IMPERX

Cheetah 3G-SDI Camera

User Guide

with SMPTE® output

The Imperx Cheetah 3G-SDI cameras provides broadcast quality video imaging with high sensitivity in a compact and ruggedized design. The camera's Sony Pregius CMOS image sensor delivers 1920 x 1080 resolution at up to 60 progressive frames per second. It provides the superior motion capture needed in a wide range of applications such as industrial imaging, surveillance, metrology, and medical and scientific imaging. The 3G-SDI cameras are easy to configure and are SMPTE 292M and 424M compliant.

Document Version 1.1

IMPERX™
Industrial Cameras & Imaging Systems

About Imperx, Inc.

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

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

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Warranty

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

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

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

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REVISION HISTORY

Revision	Date	Reviser	Comments
1.0	10/4/2017	R. Johnston	Initial release approval
1.1	11/16/17	R. Johnston	Added C1920 camera and updated GUI screens

1 About the 3G-SDI Camera

1.1 General

Imperx Cheetah 1080P 3G-SDI CMOS cameras provide a ruggedized imaging platform with the latest digital technology and industrial grade components. The 3G-SDI cameras meet the video output standards set by the Society of Motion Picture and Television Engineers (SMPTE). The Serial Digital Interface (SDI) is a standard for digital video transmission over coaxial cable.

The 3G-SDI cameras contain Sony Pregius CMOS image sensors and are SMPTE 292M and 424M compliant. The cameras are available in monochrome and color.

Model	Resolution	Type	Optics	CMOS	Model
SDI-C2010M	1920 x 1080	Mono	½”	Sony	IMX-265LLR
SDI-C2010C	1920 x 1080	Color	½”	Sony	IMX-265LQR
SDI-C1920M	1920 x 1080	Mono	1/1.2”	Sony	IMX-174LLJ-C
SDI-C1920C	1920 x 1080	Color	1/1.2”	Sony	IMX-174LQJ-C

The Cheetah 3G-SDI is an advanced, ruggedized, small profile 1080 progressive scan digital camera. It is fully programmable and field upgradeable. It features a built-in image-processing engine, low power consumption, low noise, and high dynamic range (12 F-Stops) with frame rates up to 60 frames per second. The camera provides programmable gain, offset, electronic shutter, strobe output, gamma correction, and programmable Look-up tables (LUT).

The camera supports global shutter operation for superior motion capture and is fully programmable via the serial interface using a GUI based configuration utility. The camera is suitable for many applications including machine vision, metrology, high-definition surveillance, medical, scientific imaging, intelligent transportation systems, character recognition, document processing, and more.

1.1.1 Key Features

- 1080P Mono and Color 23.98p, 24p; 25p; 29.97p, 30p; 50p; 59.94p, 60p
- Color - 3x10-bit (YCrCb) data
- RS-232/RS485 serial communication
- Analog/digital gain and offset control
- One Area of Interest (AOI) for AEC/AGC
- Automatic gain and exposure control (AEC/AGC) with optional P-Iris control
- Automatic white balance
- Internal exposure control – manual, automatic
- Test image with image superimposition
- Programmable I/O
    - 1 genlock tri-level sync input; 1 programmable TTL output

- Dynamic transfer function and gamma corrections
- field upgradeable firmware

1.2 Technical Specifications

Specifications	C2010 3G-SDI	C1920 3G-SDI
Active image resolution	1920 (H) x 1080 (V)	1920 (H) x 1080 (V)
Pixel size	3.45 µm	5.86 µm
Video output	Digital, 10 bit	Digital, 10 bit
Output structure	YUV422	YUV422
Data clock	37.08789/37.125 MHz	37.08789/37.125 MHz
Camera interface	HD-SDI SMPTE 292M and 424	HD-SDI SMPTE 292M and 424
SDI format	23.98p, 24p, 25p, 29.97p, 30p, 50p, 59.94p, 60p	23.98p, 24p, 25p, 29.97p, 30p, 50p, 59.94p, 60p
Dynamic range	71 dB (12 F Stops)	73 dB (12 F Stops)
Shutter speed	1/50,000 to 1/24	1/50,000 to 1/24
Gain	0 to 48 dB, 480 steps	0 to 48 dB, 480 steps
Gain resolution	0.1 dB/step	0.1 dB/step
Black level offset	0-511 levels	0-511 levels
Auto gain/exposure	Yes, with optional AEC/AGC within an AOI	Yes, with optional AEC/AGC within an AOI
LUT	4 user LUTs; 8 gamma LUTs; 8 black gamma LUTs	4 user LUTs; 8 gamma LUTs; 8 black gamma LUTs
Tri-level sync input	Yes	Yes
Camera size (W x H x L)	37mm x 37mm x 48.6mm	37mm x 37mm x 48.6mm
MTBF	>406,000 hours at 40°C	>406,000 hours at 40°C
Weight	91.8 grams nominal	91.8 grams nominal
Minimum illumination	0.2 lux, f=1.4	0.2 lux, f=1.4
Lens mount	C mount, ½" format	C mount, ½" format
Power	3.6W	3.6W
RS 232/RS 485 interface	Yes	Yes
Auto white balance	Yes	Yes
Optional P-Iris	Yes	Yes
Test image	Yes	Yes
Image overlay	Yes	Yes
I/O control	1 tri-level sync input, 2 outputs	1 tri-level sync input, 2 outputs
Strobe output	1 TTL strobe; one opto-isolated strobe	1 TTL strobe; one opto-isolated strobe
In-camera processing	Yes	Yes
Camera housing	6000 series aluminum	6000 series aluminum
Supply voltage range	10V min to 15VDC max	10V min to 15VDC max
Upgradeable firmware	Yes	Yes

Upgradeable LUT	4 User programmable LUTS	4 User programmable LUTS
Operating	1.5G: –40.0°C to +75°C 3.0G: –30.0°C to +75°C	1.5G: –40.0°C to +75°C 3.0G: –30.0°C to +75°C
Environmental	–50.0°C to +90.0°C storage	–50.0°C to +90.0°C storage
Vibration, shock	TBD	TBD
Relative humidity	10% to 90% non-condensing	10% to 90% non-condensing
Regulatory	FCC 15 part A, CE, RoHS	FCC 15 part A, CE, RoHS

1.3 Camera Configuration

Cheetah SDI cameras are programmable and flexible. You can control and monitor the camera's resources (internal registers and parameter flash) using a simple, register-based, command protocol via the camera's RS-232 serial interface. The interface is bidirectional enabling you to issue commands to the camera and receive responses (either status or info) from the camera. You can also program the camera's parameters using the Cheetah SDI CamConfig graphical user interface (GUI) software.

1.4 Ordering Information

Cheetah 3G-SDI Camera Ordering Codes Sample code: SDI-C2010C-RC000					
Interface	Camera model	Sensor Type	Temp. range	Lens Mount	Filter/ customization options
SDI	C2010 C1920	M – monochrome C – color	R-Ruggedized	C – Mount	000 – none
Note: PS12V06 Power Supply sold separately.					

2 Hardware

2.1 Camera Connectivity

The Cheetah 3G-SDI camera connects to outside equipment using two connectors on the back panel of the camera. The back panel also provides an LED status indicator.

The camera provides the following:

1. Camera 3G-SDI output – Amphenol-RF Division 75 Ohm coaxial connector ACX1785-ND #282121-75. Imperx offers a 3G-SDI coaxial cable with 1.0/2.3 DIN to BNC male connectors available in varying lengths. The cable has a miniature quick connect/push-pull type coupling mechanism on the camera end and a BNC connector with quarter turn coupling on the host computer end. Contact Imperx for more information.
2. 12-pin Hirose (male) connector – a male type miniature locking receptacle #HR10A-10R-12PB(71) providing power, I/O interface, and Serial RS-232/485 interface. See connector pin mapping (2.1.1 Pin Assignments) on the following page.
3. Status LED – indicates the status of the camera (2.1.2. LED Status).
4. Serial Number – provides camera model and serial number.

2.1.1 Pin Assignments

The 12-pin Hirose connector assigns signals to the following pins.

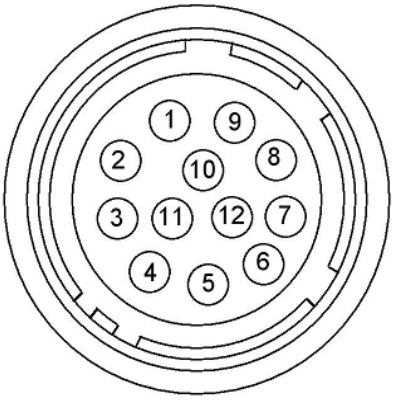


Figure 1: Connector Pin-outs.

Pin	Signal	Type	Description
1	12 VDC Return	Ground Return	12 VDC Main Power Return
2	+ 12 VDC	Power – Input	+ 12 VDC Main Power
3	RS-232 RX	Communication Input	RS-232/RS-485 Receive
4	RS-232 TX	Communication Output	RS-232/RS-485 Transmit
5	GPIO_1B	General Purpose I/O 1B	Reserved for optional P-IRIS A-Phase or Strobe 2_Return
6	RS-232 RTN	Communication Return	RS-232/RS-485 Return
7	OUT 1	TTL OUT 1	Strobe 1 Output
8	TLS IN 1	Tri-Level Sync	Tri-Level Sync Genlock Input
9	GPIO_2A	General Purpose I/O 2A	Reserved for P-IRIS B_Enable
10	GP IN and Out 1 Return	Ground Return	Tri-level Sync Input and Out 1 Return
11	GPIO_2B	General Purpose I/O 2B	Reserved for P_IRIS B_Phase
12	GPIO_1A	General Purpose I/O 1A	Reserved for optional P-IRIS A_Enable or Strobe 2_output

Table 1: 3G-SDI Power Connector Pin Mapping.

2.1.2. LED Status

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	Camera is in external genlock sync mode.
YELLOW steady ON	Test mode. You should see one of the test patterns.
YELLOW blinks at ~ 0.5 Hz	Camera is in AGC/AEC mode. In this mode, changing the shutter slider does not affect the 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.

Example

The follow illustration shows an example setup of C2010 components and cabling.

