Operations Manual

Advanced Digital Machine Vision Cameras

EMC

Embedded Machine Camera

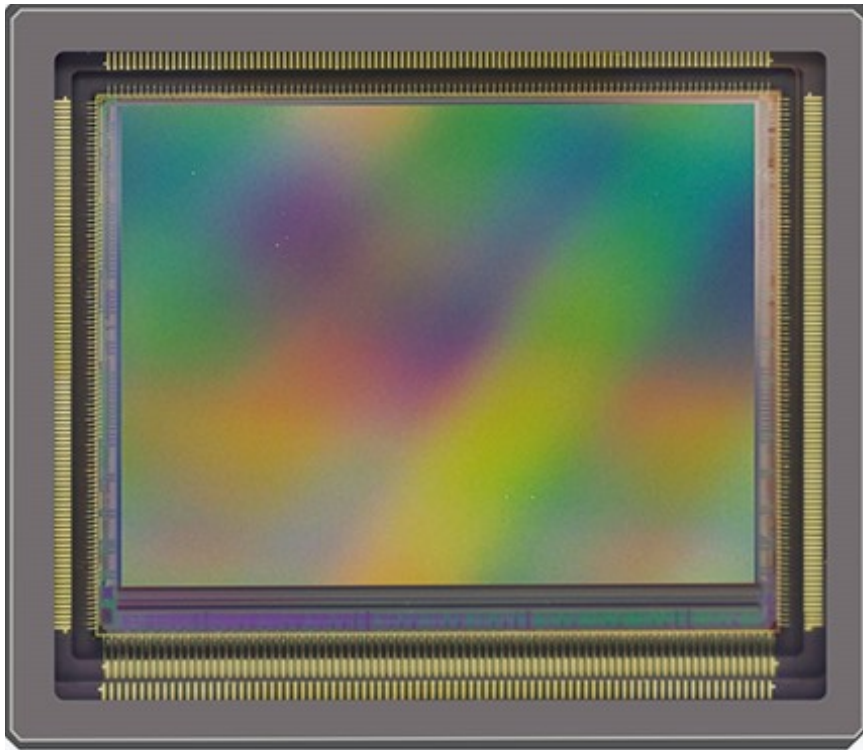
EMC-51
EMC-65
EMC-103

Rev	Date	Modification
A	01/06/23	Initial Release

Camera Communication Default Baud Rate is 115,200

Revisions

EMC (51, 65, 103)



Introduction

The EMC cameras based on the Gpixel GMAX sensors share a common FPGA and Microprocessor firmware. The EMC case design is compact and light weight, making it ideal for Arial and other embedded solutions.

Supported Sensors

- GMAX4651 : 8424x 6032 Global shutter, 3.2um pixel
- GMAX3265: 9344x7000 Global shutter, 3.2um pixel
- GMAX32103: 11,276x9200 Global shutter, 3.2um pixel

Supported Outputs

- Camera Link
- Epix mf2280 (Samtec HLCD)
- Pleora GigE
- Pleora USB3
- Pleora NTX-DECA (10G ethernet)

Note: All Output types may not be available for larger sensors.

Supported Lens Mounts

- Canon EF
- F-Mount
- M42
- M58
- OEM

Common features include:

Global Electronic Shutter
Horizontal and Vertical image flip
Vertical Subsampling and ROI
External triggering
12bit ADC with analog gain
Optical black clamp in FPGA
Low noise with excellent PLS

There are differences in the features of the supported sensors

GMAX4651 does not support VFlip
GMAX3265 does support dual exposure HDR mode

EMC Precautions

Do not drop, damage, disassemble, immerse, repair or alter the camera.

Applying incorrect power may damage the camera electronics.

The warranty is void if the camera is opened or modified in any way.

Care must be taken in handling as not to create static discharge that may permanently damage the device.

Camera Link is a DC based interface. The camera and capture device must share the same electrical ground. Failure to do so will damage the Camera Link interface chips and/or camera and capture card.

PoCL cables are compatible with EMC Camera Link cameras. PoCL camera power is not supported.

Absolute Maximum Ratings
Input Voltage: 7 to 14V DC
Storage Temperature: -40C to +70C

Recommended Maximum Ratings
Input Voltage: 7 to 14V DC
Operating Temperature: 0C to +70C
Most illunis cameras operate beyond these temperature limits, please call for details.

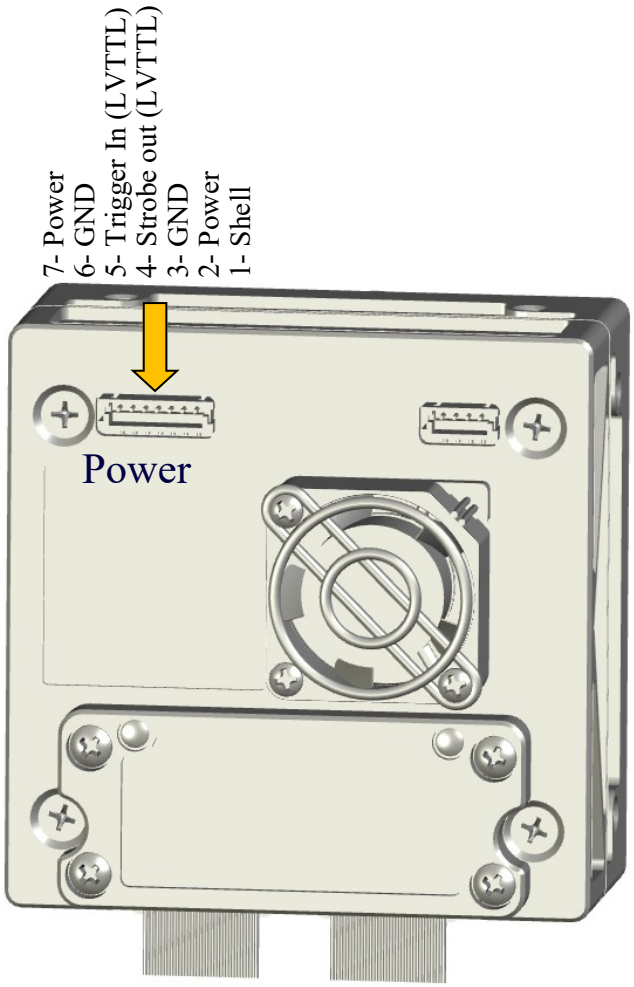
Recommended Operating Conditions
Input Voltage: 9-12V DC
Operating Temperature: 0C to +70C
Relative humidity should not exceed 80% non-condensing.

Specifications subject to change without notice.

Contents

EMC (51, 65, 103)

Camera Power Epix
6-12V DC Power to the JST ZHR-7 connector.



View from Camera Back

Capture Card
Epix PIXCI® mf2280+

Imaging SDK
XCLIB™ Frame Grabber Programming Library (epixinc.com)

Camera Communication Software
illunis Camera Control Application Help Center – illunis

Data Cable
COTS Samtec HLCD
HLCD-20-XX-00-TR-TR-1 (XX = length in inches)
Digi-Key (other lengths available)

Camera Power GigE/USB3
6-12V DC Power to the Hirose 6 pin connector.
Mating Connector: Hirose HR10A-7P-6P

PIN	SIGNAL NAME
1	+12V DC
2	DC GND
3	Trigger In
4	Strobe Out
5	DC GND
6	+12V DC

View from Camera Back

Capture Card
1 Gbps ethernet connection or compatible USB3 port.

Imaging SDK
Pleora SDK Pleora.com

Camera Communication Software
illunis Camera Control Application
Download at: Help Center – illunis

Camera Power Camera Link
6-12V DC Power to the Hirose 6 pin connector.
Mating Connector: Hirose HR10A-7P-6P

PIN	SIGNAL NAME
1	+12V DC
2	DC GND
3	Trigger In
4	Strobe Out
5	DC GND
6	+12V DC

View from Camera Back

Camera Power Pins 5 and 6 can be left unconnected for the fan cooled version of the camera.

Capture Card
Any Base, Medium or Full Format Camera Link capture card
Such as: Teledyne Dalsa Xtium-CL MX4 OR-Y4CO-XMX00.

Imaging SDK
Available from your capture card supplier.

Camera Link Cables
One or two Camera Link cables (Mini HDR to SDR) **must be** rated at 85Mhz or more (two cables for Medium or Full Format).

The following 5M cable configurations have been tested:
Standard MDR to HDR/SDR MVC-1-1-5-5M
Available from Components Express.

componentsexpress.com

Camera Communication Software
illunis Camera Control Application
Download at: illunis.com

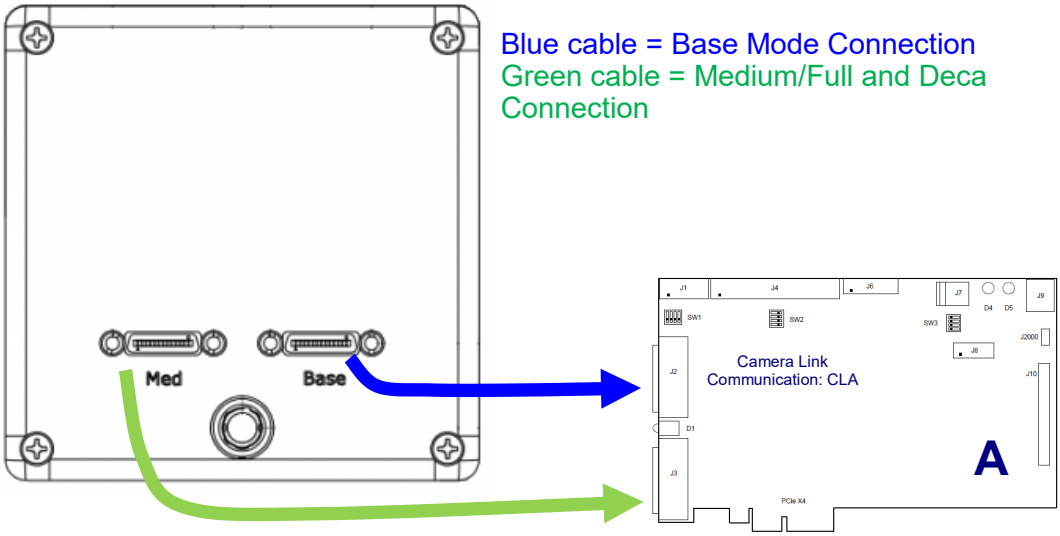
To start imaging with the EMC–CL:

Install the capture card and software per the capture card manufacturers instructions.

Connect the EMC Camera Link cables paying attention to the base and medium connections

Camera Link Medium mode setup

Blue cable = Base Mode Connection
Green cable = Medium/Full and Deca Connection



Cable Connections for Camera Link Medium/Full and Deca Mode Operation.

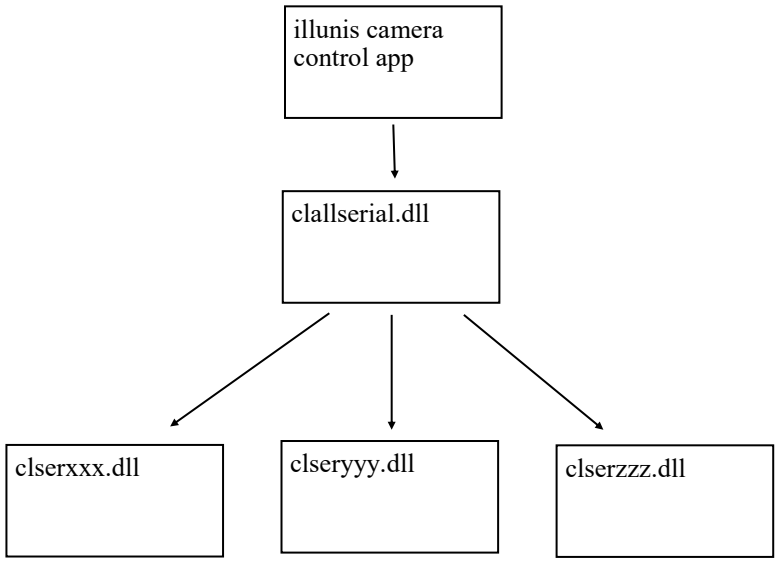
Base Mode uses only CLA Base Connection

Camera Link Serial Overview

Download and install the illunis Camera Serial Communication Software from https://www.illunis.com

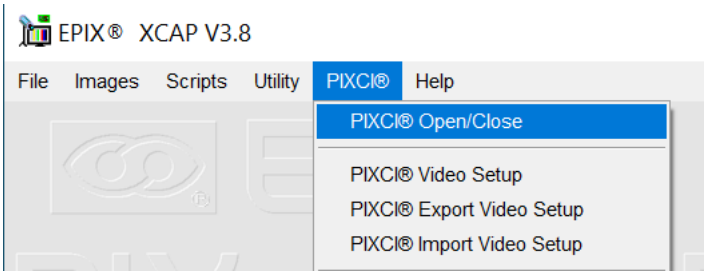
Background:
Per the CameraLink standard, all serial communication is via the .dll clallserial.dll, which dynamically loads the serial communication .dll(s) specific to the frame grabber being used. illunis installs clallserial.dll in its application directory.

clallserial.dll examines the registry to see where the capture card specific communication dll's have been installed. The naming convention for the capture card specific communication dll's is clser***.dll where *** is the manufacturer specific dll name. The files MUST be in the form clser***.dll in order to be recognized. Some capture card manufacturers will append something like clser***x64.dll for the 64 bit version of the .dll. This file name must be changed to clser***.dll in order to be recognized by clallserial.dll.

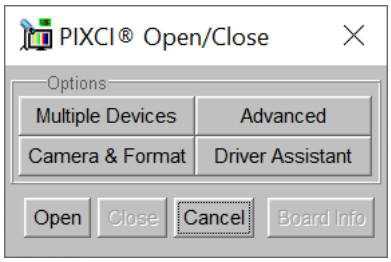


Camera Link Serial Epix

1. Install and open XCAP [EPIX® Software Download (epixinc.com)]
2. From the menu choose PIXCI -> PIXCI Open/Close

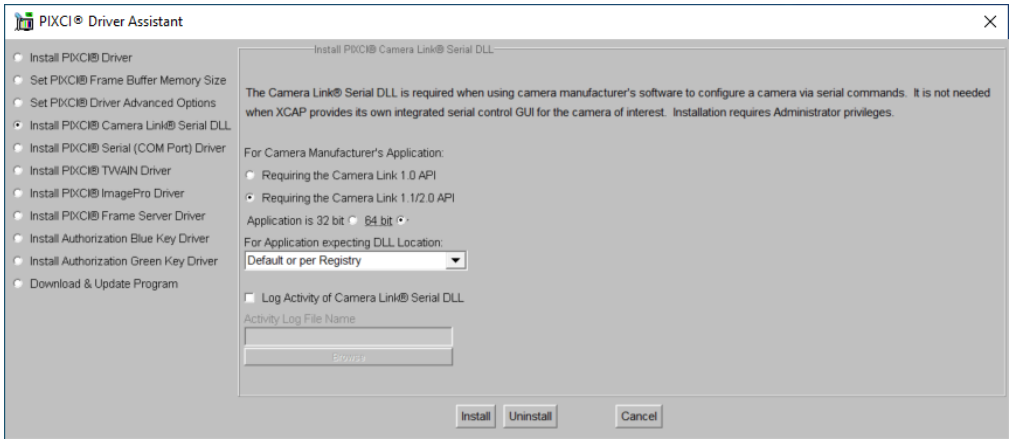


3. Close the capture card if open, then click “Driver Assistant”.



4. Choose “Install PIXCI Camera Link Serial DLL
- Choose Camera Link 1.2/2.0 API
- 64 bit

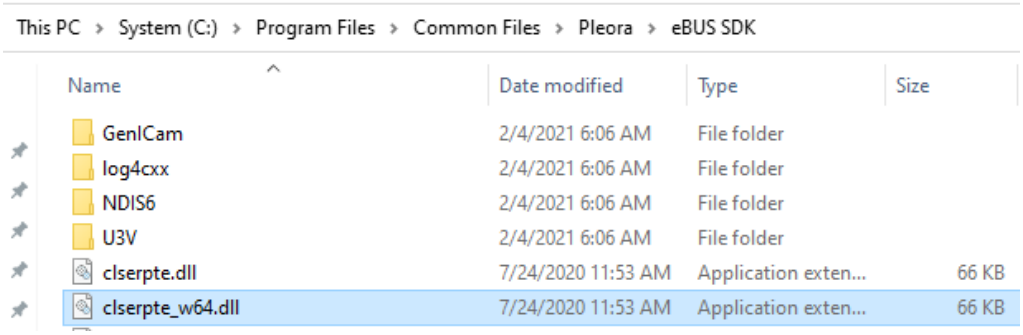
5. Then “Install”



Note: Epix Camera Link dll is names clserEPX.dll

Camera Link Serial Pleora (GigE/USB3)

1. Download and install Pleora eBUS Player or eBUS SDK. [eBUS SDK and eBUS Player (pleora.com)]
2. The Camera Link serial dll will be installed in C:\Program Files\Common Files\Pleora\eBUS SDK\ by default
3. To use the 64-bit dll, it will need to be renamed from clserpte_w64.dll to clserpte.dll (the 32-bit dll can be deleted or renamed to preserve it).

