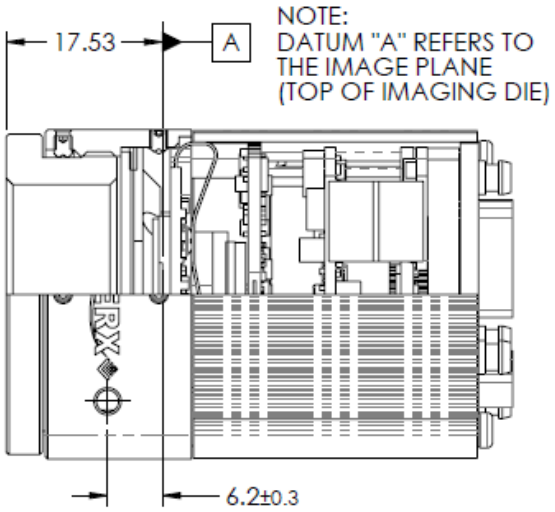


Figure 12: Mechanical drawing, image plane, side view.

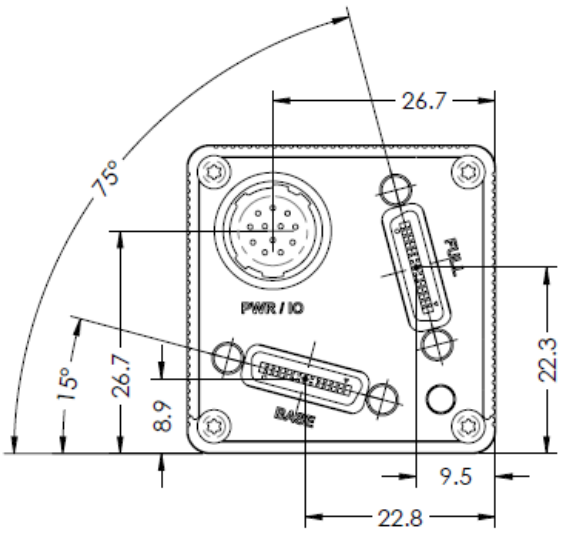


Figure 13:Mechanical drawing, back view.

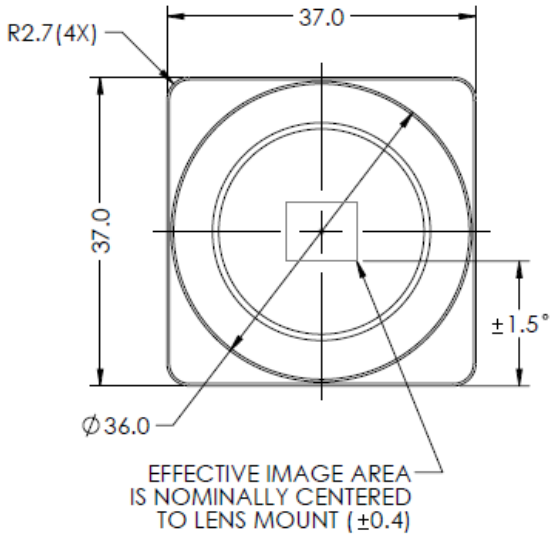


Figure 14: Mechanical drawing, front view.

2.4 Optical

The Cheetah camera provides an adapter for C-mount lenses that have a 17.53 mm back focal distance. You can use an F-mount lens with a C-mount camera using an F-mount–to-C-mount adapter. You can purchase the adapter separately (refer to the Imperx web site for more information).

TIP

Camera performance and signal to noise ratio 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 and thus decrease the signal to noise ratio.

The camera is highly sensitive in the IR spectral region. All color cameras have an IR cut-off filter installed. Monochrome cameras do not have an IR filter. If necessary, the camera can accommodate an IR filter (1 mm thickness or less) inserted under the front lens bezel.

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.

2.5 Environmental

Operate the camera in a dry environment with temperatures between -40°C and +85°C. Relative humidity should not exceed 80% non-condensing.

TIP

Always keep the camera within temperature specifications.

The camera should be stored in a dry environment with the temperature ranging from -40°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, in close proximity to an intensive heat source, strong magnetic or electric fields.
3. Avoid touching or cleaning the front surface of the optical sensor. If the sensor needs cleaning, use soft lint free cloth and an optical cleaning fluid. **Do not use methylated alcohol!** Contact Imperx support for cleaning procedures.

3 Configuration Software

3.1 Overview

The Cheetah Pregius CamConfig software ships with the C2020, C2420, C2420Z, C4020, and C4120 cameras. After installing the software, you can program the camera, change its settings, and save the settings in a file or in the camera using the Camera Link interface. The software provides a help file to assist in setting up the camera.

The CamConfig software is compatible with the following operating systems:

- Windows 7, 32-bit and 64-bit
- Windows 8 and 8.1, 32-bit and 64-bit
- Windows 10, 32-bit and 64-bit

3.2 Installing the Software

Use the installation wizard to install the Cheetah Pregius CamConfig software supplied with your camera.

CAUTION

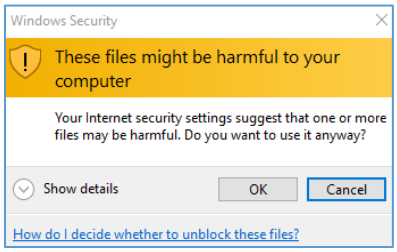
If a previous version of the GUI software is installed on your computer, you must remove it before completing the installation. The installation wizard will do this for you during the installation process. Or, you can uninstall a previous version yourself.

To remove previous versions yourself:

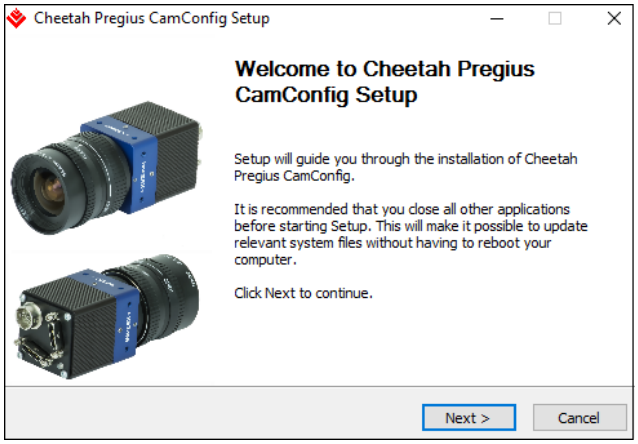
1. Open **Control Panel** on your computer.
2. Select **Programs and Features**.
3. Select the software from the list.
4. Click **Uninstall**.

Installation

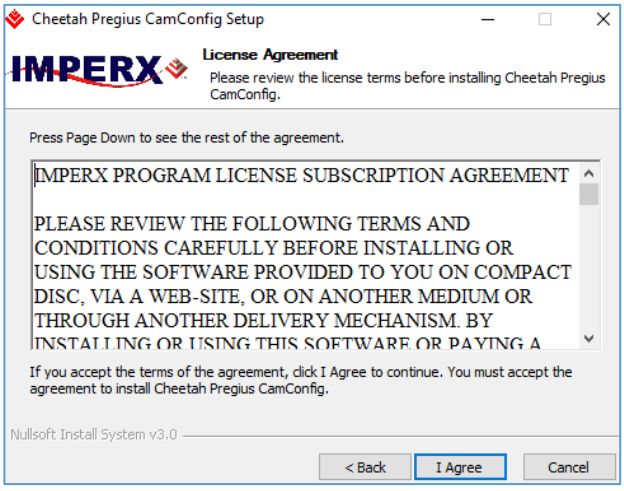
1. Locate the executable file (`Cheetah_Pregius_1_0_5_xxxx.exe`) on the media that shipped with your camera.
2. Drag the file to your computer desktop. If a Security screen appears, click **OK**.



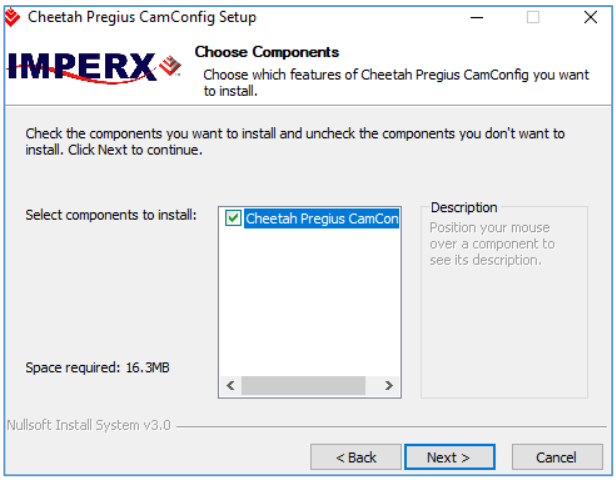
1. Double click the executable file (Cheetah_Pregius_1_0_5_xxxx.exe) on your desktop. The Welcome Setup screen opens. Note the recommendation to close other applications and then click **Next**.



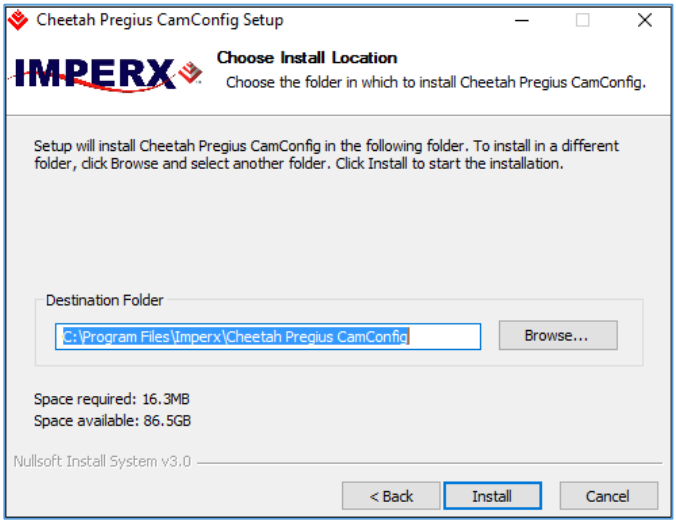
2. When the License Agreement screen appears, read the agreement and click **I Agree**.

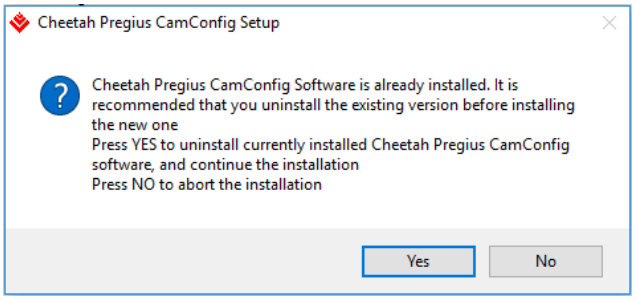


3. On the Choose Components screen, make sure the Cheetah Pregius CamConfig component is selected and then click **Next**.

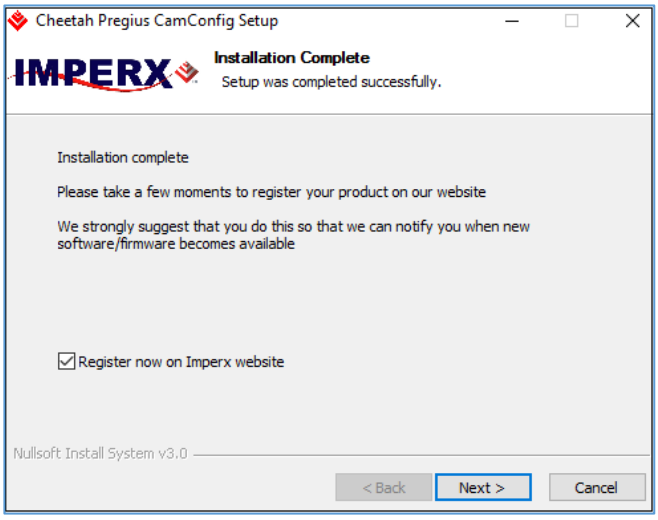


4. On the Choose Install Location screen, accept the default destination folder or click **Browse** and select a different location and then click **Install.** The installer prompts you to uninstall any existing versions of the software from your computer before continuing the installation.