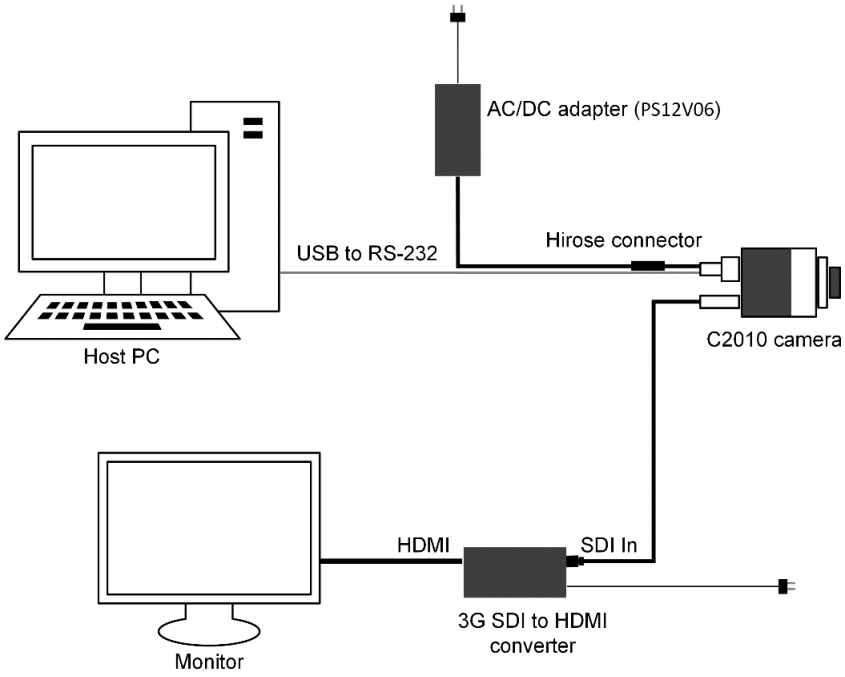


Figure 2: C2010 Connection example.

2.1.3 Power Supply

The Cheetah 3G-SDI camera can use a universal desktop power supply adapter providing +12VDC, ± 10% and up to 2.5A DC current available from Imperx (P/N: PS12V06). The operating input voltage ranges from 90 to 240 VAC.

PS12V06 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")

Electrical:

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

Regulatory:

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

The PS12V06 power supply (sold separately) terminates in a female Hirose type miniature locking receptacle #HR10A-10P-12S(73). It has a DB9 connector for serial RS-232/485 interface and a small BNC pig-tail cable providing external trigger input (black) and strobe output (white). The following table and figure show the PS12V06 power supply cabling and connectors.

Pin	Signal	Cable Color	Description
Case	In 1 Return	BNC Black	Tri-level Sync Input 1 Return
Signal	In 1 Active		Tri-level Sync Input 1 Signal
Case	Out 1 Return	BNC White	Strobe 1 Output Return
Signal	Out 1 Active		Strobe 1 Output Signal

Table 3: BNC connector pin mapping.

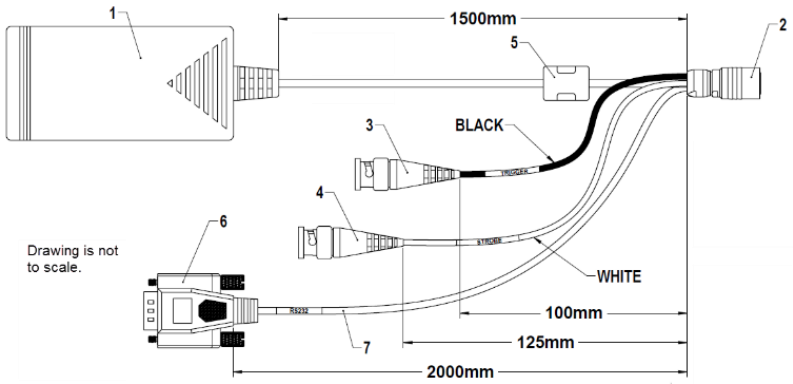


Figure 3: Power supply and cabling.

PS12V06 Power supply cable descriptions:

1 – Shielded power supply AC/DC adapter
2 – Connector, Hirose HR 10A-10P-12S

3 – BNC (M) cable subassembly (black) for genlock IN trigger
4 – BNC (M) cable subassembly (white) for strobe OUT
5 – Cable subassembly for 12V power
6 – DB9 connector female for RS232 serial communications with computer
7 – Cable, 2-conductor shielded #24AWG

CAUTION

It is strongly recommended that you use the PS12V06A power adapter from Imperx!

2.2 Electrical Connectivity

A. Inputs IN1

The external inputs in Cheetah HD-SDI cameras are connected directly to the camera hardware as shown in the following figures. The input signals "Signal" and "Return" are used to connect to an external input on the outside source. For IN1, the signal level (voltage difference between the inputs "Signal" and "Return") MUST NOT exceed 1.2Vpp.

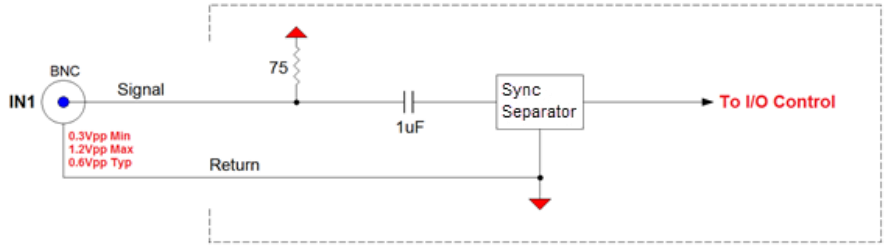


Figure 4: IN1, Tri-Level Sync electrical input connection.

B. Outputs OUT1

The OUT1 external output in Cheetah HD-SDI camera is directly connected to the camera hardware and is a TTL (5.0 Volts) compatible signal. The maximum output current MUST NOT exceed 8 mA. The following figure shows the OUT1 output external electrical connection.

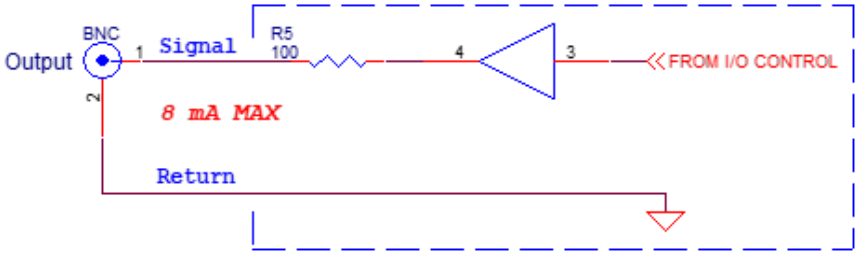


Figure 5: OUT1 electrical connection.

C. Outputs OUT2

Output OUT2 is an optically isolated switch. There is no pull-up voltage on either contact. 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.

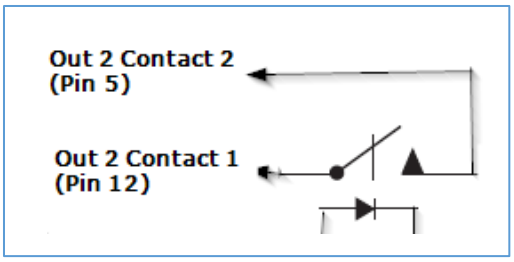


Figure 6: OUT2 Opto-Isolated electrical connection.

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 and the back. An additional plate with ¼-20 UNC (tripod mount) and hardware ship with each camera.

Figure 7: 3G-SDI camera.

The following mechanical drawings show side, front, and back views of the 3G-SDI camera.

Camera, side view:

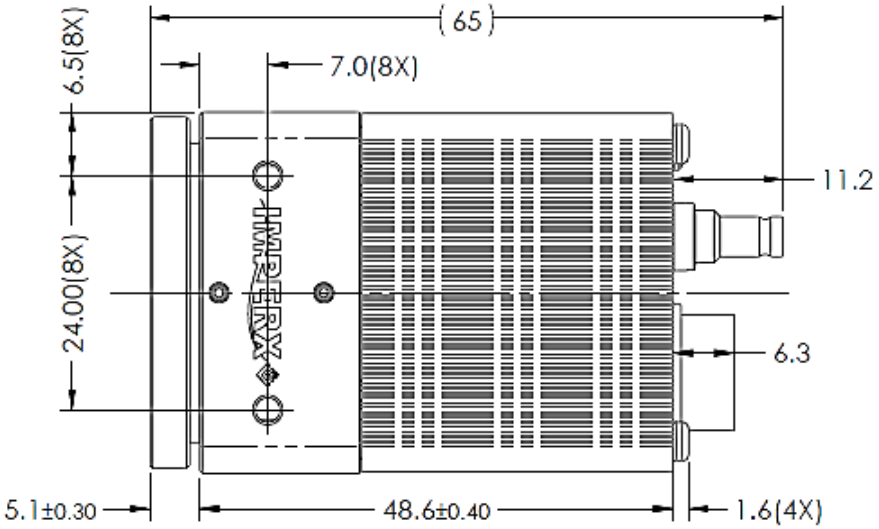


Figure 8: 3G-SDI camera, side view.

Camera, back view:

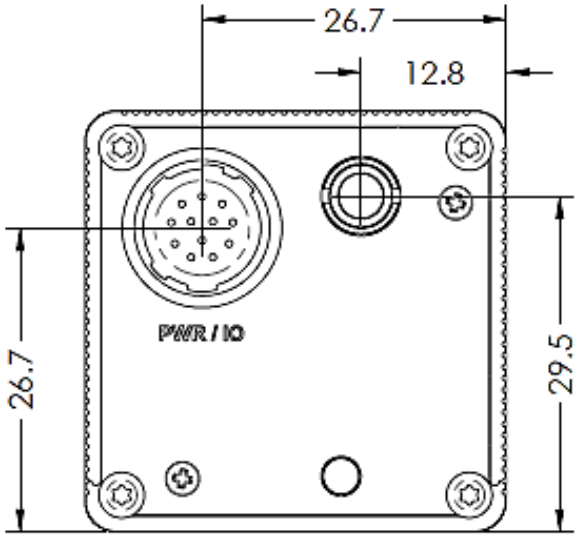


Figure 9: 3G-SDI camera, back view.