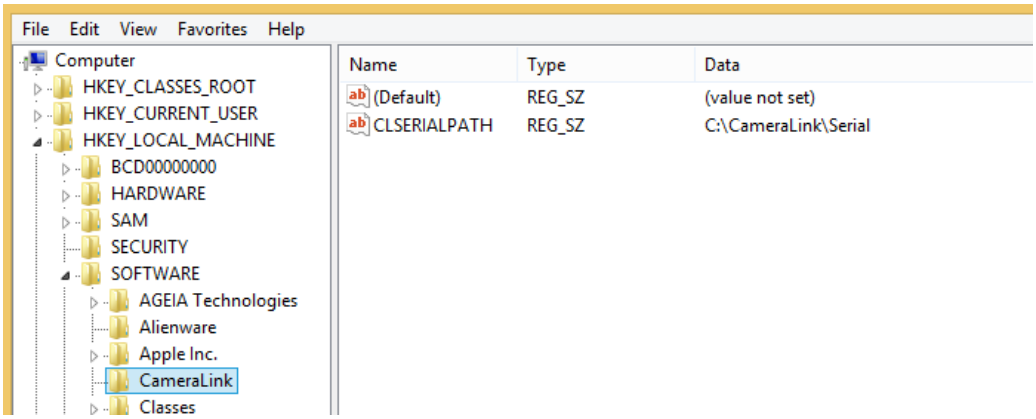


The registry:

When clallserial.dll is loaded by the illunis serial communication application, it looks at the Registry entry:

HKEY_LOCAL_MACHINE\SOFTWARE\Cameralink CLSERIALPATH.

The location pointed to by CLSERIALPATH is typically C:\Cameralink\Serial, but could be any path that a capture card install might create. It is important to note that the capture card communication dll(s), clser***.dll must be at this path location. clallserial.dll should NOT be in this location.



If the capture card communication dll is spec 1.1 compliant, the user will find this directory already created.

The illunis control app installs clallserial.dll for the appropriate operating system in the application folder. Depending on the application version, some documentation may be installed in the application folder as well.

If the registry entry above does not exist, create it as well as the directory C:\CameraLink\Serial

In either case—copy and paste the clser***.dll files to the C:\CameraLink\Serial folder.

Installing prerequisite software:

The status of these items can be checked in the Control Panel -> Programs and Features listing. If necessary download and install the following prerequisites.

1. **.NET Framework 4.6.1** to be installed from:

   https://www.microsoft.com/en-us/download/details.aspx?id=49981

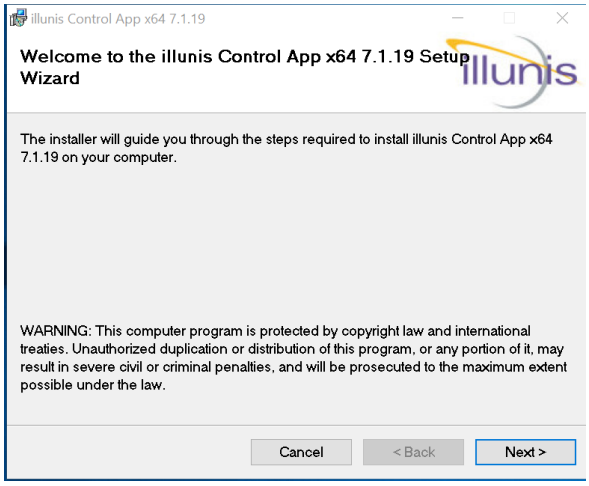
2. **Visual C++ 2010 Redistributable** from:

   https://www.microsoft.com/en-us/download/details.aspx?id=14632

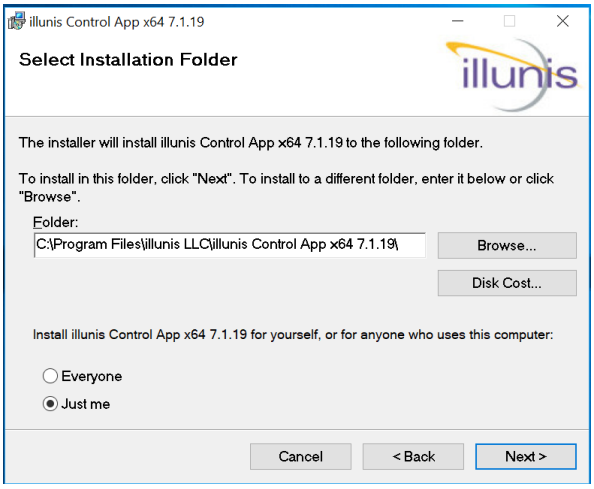
3. **Visual C++ 2013 Redistributable** from:

   https://www.microsoft.com/en-us/download/details.aspx?id=40784

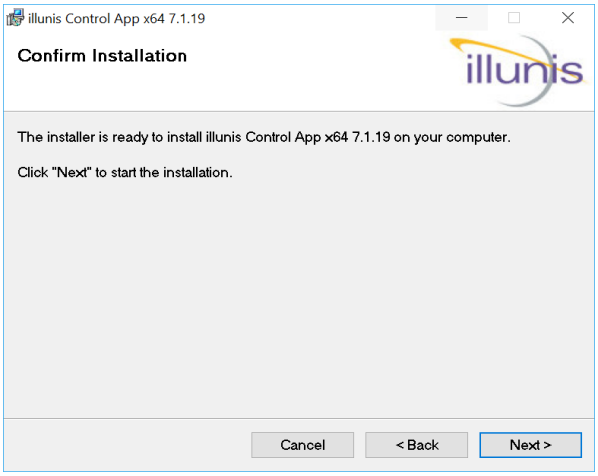
Install the Camera Serial Communication Software:



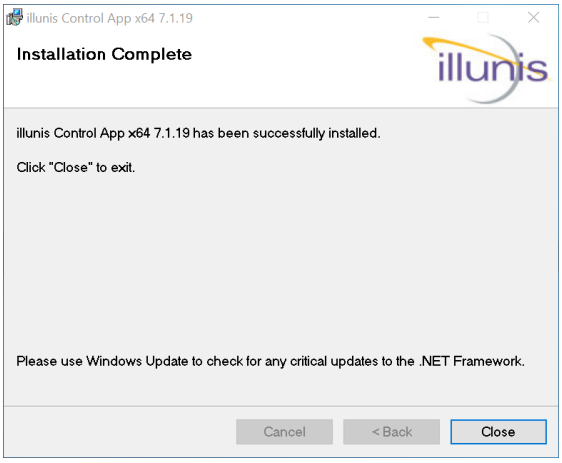
Launch the installer



Select the installation folder...



Confirm...



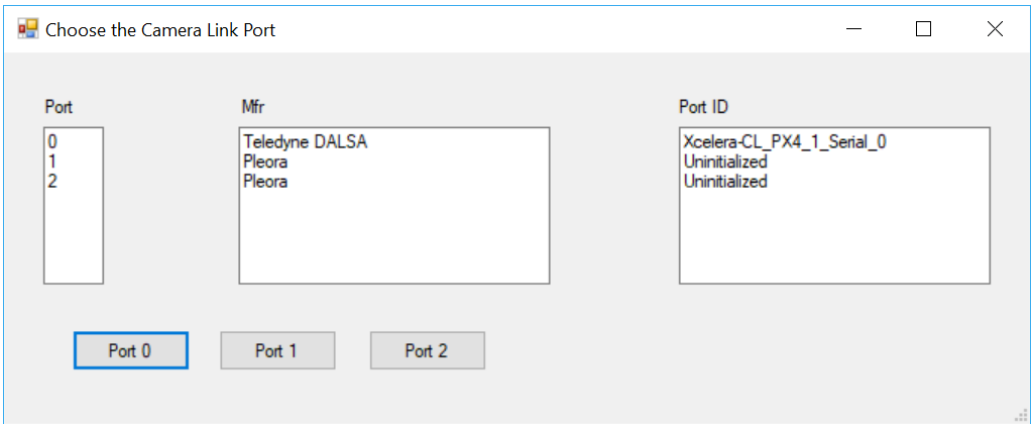
Install complete…

Note: A shortcut to the program will be placed on the desktop.

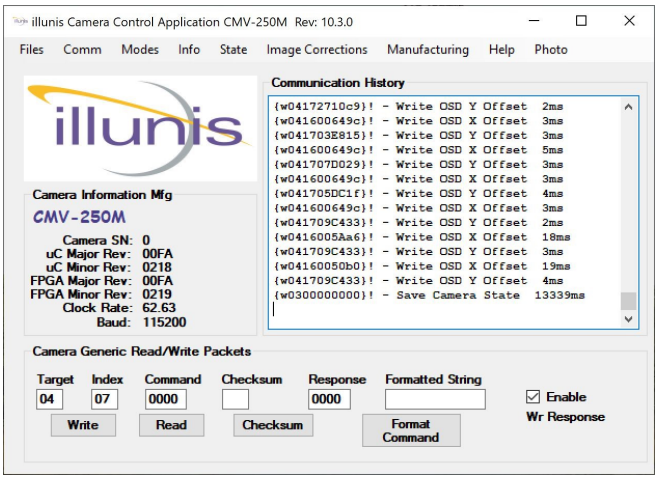
Power up the camera and run the illunis Camera Serial Communication Software.

If there are multiple clserxxx.dll's for multiple cards installed, a choice of possible connections will be presented.

If there is only a single capture board present and one clserxxx.dll, the application will simply connect to that card/port.



illunis Camera Serial Communication Software Main Window:

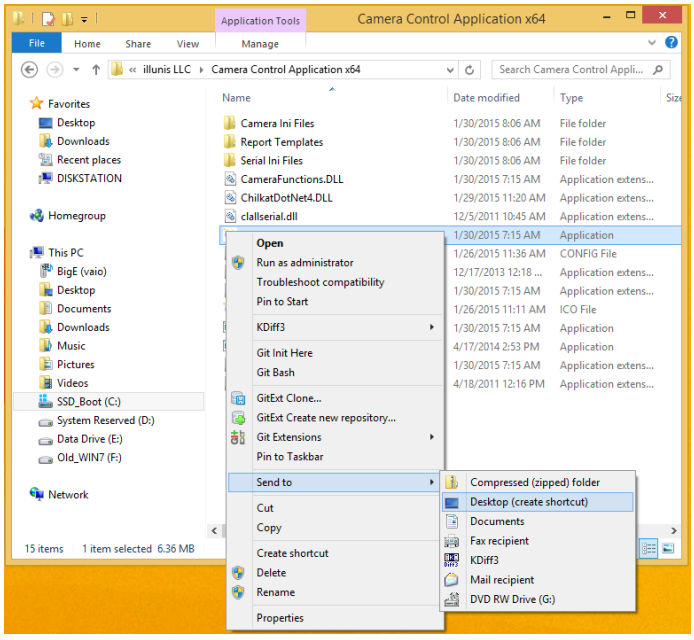


Disabled Menus

By default, sensitive menu items are disabled to prevent inadvertent changes to the camera state. To enable them, a new shortcut has to be created on the desktop.

First, delete the desktop shortcut created by the installer.

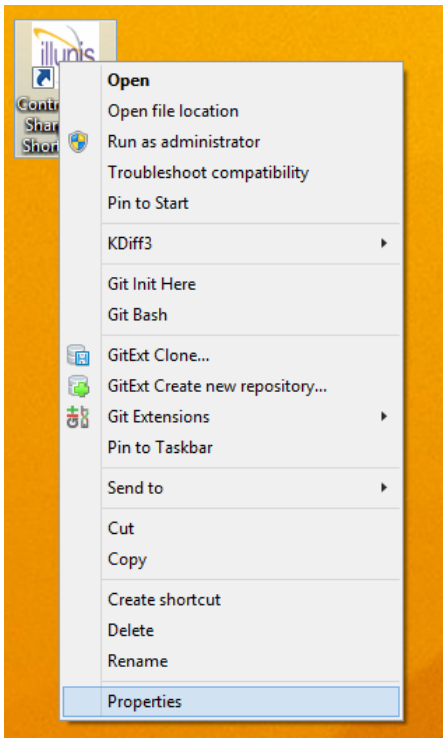
Creating a new shortcut for program options:



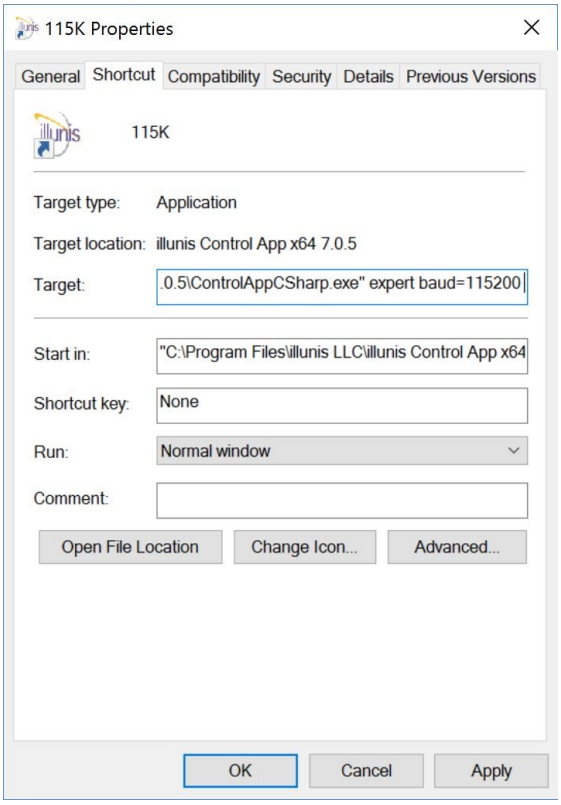
Create a new Shortcut

Navigate to the program install directory and right click on the file with the illunis icon and extension .exe. Choose -> Send to -> Desktop. This creates a new desktop shortcut icon.

Adding options to the shortcut command line:



Right click on the newly created desktop icon and select Properties.



Add a space and the words **expert baud=115200** after the close quote on the Target: line of the dialog box: .exe" expert

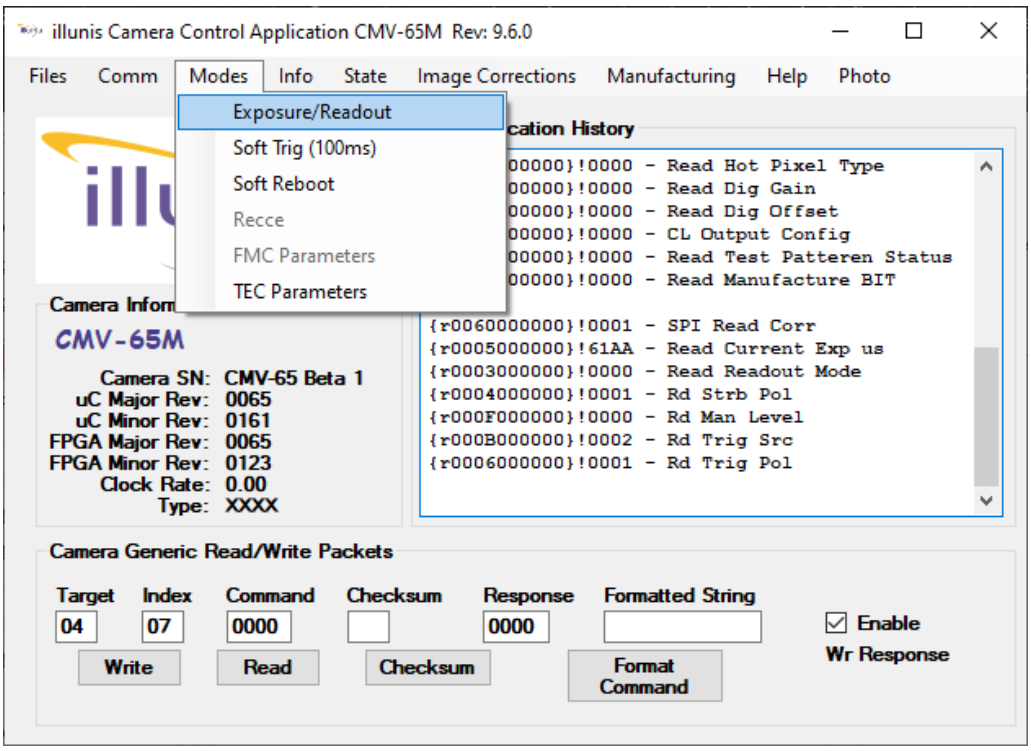
Choose OK.
When the program is launched, all menus will be enabled.