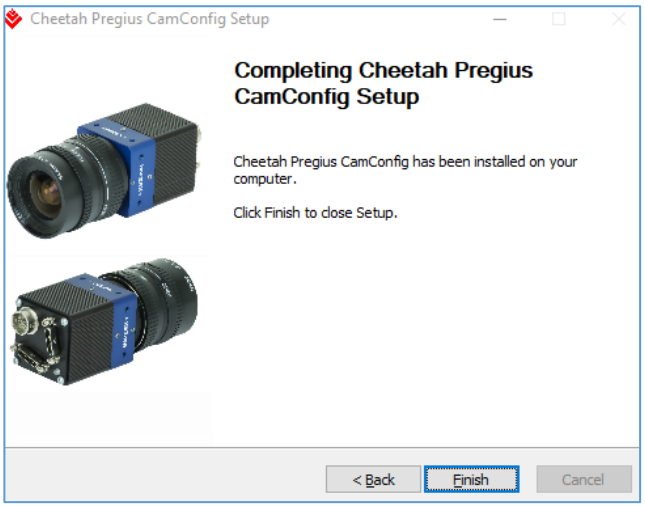




5. On the Installation Complete screen, select the check box to register your software and then click **Next**. When the Imperx website appears, complete the Subscriber Registration and click **Submit**.



6. On the Completing Cheetah Pregius CamConfig Setup screen, click Finish. The Cheetah Pregius Configurator icon appears on your desktop.



3.3 Starting CamConfig

Users sometimes install multiple frame grabbers and cameras on the same host computer. The CamConfig software automatically discovers all available Universal Asynchronous Receiver/Transmitter (UART) components on the computer and lets you select the one connected to the camera.

The CamConfig software also searches for any available COM ports installed on the host computer. It communicates with each COM port and attempts to query the attached camera. If the software detects an attached Imperx Cheetah camera, it displays the port and camera type on the Select Port screen. You can repeat the discovery procedure by clicking Rescan Ports.

TIP

If the software does not find your computer's COM ports, you might need to locate your frame grabber's DLL file and move it to C:\Windows\System32. You can search File Explorer for the DLL file by entering clser* in the search field. Note: your frame grabber's vendor name abbreviation should appear where XXX is shown in the clserXXX.dll file name.

To select a camera for programming:

1. Open the CamConfig software.
2. On the Select Port screen, click the camera of interest.
3. Click **OK**. The CamConfig Main panel appears.

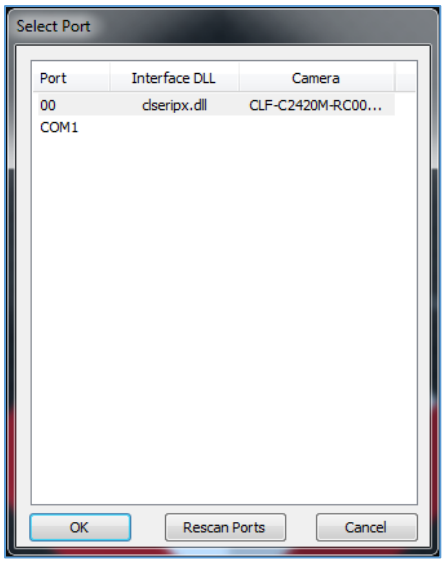


Figure 15: Select Port identifies cameras.

3.4 Main Window

The main window appears after you select a camera. It provides menu and view options, a help file, camera information, and configuration options. The camera's name and status appear at the bottom of the main window. The status indicator next to the camera name turns red if the connection between the camera and host computer is lost.

Figure 16: GUI interface.

The window also displays real-time information about the camera's current conditions and operations based on the settings you implement. The software monitors the image size (in pixels), frame per second (FPS), frame time in milliseconds (FTM), and exposure time in milliseconds (EXP).

3.4.1 Menu

The Menu provides access to load options, settings, the command terminal, and more.

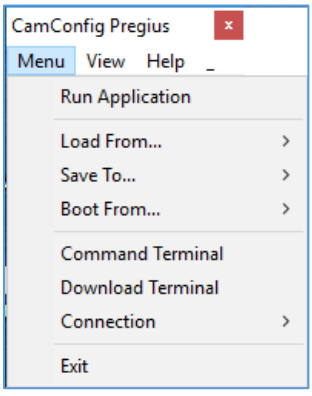


Figure 17: Menu options.

Run Application

This starts any other executable file that you normally use, such as a frame-grabber application. CamConfig remembers the location of such files in the host computer.

Load From . . .

This enables loading camera registers from a saved configuration space. Options are:

- File: Loads camera registers from a saved configuration file.
- Workspace: Updates the software with the current camera workspace settings.
- Factory: Loads the camera registers with the original factory settings.
- User Space #1 to #4: Loads the camera registers with settings saved within the camera from any of the camera user spaces: #1 to 4

Save To . . .

You can save the camera registers to a file or the camera User Spaces. Factory Space is available only for factory technicians.

Boot From . . .

This enables loading the camera registers from the Factory configuration, from User Space #1, #2, #3, or #4 upon powering up.

Command Terminal

The Command Terminal shows information about all commands sent to or received by the camera. It also lets you communicate directly with the camera by entering write or read commands directly into the text box on the Command Terminal screen.

To write a command to a camera register, the command terminal must send a sequence of 7 bytes to the camera. The write command must start with 0x followed by 57, the register address, and data.

Example:
Write to register address 0x0410, data value = 0x11223344:
Camera Write Command: <0x57> <04> <10> <11> <22> <33> <44>

To read a command from a camera register, the command terminal must send a sequence of 3 bytes to the camera. The read command must start with Ox followed by 52 and the register address.

Example:
Read from register address 0x0410:
Camera Read Command: <0x52> <04> <10>

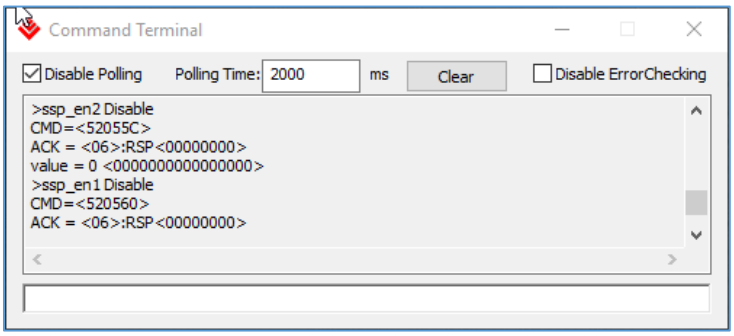


Figure 18: Command Terminal command to addresses 055C and register 0560.

The Disable Polling check box turns polling commands on or off for frame time, exposure time, frame rate, and so on. You can change the polling time in milliseconds by entering a number in the Polling Time field.

The software displays error messages when the camera returns a command error. You can disable error checking by selecting the Disable Error Checking check box.

Download Terminal

The Download Terminal lets you upgrade the camera's firmware and upload any custom files — BPM, Flat Field Correction (FFC), Lookup Tables (LUT), or Register Set (RGS).

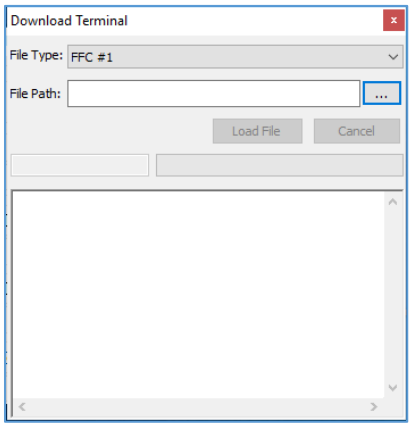


Figure 19: Download Terminal.

To download files to the camera:

1. Click **File Type** and select a file type such as BPM, or LUT1/LUT2.
2. Enter or browse to the location of the file on your computer.
3. Select the file you want to download.
4. Click **Load File**.
5. Reboot the camera and restart the GUI for the changes to take into effect.

Connection

Use the Connection menu to switch ports and change baud rates.

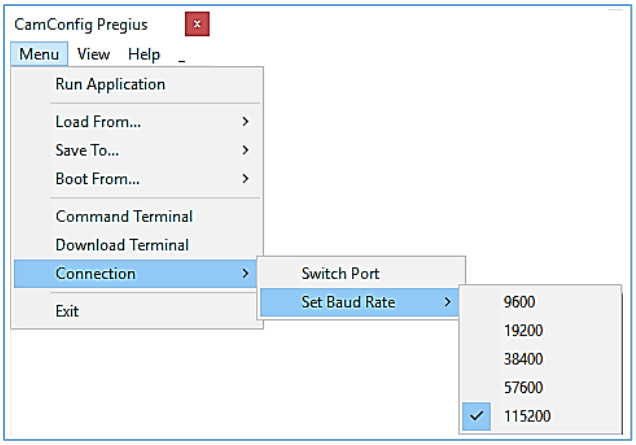


Figure 20: Connections lets you control ports and baud rates.

Switch Port – use this option to switch the com port/camera. You can also Rescan Ports before switching.

Set Baud Rate – use this to change the speed of data transmission. A higher baud rate number indicates the transfer of more bits per second. Baud rates are 9600, 19200, 28400, 57600, and 115200. The factory default is 115,200.

3.4.2 View

Use the View menu to display or hide the following panels: Acquisition, I/O Control, Strobe, Processing, Color, and Data Out on the screen.

3.4.3 Help

Help provides access to a user help file and the following options:

- **Debug.** This puts the software in debug mode for test purposes and troubleshooting.
- **Save Dump Camera Regs.** This is for saving camera registers to a file.
- **About.** This provides information about the camera's firmware build, revision, image sensor, and other components.

3.5 Gain & Exposure

Gain and Exposure Control enables adjustments to Analog gain, Digital gain and offset, black level, and Exposure Modes.

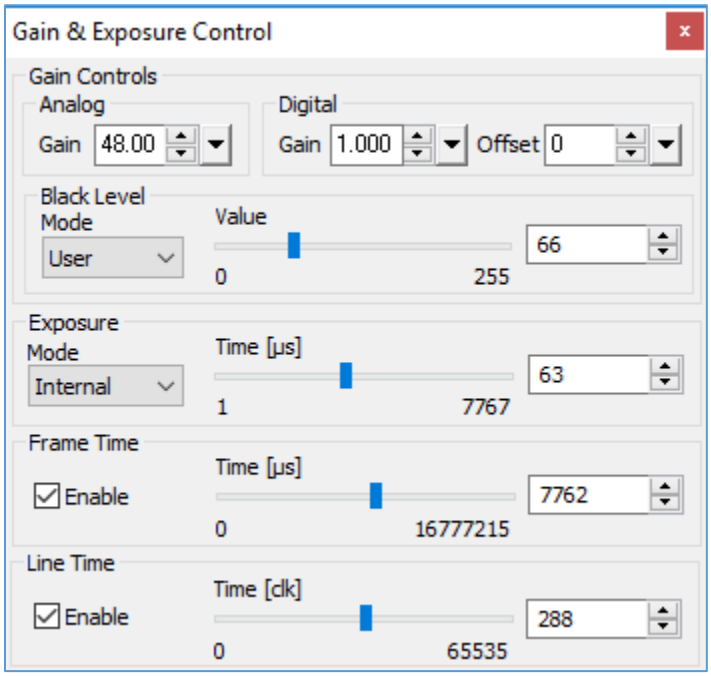


Figure 21: Gain & Exposure Control

Analog Gain: Amplifies the image signal before converting the signal to digital data. You can set the analog gain from 0 to 48 dB in 0.1 dB steps.

Digital Gain: Increases image brightness by multiplying the data by a fixed number (1.0x to 4.0x in 0.001x increments).

Digital Offset: Digital Offset increases the image brightness by adding a fixed number (a count) to data (-511 to +511 in 1-step increments).