Camera, front (lens) view:

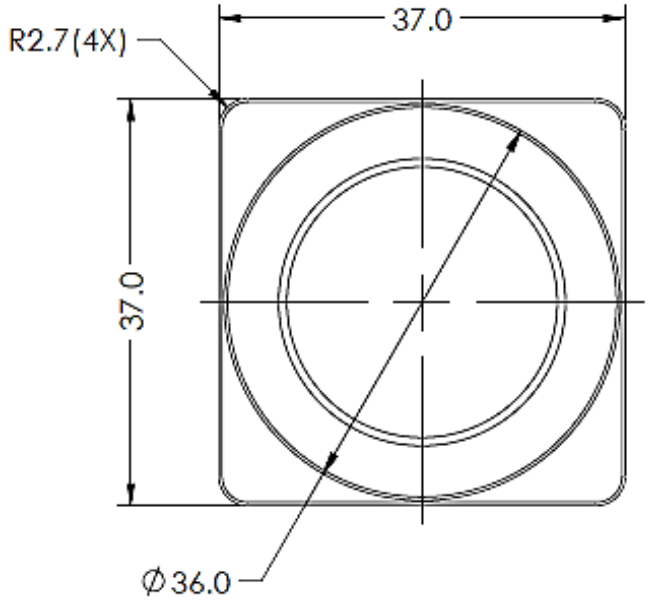


Figure 10: 3G-SDI camera, front view.

2.4 Optical

The Cheetah 3G-SDI camera cross-section comes with an adapter for C-mount lenses that have a 17.52 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 3G-SDI camera. 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 RS-232 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 3G-SDI camera.

CAUTION

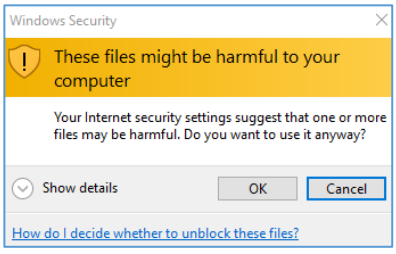
If a previous version of the Cheetah Pregius GUI software is installed on your computer, you must remove it before completing the installation. The installation wizard will do this for you during the installation process. Or, you can uninstall a previous version yourself.

To remove previous versions yourself:

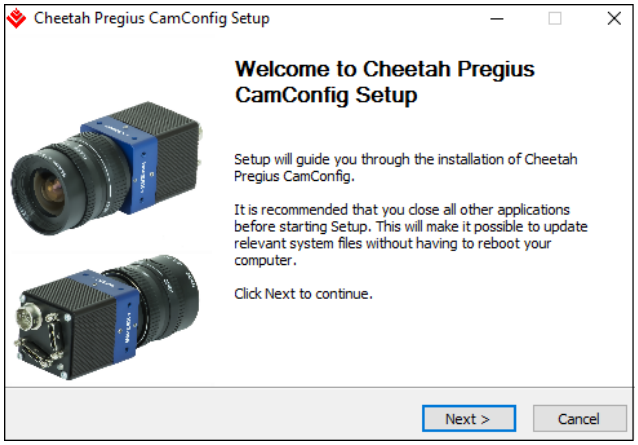
1. Open **Control Panel** on your computer.
2. Select **Programs and Features**.
3. Select the software from the list.
4. Click **Uninstall**.

Installation

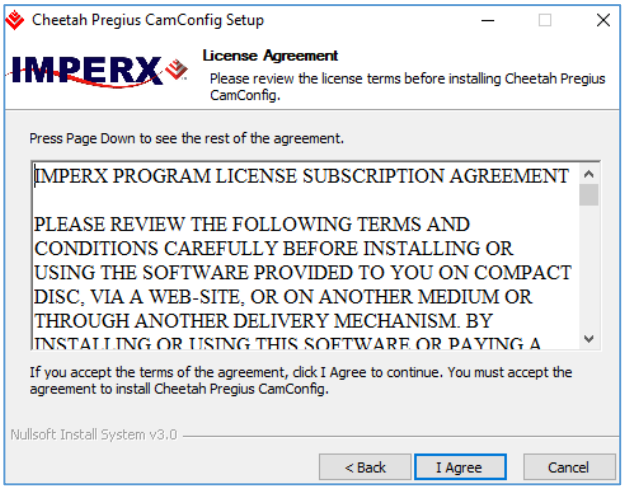
1. Locate the executable file (`Cheetah_Pregius_1_0_5_xxxx.exe`) on the media that shipped with your camera.
2. Drag the file to your computer desktop. If a Security screen appears, click **OK**.



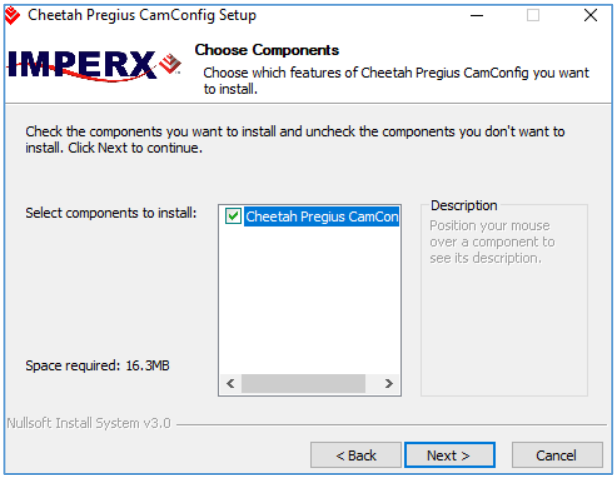
3. Double click the executable file (`Cheetah_Pregius_1_0_5_xxxx.exe`) on your desktop. The Welcome Setup screen opens. Note the recommendation to close other applications and then click **Next**.



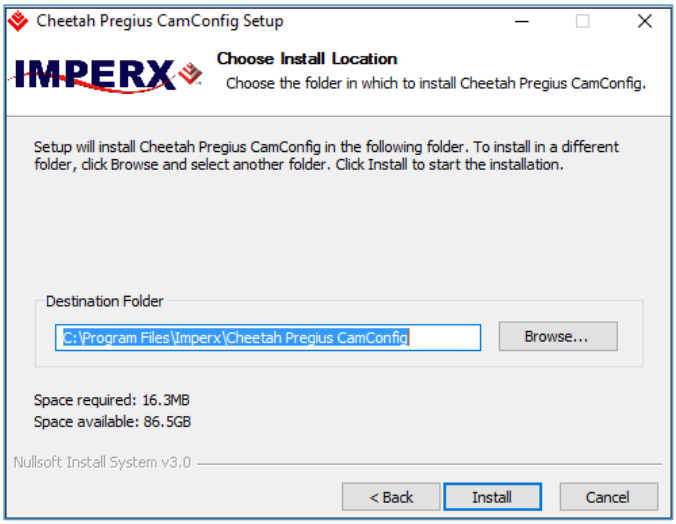
4. When the License Agreement screen appears, read the agreement and click **I Agree**.

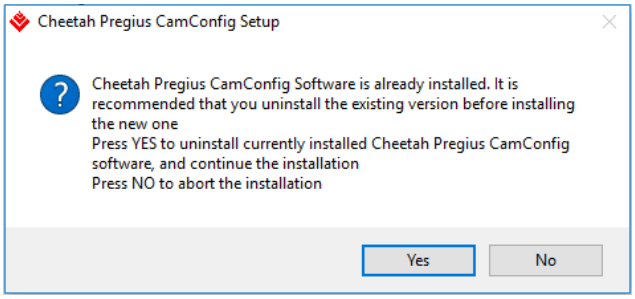


5. On the Choose Components screen, make sure the Cheetah Pregius CamConfig component is selected and then click **Next**.

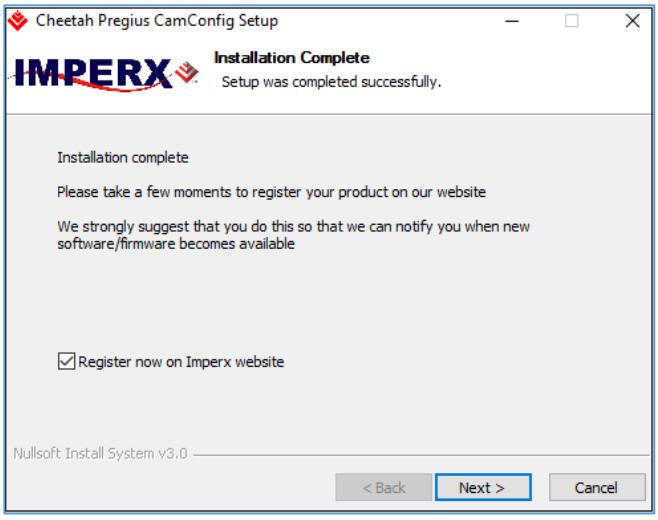


6. On the Choose Install Location screen, accept the default destination folder or click **Browse** and select a different location and then click **Install.** The installer prompts you to uninstall any existing versions of the software from your computer before continuing the installation.

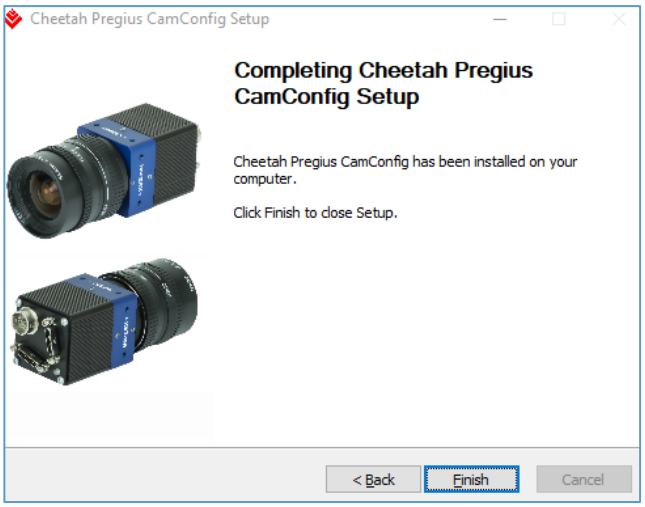




7. On the Installation Complete screen, select the check box to register your software and then click **Next**. When the Imperx website appears, complete the Subscriber Registration and click **Submit**.



8. 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 Cheetah 3G-SDI 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 3G-SDI 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 you do not see the camera as one of the selectable ports, make sure the RS232 connector is plugged into the computer from the power supply. If the computer does not have an RS232 port, you should purchase a USB-to-RS232 adapter:

1. Make sure to install the drivers from any USB device prior to connecting the USB-to-RS232 adapter to the computer. A system restart might be necessary to ensure drivers are applied properly.
2. If the device still does not work, open Device Manager, select Ports (COM & LPT), right-click on USB, and select Update Driver Software.

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.