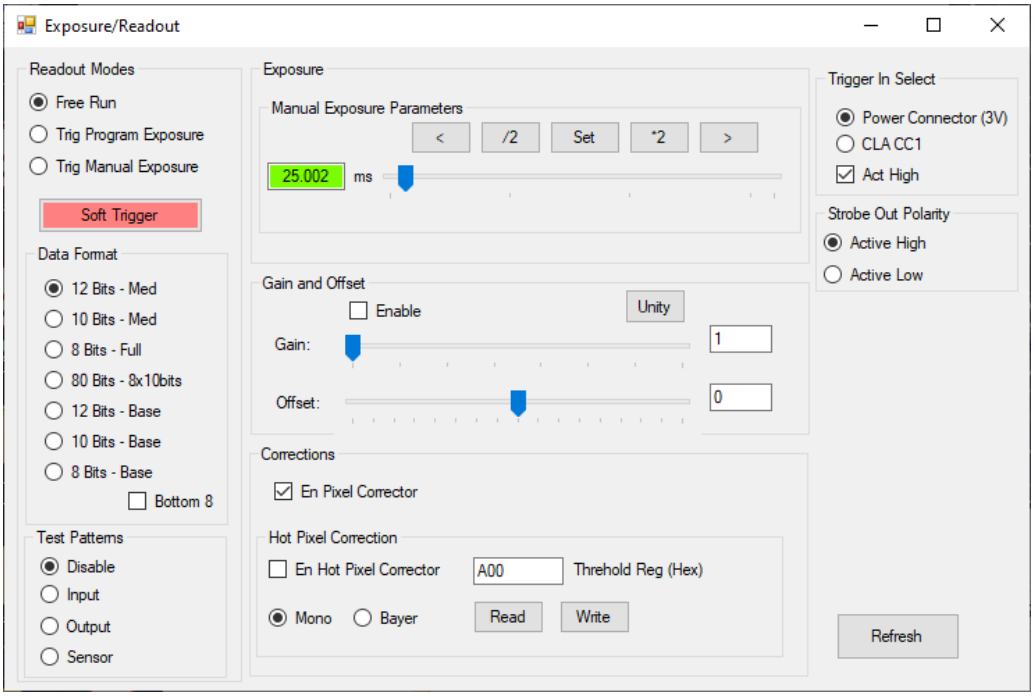
NOTE: Starting with version 10.x baud=115200 is no longer required, the app will try all baud rates on connection

NOTE: Use care with all menus enabled as some changes cannot be undone and may require the camera be returned to the factory for remedy.

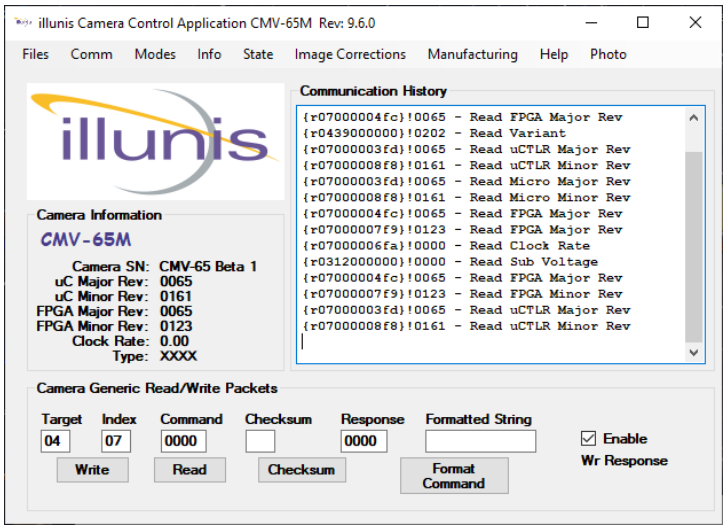
Exposure / Readout:

Start with this dialog box as most of the immediately useful controls are located here.





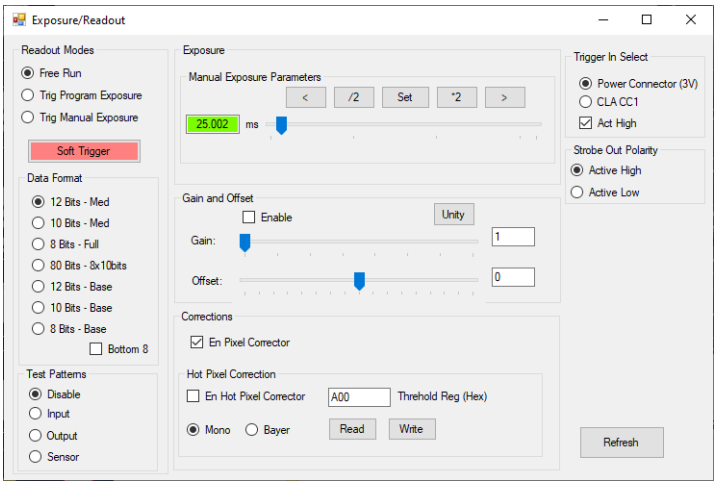
Camera Control Application Details:



Main Dialog

The main dialog box provides access to the various functions of the camera. Menus are used to access sub-dialogs. A generic camera register read/write feature is provided.

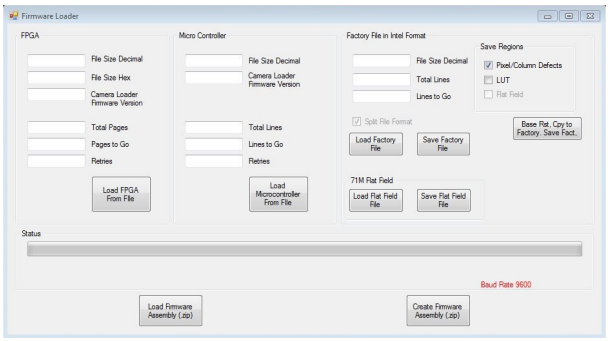
In addition, a history of communication is also provided in this dialog box.



Modes->Exposure and Readout

This dialog box is used to set the Readout Mode, Free Run, or Trigger, as well as the bit depth and exposure of the camera. In addition, the user can set the Camera Link mode, test patterns, digital gain and offset, and histogram equalization.

Camera Control Application Details:



Manufacturing->Firmware Loader

The firmware loader dialog is used to load FPGA and Microprocessor code as well as the EEPROM configuration data.

A useful feature of this dialog is the ability to save and restore the camera to and from a file. If there are problems with the camera, the camera state may be saved to a file and then emailed to illunis for support.

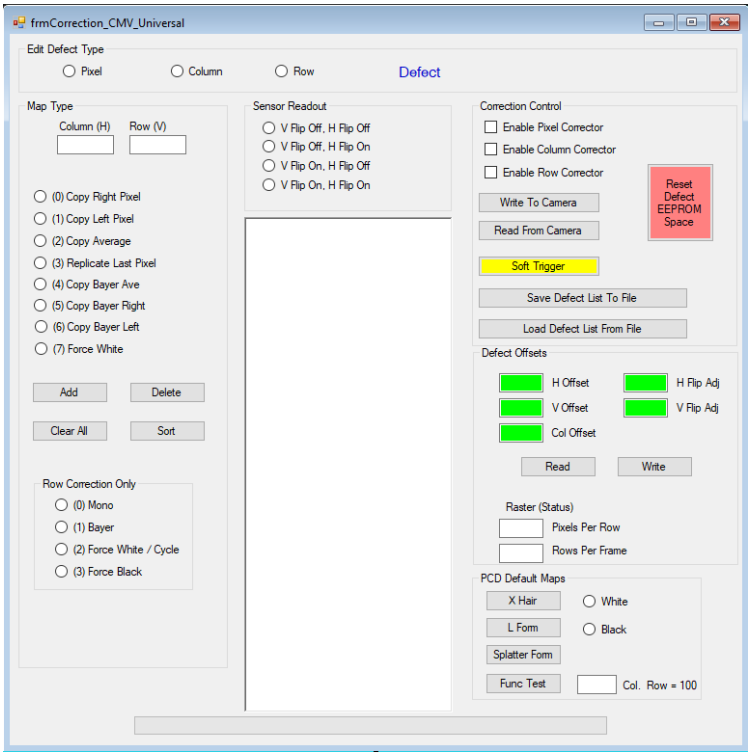


Image Corrections->Sensor Defects->Defect Editor

The defect corrector editor dialog allows editing of the defect corrector tables.

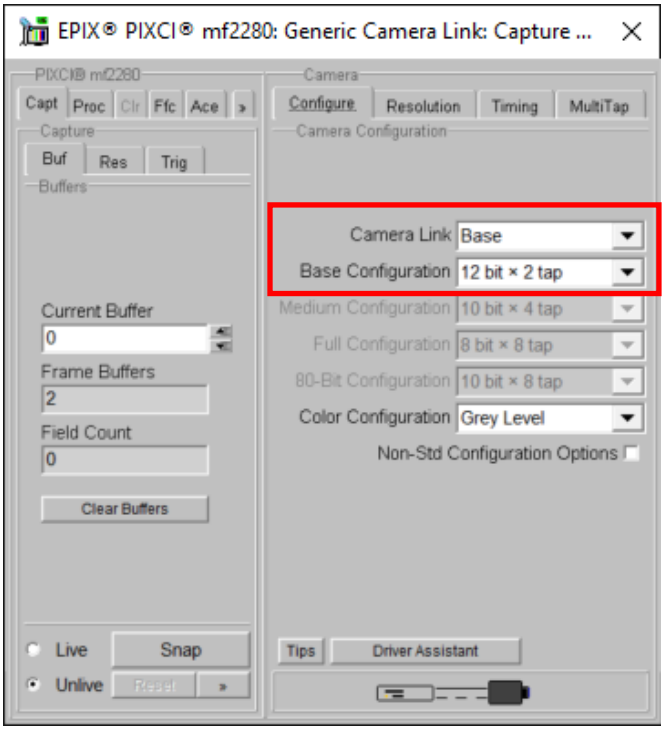
General Comments:

The control application is for communication with the camera until the user application takes over these functions. All buttons and sliders show the command that is being executed in the application main window.

In the main window, there is a generic read and write section allowing any command that can be found in the manual to be sent to the camera and see its response.

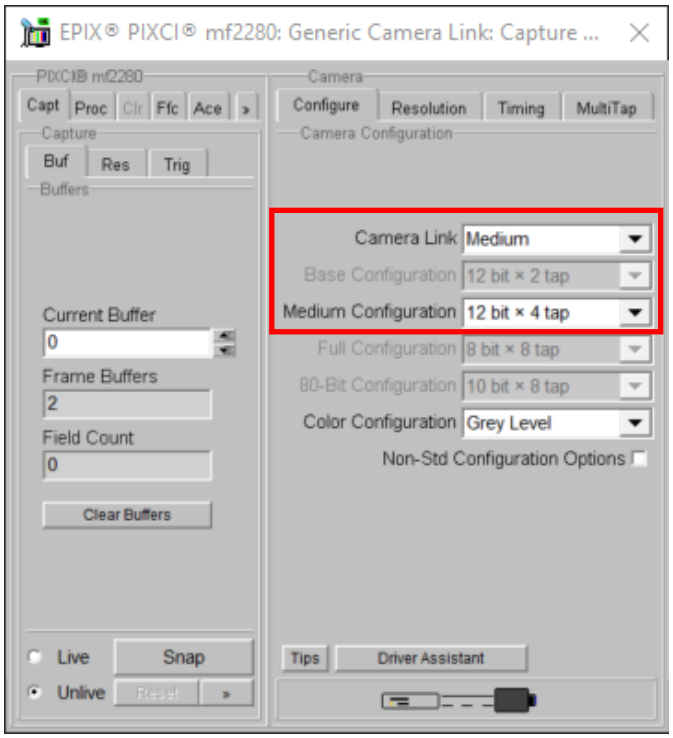
NOTE: If a camera mode is changed, the corresponding change in the capture environment will have to be made as they are independent.