Black Level Mode. Enables setting the black level. Black Level Mode options are User and Auto. Use the slider to adjust the black level from 0 to full-scale. (Response is non-linear).

TIP

Choose Auto mode with value of 5 to optimize dynamic range without black level clipping for short exposures and 10 to 15 for long exposures.

Exposure Mode: Use the following to set the camera exposure:

- Off – Sets the exposure time equal to the frame period.
- Pulse Width – Sets the exposure time equal to the trigger's input pulse width.
- Internal – Sets the internal camera timer control exposure based on the Exposure Time setting. Use the slider to adjust the Exposure Time from 0 to one frame time in microseconds.

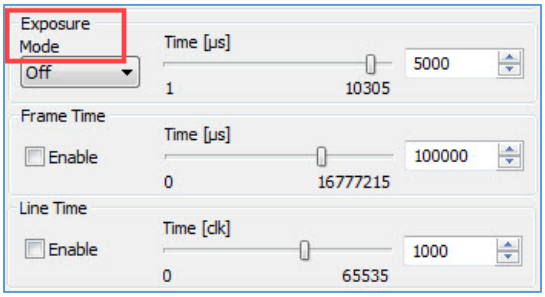


Figure 22: Set exposure time in microseconds.

Frame Time: This is the time required to read out the entire frame. Select the check box to enable Frame Time control. You can set the value from 0 to 16,777,215 microseconds (~16.8 seconds).

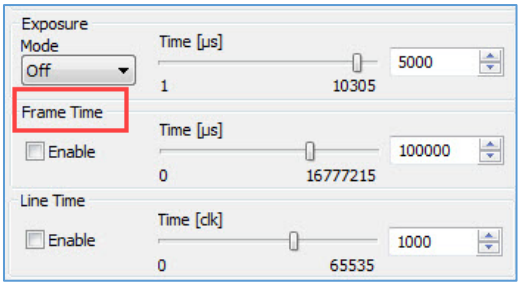


Figure 23: Frame time settings.

Line Time: This feature is disabled at this time.

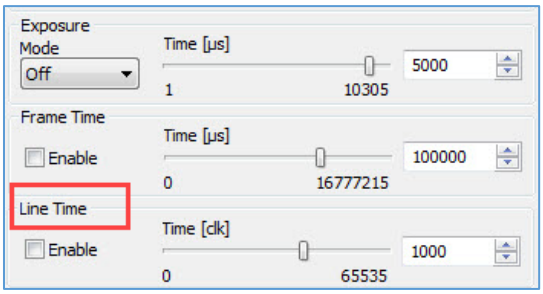


Figure 24: Line time settings.

3.6 Output

Output Control lets you configure the camera for the two strobe outputs, trigger signal, and pulse generator.

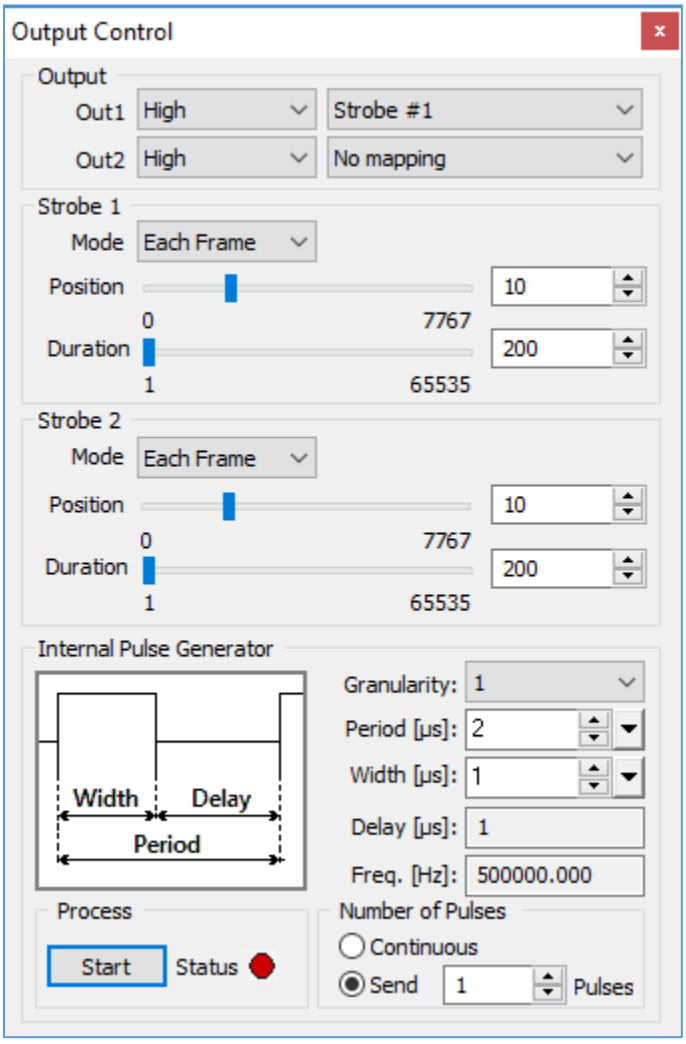


Figure 25: Output Control.

Output (OUT1 and OUT2)

The Output section enables mapping the camera's two outputs (OUT1 and OUT2) to internal output signals. For each output, you can set the signal level to active High or active Low.

The following internal output signals are available for mapping

Output Signals	Description
Exposure Start	A short pulse (2µs) indicating the beginning of the camera exposure.
Exposure End	A short pulse (2µs) indicating the end of the camera exposure.
Mid Exposure	A short pulse (2µs) indicating the middle of the camera exposure.
Active Exposure Window	A signal indicating the duration of the camera exposure.
H-Sync	A short pulse (2µs) synchronized with the camera line timing.
V-Sync	A short pulse (2µs) synchronized with the camera frame timing.
Odd/Even Frame Flag	A signal based on the camera's internal timing for indicating either odd or even frame. It alternates with every frame. If the output is set as High, it represents the even frame; odd is low.
Trigger Pulse	Maps the input trigger pulse to the output with no delay (as is).
Trigger Pulse Delayed	Maps the input trigger pulse to the output with delay set by the Exposure Delay Register.
Camera Ready	A signal indicating when the camera is ready to accept the next trigger pulse.
Pulse Generator	Maps the internal pulse generator waveform to the output.
Strobe #1	Maps the Strobe 1 signal to the corresponding external output.
Strobe #2	Maps the Strobe 2 signal to the corresponding external output.
Toggle	Controls the active polarity of the output signal.
Frame Pulse	Maps the Vertical Frame Transfer pulse.

Strobes 1 and 2

You can set the operational Mode, Position, and Delay for strobe 1 and Strobe 2 independently.

Mode: When setting up a strobe, you must assign it to a frame. Use the Mode drop-down menu to assign the strobe pulse to the following:

- Disable
- Each Frame
- Odd Frames
- Even Frames

Position and Duration: You can set the position and duration of each strobe within the entire frame timing period with a precision of 1.0 microsecond.

- The position determines when the strobe turns on during the frame period.
- The duration determines how long the strobe stays on.

Pulse Generator

In this section of the screen, you can configure the parameters of the Internal Pulse Generator.

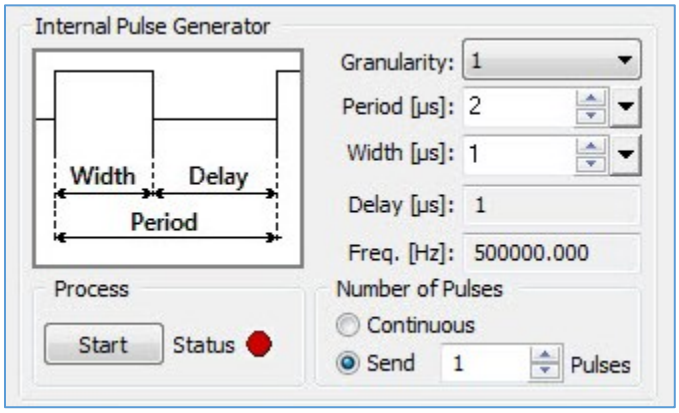


Figure 26: Internal pulse generator.

Granularity: Indicates the number of clock cycles for each increment of the width and the period. The main resolution is in microseconds, and four granularity steps are possible: x1, x10, x100 and x 1000 (x1000 is equal to 1ms timing resolution).

Period: Sets the amount of time in microseconds (determined by the granularity setting) between consecutive pulses.

Width: Sets the amount of time in microseconds (determined by the granularity setting) the pulse remains at a high level before falling to a low level.

Delay. Shows the delay calculated in microseconds as Period minus Width.

Frequency. Shows the frequency calculated as 1/Period.

Number of Pulses. Enables sending pulses either continuously or by a set number of pulses. Two modes are available:

- Continuous – provides a continuous operation. Click **Stop** button to end.
- Send – Generates a discrete number of pulses (1 to 65535). Click **Stop** to end or allow the process to end after sending the last pulse.

Process Start. Allows you to manually start and stop the pulse generator. The Status LED indicates the following:

- Red – Pulse Generator is stopped
- Green – Pulse Generator is operational

3.7 Trigger Control

Trigger Control lets you configure the camera's trigger options and trigger strobe options.

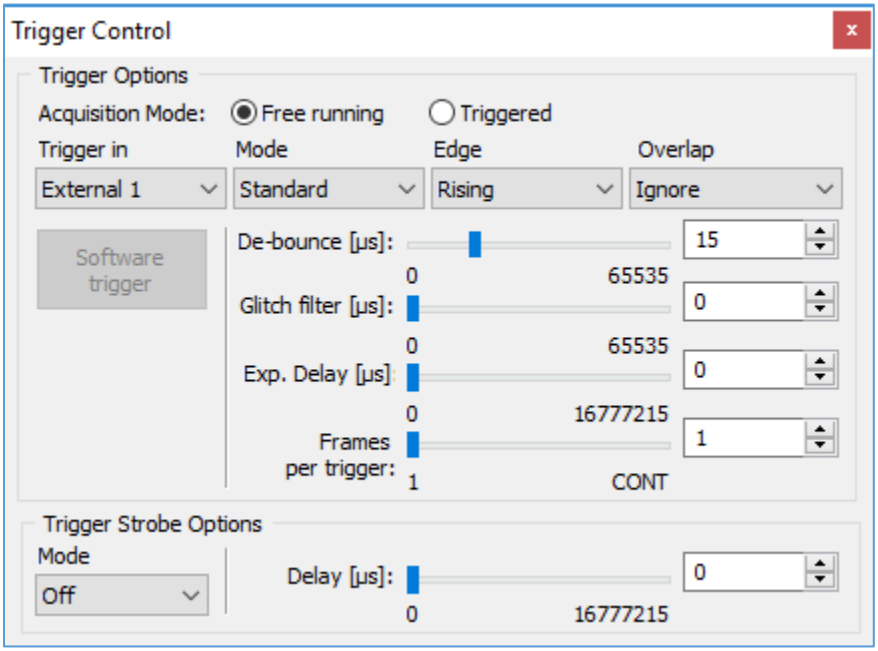


Figure 27: Trigger Control.

3.7.1 Trigger Options

The small Cheetah camera operates in free running mode or trigger mode. In free running mode, the camera runs without synchronization. In trigger mode, the camera waits for the trigger to start the image capture, synchronizing it to an external event.

To use triggers, select Trigger on the main menu. Use the following options to configure the trigger source and other settings:

Trigger in: Select one of the following active triggering input signals from the drop-down list:

- External 1. The camera expects a trigger signal coming from IN 1.
- Pulse Gen. The camera expects a trigger signal coming from the internal pulse generator.
- Computer. The camera expects a signal coming from CC 1.
- Software. Triggering starts when you click the software trigger button.
- External 2. The camera expects a trigger signal coming from IN 2.