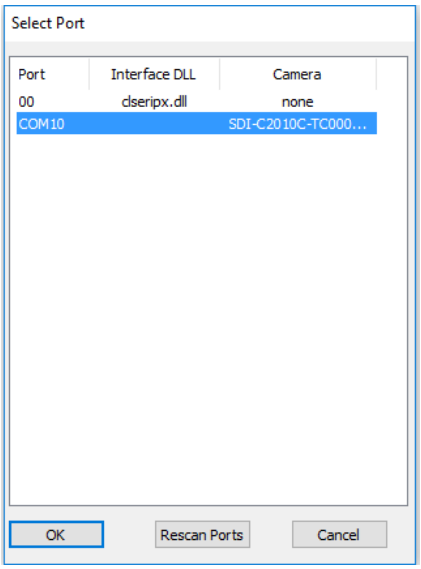


Figure 11: Select Port identifies cameras.

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.

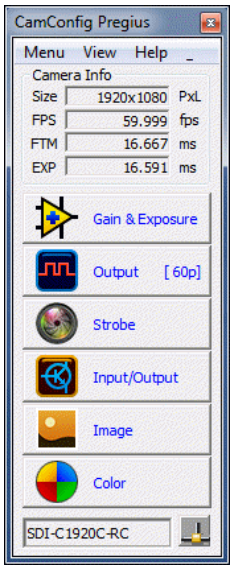


Figure 12: GUI interface.

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.

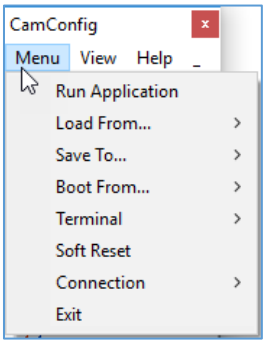


Figure 13: Menu options.

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 or #2: Loads the camera registers with settings saved within the camera in either camera user space #1 or user space #2.

Save To . . .

You can save the camera registers to a File, to camera User Space #1, or to camera User Space #2. Factory Space is available only for factory technicians.

Boot From . . .

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

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>

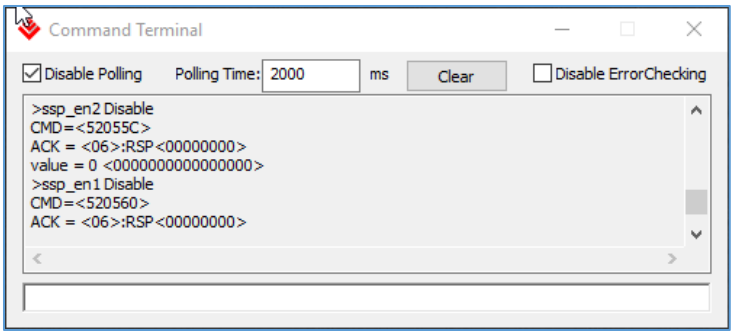


Figure 14: Command Terminal command to addresses 055C and register 0560.

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.

Soft Reset

Resets all current camera settings to default values according to the current Boot From selection.

Connection

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

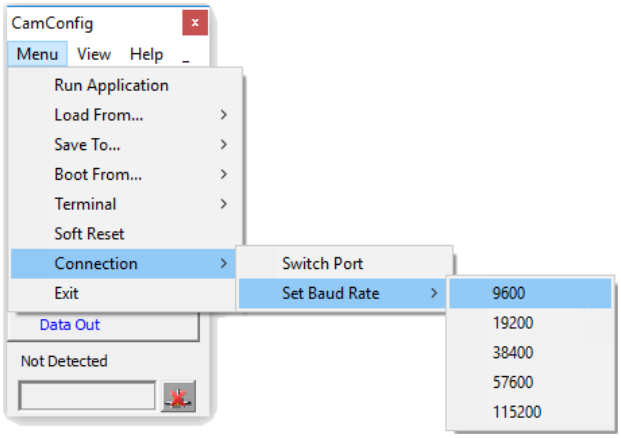


Figure 15: Connections lets you control ports and baud rates.

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: Gain & Exposure, I/O Control, Strobe, Image Control, 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 Control

Gain & Exposure control lets you set the camera's exposure, gain control, automatic exposure control, and automatic gain control. These functions are available from the Gain & Exposure tab on the Main window.

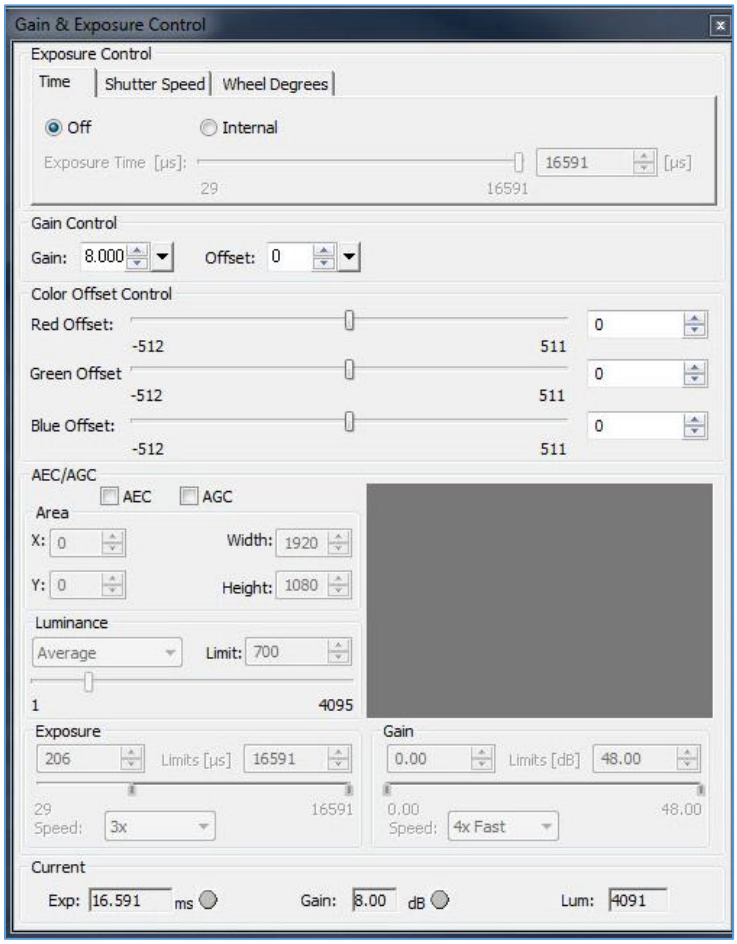


Figure 16: The Gain & Exposure screen controls exposure and gain.

3.5.1 Exposure Control

Exposure control lets you set the camera's exposure time manually from the Time tab, Shutter Speed tab, or Wheel Degrees tab. The exposure time that you set on any tab automatically adjusts the exposure time in microseconds on the other two tabs. You can use a combination of exposure time and gain adjustments to achieve image luminance goals for your specific applications.

TIP

For best image quality, always increase the exposure to the maximum allowable level before adding gain. Use gamma settings found on the Image Control screen to stretch the dark regions of the image to achieve a better match with the display characteristics of the monitor.

Time Tab

The Time tab controls the ability to set the exposure time on any of the tabs (Figure 17). If you enable **Internal**, the Exposure Time slider shows you the minimum and maximum exposure times available.

1. Click **Off** to disable setting manual exposure time. The exposure time is then set equal to the frame time.
2. Click **Internal** to enable setting manual exposure time.
    a. Use the slider to set the exposure in microseconds or enter the desired exposure in the box.
    b. Use the up/down scroll to fine tune the exposure setting.

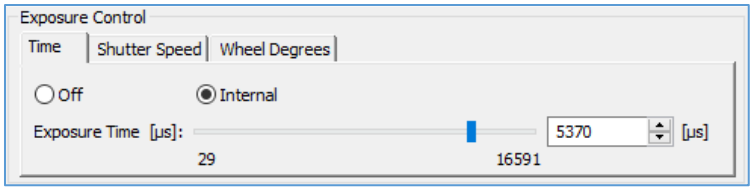


Figure 17: Time tab.

Shutter Speed Tab

Use shutter speed to set the exposure in fractions of a second as is customary with standard photographic cameras. Select from a drop-down list of shutter speeds. After selecting a shutter speed, the equivalent exposure time in microseconds appears in the up/down slider.

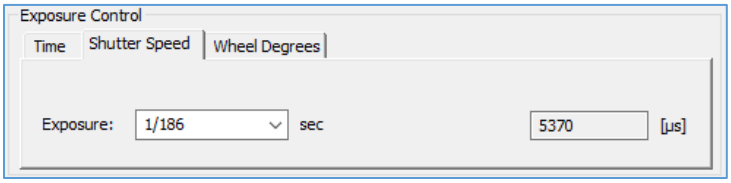


Figure 18: Shutter Speed tab.

Wheel Degrees Tab

The Wheel Degrees represents the exposure as the rotating mechanical shutter used in motion film cameras. It lets you set the exposure time in degrees from

zero (minimum exposure) to 180 (free running exposure). You can use the slider or the scroll feature to select the degrees setting. The tab also displays the degrees setting in microseconds.

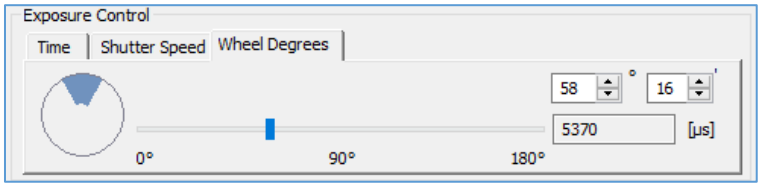


Figure 19: Wheel Degrees tab.

3.5.2 Gain Control and Color Offset

The gain control and color offset control functions allow you to manually adjust gain and offsets.

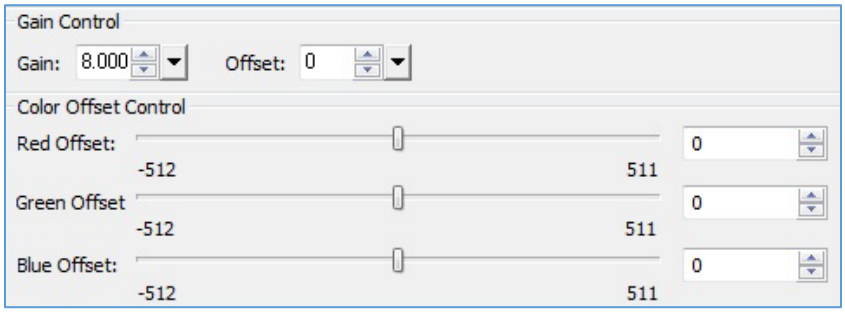


Figure 20: Gain Control and Color Offset functions provide manual settings.