Epix XCAP Setup



Base Format

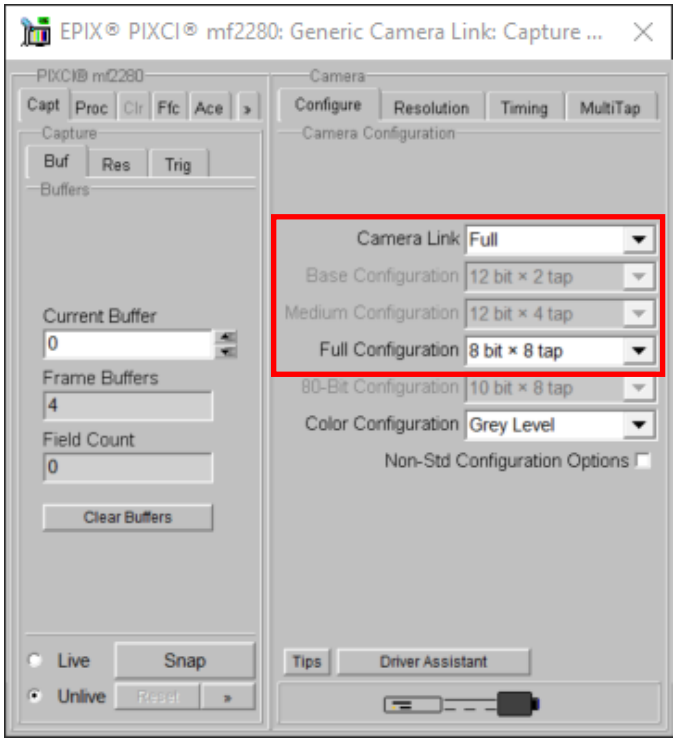
10 and 8-bit also available



Medium Format

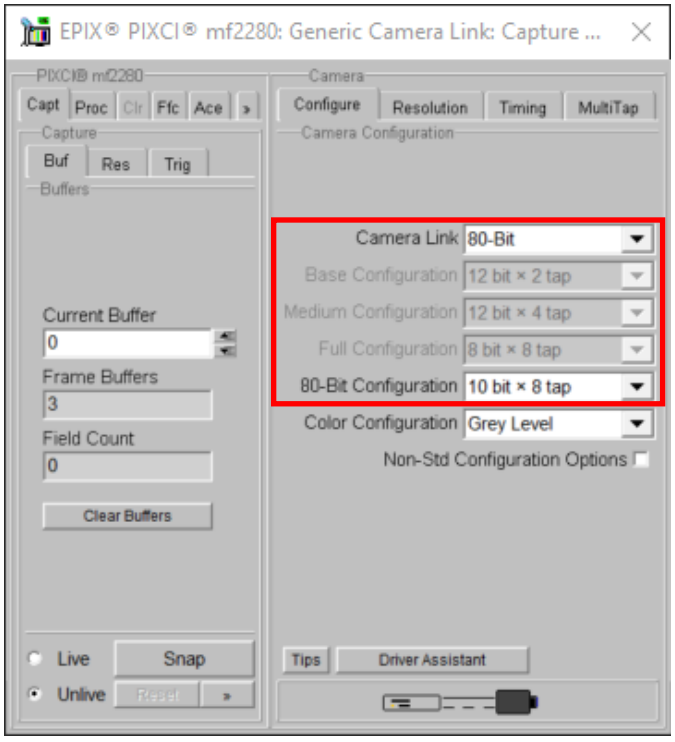
10-bit also available

Epix XCAP Setup



Full Format

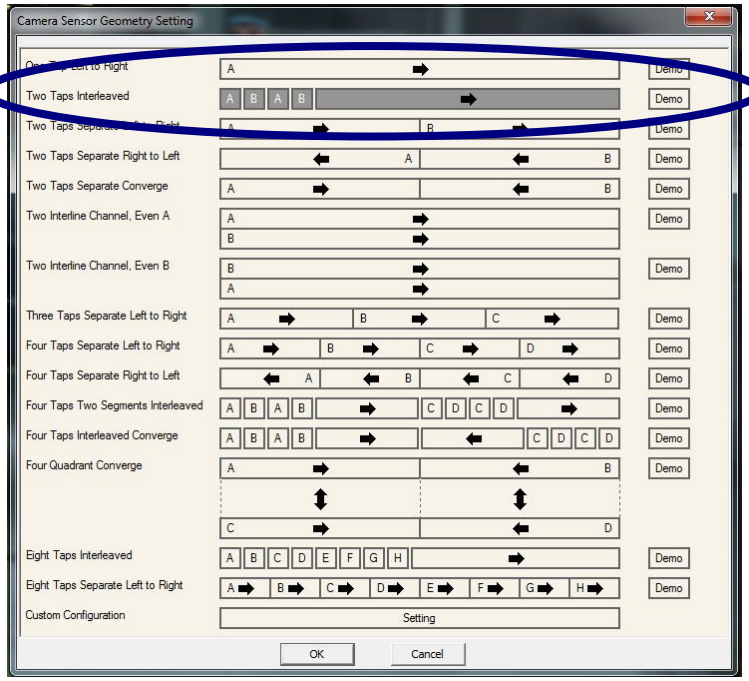
8-bit Only



DECA Format

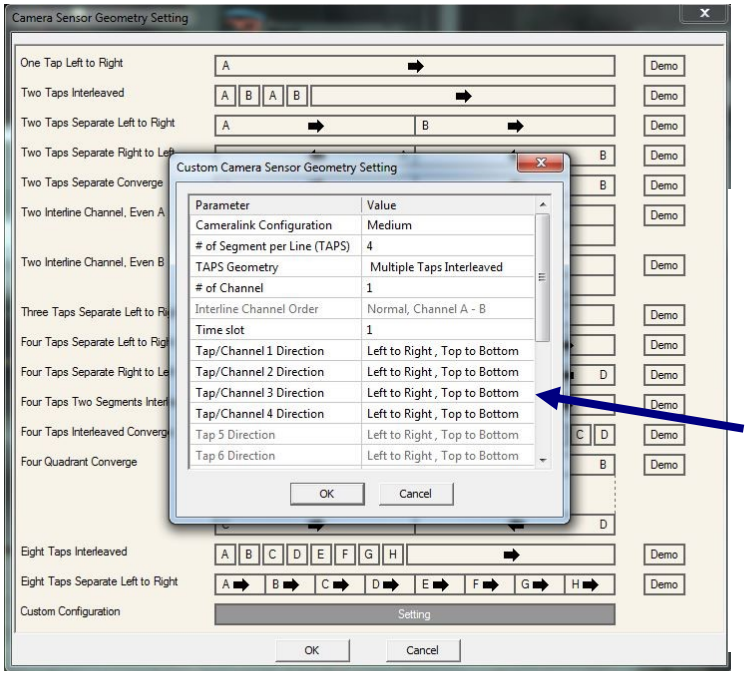
10-bit only

Teledyne Dalsa CamExpert Setup



Base Format

2 pixels per clock
Left to Right,
Top to Bottom

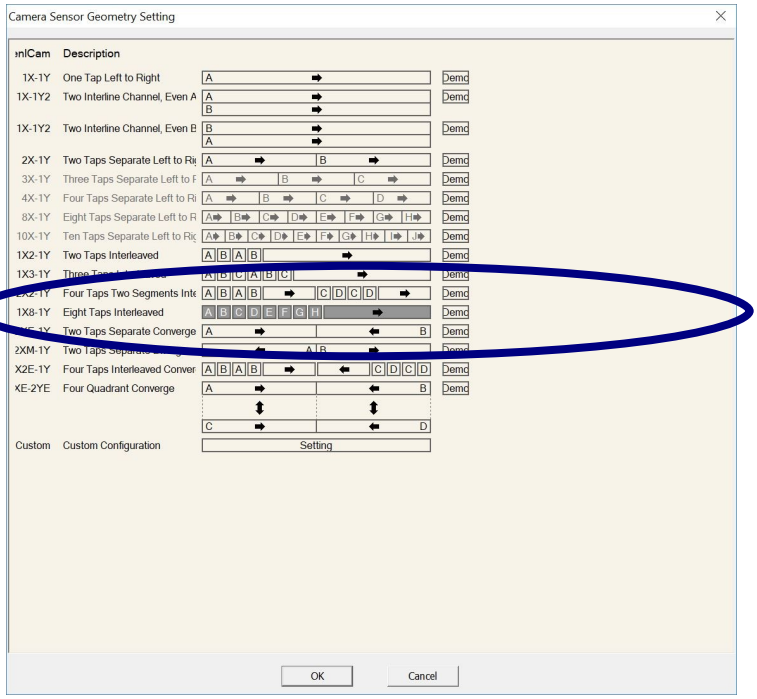


Medium Format

4 pixels per clock
Left to Right,
Top to Bottom

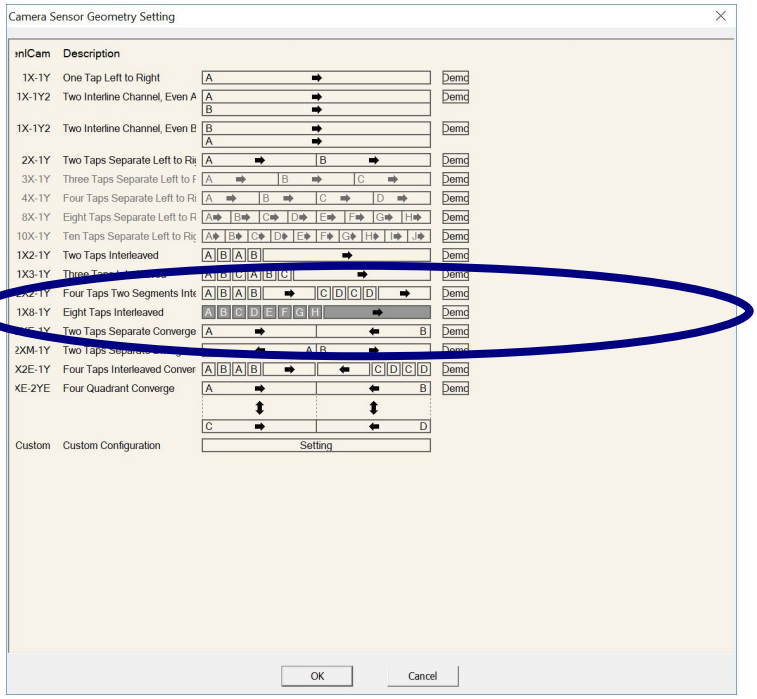
Note: Changing from Top to Bottom to Bottom to Top will flip the image vertically !

Teledyne Dalsa CamExpert Setup



Full Format

8 pixels per clock
Left to Right,
Top to Bottom



DECA

8 pixels per clock
Left to Right,
Top to Bottom

Capture card must be in 80-bit mode.
8-tap/10-bit

EMC-51 Sensor Specifications:

The EMC-51Camera incorporates the Gpixel GMAX4651 sensor.

Sensor Description

GMAX4651 is a 51 Megapixel (8424x6032) full frame(35mm) global shutter image sensor designed using the latest 4.6µm charge domain global shutter pixel. Using the advanced 65nm CIS process, it provides 18ke- FWC, 7.6e- median dark noise and more than 65dB intra-scene dynamic range. With the light pipe technology, sensor achieves >67% QE @510nm and 1/40,000 shutter efficiency.

GMAX4651 delivers 30fps in single gain operation mode running at 864Mbps. GMAX4651 is assembled with 238 pins PGA ceramic package and the optical center is fully aligned with the package mechanical center. The unique features make it an ideal solution for demanding imaging applications like machine vision, 8K broadcasting and high-end industrial inspections.

Resolution	8424 × 6032	Optical format	35mm Full Frame
Pixel size	4.6µm × 4.6µm	Photo-sensitive area	38.75mm x 27.75mm
Shutter type	Global Shutter	Quantum efficiency	67%@510nm
Full well capacity	18ke⁻ @PGA x3.5 12.5ke⁻ @PGA x5	Dark noise	9.5e⁻ @PGA x3.5 7.6e⁻ @PGA x5
Dynamic range	65.8@PGA x3.5 64.3@PGA x5	Dark current	6e⁻/p/s @ 45℃
ADC	12bit	Frame rate	30fps
Output interface	24 x sub-LVDS	Channel multiplexing	24/14/8/6/4
Max. Data rate	21Gbps	Shutter efficiency	1/40,000
CRA	>15°@ 80% response	Package	238-pin PGA
Chroma	Mono & RGB Color	Power consumption	2.7W

EMC-51 Sensor Specifications:

Item	EMC-51
Active Image	8424 x 6032 (Windowing optional)
Sensor Type	Gpixel GMAX4651
Pixel Size	4.6 µm x 4.6 µm
Data Output	8/10/12 bits
Output Format	Mono or Bayer
Camera Interface	Base, Medium, Full or DECA
Electronic Shutter	Global shutter
Max. Frame Rate at Full Res 8 bits/pixel	10.1 fps: Full 8/8bit, DECA 8x10bit 5.0 fps: Medium
Windowing	V increments of 1 rows
Black Level	Adjustable
Analog Gain	3.5, 3.75, 4, 4.25, 4.5, 4.75, 5
Digital Gain	1/16th to 16X
Exposure Modes	Free Run, Program Triggered, Pulse Width Triggered
External Trigger	3.3-5.0V TTL
Software Trigger	Per Camera API
Dynamic Range	65.5 dB @ gain 3.5
Defect Correction	Pixel, Column, Row, Hot Pixel, Shading, Black Clamp
Lens Mount	M58, Nikon F, Canon EF, M72
Power	7-12V DC
Environmental	Operating 0C to 60C, Storage –40C to +85C Camera Link tested to –30C to 70C.
Vibration/Shock	10G (20-200Hz) XYZ 70G 10ms

EMC-51 Sensor Specifications:

Item	EMC-51
Full Well	18,000e
Conversion Gain	0.21 DN/e- @ PGA gain 3.5
Temporal Noise	7.6e-@ PGA gain x5
SNR Max	42.5 dB @ PGA gain x3.5
Dark Current	6e-/s/pix @ 45°C die temperature
PRNU	Photo Response Non Uniformity 1.7% RMS typical @ PGA gain x3.5
QE	67.1%@510nm

EMC-51 Sensor Specifications:

EMC-51 Sensor Pixel Defects:

Mono	Limit	
	Grade 1	Grade 2
Total Defect Columns	0	4
Total Defect Rows	0	4
Total Defect Pixels	400	600
Maximum Cluster Size	4	36

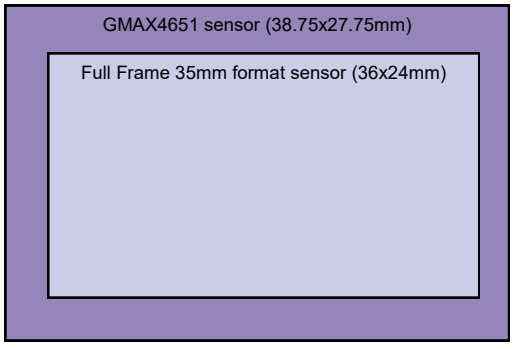
Bayer	Limit
	Grade 1
Total Defect Columns	0
Total Defect Rows	0
Total Defect Pixels	400
Maximum Cluster Size (within color plane)	4

Note: Defects are corrected in the camera hardware as part of the manufacturing process.

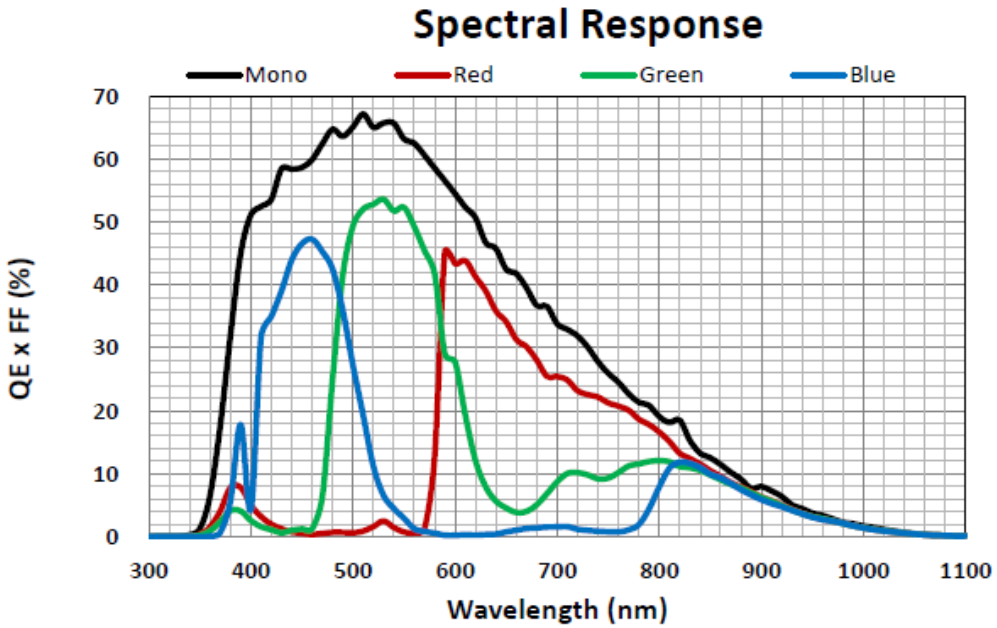
EMC-51 Sensor Size

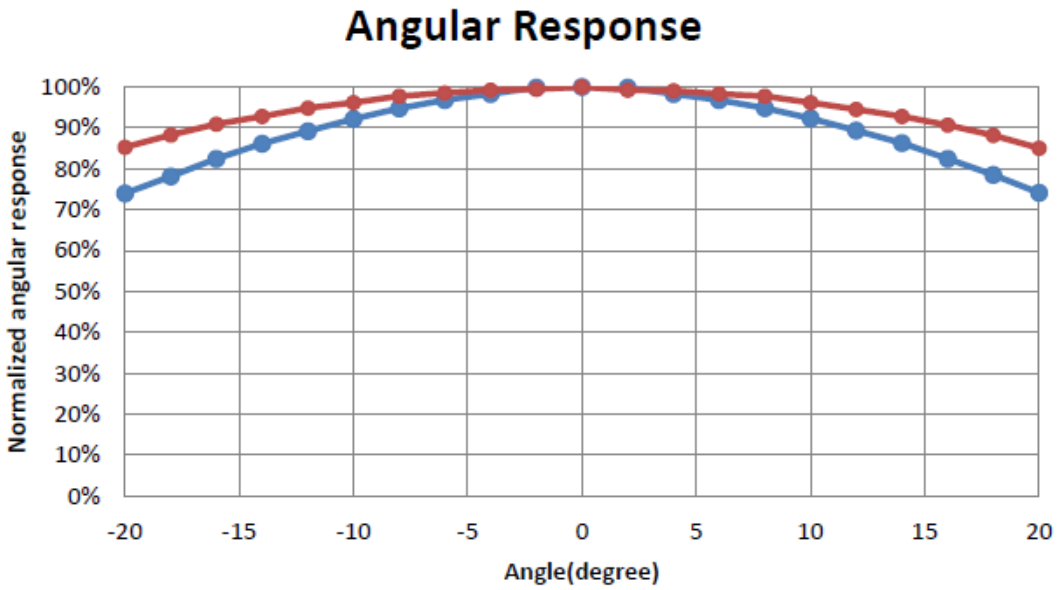
The Gpixel GMAX4651 sensor is slightly larger than the standard 35mm format. The GMAX4651 has a diagonal of 47.7mm vs the 43.3mm diagonal of the 35mm format. This results in a decrease in effective focal length of 43.3/47.7 = 0.91X.

Thus, a 50mm focal length lens for a 35mm camera will have an effective 45.5mm focal length.



EMC-51 Sensor Specifications:





EMC-65 Sensor Specifications:

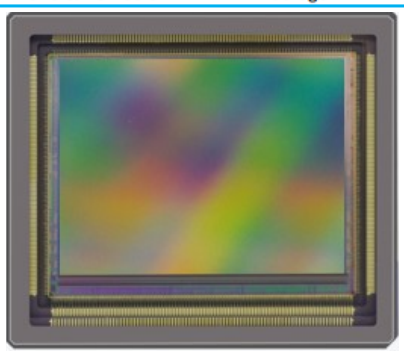
The EMC-65 Camera incorporates the Gpixel GMAX3265 sensor.

Sensor Description

Featured with the latest generation 3.2μm charge-domain global shutter pixel and 65MP (9344x7000) resolution, GMAX3265 is the leading-edge image sensor with 37.4mm diagonal for high resolution machine vision and industrial inspection applications. This new generation pixel operates with true correlated double sampling (CDS), allowing low read noise and high dynamic range. In addition, the light pipe technology provides excellent PLS (Parasitic light sensitivity) and angular response.

GMAX3265 is offered in high speed version and normal speed version. High speed version delivers 71fps at 10 bit output, normal speed version delivers 31fps at 12 bit output. The superior resolution and frame rate significantly increases the system throughput for industrial inspection applications, such as semiconductor, PCB, AOI or display inspection. The sensor integrates an on-chip sequencer, programmable through SPI, shortening time-to-market for camera manufactures. GMAX3265 is assembled with 239-pin micro-PGA ceramic package for reliability and good heat dissipation and a double-sided ARC D263 glass lid.