Mode: Select a mode from the drop-down list:

- Standard. The camera waits for the trigger, then exposes using the internal exposure timer and reads out the frames. The exposure occurs first followed by readout.
- Fast. The camera exposes a frame and then exposes the next frame while reading the previous frame. In this way, the camera overlaps the exposure and readout times. Fast trigger requires a predictable and stable trigger period.

Edge: Select the active triggering edge of the trigger pulse:

- Rising – Uses the rising edge of the trigger pulse to start the exposure.
- Falling – Uses the falling edge of the trigger pulse to start the exposure.

Overlap: Select how to handle the next trigger pulse if it arrives while the previous triggering cycle is in process:

- Ignore. Camera ignores the next trigger and continues its present operation.
- Accept. Camera uses the next trigger. The camera will stop the present operation, then reset and start the new trigger cycle.

De-bounce: This is designed to prevent multiple triggerings from ringing on the trigger input pulses. The camera ignores additional triggers received during the de-bounce time. Set the de-bounce time between 0 and 65535 microseconds.

Glitch Filter: Sets the minimum trigger pulse width. The camera ignores pulses with a width shorter than the selected value, which range from 0 to 65535 microseconds.

Exposure Delay: Sets the delay between the trigger pulse active edge and beginning of the exposure. You can set the delay from 0 to 16777215 microseconds.

Frames per trigger: When the Mode is Standard, this option lets you select the number of frames to capture (expose) and read out per trigger. Select from 1 to 65530 or CONT (continuous) frames.

Trigger Strobe Options

The camera can send a strobe pulse to synchronize the camera to an external light source. The Trigger Strobe Options section lets you enable a strobe pulse with each trigger. From the Mode drop-down list, select from the following options:

- Off
- Strobe 1
- Strobe 2
- Both

You can set a delay with respect to the trigger pulse active edge from 0 to 16,777,215 microseconds (~16.8 seconds).

3.8 AEC/AGC

Automatic exposure control (AEC) and automatic gain control (AGC) enables the camera to maintain the same image brightness under variable lighting conditions. The automatic exposure and gain control process drives the exposure and gain to achieve a target luminance level (in counts) specified in the Limit settings.

AEC/AGC Control also provides real-time statistics on the camera's exposure time, gain, and luminance values. When the camera's exposure or gain limit is reached, an indicator light on the screen changes color from green to red.

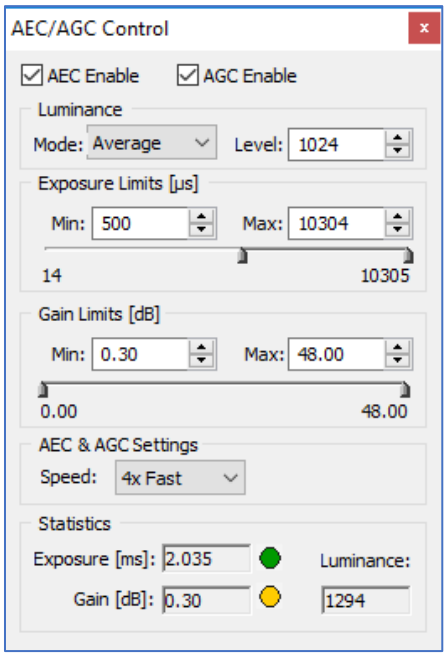


Figure 28: AEC/AGC Control.

AEC Enables and AGC Enables: Select the check box(es) to enable AEC, AGC, or both.

Luminance: Sets the desired luminance level to be maintained in the image. Two options are available: Average and Peak. Enter a desired luminance value in counts for either selection.

- Average. The camera calculates the average value of the image luminance within the image and compares that value to the value entered in the Limit field to determine changes to the exposure/gain settings.
- Peak. The camera calculates the peak luminance value (maximum luminance level) within the image and compares that value to the value entered in the Limit field to determine changes to the exposure/gain settings.

Exposure Limits: Enter a minimum and a maximum limit. For example, if motion capture is important, specify a short maximum exposure to avoid motion blur. Exposure Limits range from 25 microseconds to a maximum limit of one frame time. Generally, the minimum exposure limit should be set to a minimum of 30 microseconds to avoid control loop oscillations when the scene illumination changes suddenly.

Gain Limits: Sets the minimum and maximum gain limits. Gain Limits range from Min: 0 dB to Max: 48 dB.

AEC & AGC Settings: Sets the camera's exposure correction speed during AGC/AEC. Options are: 01x speed (slow), 2x speed, 3x speed, and 4x speed (fast).

Statistic:Provides live information about the current value of the Exposure time, Gain, and Luminance. The values are refreshed every time polling is done.

3.9 Image Control

The Image Parameters panel lets you configure the camera for your specific application, including Master Area of Interest (MAOI), Slave Area of Interest (SAOI), binning, polarization, image structure, image correction, and test mode.

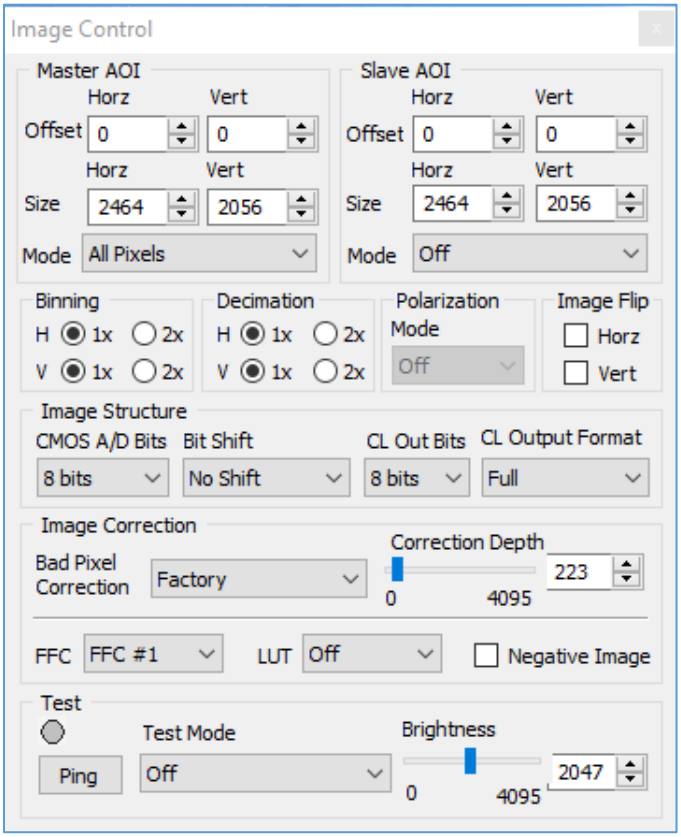


Figure 29: Image Control.

The AOI affects the camera's frame rates. The following table shows C2020 frame rates based on various AOI's.

Product	AOI	FPS
C2020	2064 x 1544	149
	2064 x 514	426
	2064 x 255	802
	2064 x 128	1412
	2064 x 64	2302
	2064 x 32	3339
	2064 x 16	4310
	2064 x 8	5025
	2064 x 4	5494
	516 x 4	5494
	256 x 4	5494
	176 x 4	5494

Table 3: C2020 frames rates by AOI.

3.9.1 Master AOI

The Master AOI (MAOI) determines the current image size. You define the MAOI by specifying horizontal and vertical size dimensions and offset coordinates. The size dimensions specify the width and height of the AOI in pixels. The offset coordinates define the boundaries of the AOI.

Mode: A drop-down lets you select the following MOAI modes:

Master AOI Modes	Descriptions
All Pixels	The entire image area is used.
Faster Frame Rate	Each AOI is read out sequentially without any vertical blanking to achieve the maximum possible frame rate.
Keep Frame Rates	The vertical size of the AOI can affect frame rates. The camera adds a vertical blanking interval after the image readout to maintain the frame rate.

3.9.2 Slave AOI

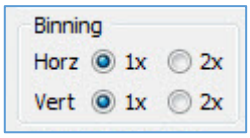
The Slave AOI (SAOI) is nested inside the Master AOI. You might use the SAOI for a region of interest for automatic gain control (AGC)/automatic exposure control (AEC), auto white balance (AWB), or LUT.

Mode: A drop-down lets you select the following SOAI modes:

Slave AOI Modes	Descriptions
Off	Turns off all modes.
Include	Displays the Master AOI image with the Slave AOI image included (the area outside of the Slave AOI appears black).
Exclude	Displays the Master AOI with the Slave AOI excluded (the Slave AIO appears black).
AGC/AEC ROI Include	Displays the Slave AOI image with Slave AOI AGC/AEC settings included.
AGC/AEC ROI Exclude	Displays the Slave AOI image with Slave AOI AGC/AEC settings excluded.
AWB ROI Include	Displays the Slave AOI image with Slave AOI AWB settings included.
AWB ROI Exclude	Displays the Slave AOI image with Slave AOI AWB settings excluded.
LUT ROI Include	Displays the Slave AOI image based on a lookup table.
LUT ROI Exclude	Displays the Slave AOI image not based on a lookup table.

3.9.3 Binning

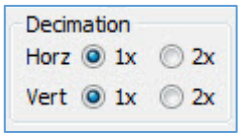
Binning combines charges from adjacent pixels to enable faster readout speeds and improved signal to noise ratios. It also reduces spatial resolution. Binning is supported in all monochrome models except the C2420Z camera.



- Horizontal. Select radio button 2x to enable horizontal binning (1x is no binning).
- Vertical. Select radio button 2x to enable vertical binning (1x is no binning).

3.9.4 Decimation

Decimation is the use of subsampling and pixel averaging to reduce output resolution.



- Horizontal. Select radio buttons 2x to enable horizontal decimation (1x – no image change).
- Vertical. Select radio buttons 2x to enable vertical decimation (1x – no image change).

The C2420Z camera does not support subsampling.

NOTE *

If planning to use both Binning and an Area of Interest (AOI), you must set up binning before defining the AOI.

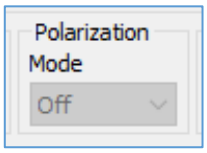
After activating Binning and AOI, if you want to change the CMOS A/D Bits settings, use the following procedure:

1. Turn off Binning and AOI.
2. Set Binning by clicking 2x for both horizontal and vertical.
3. Set the AOI horizontal and vertical sizes.
4. Select a new CMOS A/D Bits. Options are 8 bits, 10 bits, or 12 bits.

3.9.5 Polarization Mode – C2420Z Camera

Polarization mode activates the polarization capabilities of the C2420Z camera. The camera's micro-polarized sensor has a 2x2 pixel sub-array where each pixel blocks a different polarization filter angle (0, 45, 90 or 135 degrees). The camera produces a resolution of 1232 x 1028 per polarization angle.

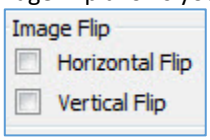
To activate polarization, select one of the following filter angles:



- 0 degrees
- 45 degrees
- 90 degrees
- 135 degrees
- Circular

3.9.6 Image Flip

Image Flip allows you to flip an active image.



- Horizontal. Select the check box to enable the horizontal flip.
- Vertical. Select the check box to enable the vertical flip.

3.9.7 Image Structure

The Image Control screen provides options for adjusting your image structure bits, bit shift, Camera Link out bits, and Camera Link output format.

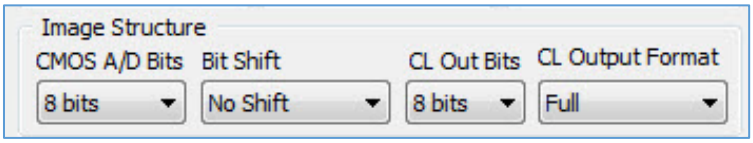


Figure 30: Image Structure.

Image Structure	Descriptions
CMOS A/D Bits	Determines the amount of tonal information available from the image sensor. Bit depth options are 8 bits, 10 bits, or 12 bits. Faster frame rates are possible at lower bit depths.
Bit Shift	Changes the relative weighting of the output data by shifting bits to the left or to the right by a number of bit positions (positions are 1x, 2x, 3x, up to 7x).
CL Out Bits	Sets the number of bits per pixel output to the Camera Link output. Options are 8, 10, and 12 bits.
CL Output Format	Sets the number of Camera Link output taps used. Options are Base (2 taps), Medium (4 taps), and Full (8 taps).