Use the Gain field to control the signal amplification from the camera sensor. You can set the gain value in decibels ranging from 0.0 to 48.0 dB.

- Settings in the 0 dB to 24 dB range operate in the analog domain.
- Settings in the 24.1 dB to 48 dB range operate in the digital domain.

You can also set the desired digital offset for each primary color R G B (-511 to +511, 1 step increment). Use the slider or enter a desired value.

3.5.3 Automatic Exposure and Gain Controls

The camera provides an automatic exposure control (AEC) mode and an automatic gain control (AGC). These controls help maintain image brightness under variable lighting conditions. You can also set the speed of convergence, which determines how fast the camera stabilizes after a change in luminance.

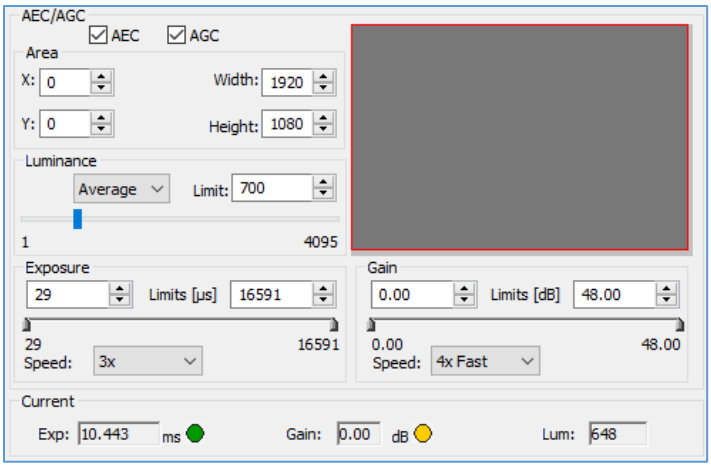


Figure 21: Automatic exposure and automatic gain settings.

TIP

- If AEC is selected, you cannot adjust exposure controls.
- If AGC is selected, you cannot adjust gain controls.

Area. Use the area controls to define an active Area of Interest (AOI). The camera uses the image data inside the AOI to calculate the luminance for adjusting exposure and gain parameters. The camera ignores brightness changes outside of the AOI. Changes in the AOI luminance, as determined by the firmware, cause changes in the exposure/gain and applies them to the entire image. In other words, if the AOI luminance deviates from the target (limit), the exposure and/or gain adjusts automatically to compensate.

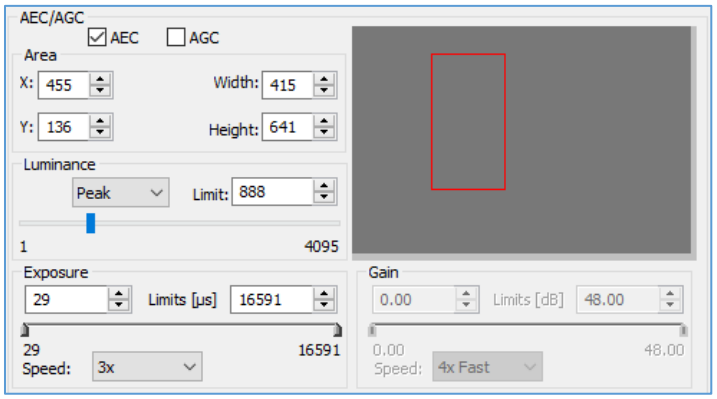


Figure 22: AEC and AGC provide the same type of controls.

To define an Area:

1. Select AEC, AGC, or both.
2. Enter the AOI width/height and offset (X, Y) values in the up/down scroll fields.
    a. X offset describes the starting column for the AOI window and is the distance in pixels from the left side of the screen.
    b. Y offset describes the starting row for the AOI window and is the distance in pixels from the top of the screen.

3. Alternatively, you can draw the AOI by clicking and dragging across the display area. A red box appears, and the dimensions and offset values of the box populate the width/height and offset fields automatically.

Luminance Limit. This sets the desired luminance level (in output counts), which the camera is to maintain within the image. The software adjusts the image exposure and gain as needed to maintain the image luminance at or near the target value. You can select either average or peak luminance as the target and specify the desired target output counts from 1 to 4096.

- Average – the firmware calculates the average value of the image luminance (in counts) within the image or within the AOI and compares the value to the target (Limit value) to determine changes to the exposure/gain settings.
- Peak – the firmware calculates the peak luminance value (maximum luminance level) within the image (in output counts) or within the AOI and compares the value to the target (Limit value) to determine changes to the exposure/gain settings.

Exposure Limits. If using AEC, you can specify the range of allowable exposures from minimum to maximum in microseconds. For example, if anticipating motion within the scene, you can specify the maximum exposure to be 1 ms to avoid motion blur. Try to set the minimum exposure value as high as possible to help prevent oscillations in the AEC control loop.

Speed. Use the speed drop-down options to set the exposure convergence to 1x (slow), 2x, 3x, or 4x (fast). Convergence is the speed at which the camera stabilizes the exposure after lighting conditions change.

CAUTION

Using faster convergence speeds might cause oscillations in exposure control if the scene changes luminance levels abruptly, for example, from extremely dark to extremely bright. In these conditions, use a slower convergence setting and/or increase the minimum exposure time limit

Gain Limits. If enabled, the automatic gain control process drives gain so the calculated luminance value from the image is equal to the digital counts specified in the Luminance Limit field. However, you may want to limit the amount of gain applied by the AGC. For example, too much gain may cause the image to be noisy. You can specify the minimum and maximum gain applied by setting the Gain limits.

Gain Convergence. The speed at which the gain converges onto the target luminance level depends on the Convergence setting. Select one of the following speed of convergence settings: 1x (slow), 2x, 3x, and 4x (fast).

TIP

If AEC and AGC are selected, exposure is first varied until the maximum exposure limit is reached, then gain is applied.

Current. This provides live information about the current value of the exposure time, gain, and calculated luminance value. Software polling automatically refreshes the values. A green indicator means the exposure or gain is within limits. A red indicator means the exposure or gain has reached maximum limits.

3.6 I/O Control

HD video signals have high data rates and the potential for timing jitter. Tri-level sync (genlock) resolves this potential issue by locking the HD video signals between the camera and the display monitor.

The I/O control screen lets you enable genlock mode when connected to an external tri-level sync generator. The format resolution, scan rate, and MHz settings you select for the genlock device automatically populate the I/O Control screen. Be sure to align genlock device settings with your current camera.

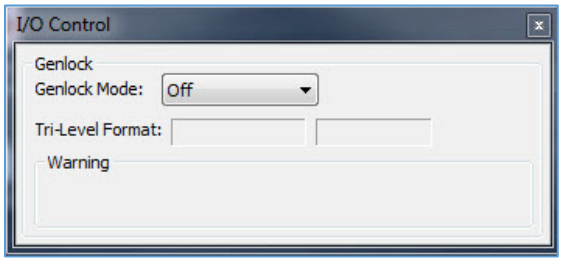


Figure 23: Genlock enables an external sync generator.

3.7 Strobe Control

The strobe output screen enables synchronizing two external light sources (strobes) with the camera timing. This helps maximize camera efficiency in low-level lighting conditions.

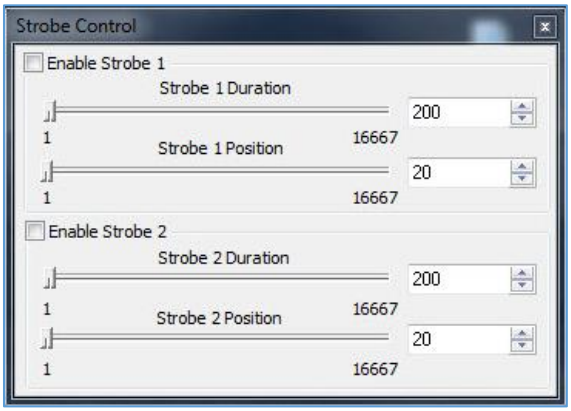


Figure 24: Strobe Control configuration screen.

To enable a strobe:

1. Click **I/O Control** on the CamConfig screen.
2. Select the Enable Strobe 1 or Enable Strobe 2 **check box**.
3. Set the position and duration of each strobe by entering a value.

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

The strobe occurs as the exposure ends and the readout from the image sensor begins. To position the strobe at the beginning of the exposure period, set the strobe position equal to the frame period minus the exposure time. If the strobe duration is set to the exposure time, then the strobe signal will define the exposure window (Refer to the following Figure).

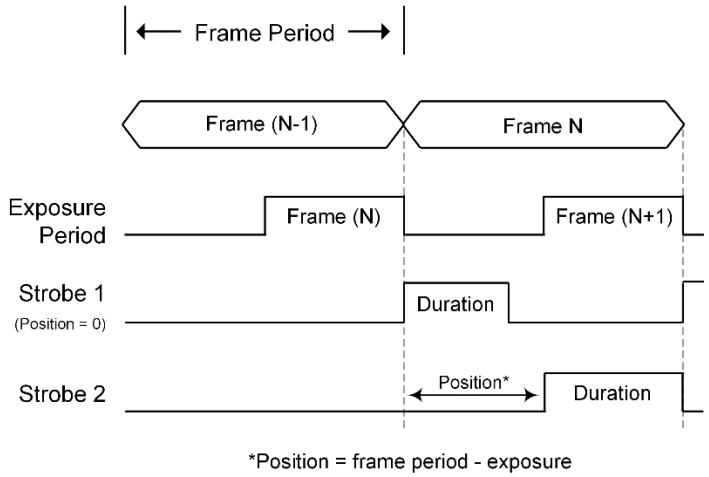


Figure 25: This diagram illustrates the position of the strobe.

3.8 Image Control

The Image Control screen controls the image processing features implemented into the camera. This includes gamma and black gamma settings, the user-defined lookup tables, one- and two-point corrections, and threshold settings.

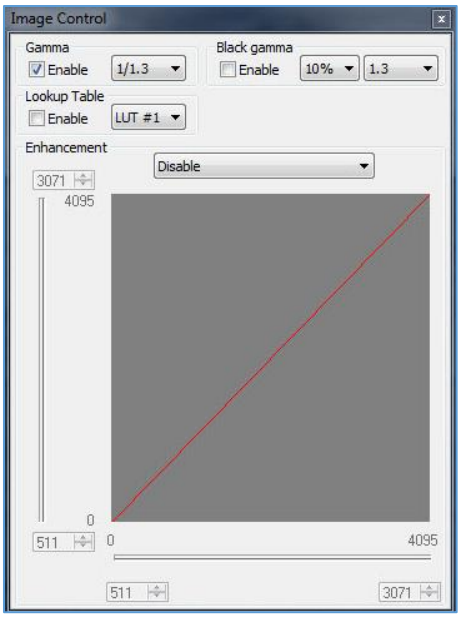


Figure 26: Image enhancement.