Resolution	9344 × 7000	Optical format	2.3"(∅37.4 mm)
Pixel size	3.2μm × 3.2μm	Photo-sensitive area	29.9mm × 22.4mm
Shutter type	Global shutter	Quantum efficiency	>65% @500nm
ADC	10/12bit	Shutter efficiency	>1/15000
Dark noise@12bit	7.7e⁻ @ PGA x0.75 5e⁻ @PGA x1.25 1.9e⁻ @PGA x6	Full well capacity@12bit	11ke⁻ @PGA x0.75 10ke⁻ @PGA x1.25 2ke- @PGA x6
Dark noise@10bit	11.8e⁻ @PGA x0.75 7.5e⁻ @PGA x1.25	Full well capacity@10bit	10.6ke⁻ @PGA x0.75 9.8ke⁻ @PGA x1.25
Max. Dynamic range	62.3dB @ 10bit 66dB @ 12bit	Frame rate	71fps @ 10bit 31fps @ 12bit
Output interface	56 pairs of sub-LVDS	Channel multiplexing	56/28/14/7/4/2/1
Dark current	<1e⁻/p/s @ 25℃	Power consumption	2.2W @ 10bit / 2W @ 12bit
Chroma	Mono & RGB Color	Package	239-pin micro-PGA



EMC-65 Specifications:

Item	EMC-65
Active Image	9344 x 7000 (Windowing optional)
Sensor Type	Gpixel GMAX3265
Pixel Size	3.2 µm x 3.2 µm
Data Output	8/10/12 bits
Output Format	Mono or Bayer
Camera Interface	Base, Medium, Full or DECA
Electronic Shutter	Global shutter
Max. Frame Rate at Full Res 8 bits/pixel	2.4 Base CL, 4.9 Medium CL, 9.4 Full CL, 9.4 DECA
Windowing	V increments of 1 rows
Black Level	Adjustable
Analog Gain	.75, 1, 1.25, 1.5, 6x
Digital Gain	1/16th to 16X
Exposure Modes	Free Run, Program Triggered, Pulse Width Triggered
External Trigger	3.3-5.0V TTL
Software Trigger	Per Camera API
Dynamic Range	66dB @ gain x1.25
Defect Correction	Pixel, Column, Row, Hot Pixel, Shading, Black Clamp
Lens Mount	M58, Nikon F, Canon EF, M72
Power	7-12V DC
Environmental	Operating 0C to 60C, Storage –40C to +85C Camera Link tested to –30C to 70C.
Vibration/Shock	10G (20-200Hz) XYZ 70G 10ms

EMC-65 Specifications:

Item	EMC-65
Full Well	10,900e- @ PGA gain x0.75
Conversion Gain	0.38 DN/e @ PGA gain x1.25
Temporal Noise	1.9 e- @ 12 bit, PGA gain x0.75
SNR Max	40 dB @ PGA gain x1.25
Dark Current	5.3 e-/s @ 40°C Sensor Temperature and PGA gain x1.25
PRNU	Photo Response Non Uniformity 1.3% RMS typical @ PGA gain x1.25
QE	65.3% @ 500nm

EMC-65 Sensor Pixel Defects:

Mono	Limit		
	Grade 1	Grade 2	Grade 3
Total Defect Columns	0	0	0
Total Defect Rows	0	0	0
Total Defect Pixels	200	400	600
Maximum Cluster Size	-	4	9
Maximum # of Clusters	0	12	20

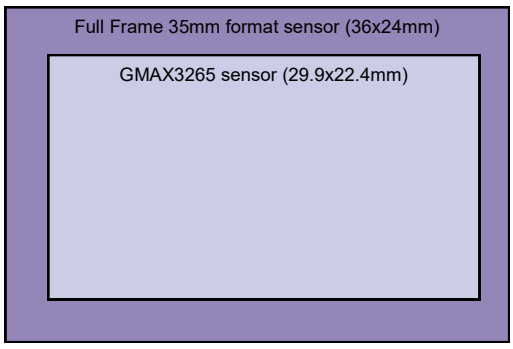
Bayer	Limit	
	Grade 1	Grade 2
Total Defect Columns	0	0
Total Defect Rows	0	0
Total Defect Pixels	200	400
Maximum Cluster Size (within color plane)	-	4
Maximum # of Clusters	0	12

Note: Defects are corrected in the camera hardware as part of the manufacturing process.

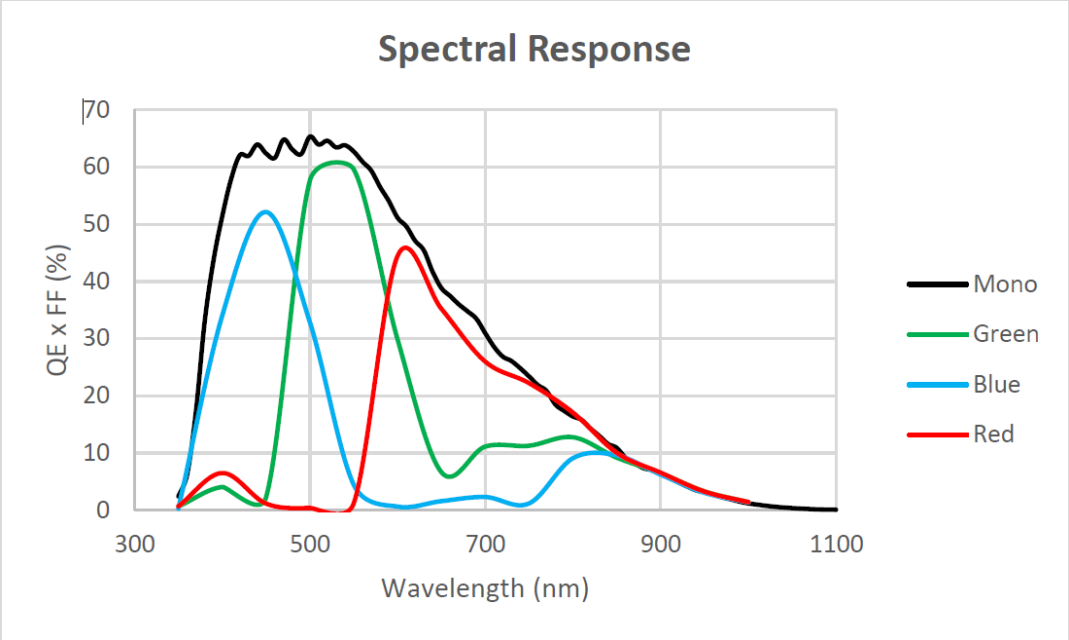
EMC-65 Sensor Size

The Gpixel GMAX3265 sensor is slightly smaller than the standard 35mm format. The GMAX3265 has a diagonal of 37.4mm vs the 43.3mm diagonal of the 35mm format. This results in an increase in effective focal length of 43.3/37.4 = 1.158X.

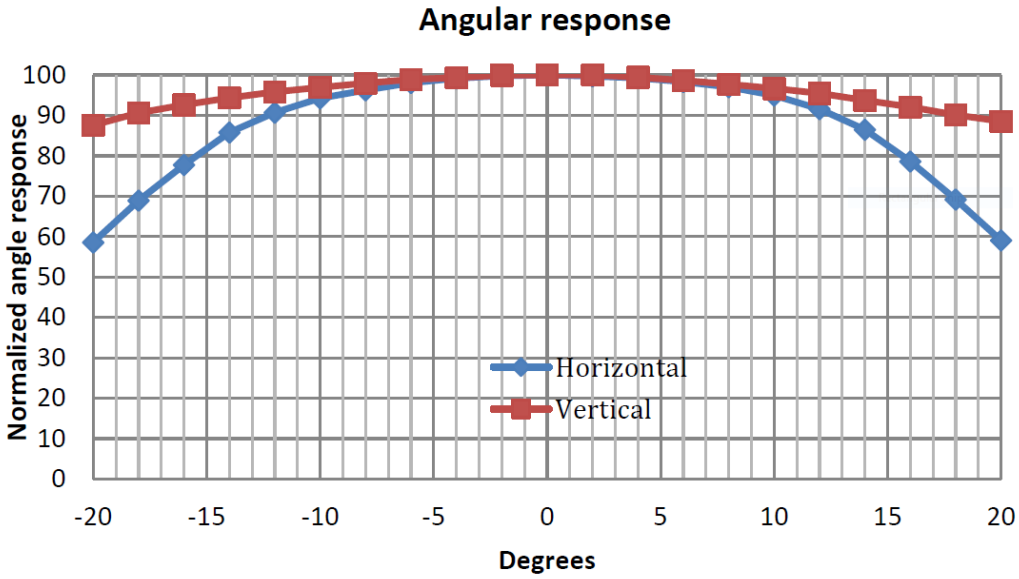
Thus, a 50mm focal length lens for a 35mm camera will have an effective 57.9mm focal length.



EMC-65 Sensor Pixel Response:



EMC-65 Sensor Microlens Angular Response:



EMC-103 Sensor Specifications:

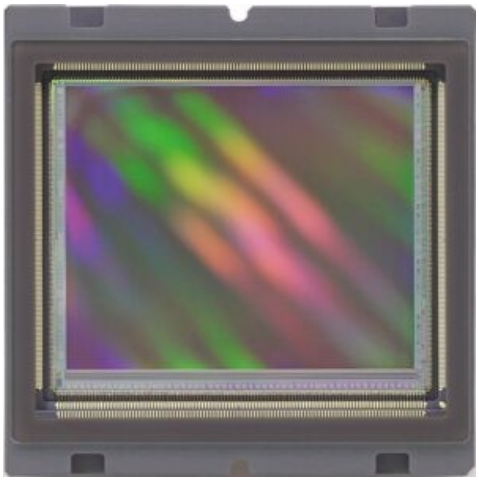
The EMC-103 Camera incorporates the Gpixel GMAX32103 sensor.

Sensor Description

GMAX32103 is a 103 Megapixel (11,276 x 9,200) medium-sized (ø 46.6mm) ultra-high resolution, global shutter image sensor designed with the latest 3.2 µm charge domain global shutter pixel. It achieves more than 9k e - FWC at low gain and 2.8 e - read noise at high gain separately with 66 dB intra-scene dynamic range. Using advanced 65nm CIS process and light pipe technology, sensor achieves 68% peak QE @ 510nm and more than 1/15,000 shutter efficiency.

The full speed version sensor consists of 52 pairs sub-LVDS channels running at 960 Mbps which delivers a 24 fps in 12-bit operation at full resolution. The unique features make it an ideal solution for demanding imaging high end applications such as high-resolution inspection, aerial imaging and many more. and high-end industrial inspections.

Resolution	11,276 (H) × 9,200 (V)	Optical format	Medium sized (∅ 46.6mm)
Pixel size	3.2 µm × 3.2 µm	Photo-sensitive area	36.1 mm x 29.4 mm
Shutter type	Global Shutter	Quantum efficiency	68% @ 510nm
Full well capacity	9k e- (max in LG mode)	Shutter efficiency	1/15,000
Dark noise	2.8 e^- (min in HG mode)	Dark current	12 e - / s @ 50 °C
Dynamic range	66 dB	Frame rate	24 fps @ 12 bit
Output interface	52 x sub-LVDS	Channel multiplexing	52/26/18/14/10/8/6/4
ADC	12 bit	Max. Data rate	960M bps
Chroma	Mono / Color	Package	209 pins µPGA
Power supply	3.3V / 1.8V / 1.2V Dedicated pixel supplies	Power consumption	2.47 W



EMC-103 Specifications:

Item	EMC-103
Active Image	11276 x 9200 (Windowing optional)
Sensor Type	Gpixel GMAX32103
Pixel Size	3.2 µm x 3.2 µm
Data Output	8/10/12 bits
Output Format	Mono or Bayer
Camera Interface	Base, Medium, Full or DECA
Electronic Shutter	Global shutter
Max. Frame Rate at Full Res 8 bits/pixel	6.1 fps: Full 8/8bit, Deca 8x10bit 3.0fps: Medium, 12/10/8 bits 1.5fps: Base, 12/10/8 bits
Windowing	V increments of 1 rows
Black Level	Adjustable
Analog Gain	1.4 - 5.2x
Digital Gain	1/16th to 16X
Exposure Modes	Free Run, Program Triggered, Pulse Width Triggered
External Trigger	3.3-5.0V TTL
Software Trigger	Per Camera API
Dynamic Range	66.4dB @ PGA Gain x1.4
Defect Correction	Pixel, Column, Row, Hot Pixel, Shading, Black Clamp
Lens Mount	M58, Nikon F, Canon EF, M72
Power	7-12V DC
Environmental	Operating 0C to 60C, Storage –40C to +85C Camera Link tested to –30C to 70C.
Vibration/Shock	10G (20-200Hz) XYZ 70G 10ms

EMC-103 Specifications:

Item	EMC-103
Full Well	9.0ke- @ PGA Gain 1.4
Conversion Gain	0.4 DN/e- @ PGA gain x1.4
Temporal Noise	4.3e @PGA Gain x1.4
SNR Max	39.5 dB @ PGA gain x1.4
Dark Current	1.4e-/s @ 30°C die temp and PGA Gain x1.4
PRNU	Photo Response Non Uniformity 1.1% RMS typical @ PGA gain x1.4
QE	66.9% @ 500nm

Important Note: The GMAX32103 sensor is slightly larger than the standard 35mm format. This can lead to vignetting in the corners when using F and EF mount lenses. This area can be cropped out of the image, or a different mount/lens combination can minimize the issue.

A centered raster height of 7500 will conform to 35mm dimensions.

EMC-103 Sensor Pixel Defects:

Mono	Limit		
	Grade 1	Grade 2	Grade 3
Total Defect Columns	0	0	10
Total Defect Rows	0	0	10
Total Defect Pixels	400	600	800
Maximum Cluster Size	4	13	13

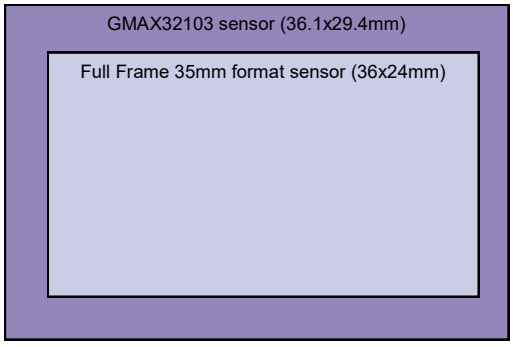
Bayer	Limit		
	Grade 1	Grade 2	Grade 3
Total Defect Columns	0	0	10
Total Defect Rows	0	0	10
Total Defect Pixels	400	600	800
Maximum Cluster Size (within color plane)	4	13	13

Note: Defects are corrected in the camera hardware as part of the manufacturing process.

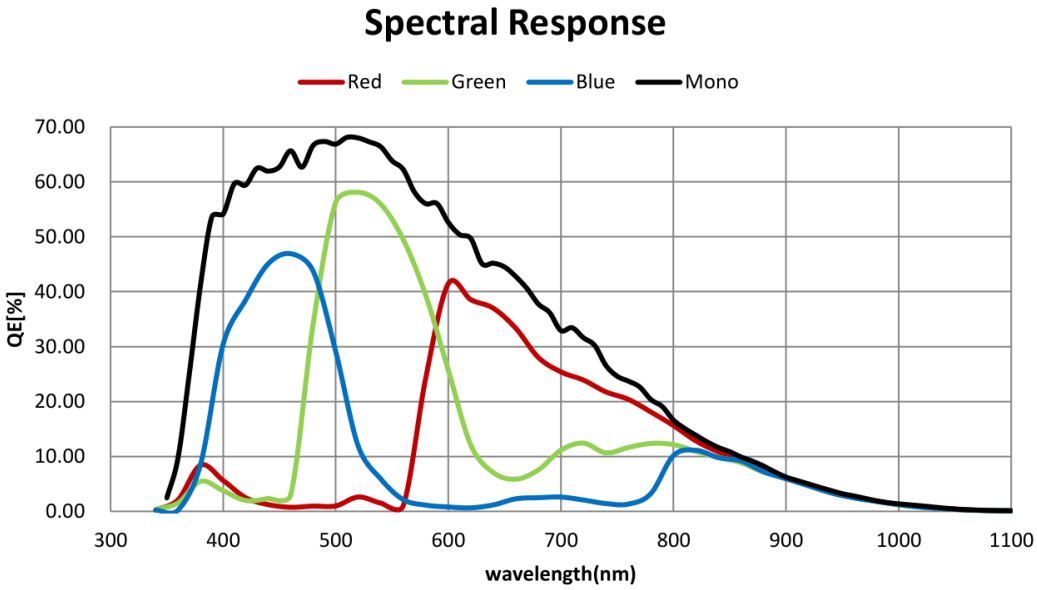
EMC-103 Sensor Size

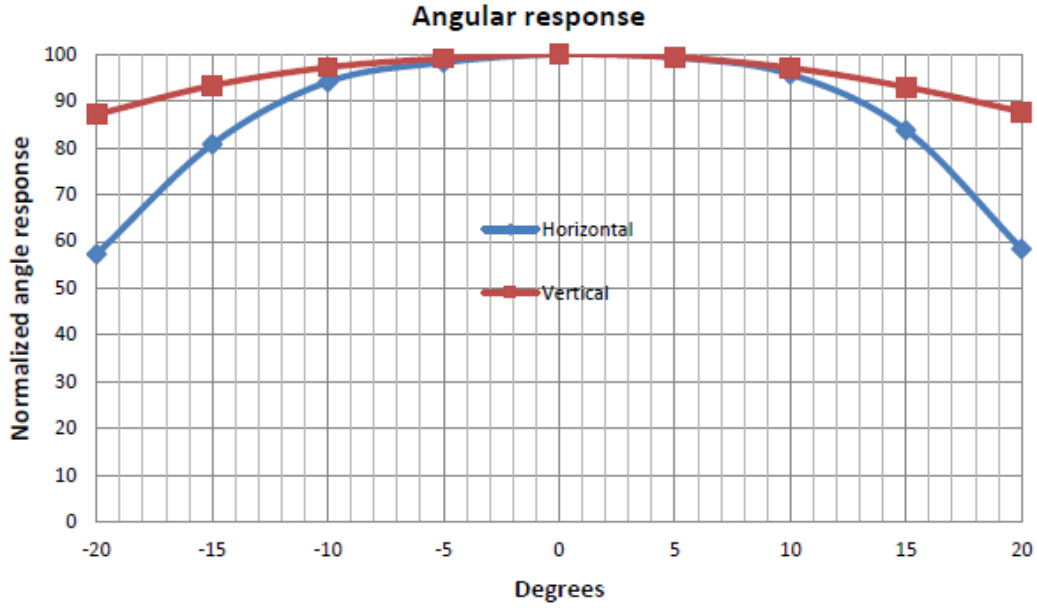
The Gpixel GMAX32103 sensor is slightly larger than the standard 35mm format. The GMAX4651 has a diagonal of 46.5mm vs the 43.3mm diagonal of the 35mm format. This results in a decrease in effective focal length of 43.3/46.5 = 0.93X.

Thus, a 50mm focal length lens for a 35mm camera will have an effective 46.5mm focal length.