TIP

Camera Link cameras require a frame grabber device on the computer for capturing individual frames from the camera's video stream. Be sure to set the number of camera link taps in the frame grabber to match the number of camera link taps coming out of the camera.

TIP

Camera Link Base and Medium support 8, 10, or 12-bit output whereas Camera Link Full only supports 8 or 10 bits per pixel.

3.9.8 Image Correction

The camera provides image correction with preloaded defect maps and tables (static) and without preloaded defect maps or tables (dynamic).

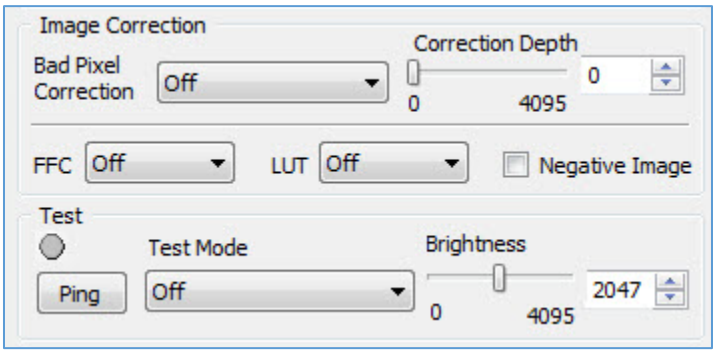


Figure 31: Image Correction.

Image Corrections	Descriptions
Bad Pixel Correction	Enables static or dynamic pixel corrections. You can enable static and dynamic pixel correction independently or simultaneously. You can adjust the intensity threshold for the hot pixel or defective corrections using the Threshold slider (0 – 4095). • **Off:** disables Bad Pixel Correction. • **Factory:** corrects bad pixels identified with predetermined and preloaded defective and hot pixel maps created by the factory. • **Dynamic:** pixel correction works independently of defective or hot pixel maps. The camera determines which pixels need correction based on a threshold value you create and performs the correction automatically. • **Dynamic&Factory:** Combines dynamic pixel correction and use of factory bad pixel maps. • **User:** Corrects bad pixels identified by user-created correction maps. • **Dynamic&User:** Combines dynamic pixel correction and use of factory bad pixel maps.
Correction Depth	For Dynamic Pixel Correction, you can set a threshold level from 0 to 4095 for 12-bit images. The camera will correct all hot pixels having an amplitude (hot pixel intensity minus average pixel intensity) higher than the threshold setting.
FFC	Activates a flat field correction table created by the factory or user. The Flat Field Correction mechanism corrects for variation in illumination caused by the lens over the field of the array. You can turn FFC off or select from one of two FFC tables, FFC #1 and FFC #2. FFC is not available for small format image sensors.
LUT	Activates a Lookup Table for modifying and transforming the original video data into any arbitrary value. The camera supports four lookup tables. LUT#1 is pre-loaded with standard Gamma 0.45.
Negative Image	Reverses the image (2's complement) so that the lightest areas appear darkest and the darkest areas appear lightest.

3.9.9 Test

Use the test function on the Image Parameters panel to check camera communications and to generate test images.

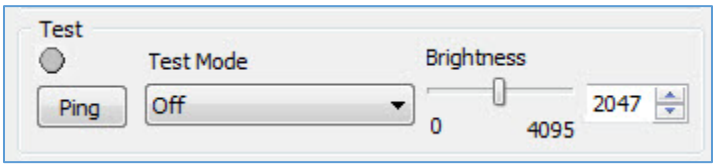


Figure 32: Test checks for communications.

The Ping function checks the serial connection status of the camera. Click Ping for a visual indication of the following status indicators:

- GREEN (OK) indicates a successful connection.
- RED (ERR) indicates no connection.
- YELLOW indicates a ping command was sent to the camera. IF no valid return is received, the indicators becomes gray.

Use the drop-down menu to display several test patterns.

Test Mode	Descriptions
Off	Test mode is off.
BW Checkerboard	A black and white checkerboard pattern.
Gray Image	A uniformly dark gray image. User can set the value.
Tap Segmented	An image segmented by each tap output.
H Ramp	A stationary horizontal ramp image.
V Ramp	A stationary vertical ramp image.
H & V Ramp	A pair of horizontal and/or vertical lines positioned in the image at any pixel/line in the image. You can use the horizontal and vertical lines as a measuring tool; the pixel and line positions are referenced to the CCD pixels and lines, not to the image pixels and lines.
H & V Ramp Moving	A moving horizontal and vertical ramp image.
Vertical Bars	A set of 8 vertical gray bars with different gray levels.
Superimpose Crosshair	Superimposes crosshair watermark (2 pixels and 2 lines thickness) indicating the absolute center of the image.

3.10 Color

White balance lets you adjusts the camera's color setting to preserve the original colors and make white objects appear white. The screen displays the current (calculated) white balance coefficients for each color (red, green, blue). The Color screen is disabled for monochrome cameras.

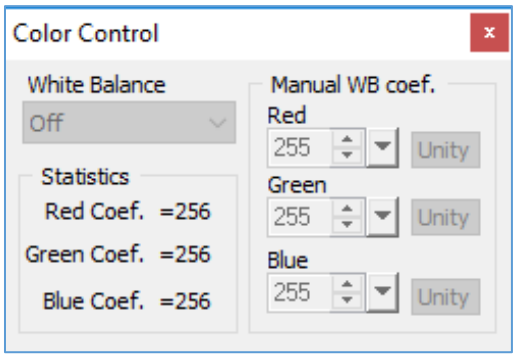


Figure 33:Color Control.

Use the White Balance drop-down menu to select a white balance preset:

White Balance Presets	Descriptions
Off	No white balance performed.
Once	The camera analyzes only one image frame, calculates only one set of color correction coefficients, and corrects all subsequent frames with this set of coefficients.
Auto	The camera analyzes each frame, derives a set of correction coefficients on each frame, and applies them to the next frame.
Manual	The camera uses the correction coefficients as entered from the user.

Table 4: White balance presets

Use Manual WB Coefficients to manually define white balance coefficients for each color (red, green, and blue). Coefficient values affect the intensity of each color and range from 0 to 4095. The Statistic area of the screen gives you the current (calculated) white balance coefficients per color.

TIP

For best color accuracy and stability when the spectral source is constant, image a uniform grey target with the camera using a desired light source. Select **Once** to find the correct R, G, and B coefficients and write down the values. Then select **Manual** and load these coefficients into the camera. Leave Manual selected. The camera will now apply these coefficients to every frame captured.

4 Camera Features

4.1 Exposure Control

During normal camera operation with exposure control off, the readout frame time determines the exposure time. However, the camera's electronic exposure control can precisely control the image exposure time under bright light conditions. The electronic exposure control does not affect the frame rate; it only changes the exposure time. When Internal exposure control is active, the camera controls the start of exposure so the new exposure ends just as the readout of the current frame ends and the readout of the next frame begins. The maximum exposure is equal to the frame time, and the minimum exposure is about 25 microseconds.

4.2 Automatic Exposure Control

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.

In AEC mode, you can set the image luminance (brightness) target, and the camera adjusts the exposure accordingly. The slave Area of Interest (AOI) supports a mode where the camera adjusts the exposure to maintain the target luminance calculated only within the AOI. You can select the target luminance to be either the average luminance or peak luminance within the image or within the AOI. The camera adjusts the exposure starting within the preset limit established by the user-specified minimum/maximum limits. When AEC and AGC are enabled, exposure is always varied first until the exposure reaches the maximum limit. The camera then indicates the limit has been reached and begins increasing the gain until either the luminance target is achieved or the maximum gain limit is reached. You can preset the speed of convergence (how fast the camera stabilizes after an illumination change) from four possible rates. Slower convergence rates are more stable than faster convergence rates, if the illumination levels change quickly over a wide intensity range. The camera displays the current luminance, current exposure, and current gain. For auto gain control, refer to Automatic Gain Control (AGC) section.

CAUTION

In some rapidly changing and bright light conditions, an image brightness oscillation (image intensity flipping from bright to dark) could occur. To prevent this, increase the AEC minimum exposure settings, decrease the convergence speed, increase the target luminance level, or change the AOI or the lens iris.

4.3 Automatic Gain Control

Automatic gain control (AGC) enables the camera to maintain the same image brightness during changing light conditions. In AGC mode, you can set the image luminance (brightness), and the camera will adjust the gain accordingly. Luminance options are average or peak.

The camera starts by changing the gain within the specified min-max limits.

- If reaching one of the gain limits, the camera indicates the limit has been reached and maintains this value until the light condition change. You can set the speed of convergence from four possible options.
- If enabling AEC mode and AGC mode together, the camera starts by changing the exposure first within the specified min-max limits until the maximum exposure limit is reached.
- Upon reaching the maximum exposure limit, the camera adds gain and changes it within the specified min-max limits.

The AEC/AGC algorithm samples all pixels for the entire frame, but you can select only a portion of the image (AOI) to calculate the luminance level using the slave AOI mode. The camera displays the current luminance within the frame (or AOI, if selected), the current exposure, and the current gain.

4.4 I/O Control

The camera supports one TTL output and one opto-isolated output. The camera also supports one TTL compatible and one opto-isolated trigger input.

4.5 Strobe and Synchronization Controls

The camera allows you to synchronize your system from several references. You can synchronize with the trigger input, the start, middle or end of exposure, or the start of image readout.

1) The Trigger Strobe feature creates a strobe output signal from the trigger input signal. The strobe can be delayed with respect to trigger using the Trigger Strobe delay feature (see Trigger Control – Trigger Strobe Options).
2) The camera provides signals indicating the start of exposure, mid-exposure, and end of exposure (see Output Control: Output Mapping). These signals have a fixed duration of 2 microseconds These signals can be delayed using the Exposure delay feature in the trigger menu to also synchronize multiple cameras or light sources. If a longer pulse period is required, the strobe feature can be used.
3) The camera also provides strobes that activate just as the readout period begins and can be activated on all frames or just even or odd frames (see Output Control: Strobe 1 and 2). If using internal exposure control, you can position the strobe to occur when the exposure time starts by using the strobe delay feature. You can position each strobe pulse within the entire frame-timing period with a precision of 1.0 microsecond. You can set the strobe position and duration from 1.0 microsecond to the maximum frame time with a precision of 1.0 microsecond.

4.6 Gamma Control

The camera's built-in processing engine enables adjustments to the luminance (brightness) of an image on the monitor. Using gamma correction, you can control, stretch, or compress the image luminance with one of four different LUTs.

4.7 Color Control

The camera provides white balance options for controlling image color under different lighting conditions. White balance control options are Off, Once, Auto, Manual, Indoor 3200K, and Outdoor 5600K.

4.8 Image Sensor Technology

A CMOS camera is an electronic device for converting light into an electrical signal. The C2020, C2420, C2420Z, C4020, and C4120 cameras contains the latest Sony Pregius CMOS (Complementary Metal-Oxide Semiconductor) image sensors with 3.45-micron square pixels. The Pregius sensors have groundbreaking performance with sensitivity better than many traditional Charge Coupled Device (CCD) image sensors. The sensors have extremely low dark current and no visible fixed pattern noise, which has been the bane of traditional CMOS image sensors.

The Sony CMOS sensor consists of a two-dimensional array of sensitive elements called silicon photodiodes, also known as pixels. The photons falling on the CMOS surface create photoelectrons within the pixels. 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 level and exposure time, the number of electrons varies with the wavelength of the incident light.

When the camera reaches the desired exposure time, it shifts the charges from each pixel photodiode onto a storage register within the pixel, reads out one row at a time, and then digitizes each pixel at either 8, 10 or12 bits as selected by the user. Frame time, or read-out time, is the time interval required for all the pixels to be read out of the image sensor. While reading out the image from the storage registers within each pixel, the camera captures the next image. The exposure ends just as the readout of the previous frame ends and the next frame begins.