3.8.1 Gamma

Enabling gamma allows stretching and compressing image luminance (brightness) in a scene with wide dynamic range so both bright and dark areas are visible on the display. The drop-down menu provides a choice of eight settings ranging from darker (1.3) to brighter (1/1.3). Values from 1.3 to 2.2 compress the dark regions and stretch the brighter regions of the image so the bright regions have more detail in the display. Values from 1/1.3 to 1 / 2.2 stretch the dark intensities while compressing the bright regions so more detail is visible in the darker regions of the image.

Black gamma provides adjustments to the dark parts of the image. Applying both black gamma and normal gamma enables compressing the mid-range intensities while stretching the detail in the brightest and darkest regions of the image. The drop-down menu provides a choice of eight settings ranging from darker (1.3) to brighter (1/1.3). You can also apply a weighting factor of 10%, 20%, or 30% to your black gamma settings.

3.8.2 Lookup Table

The Lookup Table (LUT) feature allows you to modify the original video data to create a better match between the intensity values of interest and the dynamic range of the display screen. The camera supports up to four LUTs; one is factory pre-set with Gamma 0.45. Users can upload custom LUTs using the Imperx Upload Utility. Select an LUT from the Lookup Table drop-down. The check box enables/disables your selected LUT's control of the camera's base gamma settings.

The following user-configurable LUTs are pre-programmed:

1. LUT#1: Gamma 0.45 (1/2.22)

2. LUT#2: Inverts the image intensity
3. LUT#3: Gain of 2x
4. LUT#4: Repeat: input = output.

3.8.3 Enhancement

The Enhancement feature gives you the ability to perform one point or two-point corrections on the images.

When customizing enhancements, you can click and drag lines or points to define knee points and slopes. Alternatively, you can use the horizontal and vertical sliders or up/down scrolls to set coordinates.

Select the following enhancement options from the drop-down menu:

Enhancement Options	
Disable	No enhancement operation performed.
One Point Correction	This performs a single knee-point image enhancement. Click and drag the knee point to create the desired transfer function.
Two Point Correction	This performs a two knee-point image enhancement. Click and drag either knee point to create the stretch/compress image data.

Table 4: Image Enhancement Options.

3.9 Color Control

White balance adjusts the gains of the red, green and blue channels to compensate for the spectral content of the source. The Color Control screen provides several options for adjusting white balance. The screen displays the real-time white balance values of each color (red, green, and blue) based on your adjustments.

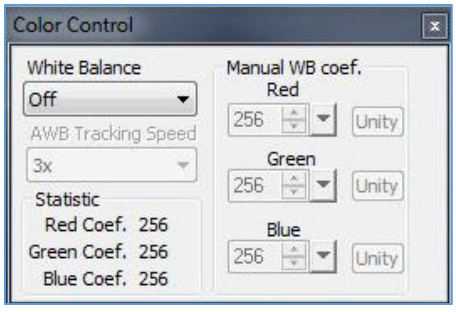


Figure 27: Adjust white balance.

3.9.1 Adjusting White Balance

The White Balance drop-down provides presets you can select for controlling white balance.

White Balance Presets	
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 the entire 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.
Indoor 3200	Color temperature setting typically used for indoor lighting.
Outdoor 5600	Color temperature setting typically used for outdoor lighting.

Table 5: White balance presets.

Selecting Auto or Manual provides additional options and settings.

To set Auto or Manual white balance:

1. Click the **White Balance** drop-down and select a preset.
2. If selecting **Auto**, you can change the auto tracking speed by clicking the AWB Tracking Speed drop-down and selecting 1x, 2x, 3x, 4x, or 5x.

   Tracking speed settings control the camera's speed of response to changes in scene illumination — 1x is the slowest response, 5x is the fastest response.
3. If selecting **Manual**, use the up/down scroll to enter white balance coefficients for each color (Red, Green, and Blue). Coefficient values affect the intensity of each color and range from 0 to 4095.

TIP

For best color accuracy and stability when the spectral source is constant, image a uniform grey target with the camera using the desired light source. Select Once to find the correct R, G, and B coefficients and jot down these 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.

3.10 Output Control

The Output Control screen provides full control over the camera's digital data output.

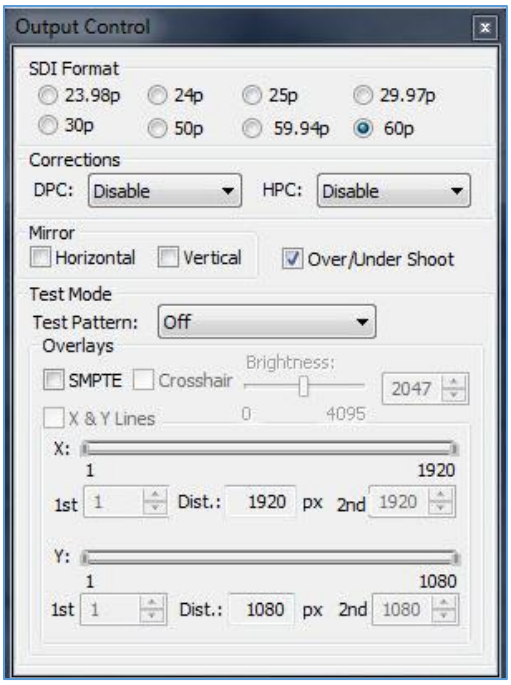


Figure 28: Output Control screen.

Use the following functions to control or test the camera's data output:

SDI Format. Select the progressive scanning rate supported by your monitor. Options are 23.98p, 24p; 25p; 29.97p, 30p; 50p; 59.94p, 60p.

Corrections. The camera provides static Defective Pixel Correction (DPC) and Hot Pixel Correction (HPC) independently or simultaneously. Static DPC and HPC correction works with predetermined and preloaded pixel correction maps created at the factory. The maps identify the coordinates of defective and hot pixels. The camera uses these maps to correct the pixels during output.

Mirror. Select Horizontal to flip the image horizontally. Select Vertical to flip the image vertically.

Over/Under Shoot. The SMPTE standard specifies data ranges for overshoot/undershoot values. When enabled, overshoot words and undershoot words provide for dynamic range "headroom" in processing. The following table provides the digital range assignments for different word sizes on a parallel signal bus.

Overshoot/Undershoot Check Box	Bit Range	10-bit (hex)
If Enabled	Overshoot words range	0x3AD-0x3FB (941-1019) Y 0x3C1-0x3FB (961-1019) CbCr
If Disabled	100% white signal level	0x3AC (940) Y 0x3C0

		(960) CbCr
If Disabled	0% black signal level	0x64 (64)
If Enabled	Undershoot words range	0x04-0x3F (4-63)

Table 6: Data ranges for overshoot/undershoot values

3.10.1 Test Patterns

Use the test mode controls to generate test patterns for gauging image quality. The GUI provides several types of test patterns.

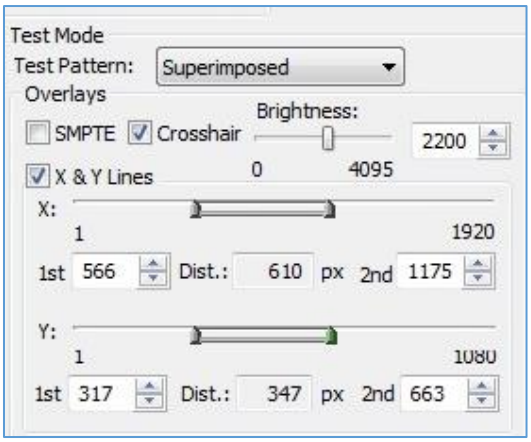


Figure 29: Test pattern options.

Test Pattern. Click the drop-down and select any of the following test patterns to appear on your monitor:

Test Patterns	
Off	Exits test mode.
Black	Generates a black screen.
Gray Image	Generates a gray screen.
White Image	Generates a white screen.
H Ramp	Generates a horizontal intensity ramp, decreasing the output code value by one count on each column moving left to right across the display.
V Ramp	Generates a vertical intensity ramp, decreasing the output code value by one count on each new row starting from the top and moving down the display.
H Ramp Move	Generates a moving horizontal intensity ramp.
V Ramp Move	Generates a moving vertical intensity ramp.
Vertical Bars	Generates vertical color bars. Select the SMPTE check box to change the color bars to the HD SMPTE color bars test pattern.
Superimposed	The following Overlays section describes Superimposed mode.

Table 7: Test pattern options.

3.10.2 Overlays

Superimposed mode allows you to overlay patterns on live video. The Output Control screen provides several options:

Crosshair. Selecting the Crosshair check box displays a single crosshair centered in the middle of the image. You can adjust the brightness of the crosshair to improve its visibility on top of the images.

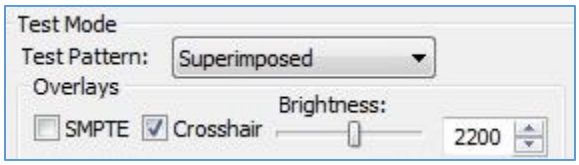


Figure 30: Use the slider to brighten or darken the crosshair.

SMPTE. Selecting the SMPTE check box displays the SMPTE color bar test pattern.

X & Y Lines. Selecting the X & Y Lines check box superimposes a pair of horizontal and vertical lines on the image. You can enable the lines in horizontal direction, vertical direction, or both directions. You can position the lines at any pixel or line in the image.

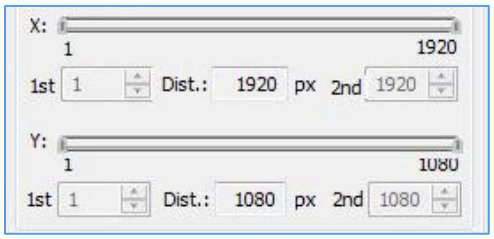


Figure 31: Line spacing to measure pixel/line positions.

Since the spacing between parallel lines can serve as a measuring tool, the software references the pixel and line positions to the image sensor's pixels and lines, not to the image pixels and lines.

The spacing between the lines can appear in either pixels or metrical units. When using the lines as a measuring tool, you can apply a scale coefficient and calculate the spacing in linear measuring units (micrometers, millimeters, or meters).