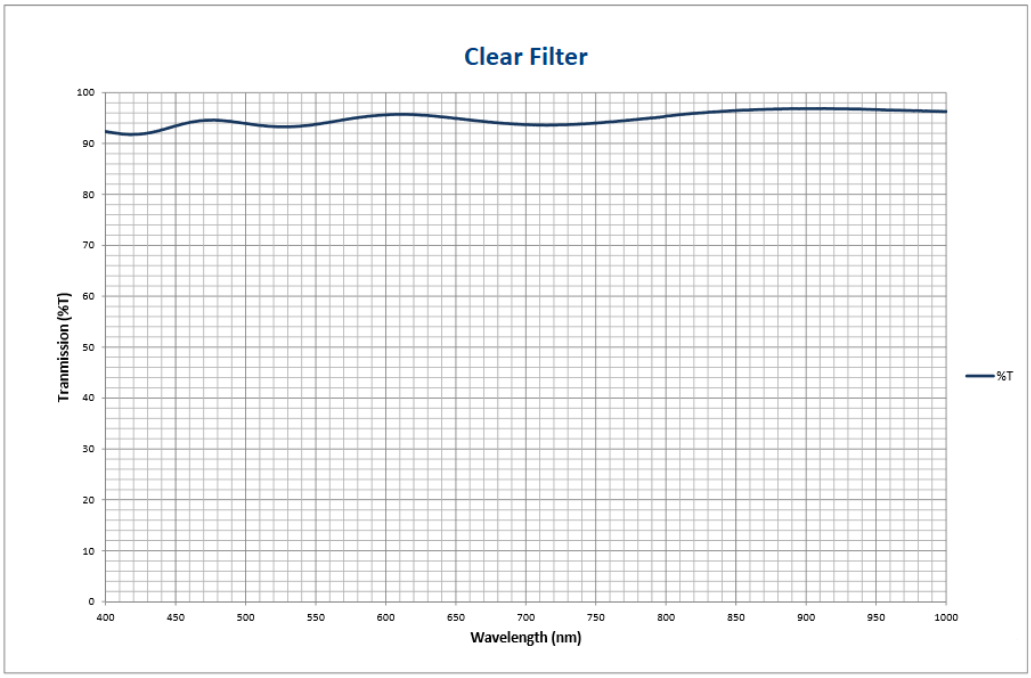


EMC-103 Sensor Specifications:

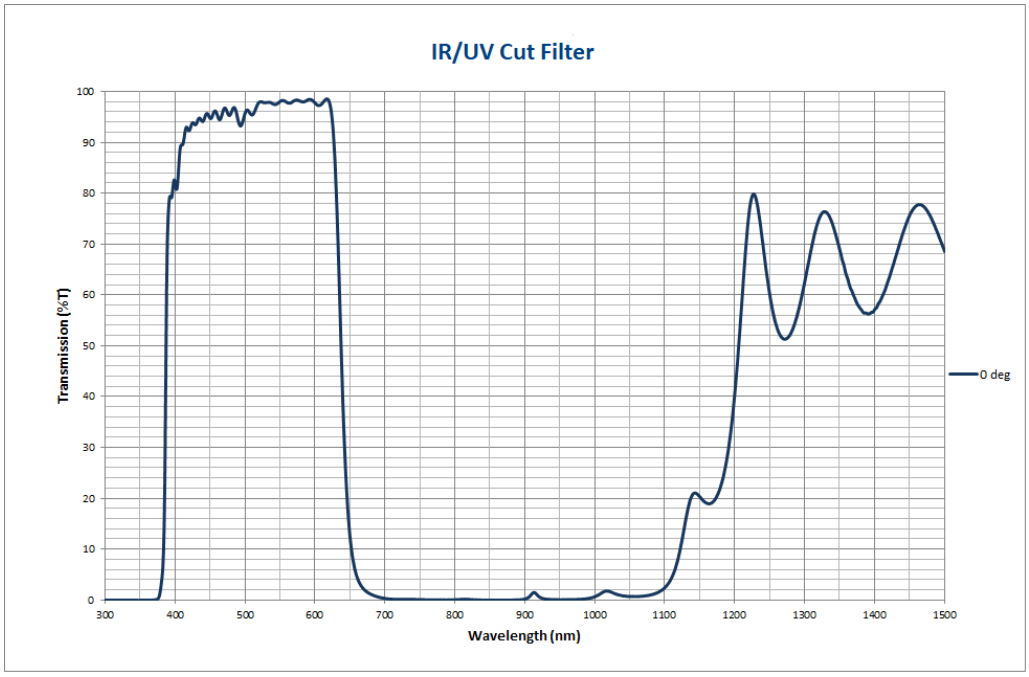




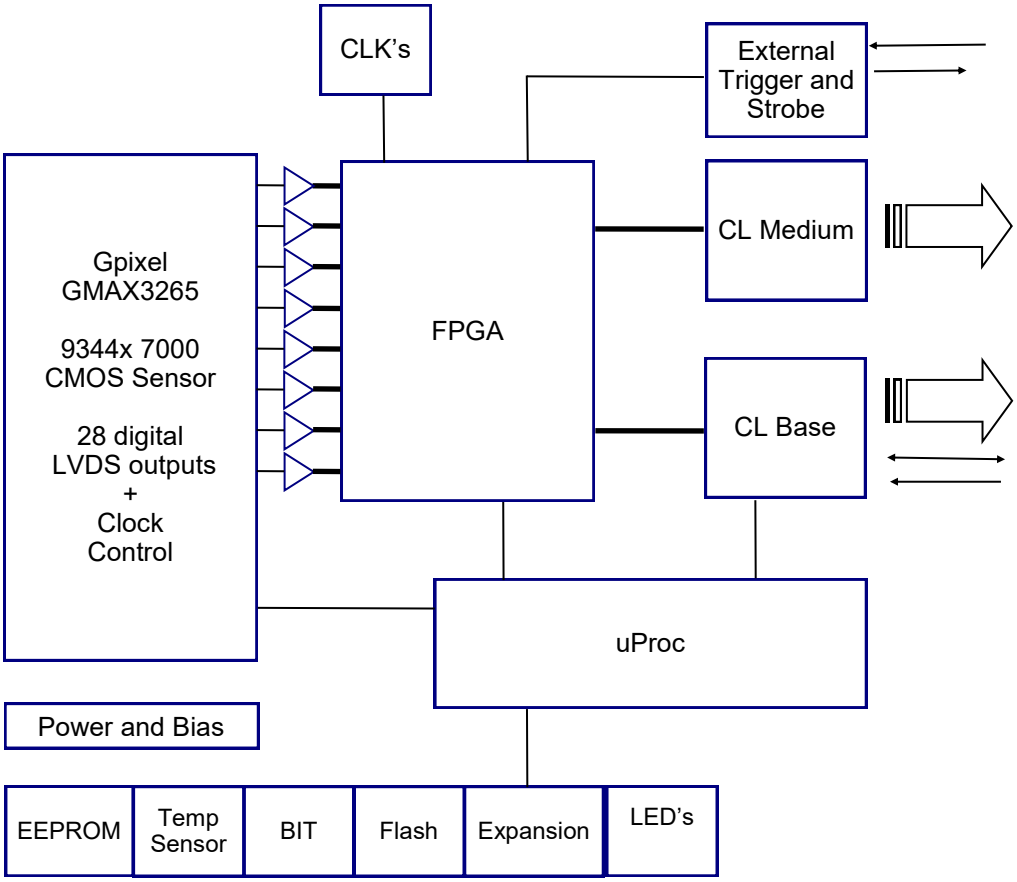
Skylight Filter response:



IR/UV Filter response:



Camera Link output block diagram:



Each tap is digitized with an analog to digital converter (ADC) with 12 bit precision. All pixels are optically black clamped and row noise reduced based on the optical black pixel data.

The FPGA reorders the tap data into eight paths of pixels and outputs the pixels onto a one or two Camera Link buses. The output data is formatted to Camera Link. The Camera Link interface includes trigger and serial communications. The camera can output Base, Medium, Full and DECA Camera Link configurations.

In addition, an external trigger and strobe are provided on the power connector.

The on-board microprocessor controls the sensor and FPGA operation, as well as monitors the various sensors within the camera.

Camera Link

Camera Link is a communication interface for visual applications that use digital imaging. The Camera Link (CL) interface is built upon the National Semiconductor Channel Link technology and specifies how image data is formatted and transferred. Channel Link consists of a driver and a receiver pair. The driver accepts 28 single ended data signals and a single ended clock. The data is serialized 7:1 and the four data streams and a dedicated clock are transmitted over five LVDS pairs. The receiver accepts the four data streams and the clock, decodes the data, and drives the 28 bits of data to the capture circuit.

Image data and image enable signals are transmitted on the Camera Link bus. The four Enable signals are:

FVAL: Frame Valid is defined HIGH for valid lines.
LVAL: Line Valid is defined HIGH for valid pixels.
DVAL: Data Valid is defined HIGH for valid data.
SPARE: undefined, for future use.

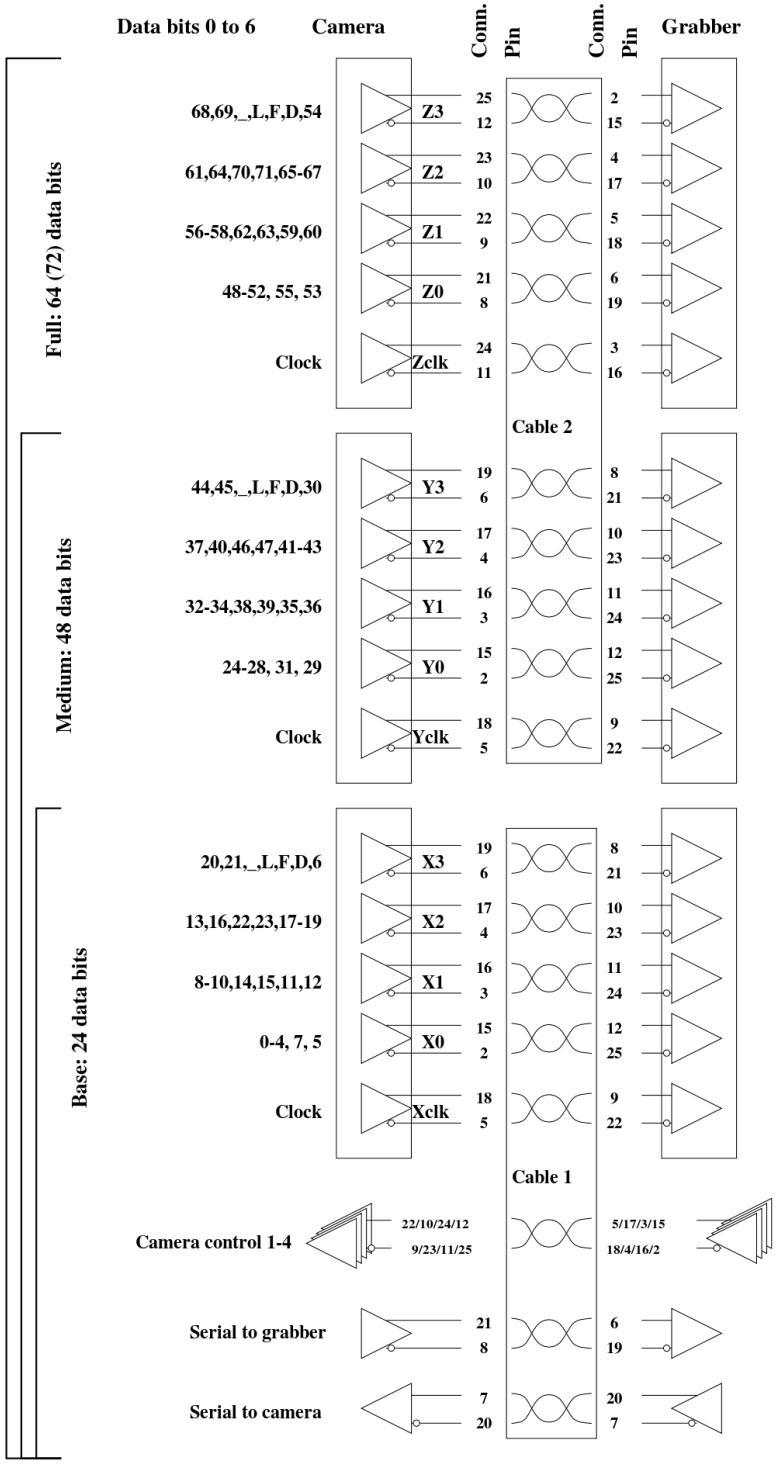
Four LVDS pairs are reserved for general purpose camera control. They are defined as camera inputs and frame grabber outputs. The signals are CC1, CC2, CC3, CC4. The EMC cameras use CC1 as the trigger source.

The Camera Link interface has four configurations:

Base:	Single Channel Link chip, single cable connector.
Medium:	Two Channel Link chips, two cable connectors.
Full:	Three Channel Link chips, two cable connectors.
Deca	Three Channel Link chips, two cable connectors.

Note: EMC cameras can operate in **Base, Medium, Full or DECA** Camera Link Configurations.

Camera Link


Data bits 0 to 6
Camera
Conn.
Pin
Conn.
Pin
Grabber
Full: 64 (72) data bits
68,69,_,L,F,D,54
Z3
25
12
2
15
61,64,70,71,65-67
Z2
23
10
4
17
56-58,62,63,59,60
Z1
22
9
5
18
48-52, 55, 53
Z0
21
8
6
19
Clock
Zclk
24
11
3
16
Cable 2
Medium: 48 data bits
44,45,_,L,F,D,30
Y3
19
6
8
21
37,40,46,47,41-43
Y2
17
4
10
23
32-34,38,39,35,36
Y1
16
3
11
24
24-28, 31, 29
Y0
15
2
12
25
Clock
Yclk
18
5
9
22
Base: 24 data bits
20,21,_,L,F,D,6
X3
19
6
8
21
13,16,22,23,17-19
X2
17
4
10
23
8-10,14,15,11,12
X1
16
3
11
24
0-4, 7, 5
X0
15
2
12
25
Clock
Xclk
18
5
9
22
Cable 1
Camera control 1-4
22/10/24/12
9/23/11/25
5/17/3/15
18/4/16/2
Serial to grabber
21
8
6
19
Serial to camera
7
20
20
7

Pixel Format

The EMC cameras sample the sensor with 12 bit precision and processes the data throughout the FPGA at 12 bits.

During the data format stage, the 12 bit image data can be down sampled to 10 or 8 bits.

Sensor ADC pixel sample to Camera Link mapping			
ADC bits	12 bit CL	10 bit CL	8 bit CL
11	11>11	11>9	11>7
10	10>10	10>8	10>6
9	9>9	9>7	9>5
8	8>8	8>6	8>4
7	7>7	7>5	7>3
6	6>6	6>4	6>2
5	5>5	5>3	5>1
4	4>4	4>2	4>0
3	3>3	3>1	
2	2>2	2>0	
1	1>1		
0	0>0		

Channel Format

The Camera Link Base Mode used on the EMC cameras, can transfer pixel data in 8, 10, 12 bit depths.

Target	Index	Command	R/W	Description
0x00	0x02	Camera Link Output	R/W	0x0000 = 12 bit Medium 0x0001 = 10 bit Medium 0x0003 = 8x8 Full 0x0004 = 8x10 Deca 80bit 0x0005 = 12 bit Base 0x0006 = 10 bit Base 0x0007 = 8 bit Base

The EMC camera serial interface was developed for high reliability applications. The interface incorporates error checking and a handshake protocol, which responds with either a positive or negative acknowledge signal. The communication path from the frame grabber to the EMC camera is through the Camera Link cable.

The EMC camera microprocessor is a flash programmable device with many features vital to the operation of the camera. Some of these features include:

- Hardware UART used for serial communications.
- A watchdog timer used to monitor communication errors and system faults.
- Onboard RAM and EEPROM for saving camera settings.
- Parallel data bus for high speed interfaces to the FPGA and NAND FLASH memories.
- Brown out detection and reset.

SERIAL INTERFACE PROTOCOL

Implementation

Camera communication is accomplished via asynchronous serial communication according to EIA Standard RS 232 C through the Camera Link cable.

Data rate: Full Duplex, 115200 baud.

- 1 START bit.
- 8 DATA bits – The LSB (D0) is transfered first.
- 1 STOP bit.
- No parity.

Protocol

The EMC camera is controlled through command packets. The EMC camera is considered a slave device and never generates data without a read request. The data packet formatting is described in detail below. ***Note:*** the checksum is calculated only on the 4 ascii characters comprising the Data.

Data Packets

Data packets are of either ‘read’ or ‘write’ types. For example: to read the camera serial number, the packet sent to the camera would be {r07000002fe}. The camera would respond by issuing an acknowledge character ! followed by the response {r0700sssscc}, where ssss is the camera serial number and cc is the checksum calculated in hex as 0x0100 – (ss (high byte hex) + ss (low byte).

Packet Format							
1 Char	2 Char	2 Char	2 Char	4 Char	2 Char	1 Char	1 Char
Start	**Command**	**Target**	**Index**	**Data**	**Checksum**	**End**	**Ack/ Nack**

Start:

Indicates the Start of the frame
Size = 1 ascii character
Value = 123 Decimal (ascii {)

Command:

Command descriptor
Size = 1 ascii character
Value = 114 Decimal (ascii r) for Read
Value = 119 Decimal (ascii w) for Write

Target:

Command descriptor
Size = 2 ascii characters

Index:

Command descriptor
Size = 2 ascii characters

Data:

The data transferred
Size = 4 ascii characters

Checksum of Data

Size = 2 ascii characters - Intel-Standard - two's compliment of sum of data.