Unlike traditional CCD image sensors, the Sony 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 and extremely low dark current, translates into a large dynamic range of 71 dB (12-bits) or 12 F-stops.

The sensor allows you to apply up to 48 dB of gain to the image. The first 24 dB of gain is analog gain and some improvement in noise performance may result. The camera applies the last 24 dB of gain digitally, which affects both signal and noise equally.

A set of color filters (red, green, and blue) arranged in a Bayer pattern over the pixels generates color images. The starting color is Red for SONY Pregius image sensors. The following figure shows the sensor's color response (Figure 34).

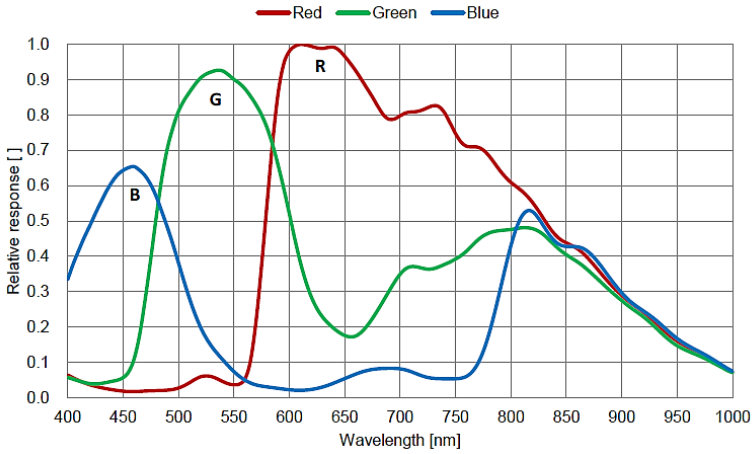


Figure 34: Color relative response to IMX252 sensor.

4.9 Micro-polarized Camera

Light travels in electromagnetic waves that vibrate in multiple, random directions. When these unpolarized light waves strike certain surfaces, they tend to reflect or refract light and obscure the imaging target. A polarizer filter integrated into the camera can block certain light waves from reaching the image sensor and thereby improve image quality.

The Sony IMX-250MZR image sensor in the Cheetah C2420Z camera includes a micro-polarizer filter that blocks light waves based on a polarization angle. The filter consists of an array of four polarizers grouped in a 2x2 sub-array. As shown in the following illustration, each array covers a block of four pixels in the sensor with each polarizer absorbing light at one of four angles -- 90 degrees, 45 degrees, 135 degrees, or 0 degrees.

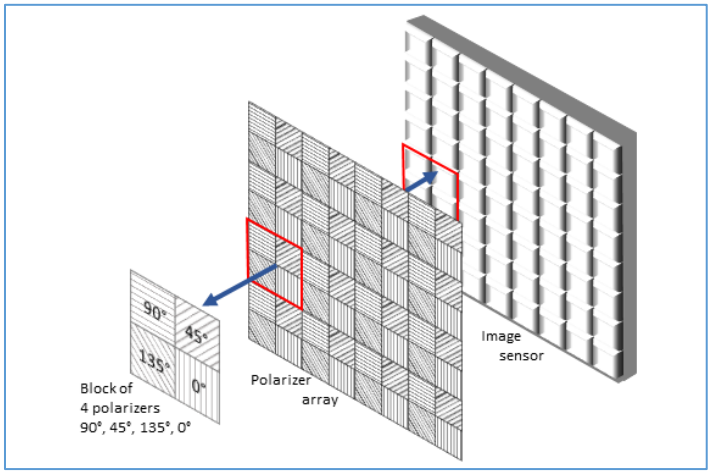


Figure 35: The C2420Z camera micro-polarizer blocks image obscuring light waves from reaching the sensor.

5 Register-based Commands

You can control all of the cameras resources (internal registers, video amplifiers and parameter flash) using a simple, register-based command protocol (Appendix A – Camera Register) with the Camera's RS-232 serial interface. The interface is bi-directional. You issue commands, and the camera issues responses (status or information type).

5.1 Configuration Memory

The camera provides configuration memory divided into these 4 segments: factory-space, user-space #1, user-space #2, user-space #3, and user-space #4.

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 and retrieve the registers by issuing commands. The work-space is RAM based. Powering down the camera clears the work-space memory.

The factory-space segment is ROM based and write protected. It contains the default camera settings. This space is available for read operations only.

The user-space #1, user-space #2, user-space #3, and user-space #4 segments are non-volatile and Flash-based. The camera allows you to save the contents of the workspace to either one of these memory spaces and allows you to load these contents into the workspace. In this way, you can easily save and restore up to four different camera configurations.

Upon powering up the camera, the firmware loads the work-space registers from the factory space and user-space #1, user-space #2, user-space #3, and user-space #4 as determined by a boot control register stored in the configuration memory. At any time, you can instruct the camera to loads its workspace with the contents of the factory-space, user-space #1, user-space #2, user-space #3, and user-space #4. You can also instruct the camera to save the current workspace as user-space #1, user-space #2, user-space #3, and user-space #4.

The non-volatile parameter Flash memory also contains Lookup tables (LUTs) and DPM/HPM maps that you can update using the Bobcat Upload Manager program.

5.1.1 Camera Serial Protocol

To access the camera registers and resources, transmit a sequence of bytes to the camera using the RS-232 serial interface. This is an RS-232 asynchronous, full-duplex serial protocol with 1 start bit, 8 data bits, 1 stop bit, no handshake, and no parity. The following diagram illustrates the RS-232 serial protocol format. You can configure the default baud rate as 9600, 19200, 38400, 57600, or 115200 (default).

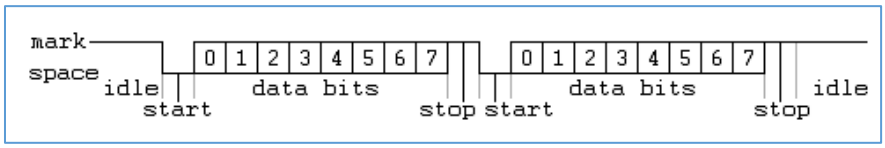


Figure 36: RS-232 serial protocol format

You can update each camera control register independently. The serial protocol defines all registers as 16-bit address (hex format) and 32-bit data (hex format). Camera registers using fewer than 32-bits in width must be padded with 0s on writes; unused bits are ignored on reads. Register data is always packed low within 32-bit data words for registers defined less than 32-bits.

Each command experiences delay due to command execution and data transmission over the serial port. This latency varies from command to command because of resource location and command response length.

5.1.1.1 Write Operation

To write to any given camera register, send a sequence of 7 bytes to the camera. If there is no error, the camera returns a one byte acknowledge for the write command <Ack>.

Write to camera (7 Bytes): <Write_Cmd> <Address> <Data>
- 1st byte: 0x57 (Write Command)
- 2nd byte: <Register Address_High> MSB
- 3rd byte: <Register Address_Low> LSB
- 4th byte: <Register Data Byte 4> MSB
- 5th byte: <Register Data Byte 3> …
- 6th byte: <Register Data Byte 2> …
- 7th byte: <Register Data Byte 1> LSB

Write Acknowledge (1 Byte): <Ack>
- 1st byte: 0x06 (Acknowledge)

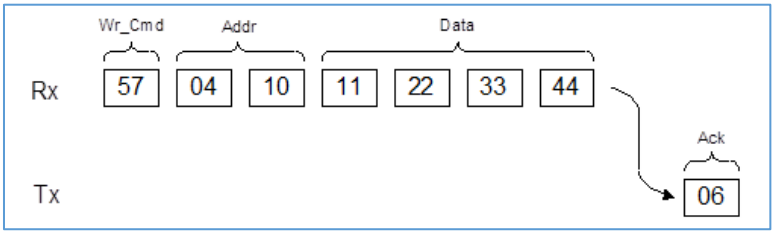


Figure 37: Normal write cycle

If there is an error, the camera returns two bytes not-acknowledge for the write command – the first byte is <Nac> <Err>, the second is the error code as shown in the following diagrams:

Write Not-acknowledge (2 Bytes): <Nak> <Error Code>
- 1st byte:0x15 (Not-acknowledge)
- 2nd byte: <XX> (Nck Error Code. See Error Code Description section)

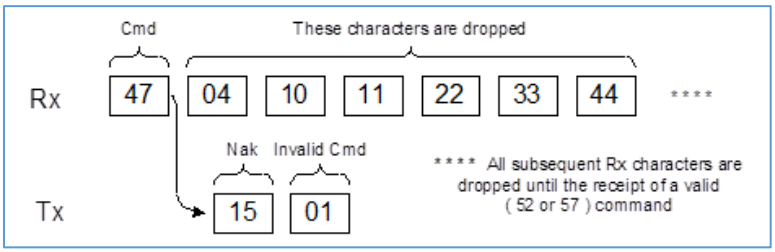


Figure 38: Invalid command error

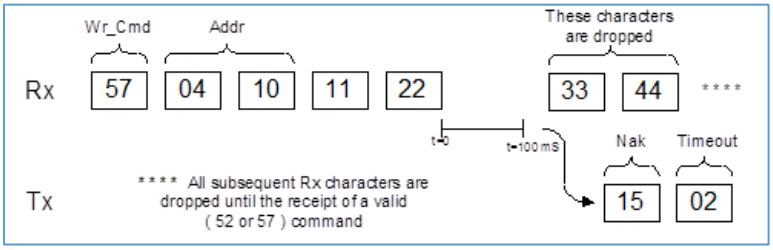


Figure 39: Rx timeout error

Example: Write to register address 0x0410, data value = 0x11223344:
Camera Write Command: <0x57> <04> <10> <11> <22> <33> <44>

5.1.1.2 Read Operation

To read from any given camera register, send a sequence of 3 bytes to the camera. If there is no error, the camera returns 5 bytes – one-byte acknowledge for the read command <Ack> and four bytes of data <DD> <DD> <DD> <DD>.

During read operation, the camera does not return an error or <Nac>. The only exception is the case of invalid command shown in the Normal read cycle diagram below. If you specify a wrong address, the camera returns acknowledge <06> and four bytes of data <00> <00> <00> <00>.

Read from camera (3 Bytes): <Read_Cmd> <Address>
1st byte: 0x52 (Read Command)
2nd byte: <Register Address_Low>
3rd byte: <Register Address_High>

The camera returns (5 bytes): <ACK> <Data>
1st byte: 0x06 (Acknowledge)
2nd byte: <Register Data Byte 4> MSB
3rd byte: <Register Data Byte 3> …
5th byte: <Register Data Byte 2> …
6th byte: <Register Data Byte 1> LSB

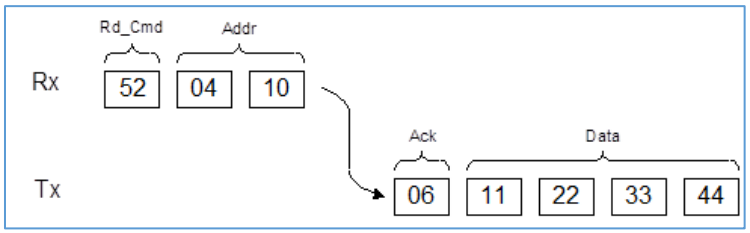


Figure 40: Normal read cycle.

Example: Read from camera register address 0x0410:

Camera Read Command: <0x52> <04> <10>

Camera returns register data payload value 0x11223344:
Register data <0x06> <11> <22> <33> <44>

5.1.1.3 Error Code Description

To manage camera reliability, use the following not-acknowledge error codes:

x00 – No error
x01 – Invalid command. An invalid command (not 52 or 57) sent to the camera.
x02 – Time-out
x03 – Checksum error
x04 – Value less than minimum
x05 – Value higher than maximum
x06 – AGC error
x07 – Supervisor mode error
x08 – Mode not supported error

Appendix A – Camera Registers

The Cheetah Pregius series of cameras are programmable and flexible. You can control all of the cameras resources (internal registers, video amplifiers, and parameter FLASH). The user communicates with the camera using a simple, register-based, command protocol via the Camera Link serial interface. The interface is bi-directional with the user issuing commands to the camera and the camera issuing responses (either status or info) to the user. You can also configure and monitor the camera registers and resources. The camera's parameters are programmed using the Cheetah Sony Configurator graphical user interface.