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. If selecting an Area of Interest (AOI) (entering X, Y settings), 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 established by the user-specified minimum/maximum limits. When AEC and AGC are enabled, if the exposure reaches the maximum limits, the camera 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 change) from four possible options. 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 change 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 reaching the limit and keeps the 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.
- If 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. 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 tri-level sync input for analog video synchronization, one TTL output (strobe), and one opto-isolated strobe (or optional P-Iris). You can enable genlock mode when connected to an external tri-level sync device providing input/output synchronization of frame rates. A second opto-isolated strobe is available. An optional P-Iris control can replace the second opto-isolated strobe. A custom interface cable to support the second strobe and firmware update are required. Contact IMPERX customer service for details.

4.5 Strobe Control

The 3G-SDI camera supports two independently controlled strobe signals. Typically, the strobe output synchronizes an external light source or additional cameras with the master camera timing. The strobe activates at the end of the exposure period just as the readout period begins. 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 eight different gamma curves from darker (2.2) to brighter (1/2.2).

You can also apply black gamma correction specifically to adjust the darker portions of an image or the brighter portions of the image and apply one of four User configurable LUTs. The User configurable LUTs are pre-programmed as follows:

1. LUT#1: Gamma 0.45 (1/2.22)
2. LUT#2: Inverts the image intensity
3. LUT#3: Gain of 2x
4. LUT#4: Repeat: input = output.

The Image enhancement tab also provides the ability to apply one-point or two-point knee corrections to the image

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.

5 Image Sensor Technology

5.1 General Information

A CMOS camera is an electronic device for converting light into an electrical signal. The 3G-SDI camera contains the latest Sony Pregius CMOS (Complementary Metal-Oxide Semiconductor) image sensor. The Sony Pregius image sensor has groundbreaking performance with sensitivity better than traditional Charge Coupled Device (CCD) image sensors. The sensor has extremely low dark current and virtually no fixed pattern noise, which has been the bane of traditional CMOS image sensors.

The Sony CMOS image 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 to 12 bits. 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, translates into a large dynamic range.

The camera 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 figures show the sensor's color response (Figure 32).

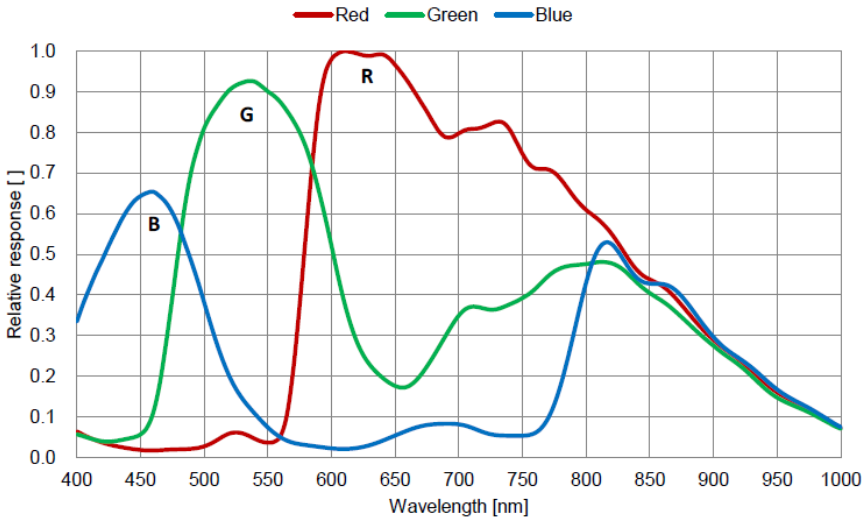


Figure 32: Color relative response to IMX252 sensor.

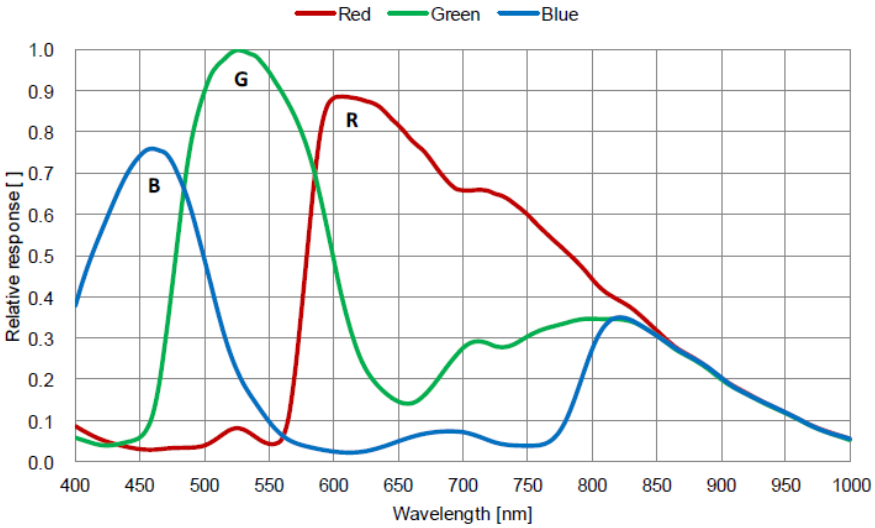


Figure 33: Color relative response to IMX174 sensor.

6 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).

6.1 Configuration Memory

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

The work-space segment contains the current camera settings while the camera is powered-up and operational. All camera registers are located in this space. You can program 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 and user-space #2 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 two different camera configurations.

Upon powering up the camera, the firmware loads the work-space registers from the factory space and user-space #1 or user-space #2 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, or user-space #2. You can also instruct the camera to save the current workspace as either user-space #1 or user-space #2.

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.

6.1.1 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).

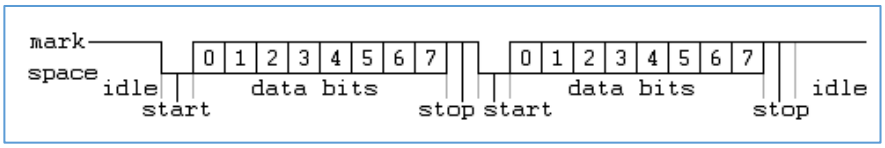


Figure 34: RS-232 serial protocol format

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.

6.1.1.1 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)

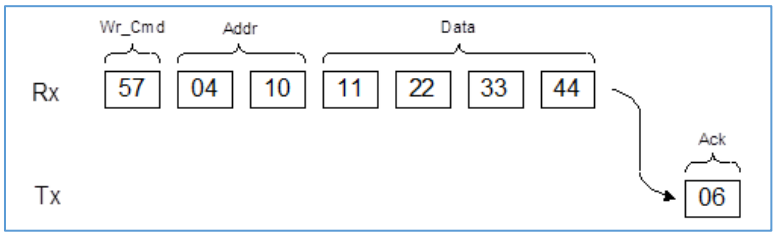


Figure 35: Normal write cycle

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)

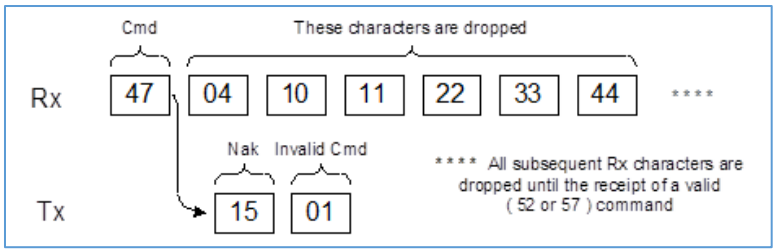


Figure 36: Invalid command error

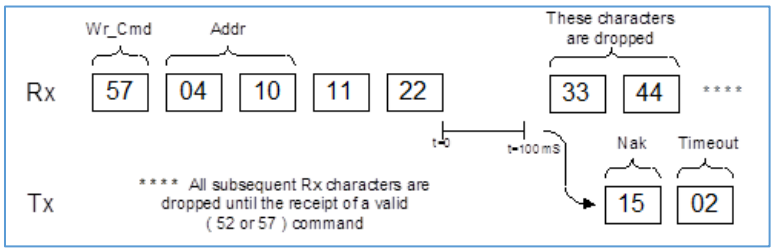


Figure 37: Rx timeout error

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

6.1.1.2 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

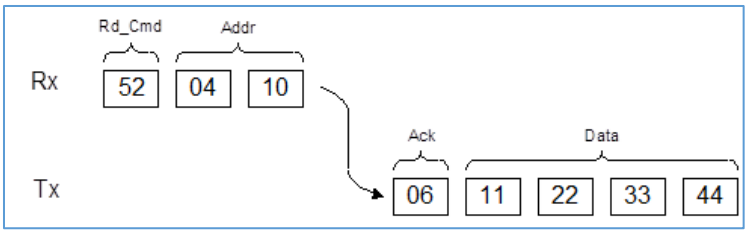


Figure 38: Normal read cycle.

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>

6.1.1.3 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

This appendix provides a quick reference to the 3G-SDI camera configuration workspace registers.

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

Gain & Exposure and AEC/AGC

Address	Register Name	Data	Type	Usage
0x609C	Cam_Exp_Tim	Data (23:10) <Current exposure increment from 6 (Hex) to 464(H)> Data (31:11) <N/A>	RO	Exposure increment (1,118 increments) 6H Max exposure, 464H min exposure.
0x0544	Exposure Control Mode	Data (1:0) 00 – off – no exposure control 10 – internal – exposure control register 0x0548 sets the camera exposure Others – reserved Data (31:2) N/A	RW	Determines mode.
0x0548	Internal Exposure Timer	Data (10:0) <value> –exposure increments** Exposure increment 0006 H (max exp) 464H (min exp) Data (31:24) N/A **To calculate exposure in units of microseconds, use the calculated line times and minimum exposures listed in the table below to calculate the exposure increment or exposure time in the equations below: 1) Exposure time = [(1124 – Exposure increment (Decimal)) *Line Time] + 4 Min Exposure To calculate Exposure increment from Exposure Time: 2) Exposure Increment = 1124 - (Exposure time (us) Min Exposure) / Line Time). Convert Decimal to Hex.	RW	Exposure is divided into 1,118 equal increments based on frame time.