Example 1: Data = 2002, checksum = lower byte of (0x100 – (0x20 + 0x02)) = 0xde
Example 2: Data = 0000, checksum = lower byte of (0x100 – (0x00 + 0x00)) = 0x00
Example 3: Data = fef0, checksum = lower byte of (0x100 – (0xfe + 0xf0)) = 0x12

End:

Indicates the End of the frame
Size = 1 ascii character
Value = 125 Decimal (ascii })

Ack/Nack:

Positive **Ack**nowledge - **N**egative **ack**nowledge
Size = 1 ascii character
Ack Value = 33 Decimal (ascii !)
Nack Value = 63 Decimal (ascii ?)

COMMAND DESCRIPTIONS

Read Command Structure

The EMC camera parses the sequence byte by byte. An invalid read command, target , or index will cause the camera to issue a NACK. The Host (the user) will generate dummy data with a valid checksum then an end. The camera will respond with an ACK and re-send the command with valid data and checksum. If the Host detects an error, it will re-issue the command.

Host {r tt ii 0 0 0 0 cc}, camera issues !
Camera issues {r tt ii data data data data cc} (NOTE no ACK).

Write Command Structure

The EMC camera parses the sequence byte by byte. An invalid write command, target, index, or checksum will cause the camera to issue a NACK; otherwise, the write sequence will complete and the camera will issue an ACK after the command has been executed. The camera receives the checksum from the Host.

Host {w tt ii data data data data cc} camera issues !

Error Checking

The EMC camera parser is character by character and will respond with an immediate NACK if any unrecognized command, target, index, or checksum occurs.

Communication Timeouts

The EMC camera micro-controller uses a hardware watchdog timer that will time out if the time between bytes are longer than 500ms. When sending command frames to the camera, the host must not have significant delays between bytes sent.

Camera Control

Target	Index	Description	Read Write	Modes
0x00	0x02	Camera Link Output	R/W	0x0000 = 12 bit Medium 0x0001 = 10 bit Medium 0x0003 = 8x8 Full 0x0004 = 8x10 Deca 80bit 0x0005 = 12 bit Base 0x0006 = 10 bit Base 0x0007 = 8 bit Base
0x00	0x01	Exposure MS	R/W	Exposure in milliseconds.
0x00	0x03	Readout Mode	R/W	0x0000 = Free Run 0x0001 = Triggered Program Exposure (TPE) 0x0002 = Triggered Pulse Width Exposure (TME)
0x00	0x04	Strobe Polarity	R/W	0x0000 = Active Low 0x0001 = Active High
0x00	0x05	Exposure US	R/W	Exposure in microseconds.
0x00	0x06	Trigger Polarity	R/W	0x0000 = Active Low 0x0001 = Active High
0x00	0x07	Test Pattern	R/W	0x0000 = Inactive 0x0001 = Input 0x0002 = Output 0x0003 = Sensor
0x00	0x08	Black Clamp Enable	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x09	Black Clamp Value	R/W	12bit dN space
0x00	0x0B	Trigger Source	R/W	0x0000 = Camera Link 0x0002 = Power Connector/Cable
0x00	0x0C	Software Trigger	W	Exposure in milliseconds
0x00	0x0E	Enable Digital Gain and Offset	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x0F	Exposure Data	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x13	Digital Gain	R/W	0x1000 = 1.0X 0xFFFF = 16X
0x00	0x14	Digital Offset	R/W	Signed 12bit dN
0x00	0x20	Color Mode	R/W	0x0000 = Mono 0x0001 = Color
0x00	0x23	Number of frames	R/W	0x0001 = Single triggered frame

Camera Control Continued

Target	Index	Description	Read Write	Modes
0x00	0x60	Pixel Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0x61	Column Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0x62	Row Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0x64	Set H Flip	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0x65	Set V Flip	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0xA0	Hot Pixel Corrector (HPC)	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0xA1	Hot Pixel Corrector Type	R/W	0x0000 = Mono 0x0001 = Bayer
0x00	0xA2	Hot Pixel Threshold	R/W	12bit dN (0x80 recommended)
0x00	0x21	Set Analog Gain	R/W	Values vary by sensor type
0x03	0x00	Save Camera State	W	Save Camera State
0x04	0x15	On Screen Displays	R/W	0x0000 - All OSD off 0x0001 - Detectors OSD 0x0005 - Raster OSD 0x0006 - Revision OSD 0x0007 - Frame Counter OSD 0x000C - Serdes OSD

Gain and Black Level

The EMC camera has 28 digital taps. Each tap is processed by an analog front end (AFE). Each AFE has a gain stage and a 12 bit analog to digital converter.

Digital Gain is set as a fixed point number:
In units of 1/4096 gain
Example 0x1000 = 1X gain
0xC800 = 12.5X gain

Target	Index	Description	Read Write	Modes
0x00	0x0E	Enable Digital Gain and Offset	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x13	Digital Gain	R/W	In units of 1/4096 gain Example 0x1000 = 1X gain 0xC800 = 12.5X gain
0x00	0x14	Digital Offset	R/W	Signed 12bit dN
0x00	0x09	Black Clamp Value	R/W	12bit dN space
0x00	0x08	Black Clamp Enable	R/W	0x0000 = Inactive 0x0001 = Active (default)
0x00	0x21	Set “Analog” Gain	R/W	Varies, see following pages

Gain and Black Level Continued

GMAX4561 Analog Gain Values

Value	11	12	13	14	15	16	17
Gain	3.5	3.75	4	4.25	4.5	4.75	5

GMAX3265 Analog Gain Values

Value	Gain	Value	Gain
0	0.75	11	3.5
1	1	12	3.75
2	1.25	13	4
3	1.5	14	4.25
4	1.75	15	4.5
5	2	16	4.75
6	2.25	17	5
7	2.5	18	5.25
8	2.75	19	5.5
9	3	20	5.75
10	3.25	21	6

Gain and Black Level Continued

GMAX32103 Analog Gain Values

Value	Gain	Value	Gain	Value	Gain
9	1.4	24	2.1	31	2.8
10	1.5	25	2.2	35	3.2
11	1.6	26	2.3	36	3.6
12	1.7	27	2.4	37	4
13	1.8	28	2.5	38	4.4
14	1.9	29	2.6	39	4.8
15	2	30	2.7	40	5.2

Fast Meter and AE Commands

illunis Meter Commands				
Target	**Index**	**Description**	**R/W**	**Modes**
0x00	0xB8	AE Exposure Meter Setup	R	Data = 1 Enabled Exposure meter Data = 0 Disable Exposure meter
0x00	0xB9	AE Exposure Meter	R	Data = Exposure in µs Returns Average signal dN
0x00	0xBA	AE Focus Meter Setup	R	Data = 1 Enabled Focus meter Data = 0 Disable Focus meter
0x00	0xBB	AE Focus Meter	R	Data = Exposure in µs Returns focus value
0x00	**0xBC**	**Fast Exposure Meter** Wait until end of frame to execute (No setup required) **Triggers Allowed**	**R**	**Data = Exposure in µs** **Returns average dN**
0x00	**0xBE**	**Fast Exposure Meter** **(**No setup required)	**R**	**Data = Exposure in µs** **Returns average dN**
0x00	**0xBF**	**Fast Focus Meter** (No setup required)	**R**	**Data = Exposure in µs** **Returns focus value**

illunis Detector Commands				
Target	**Index**	**Description**	**R/W**	**Modes**
0x00	0xB0	Maximum pixel value	R	Returns maximum pixel value (12bit)
0x00	0xB1	Sum of pixels in AE Window (32bit) Brightness	R	Data = 0 Returns bottom 16bits Data = 1 Returns top 16 bits
0x00	0xB2	Sharpness Window (32bit)	R	Data = 0 Returns bottom 16bits Data = 1 Returns top 16 bits
0x00	0xB3	# pixels in AE Win-dow (32bit)	R	Data = 0 Returns bottom 16bits Data = 1 Returns top 16 bits
0x00	0xB4	# saturated pixels in AE Window (32bit)	R	Data = 0 Returns bottom 16bits Data = 1 Returns top 16 bits
0xFE	0x3C	AE Window Left	R/W	Data = left x 8 (10 => 80 pixels)
0xFE	0x3D	AE Window Top	R/W	Data = pixels from top of image
0xFE	0x3E	AE Window Right	R/W	Data = right x 8 (100 => 800 pix-els)
0xFE	0x3F	AE Window Bottom	R/W	Data = pixels from top of image
0x04	0x19	Display AE Window	W	Data = 0x0002
0x04	0x19	Hide AE Window	W	Data = 0x0009

Note: See “EMC AppNote Fast Meter Commands and AE” document for further details

DOSD Commands

illunis Meta Data (DOSD) Commands				
Target	**Index**	**Description**	**R/W**	**Modes**
0x06	0x40	DOSD Enable	R/W	1 = Enable, 0 = Disable
0x06	0x41	DOSD Column Start	R/W	Data starts at value * 8
0x06	0x42	DOSD Row	R/W	Data starts at row (May be offset due to vflip and FVAL start.
0x06	0x43	DOSD User Ram reset	W	Resets the user DOSD index
0x06	0x44	DOSD User Ram write	W	Sets DOSD user ram with two pixels (bytes) of data.

Meta Data is a feature that embeds data into a specified line in the image. Typically the image is increased by one line and the data is inserted into the last line. Data specific to the current image is inserted after the detector window's last line to be valid. This includes frame count, number of pixels sampled, sum of pixels sampled, number of saturated pixels sampled, sharpness value of pixels. In addition, operation and AE data is embedded into the selected line. Data is placed byte wise in the msb byte of the readout pixels.

Historically this was known as Data On Scree Display (DOSD)

Fixed data from the current image is embedded into the DOSD (30 pixels/bytes)

Note: See "EMC AppNote Fast Meter Commands and AE" document for further details

DOSD Commands Continued

Pixel	Description	Data Type
0	Header	0xAA
1	Header	0x55
2	Header	0x55
3	Header	0xAA
4	Frame Cnt (7..0)	DOSD FIFO
5	Frame Cnt (15..8)	DOSD FIFO
6	Frame Cnt (23..9)	DOSD FIFO
7	Frame Cnt (31..24)	DOSD FIFO
8	SNR Num of Pixels(7..0)	DOSD FIFO
9	SNR Num of Pixels(15.8)	DOSD FIFO
10	SNR Num of Pixels(23..16)	DOSD FIFO
11	SNR Num of Pixels(31..24)	DOSD FIFO
12	SNR Sum of Squares(7..0)	DOSD FIFO
13	SNR Sum of Squares(15..8)	DOSD FIFO
14	SNR Sum of Squares(23..16)	DOSD FIFO
15	SNR Sum of Squares(31..24)	DOSD FIFO
16	SNR Sum of Pixels(7..0)	DOSD FIFO
17	SNR Sum of Pixels(15..8)	DOSD FIFO
18	SNR Sum of Pixels(23..16)	DOSD FIFO
19	SNR Sum of Pixels(31..24)	DOSD FIFO
20	AEW Sharpness Detector(7..0)	DOSD FIFO
21	AEW Sharpness Detector(15..8)	DOSD FIFO
22	AEW Sharpness Detector(23..16)	DOSD FIFO
23	AEW Sharpness Detector(31..24)	DOSD FIFO
24	AEW Brightness Detector(11..4) *	DOSD FIFO
25	AEW Brightness Detector(19..12) *	DOSD FIFO
26	AEW Brightness Detector(27..20) *	DOSD FIFO
27	AEW Brightness Detector(35..28) *	DOSD FIFO
28	AEW Saturated Detector(7..0)	DOSD FIFO
29	AEW Saturated Detector(15..8)	DOSD FIFO
30	AEW Saturated Detector(23..16)	DOSD FIFO
31	AEW Saturated Detector(31..24)	DOSD FIFO
32	AEW Num of Pixels (7..0)	DOSD FIFO
33	AEW Num of Pixels (15..8)	DOSD FIFO
34	AEW Num of Pixels (23..16)	DOSD FIFO
35	AEW Num of Pixels (31..24)	DOSD FIFO
36	AEW Max Pixel(7..0)	DOSD FIFO
37	AEW Max Pixel(11..8)	DOSD FIFO
38	DOSD RAM(0)	Programmable
39	DOSD RAM(1)	Programmable
40	DOSD RAM(2)	Programmable
	….	….
549	DOSD RAM(511)	Programmable

Auto Exposure PBM

The Auto exposure meter uses the special readout modes of the GMAX sensors to provide a fast brightness measurement and calculation of optimum exposure. The parameters of the AEM are as follows:

AE Enable	:	0 = disabled, all others = enabled
Target dN	:	The average dN of the image as desired.
Minimum Exposure	:	The smallest exposure allowed
Maximum Exposure	:	The longest exposure allowed
Image Sub Sample	:	Readout subsample : 8 = 1/8th
Gain	:	Algorithm
Slope	:	Algorithm
Saturation %	:	Algorithm
Gain	:	Algorithm

The camera must be in TPE (triggered exposure mode) and external triggers are required for frame readout. When this mode is enabled the camera enters a continuous loop performing the following:

1. Calculate the PBM value
2. Measure the image brightness and recalculate the exposure
3. Watch for incoming trigger and if detected
    A. Setup the sensor for full readout
    B. Soft trigger the trigger state machine and begin exposure/readout
    C. Save parameters to the on screen data
    D. Perform internal Built In Test (BIT)
4. Process any incoming commands

All exposures are in micro seconds (us).

Additional sensors will be added ASAP.

Auto Exposure PBM Continued

illunis AE/PBM Commands				
Target	**Index**	**Description**	**R/W**	**Modes**
0x06	0x00	AE/PBM Start	R/W	W: Starts AE/PBM R: Returns current average dN
0x06	0x01	AE/PBM Disable	R/W	W: 0 = disable, 1 = enable R: Returns enable status
0x06	0x04	AE Current Exposure	R	Returns current exposure in us
0x06	0x12	Max Exposure in US	R/W	Data = Maximum Exposure in ms
0x06	0x13	Min Exposure in US	R/W	Data = Minimum Exposure in ms
0x06	0x14	Target dN	R/W	0 to 4095, 1000 default
0x06	0x15	Hysteresis	R/W	TBD
0x06	0x16	Image Sub Sample	R/W	Default = 8
0x06	0x17	Step Size us	R/W	Default = 128 us
0x06	0x18	Enable AE PBM	R/W	Enables Pixel Burn Meter test in AE Loop Date is imbedded in Meta Data. Uses resources that reduce AE rate by about one half.
0x06	0x19	PBM Sat Count	R	Returns current Pixel Burn Meter Count
0x06	0x1A	AE Algorithm Gain	R/W	AE Gain * 100. 50 = 0.5 Gain
0x06	0x1B	AE Slope	R/W	AE Slope * 10,000. 3054 = 0.3054 Slope
0x06	0x1C	AE Sat Percent Limit	R/W	AE Sat Percent * 100. 20 = 0.2%
0x06	0x1D	Current Saturate Pixels as percent of pix	R	Sat * 100: 100 = 1% saturate pixels
0x06	0x1E	AE IRIS Flag	R/W	0 = NOP 1 = CLOSE 2 = OPEN
0x06	0x1F	AE/PBM Status	R	1 = Enabled
0x06	0x20	AE Cycle Count	R	# of AE measurements between frame
0x06	0x21	PBM Cycle Count	R	# of PBM measurements between frame
0x06	0x22	AEPBM Cycle Time	R	In ms

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Baud Rate

NOTE: The EMC default baud rate is 115200.

The EMC camera allows for the setting of the baud rate to one of five rates. This setting can be made for only the current power cycle or for the boot cycle.

The EMC camera allows the user the option of saving the communication speed in the camera EEPROM. This can cause communication with the camera to be lost if the command is not used carefully. ***Note:*** only one of the baud rates will be used so that if communication is lost it can be restored by trying the other baud rates.

Once the EEPROM baud rate is set, the camera must be re-powered to set the rate.

Target	Index	Description	Read Write	Modes
0x04	0x09	Set Current Baud Rate	W	0x0000 = 9600 0x0001 = 19200 0x0002 = 38400 0x0003 = 57600 0x0004 = 115200 Save the state to EEPROM to retain baud rate

Readout Control

The exposure type is either Free Run Mode or Trigger Mode.

In Free Run Mode, the camera outputs continuous images in a global shutter mode.

In Trigger Mode, the camera receives the trigger, erases the pixels, exposes the image, and then reads it out.

Target	Index	Description	Read Write	Modes
0x00	0x03	Readout Mode	R/W	0 = Free Run 1 = Trigger Program Exposure 2 = Trigger Manual Exposure

Exposure Time

The exposure time is set in either milliseconds or microseconds. The resolution of the exposure is in horizontal line times. Two commands are provided for calculating the Free Run time from a specified time variable (milliseconds or microseconds). **The closest available time is selected and set in the internal time variable.**

Target	Index	Description	Read Write	Modes
0x00	0x01	Exposure ms	R/W	Exposure time in milliseconds, max is 0xFFFF = 65.535 seconds
0x00	0x05	Exposure us	R/W	Exposure time in Microseconds, max is 0xFFFF = 0.065 seconds

Strobe Signal

The EMC Strobe Signal is a 3.3V LVTTL signal that is active when the sensor is triggered and exposing an image. The Strobe Signal is useful for analyzing and optimizing imaging applications. The strobe can be used to activate an illumination source. If used in this fashion, the Strobe Signal cannot drive significant current and should be buffered.