A.1 Camera Register Structure

The register space is structured in four main sections:

1. Camera Local Space – starting address 0x6000. This space contains all local camera settings, test registers, user command, FW info and all camera status registers
2. Camera Manufacturing Space – starting address 0x7000. This space contains all camera manufacturing information. Writing to the Manufacturing space is allowed only when the Supervisory mode is enabled.
3. Camera EEPROM – starting address 0x5000. This space contains the "Boot From" settings.
4. Camera Factory Space – This space contains all camera registers. This space can be replicated with changes to User (1, 2, 3, and 4) spaces. Save to Factory space is allowed only when the "Supervisory" mode is enabled.

Abbreviation	Description
RW	read/write
RO	read only
WO	write only

Local Space

Address	Register Name	Data	Type	Usage
0x6000	SER_Spare1		RW	
0x6004	Firmware_Revision	Data (31:28) <FW image> Data (27:24) <CMOS Color> Data (23:0) <FW revision>	RO	Returns camera main firmware revision.
0x6008	FPGA_EPCS_CustomerID	Address: 0x6008 Data (15 : 0): <Custom ID #> Data (19 : 16): <EPCS Type> Data (23 : 20): <FPGA Type> Data (27 : 24): <CMOS Chip ID> Data (31 : 28): <Application type>	RO	Returns firmware parameters such as FPGA type, EPCS type, Customer ID #
0x600C	Test		RW	Sends serial connection status of camera.

Address	Register Name	Data	Type	Usage
0x601C	Soft_Reset	Firmware reset command = 0xDEADBEEF	WO	Initiates software reset.
0x6030	SW Trigger		WO	Command instructs camera to generate one short trigger pulse.
0x6038	Firmware Build#	Data (13:0) <FBN revision> Data (31:14) N/A	RO	Returns firmware build number.
0x603C	Camera family ID	Data (13:0) <FBN revision> Data (31:14) N/A	RO	Returns camera Family ID

Boot Loader

Address	Register Name	Data	Type	Usage
0x6060	User Set Selector	Data (2:0) 0x0 – Factory 0x1 – User 1 0x2 – User 2 0x3 – User 3 0x4 – User 4 0x5 to 0x7 – reserved Data (31:3) N/A	RW	Instructs camera which FLASH sector will be accessed: factory space or one of 4 user spaces.
0x6064	User Set Load		WO	Commands camera to load workspace from selected space 0x6060.
0x6068	User Set Save		WO	Commands camera to load workspace from selected space 0x6060.

Camera Info Registers

Address	Register Name	Data	Type	Usage
0x6070	Hor_Frm_Range	Data (15:0) Min. Horizontal Size Data (31:16) Max. Horizontal Size	RO	Returns min./max. horizontal image frame size in pixels.
0x6074	Ver_Frm_Range	Data (15:0) Min. Vertical Size Data (31:16) Max. Vertical Size	RO	Returns min./max. vertical image frame size in lines
0x6078	Cam_Img_Sze	Data (15:0) Horizontal Size Data (31:16) Vertical Size	RO	Returns current image frame size in pixels
0x6080	Cam_Frm_Tim	Data (31:0): Current Frame Time	RO	Returns current camera frame time in micro-seconds.
0x6084	Min_Frm_Time	Data (23:0) Min. Frame Time Data (31:24) N/A	RO	Returns current min. frame time in micro-seconds.
0x6088	Cam_Exp_Time	Data (23:0) Current Exposure Time Data (31:24) Min. Exposure Time	RO	Returns current and min. exposure time in micro-seconds.

Address	Register Name	Data		Type	Usage
0x6094	Wbc_Red, Wbc_Green	Data (11:0) Data (23:12) Data (31:24)	Current Red WBC Current Green WBC N/A	RO	Returns current white balance coefficient values for Red and Green.
0x6098	Wbc_Blue, wbc_White	Data (11:0) Data (23:12) Data (31:24)	Current Blue WBC Current White WBC N/A	RO	Returns current white balance coefficient values for Blue and White.
0x60A0	Agc_Lum_Agn	Data (11:0) Data (23:12) Data (25:24) Data (27, 26) Data (29:28) Data (31, 30)	Current Analog Gain Current Average Luminance Gain Max(25)/Min(24) Limit Reached N/A Exposure Max(29/Min(28) Limit Reached N/A	RO	Returns current analog gain and current average image luminance during normal and AGC operation.

EEPROM Space

Address	Register Name	Data		Type	Usage
0x5000	Boot User Set Default Selector	Data (2:0) Data (31:3)	0x0 – Boot from Factory 0x1 – Boot from User #1 0x1 – Boot from User #2 0x1 – Boot from User #3 0x1 – Boot from User #4 0x5 or 0x7 – reserved	RW	Determines configuration space (factory, user #1 -- user #4) to load in camera after a power cycle or reset ('SW_Reset') command.

Factory/User1/User2/User3/User4 FLASH Store

Sony IMX xxx Registers

Address	Register Name	Data		Type	Usage
0x0000	IMX_Analog_Gain	Data (8:0) Data (31:9)	<value> -Gain setting with 0.1dB per step to 48dB N/A	RW	Sets Analog Gain: 0 -- 48 dB; 0.1 dB step
0x0008	IMX_A2D_Bits	Data (1:0) Data (31:4)	0x0 – 8 bits 0x1 – 10 bits 0x2 –12 bits N/A	RW	Sets number of IMX A/D conversion bits per Sony.
0x0010	AOI_Control	Data (1:0)	0x0 – MAOI disable 0x1 – MAOI enable with frame rate increase 0x2 – MAOI enable with constant frame rate	RW	Controls AOI parameters.

Address	Register Name	Data		Type	Usage
		Data (31:2)	N/A		
0x0014	Aoi_HwM_Ofs	Data (12:0) Data (31:13)	<value> MAOI offset in horizontal direction N/A	RW	Sets Master AOI Horizontal offset.
0x0018	Aoi_HwM_Wdt	Data (12:0) Data (31:13)	<value> MAOI width in horizontal direction N/A	RW	Sets Master AOI Horizontal size.
0x001C	Aoi_VwM_Ofs	Data (12:0) Data (31:13)	<value> MAOI offset in vertical direction N/A	RW	Sets Master AOI Vertical offset.
0x0020	Aoi_VwM_Hgh	Data (12:0) Data (31:13)	<value> MAOI height in vertical direction N/A	RW	Sets Master AOI Vertical size.
0x0024	Hrz_Decim_En	Data (0) Data (31:1)	0x0 – Horizontal Decimation disable 0x1 – Horizontal Decimation enable N/A	RW	Sets Horizontal Subsampling 2:1.
0x0028	Ver_Decim_En	Data (0) Data (31:1)	0x0 – Vertical Decimation disable 0x1 – Vertical Decimation enable N/A	RW	Sets Vertical Subsampling 2:1.
0x002C	Ver_Bin_En	Data (0) Data (31:1)	0x0 – No Vertical Binning 0x1 – 2x Vertical Binning N/A	RW	Vertical Binning 2:1 Mode Enable.
0x0030	Img_Hrev_en	Data (0) Data (31:1)	0x0 – Horizontal Flip Disable 0x1 – Horizontal Flip enable N/A	RW	Flips image left to right.
0x0034	Img_Vrev_en	Data (0) Data (31:1)	0x0 – Vertical Flip Disable 0x1 – Vertical Flip enable N/A	RW	Flips the image upside down.
0x0038	BLK_Adj_en	Data (0) Data (31:1)	0x0 – enable user black level correction 0x1 – Auto black level correction N/A	RW	Enables the black level correction.
0x003C	BLK_Adj_Value	Data (7:0) Data (31:8)	<value> -- Black level value N/A	RW	Sets black Level value.
0x0040	Exp_Ctl_Mod	Data (1:0) Data (31:2)	0x0 – off – no exposure control 0x1 – pulse width – for triggering 0x2 – internal – exposure control 0x3 – N/A N/A	RW	Sets Exposure control mode.
0x0044	Exp_Tim_Abs	Data (23:0) Data (31:1)	<value> -- actual exposure time in micro-seconds N/A	RW	Sets Exposure time.

Address	Register Name	Data		Type	Usage
0x0048	Prg_Frmt_En	Data (0) Data (31:1)	0x0 – disable Long Integration time 0x1 -- enable Long Integration time N/A	RW	Programmable Frame Time enable
0x004C	Prg_Frm_Tim	Data (23:0) Data (31:24)	<value> – actual frame time in micro-seconds. N/A	RW	Sets Frame Time (long integration) in micro-seconds.
0x0058	Aec_Exp_Min	Data (23:0) Data (31:24)	<value> – minimum exposure time limit N/A	RW	Sets AEC Exposure Lower Limit (min.) in microseconds.
0x005C	Aec_Exp_Max	Data (23:0) Data (31:24)	<value> – maximum exposure time limit N/A	RW	AEC Exposure Upper Limit (max.) in microseconds

Data 1 Registers

Address	Register Name	Data		Type	Usage
0x0100	Bit_Dpt_Sel	Data (1:0) Data (31:2)	0x0 – 8-bit 0x1 – 10-bit 0x2 – 12-bit 0x3 – reserved N/A	RW	Selects bit depth transmitted over Camera Link output.
0x0104	Dat_Fmt_Sel	Data (2:0) Data (31:3)	0x0 – Base (2 taps) 0x1 – Base (3 taps) 0x2 – Medium 0x3 – Full 0x4 -- DECA 0x5 to 0x7 – reserved N/A	RW	Selects tap format for the CL camera data output.
0x0108	Test_Mod_Sel	Data (3:0) Data (31:4)	0x0 – no test pattern 0x1 – BW checkerboard 0x2 – gray image – user selectable value 0x3 – tap segmented (each CL tap has a fixed value) 0x4 – steady horizontal image ramp 0x5 – steady vertical image ramp 0x6 – steady vertical & horizontal image ramp 0x7 – moving vertical & horizontal image ramp 0x8 – 8 gray scale vertical bars 0x9 – Center cross superimposed over live image 0xA to 0xF - reserved N/A	RW	Selects test mode pattern.

Address	Register Name	Data		Type	Usage
0x010C	Test_Img_Brt	Data (11:0) Data (31:12)	<value> - image brightness N/A	RW	Sets test image brightness.
0x0110	Hor_Bin_En	Data (0) Data (31:1)	0x0 – No horizontal binning 0x1 – 2x horizontal binning N/A	RW	Sets current binning format in horizontal direction
0x0114	LUT_En	Data (2:0) Data (31:3)	0x0 – No LUT selected 0x1 – LUT #1 selected 0x2 – LUT #2 selected 0x3 – LUT #3 selected 0x4 – LUT #4 selected 0x5 to 0x7 – unused N/A	RW	Selects LUT to use.
0x011C	BPC_En	Data (1:0) Data (31:2)	0x0 – BPC disable 0x1 –Factory Map BPC enable 0x2 – Dynamic BPC enable 0x3 – Factory & Dynamic BPC enable 0x4 – User Map BPC enable 0x5 – User Map & Dynamic BPC enable N/A	RW	Enables Bad Pixel Correction (BPC).
0x0120	Dyn_BPC_Thld	Data (11:0) Data (31:2)	<value> - Threshold value N/A	RW	Sets Dynamic Pixel Correction (DPC) threshold.
0x0124	FFC_En	Data (1:0) Data (31:2)	0x0 – FFC disable 0x1 – FFC 1 enable 0x2 – FFC 2 enable N/A	RW	Enables Flat Field Correction (FFC).
0x0128	Neg_Img_En	Data (0) Data (31:1)	0x0 – Positive image 0x1 – Negative image N/A	RW	Enables negative image.
0x012C	Aoi_Slv1_En	Data (2:0) Data (31:3)	0x0 – SAOI disable 0x1 – SAOI include 0x2 – SAOI exclude 0x3 –AEC/AGC target level uses pixel values inside the SAOI 0x4 – AEC/AGC target value excludes pixel values inside SAOI 0x5 –AWB coefficients determined by values inside the SAOI 0x6 –AWB coefficients determined by values outside the SAOI 0x7 – LUT applies to pixels inside the SAOI 0x8 – LUT applies to pixels outside the SAOI N/A	RW	Enables Slave AOI and sets window size and various ways slave AOI can be used by the camera.
0x0130	Aoi_HwS_Ofs	Data (12:0)	<value> SAOI offset in horizontal direction	RW	Sets Slave AOI Horizontal offset.