Frame Rate (fps)	Max Exp	Min Exp	Line Time
60	16,591	29	14.81395

Address	Register Name	Data	Type	Usage
		59.94 16,608 29 14.82916 50 19,907 32 17.77728 30 33,169 44 29.6288 29.97 33,202 44 29.65832 25 39,800 50 35.55456 24 41,458 51 37.03667 23.98 41,499 51 37.07335		
0x0150	AFC_Control Enable	Data (0) 0 – disable AEC 1 – enable AEC Data (31:1) N/A	RW	
0x0154	AGC_Control Enable	Data (0) 0 – disable auto gain control 1 – enable auto gain control Data (31:1) N/A	RW	
0x0158	Luminance Target	Data (11:0) <value> – desired luminance level in counts Data (31:12) N/A	RW	
0x017C	AEC AGC Luminance Average or Peak Select	Data (1:0) 00 – average luminance 01 – peak luminance 10 or 11 – reserved Data (31:2) N/A	RW	
0x0004	CMOS_Sensor_ Gain	Data (8:0) <value> –gain Data (31:9) <N/A>	RW	Gain, 0 dB to 48 dB (0.1 dB per step).
0x0008	CMOS_Offset	Data (8:0) <value> – analog offset Data (31:9) <N/A>	RW	Offset Value: 0x0000 to 0x01FF.
0x0160	AGC_Gain Maximum Limit	Data (8:0) <value> – max. AGC gain limit Data (31:9) N/A	RW	0 to 48dB in 0.1 dB steps (1E0H max).
0x018C	AGC_Minimum _Gain Limit	Data (8:0) <value> – min. AGC gain limit Data (31:9) N/A	RW	
0x0164	AEC AGC_AOI Horizontal Width	Data (10:0) <value> AOI width in horizontal direction Data (31:11) N/A	RW	AEC/AGC AOI X Width (780H max).
0x0168	AEC AGC_AOI 'X' offset	Data (10:0) <value> AOI offset in horizontal direction Data (31:11) N/A	RW	AEC/AGC Area X Offset
0x016C	AEC AGC_AOI Vertical Height	Data (10:0) <value> AOI height in vertical direction Data (31:11) N/A	RW	AEC/AGC AOI Y Height (438H Max).
0x0170	AEC AGC_AOI Y Offset	Data (10:0) <value> AOI offset in vertical direction Data (31:11) N/A	RW	AEC/AGC AOI Y Offset from bottom of image.
0x0174	AEC_Convergence Speed	Data (1:0) 00 – 1x speed – slow 01 – 2x speed 10 – 3x speed 11 – 4x speed – fast Data (31:2) N/A	RW	

Address	Register Name	Data	Type	Usage
0x0178	AGC_Convergence Speed	Data (1:0) 00 – 1x speed – slow 01 – 2x speed 10 – 3x speed 11 – 4x speed – fast Data (31:2) N/A	RW	
0x05B0	AEC Exposure Max	Data (10:0) <value> – maximum exposure time limit in exposure increments Max exposure is 6 increments Min exposure is 1124 increments (See Internal Exposure Timer Register 0x0548 description) Data (31:11) N/A	RW	AGC Exposure The frame time is divided into 1118 exposure increments.
0x05C8	AEC_Minimum_Exposure Limit	Data (10:0) <value> – minimum exposure time limit in exposure increments. Max exposure is 6 increments Min exposure is 1124 increments (See Internal Exposure Timer Register 0x0548 description) Data (31:11): N/A	RW	

Image Control

Address	Register Name	Data	Type	Usage
0x0118	LUT_Selector	Data (2:0) 000 – User LUT disabled 001 – User LUT #1 selected 010 – User LUT # 2 selected 011 – User LUT #3 selected 100 – User LUT #4 selected 101 … 111 – N/A Data (31:1) N/A	RW	Look-Up-Table selector.
0x011C	Gamma _Enable	Data (3:0) 0000 – LUT disable 0001 Gamma Y = 1.3 0010 – Gamma Y = 1.6 0011 – Gamma Y = 1.9 0100 – Gamma Y = 2.2 0101 – Gamma Y = 1/1.3 0110 – Gamma Y = 1/1.6 0111 – Gamma Y = 1/1.9 1000 – Gamma Y = 1 / 2.2 Data (31:4) N/A	RW	Gamma Look-Up-Table.
0x01AC	Black Gamma	Data (0:3) N/A 0000 – Black Gamma disable 0001 - Black Gamma Y = 1.3 0010 – Black Gamma Y = 1.6 0011 – Black Gamma Y = 1.9 0100 – Black Gamma Y = 2.2 0101 – Black Gamma Y = 1/1.3	RW	

Address	Register Name	Data		Type	Usage
			0110 – Black Gamma Y = 1/1.6 0111 – Black Gamma Y = 1/1.9 1000 – Black Gamma Y = 1 / 2.2		
		Data (31:4)	N/A		
0x019C	Black Gamma Values	Data (1:0)	00 (10%) 01 (20%) 10 (30%)	RW	Selects Black Gamma values 10%, 20%, and 30%.
		Data (31:2)	N/A		

Data Out and Test Patterns

Address	Register Name	Data		Type	Usage
0x060C	3G-SDI Output Format	Data (3:0)	0x0 – 1080p@23.98 0x1 – 1080p@24 0x2 – 1080p@25 0x3 – 1080p@29.97 0x4 – 1080p@30 0x5 – 1080i@50 0x6 – 1080i@59.94 0x7 – 1080i@60 others - reserved	RW	
		Data (31:4)	N/A		
0x0120	DPC_Enable	Data (0)	0 – DPC disable 1 – DPC enable	RW	Enables Defective Pixel Correction.
		Data (31:1)	N/A		
0x0124	HPC_Enable	Data (0)	0 – HPC disable 1 – HPC enable	RW	Enables Hot Pixel Correction.
		Data (31:1)	N/A		
0x0610	SMPTE Test Pattern	Data (1:0)	00– disable SMPTE test pattern 10– enable SMPTE test pattern	RW	
		Data (31:2)	N/A		
0x0584	Genlock_select	Data (1:0)	00 - Disable Genlock 10 - Enable Genlock	RW	Genlock.
		Data (31:2)	N/A		
0x012C	Test_Mode_ Selector	Data (3:0)	0x0 – live image 0x1 – black image – 0x000 0x2 – gray image – 0x1FF 0x3 – white image – 0xFFF 0x4 – steady horiz image ramp 0x5 – steady vertical image ramp 0x6 – moving horiz image ramp 0x7 – moving vertical image ramp 0x8 – 8 gray scale vertical bars 0x9 – H & V lines superimposed over live image – enables X & Y lines below. 0xA to 0xF - reserved	RW	
		Data (31:4)	N/A		

Address	Register Name	Data	Type	Usage
0x0130	Superimpose X & Y Lines	Data (0) 0 – disable X&Y lines 1 – enable X&Y Lines Data (31:1) N/A	RW	
0x0134	Superimposed_ Cross Hair	Data (0) 0 – disable cross hair 1 – enable cross hair Data (31:1) N/A	RW	
0x0148	Cross Hair and X&Y Line Brightness	Data (11:0) <value> – line brightness Data (31:12) N/A	RW	default 2047.
0x015C	Horizontal Image Mirror	Data (01:0) 00: disable Horiz and Vertical flip 01: Horizontal Flip only 10: Vertical Flip only 11: Horizontal and Vertical flip Data (31:2) N/A	RW	
0x0138	Superimpose Horizontal Row Position #1	Data (10:0) <value> – H1 line position Data (31:11) N/A	RW	H1 Line, Row position Range: 1 to 1080.
0x013C	Superimpose Horizontal Row Position #2	Data (10:0) <value> – H2 line position Data (31:11) N/A	RW	H2 Line, row position Range 1 to 1080.
0x0140	Superimpose_X Vertical Column Position #1	Data (10:0) <value> – V1 column position Data (31:11) N/A	RW	Y1 Column Position Range: 1 to 1920.
0x0144	Superimpose Vertical Column Position #2	Data (10:0) <value> – V2 column position Data (31:11) N/A	RW	Y2 Column Position Range: 1 to 1920.

Color

Address	Register Name	Data	Type	Usage
0x0300	White Balance Options	Data (2:0) 000 – Off 001 – WB Once 010 – WB Auto 011 – WB Manual 100 – Indoor 3200K 101 – Outdoor 5600K 110, 111 – N/A Data (31:3) N/A	RW	
0x0304	WB_Red	Data (11:0) <value>; 000hex ... FFFhex; 1 step 1/4095 range Data (31:12) N/A	RW	White Balance Manual Gain for Red.
0x0308	WB_Green	Data (11:0) <value>; 000hex ... FFFhex; 1 step 1/4095; range Data (31:12) N/A	RW	White Balance Manual Gain for Green.

Address	Register Name	Data	Type	Usage
0x030C	WB_Blue	Data (11:0) <value>; 000h….FFFh; 1 step = 1/4095 Data (31:12) N/A	RW	White Balance Manual Gain for Blue.
0x01B0	DC_Offset_Red –	Data (10:0) <value>; 000h….3FFh; – 512 . . . + 511; twos complement Data (31:11) N/A	RW	Sets the digital offset for Red.
0x01B4	DC_Offset_Green–	Data (10:0) <value>; 000h….3FFh; – 512 . . . + 511; two's complement Data (31:11) N/A	RW	Sets the digital offset for Green.
0x01B8	DC_Offset_Blue –	Data (10:0) <value>; 000h….7FFh; – 512 . . . +511; two's complement Data (31:11) N/A	RW	Sets the digital offset for Blue.

Strobe

Address	Register Name	Data	Type	Usage
0x055C	Strobe One Enable	Data (1:0) 00 – disable Strobe #1 01 – enable Strobe #1 each frame Data (31:2) N/A	RW	Standard.
0x0560	Strobe Two Enable	Data (1:0) 00 – disable Strobe #2 01 – Enable Strobe #2 each frame Data (31:2) N/A	RW	Optional.
0x05B4	Strobe Two Duration	Data (23:0) <value> – strobe pulse duration in microseconds Data (31:24) N/A	RW	Strobe 2 duration, 1 to Max Frame Time.
0x0564	Strobe One Pulse Width	Data (23:0) <value> – strobe pulse duration in microseconds Data (31:24) N/A	RW	Strobe 1 duration, 1 to Max Frame Time.
0x0568	Strobe One Position	Data (23:0) <value> – strobe #1 pulse position in microseconds with respect to Start of Readout Data (31:24) N/A	RW	Strobe 1 position, 1 to Max Frame Time.
0x056C	Strobe Two Position	Data (23:0) <value> – strobe #2 pulse position in microseconds wrt Start of Readout Data (31:24) N/A	RW	Strobe 2 position, 1 to Max Frame Time.