Address	Register Name	Data		Type	Usage
		Data (31:13)	N/A		
0x0134	Aoi_HwS_Wdt	Data (12:0) Data (31:1)	<value> SAOI width in horizontal direction N/A	RW	Sets Slave AOI Horizontal size.
0x0138	Aoi_VwS_Ofs	Data (12:0) Data (31:13)	<value> SAOI offset in vertical direction N/A	RW	Sets Slave AOI Vertical offset.
0x013C	Aoi_VwS_Hgh	Data (12:0) Data (31:13)	<value> SAOI height in vertical direction N/A	RW	Sets Slave AOI Vertical size.
0x0140	Aec_Ctl_En	Data (0) Data (31:1)	0x0 – disable auto exposure control 0x1 – enable auto exposure control N/A	RW	Enables Auto Exposure Control (AEC).
0x0144	Agc_Ctl_En	Data (0) Data (31:1)	0x0 – disable auto gain control 0x1 – enable auto gain control N/A	RW	Enables Auto Gain Control (AGC).
0x0148	Agc_Lum_Lev	Data (11:0) Data (31:12)	<value> – desired luminance level N/A	RW	Provides AGC luminance level control.
0x014C	Avg_Peak_Sel	Data (1:0) Data (31:2)	0x0 – average luminance 0x1 – peak luminance 0x2 or 0x3 – reserved N/A	RW	Sets luminance mode during AEC or AGC process.
0x0150	Agc_Agn_Min	Data (8:0) Data (31:9)	<value> – minimum AGC gain limit N/A	RW	Sets AGC Gain Lower Limit (min.) in dB (0 to 48 dB, 0.1 dB per step).
0x0154	Agc_Agn_Max	Data (8:0) Data (31:9)	<value> – Maximum AGC gain limit N/A	RW	Sets AGC max. limit in dB (0 to 48dB with 0.1dB per step).
0x0158	Dat_Shft_Sel	Data (3:0) Data (31:4)	0x0 – no shift 0x1 – 1 bit left 0x2 – 2 bits left 0x3 – 3 bits left 0x4 – 4 bits left 0x5 – 5 bits left 0x6 – 6 bits left 0x7 – 7 bits left 0x8 – reserved 0x9 – 1 bit right 0xA – 2 bits right 0xB – 3 bits right 0xC – 4 bits right 0xD – 5 bits right 0xE – 6 bits right 0xF – 7 bits right N/A	RW	Selects bit shift steps for camera data output.

Address	Register Name	Data		Type	Usage
0x0164	Agc_Aec_Spd_Ctl	Data (1:0) Data (31:2)	00 – 01x speed (slow) 01 – 2x speed 10 – 3x speed 11 – 4x speed (fast) N/A	RW	Sets the exposure correction speed during AGC.AEC.

Data 2 Registers

Address	Register Name	Data		Type	Usage
0x0200	WB_en	Data (0:1) Data (31:2)	00 – Off 01 – WB Once 10 – WB Auto 11 – WB Manual N/A	RW	Selects the white balance mode.
0x0204	WB_Red	Data (11:0) Data (31:12)	<value> – WB Red coefficient N/A	RW	Contains white balance correction coefficients for Red. In manual mode, user enters the coefficients.
0x0208	WB_Green	Data (11:0) Data (31:12)	<value> – WB Green coefficient N/A	RW	Contains the white balance correction coefficients for Green. In manual mode, user enters the coefficients.
0x020C	WB_Blue	Data (11:0) Data (31:12)	<value> – WB Blue coefficient N/A	RW	Contains the white balance correction coefficients for Blue. In manual mode, user enters the coefficients.

I/O Interface Registers

Address	Register Name	Data		Type	Usage
0x0500	Trg_Mode_En	Data (0) Data (31:1)	0x0 – trigger is disabled, free running mode 0x1 – trigger is enabled; camera in trigger mode N/A	RW	Enables Trigger mode.
0x0504	Trg_Inp_Sel	Data (2:0)	0x0 – N/A 0x1 – External 1; camera expects trigger from Input #1, IN1 0x2 – Internal; camera expects trigger from programmable pulse generator. 0x3 – computer; camera expects trigger from CC1 via Camera Link cable.	RW	Selects Trigger input.

Address	Register Name	Data		Type	Usage
			0x4 – software trigger; expects a one clock cycle pulse generated by software. Exposure is internal timer controlled. Pulse duration exposure not allowed. 0x5 – External 2; camera expects trigger from Input #2, IN 2. 0x6 to 0xF – N/A		
		Data (31:3)	N/A		
0x0508	Trg_Edg_Sel	Data (0)	0x0 – rising edge 0x1 – falling edge	RW	Selects Trigger active edge.
		Data (31:1)	N/A		
0x050C	Trg_Dbn_Tim	Data (15:0)	<value> –debounce time	RW	Selects trigger signal de-bounce time in micro-seconds
		Data (31:16)	N/A		
0x0510	Trg_Flt_Tim	Data (15:0)	<value> –glitch time	RW	Selects Filter time in micro-seconds. Any pulse shorter than the selected time is ignored.
		Data (31:16)	N/A		
0x0514	Trg_Ovr_Sel	Data (1:0)	0x0 – ignore next trigger 0x1 – accept only after exposure is completed 0x2 – N/A 0x3 – N/A	RW	Selects trigger overlap mode. If camera receives a trigger pulse while still processing previous trigger, user has option to ignore the incoming trigger or to terminate previous process and start a new one.
		Data (31:2)	N/A		
0x0518	Trg_Mod_Sel	Data (3:0)	0x0 – standard triggering 0x1 – fast triggering 0x2 – reserved 0x3 to 0xF – reserved	RW	Selects triggering mode.
		Data (31:4)	N/A		
0x051C	Trg_Frm_Cap	Data (15:0)	<value> –number of frames per trigger	RW	Selects number of frames captured after each trigger signal.
		Data (31:16)	N/A		
0x0520	Trg_Exp_Del			RW	Selects delay in microseconds between trigger signal and beginning of exposure.
0x0524	Trg_Str_En	Data (1:0)	0x0 – disable Trigger Strobe 0x1 – enable Trigger Strobe #1	RW	Enables Trigger strobe.

Address	Register Name	Data		Type	Usage
			0x2 – enable Trigger Strobe #1 0x3 – enable both Trigger Strobe #1 and #2		
		Data (31:2)	N/A		
0x0528	Trg_Str_Del	Data (23:0)	<value> –Strobe delay in microseconds	RW	Sets delay between trigger pulse and strobe pulse.
		Data (31:24)	N/A		
0x052C	Str_One_En	Data (1:0)	0x0 – disable Strobe #1 0x1 – enable Strobe #1, each frame 0x2 – enable Strobe #1, odd frames only 0x3 – enable Strobe #1, even frames only	RW	Sets Strobe 1 mode of operation.
		Data (31:2)	N/A		
0x0530	Str_One_Dur	Data (15:0)	<value> –Strobe #1 Pulse width in microseconds	RW	Sets Strobe 1 duration in microseconds.
		Data (31:16)	N/A		
0x0534	Str_One_Pos	Data (23:0)	<value> –Strobe #1 Pulse position in microseconds up to one frame time	RW	Sets Strobe 1 position in microseconds.
		Data (31:24)	N/A		
0x0538	Str_Two_En	Data (1:0)	0x0 – disable Strobe #2 0x1 – enable Strobe #2 each frame 0x2 – enable Strobe #2 odd frames only 0x3 – enable Strobe #2 even frames only	RW	Sets Strobe #2 mode of operation.
		Data (31:2)	N/A		
0x053C	Str_Two_Dur	Data (15:0)	<value> –Strobe #2 Pulse width in microseconds	RW	Sets Strobe 2 duration in microseconds.
		Data (31:16)	N/A		
0x0540	Str_Two_Pos	Data (23:0)	<value> –Strobe #2 Pulse position in microseconds up to one frame time	RW	Sets Strobe 2 position in microseconds.
		Data (31:24)	N/A		
0x0544	Pls_Gen_Stp	Data (1:0)	0x0 – x1 0x1 – x10 0x2 – x100 0x3 – x1000	RW	Sets pulse generator main timing resolution.
		Data (31:2)	N/A		
0x0548	Pls_Gen_Wdt	Data (23:0)	<value> –Sets Pulse width in microseconds when multiplied by granularity setting	RW	Sets the value of the pulse width in microseconds
		Data (31:24)	N/A		

Address	Register Name	Data		Type	Usage
0x054C	Pls_Gen_Per	Data (23:0) Data (31:24)	<value> –Sets Pulse period in microseconds when multiplied by granularity setting N/A	RO	Sets the value of the pulse period in microseconds.
0x0550	Pls_Gen_Nmb	Data (15:0) Data (16) Data (31:17)	<value> – number of discrete pulses 0x1 – continuous pulse generation N/A	RW	Sets the number of the pulses generated. If Bit 16 is set, continuous mode selected.
0x0554	Pls_Gen_En	Data (0) Data (31:1)	0x0 – disable Pulse Gen 0x1 – enable Pulse Gen N/A	RW	Enables pulse generator.
0x0558	OUT1_Pol_sel	Data (0) Data (31:1)	0x0 – active LOW 0x1 – active HIGH N/A	RW	Selects OUT1 polarity (active Low or High).
0x055C	OUT1_Map_Sel	Data (7:0) Data (31:8)	0x00 – no mapping 0x01 – exposure start 0x02 – exposure end 0x03 – mid exposure 0x04 – active exposure window 0x05 – H sync 0x06 – V sync 0x07 – odd/even frame flag 0x08 – trigger pulse actual 0x09 – trigger pulse delayed 0x0A – camera ready 0x0B – pulse generator 0x0C – strobe #1 0x0D – strobe #2 0x0E – toggle OUT 1 0x0F – Frame pulse N/A	RW	Maps the various internal signals to OUTPUT # 1 (OUT 1).
0x0560	OUT2_Pol_sel	Data (0) Data (31:1)	0x0 – active LOW 0x1 – active HIGH N/A	RW	Selects OUT2 polarity (active Low or High).
0x0564	OUT2_Map_Sel	Data (7:0)	0x00 – no mapping 0x01 – exposure start 0x02 – exposure end 0x03 – mid exposure 0x04 – active exposure window 0x05 – H sync 0x06 – V sync 0x07 – odd/even frame flag 0x08 – trigger pulse actual 0x09 – trigger pulse delayed 0x0A – camera ready 0x0B – pulse generator 0x0C – strobe #1 0x0D – strobe #2 0x0E – toggle OUT 1	RW	Maps the various internal signals to Output #2 (OUT 2)

Address	Register Name	Data	Type	Usage
		0x0F – Frame Pulse Data (31:8) N/A		

Miscellaneous Registers

Address	Register Name	Data	Type	Usage
0x0604	Baud_rate_sel	Data (2:0) 0x0 – 9600 0x1 – 19200 0x2 – 38400 0x3 – 57600 0x4 – 115200 (default) 0x5 to 0x7 - reserved Data (31:3) N/A	RW	RS-232 Baud Rate Selector 0=9600, 1=19200, 2=38400, 3=57600 and 4=115200 bps
0x060C	RGS_ID#_Register		RW	Contains RGS ID number register.