Target	Index	Description	Read Write	Modes
0x00	0x04	Strobe Control	R/W	0x0000 = negative strobe polarity 0x0001 = positive strobe polarity

Software Trigger

The Software Controlled Trigger command forces an internal trigger from a software command.

- In TPE mode the data field is ignored.
- In TME the software trigger pulse has a width in ms as specified in the data field. The range is 1 to 65535 ms (65sec).

Target	Index	Description	Read Write	Modes
0x00	0x0C	Soft Trigger	W	Software trigger in ms 1-65535

Test Patterns

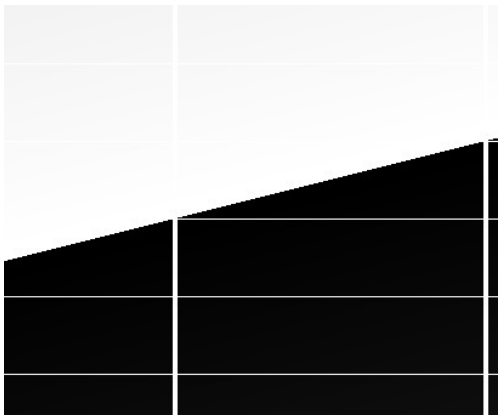
The EMC camera has two synthetic test patterns that can be used for testing both the digital path and Camera Link communications.

The Input Test Pattern can be used to test the internal data path of the EMC FPGA.

The Output Test Pattern can be used to test the Camera Link digital communication path.

Target	Index	Command	R/W	Description
0x00	0x07	Test Pattern	R/W	0x0000 = Normal Video 0x0001 = Input (CCD) Test Pattern 0x0002 = Output Test Pattern 0x0003 = Sensor Test Pattern

Input Test Pattern



Output Test Pattern

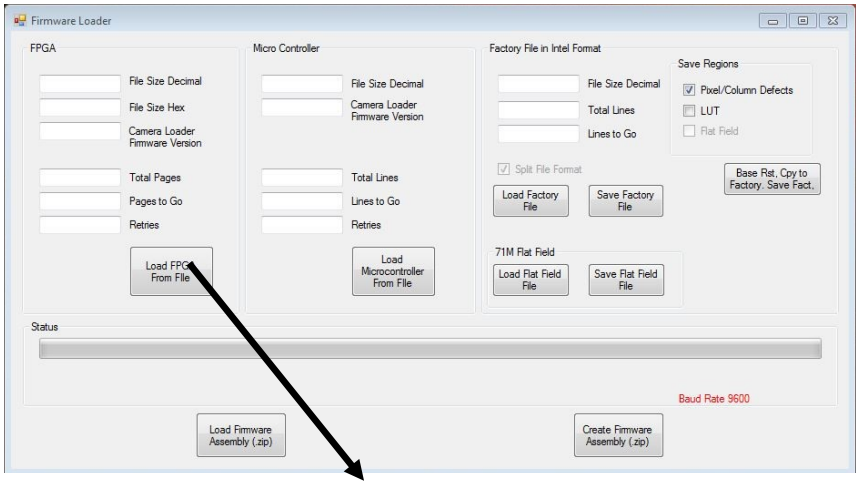
Sensor Test Pattern

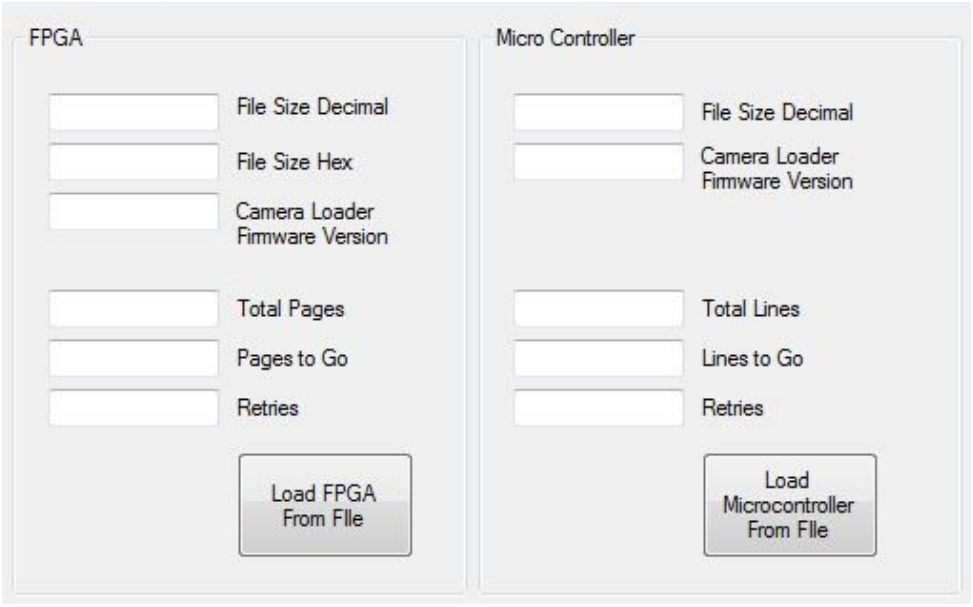
Manufacturing->Firmware Loader

The camera firmware is field upgradeable.

Load FPGA from file: Loads the FPGA configuration data. The camera must be repowered to enable the new configuration.

Load Microcontroller from file: Loads the Micro configuration data. The camera must be repowered to enable the new configuration.





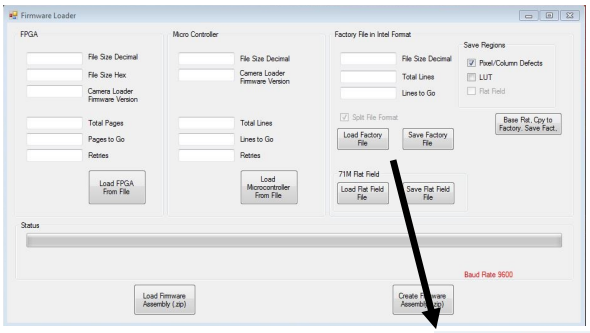
Backup/Restore

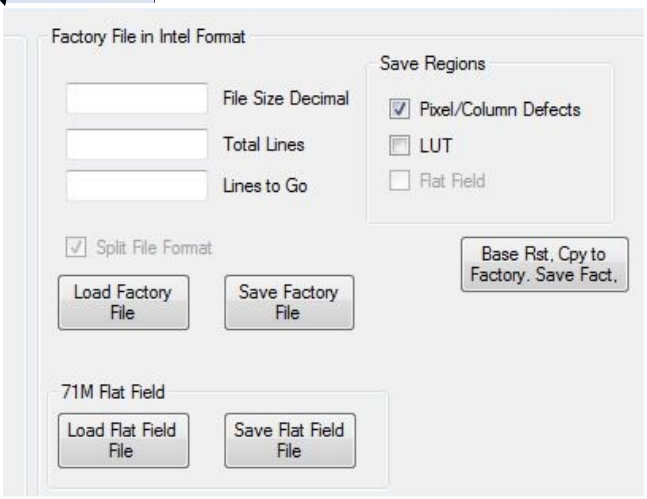
The EMC camera control program provides features for saving and restoring the camera state. Please save the camera state before changing the default state of the camera by choosing the Save Factory File button.

State data can be saved and restored (from files) for the following:

1) Camera state with optional defect tables.

Note: The camera control program may change the communication rate during this operation.





Camera Save/Restore

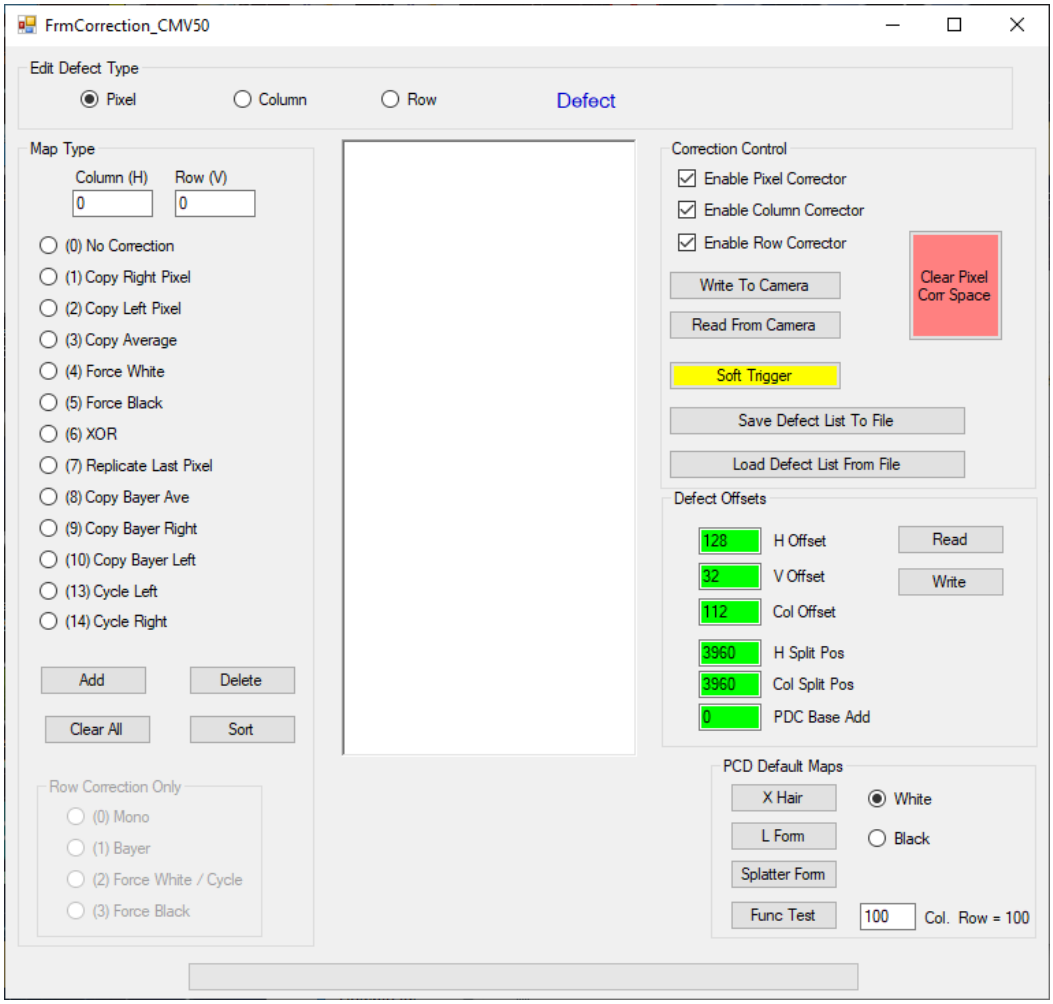
Save Factory File: Saves the camera state to a file for future restores. Options include defect table.

Load Factory File: Restores camera state from a file. The camera state is saved in manufacturing and can be emailed to the user.

Pixel, Column and Row Defects

Defect correction is used to “map out “ defective pixels in the camera and substitute synthesized pixel values. The illunis Camera Control Application provides a defect editor to simplify the editing of defect mapping.

Target	In-dex	Description	Read Write	Modes
0x00	0x60	Pixel Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0x61	Column Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0x62	Row Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled



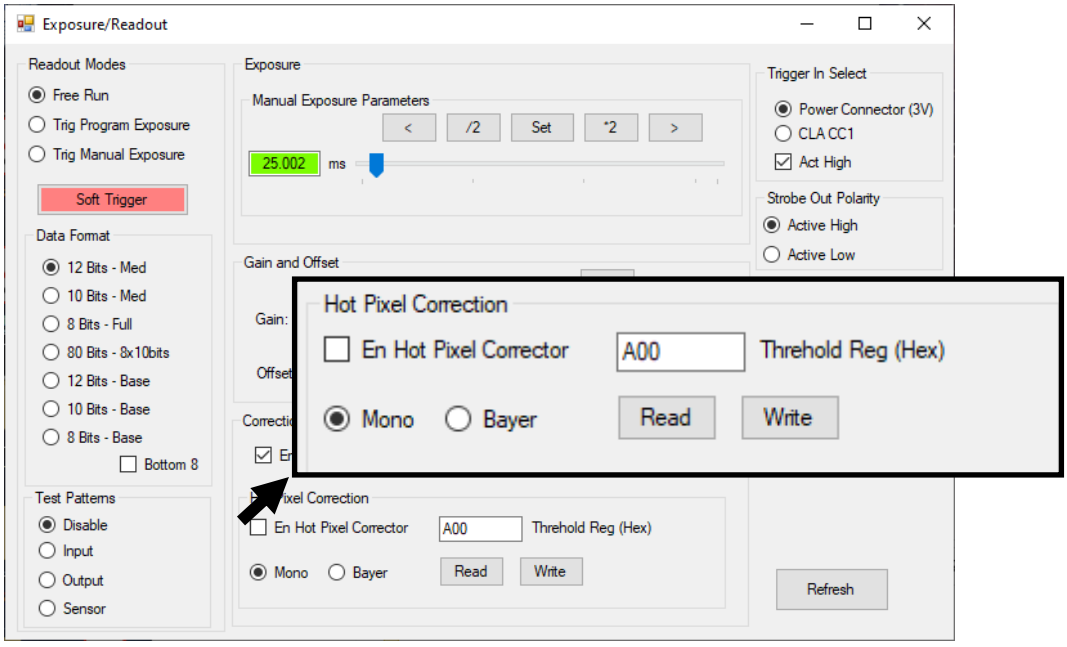
Hot Pixel Correction

The Hot Pixel Correction (HPC) algorithm dynamically analyzes the video data for single bright (hot) pixels.

Hot pixels are generated by thermal noise in the photo diode of the sensor. Long exposures will create more hot pixels than short exposures.

The HPC does not require calibration. It compares a target pixel with its horizontally adjacent pixels. The difference of left/right neighbor and the pixel is calculated. If the difference is greater than the set **Threshold,** then the pixel is replaced with the average of the adjacent pixels.

Target	Index	Description	Read Write	Modes
0x00	0xA0	Hot Pixel Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x00	0xA1	Hot Pixel Correction Type	R/W	0x0000 = Monochrome 0x0001 = Color Bayer
0x00	0xA2	Hot Pixel Threshold	R/W	Threshold in dn Recommended > 0x0100



Hot Pixel Correction

In the Camera Control Program set the sensor type: mono or color, threshold, and the enable.

Hot Pixel Correction

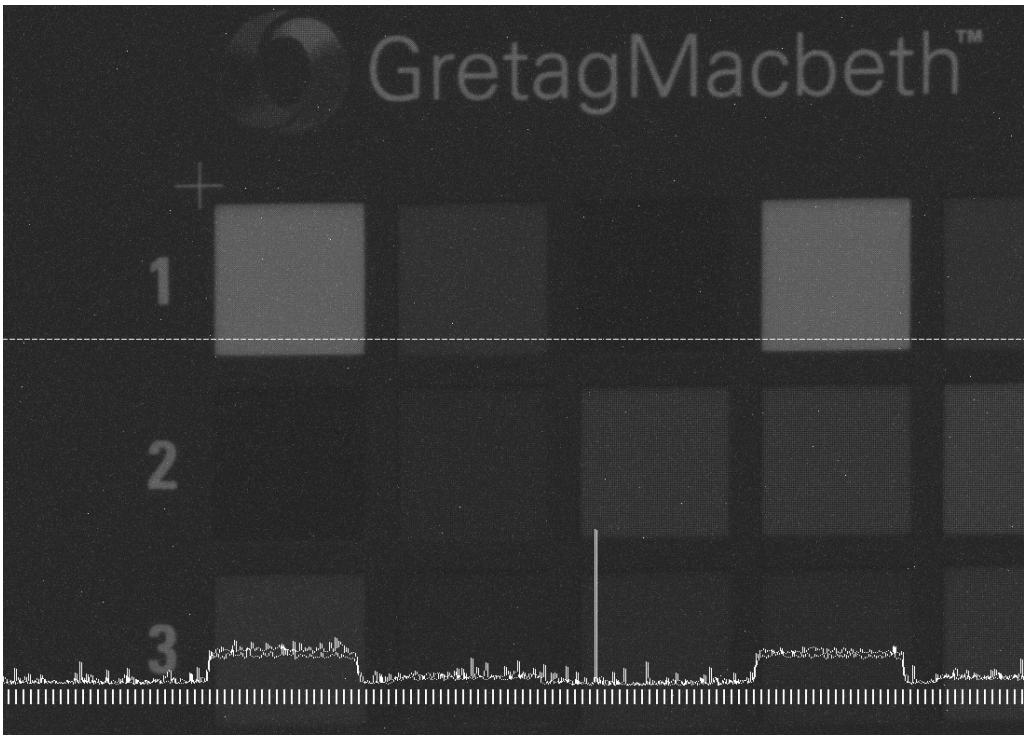


Image with Hot pixels

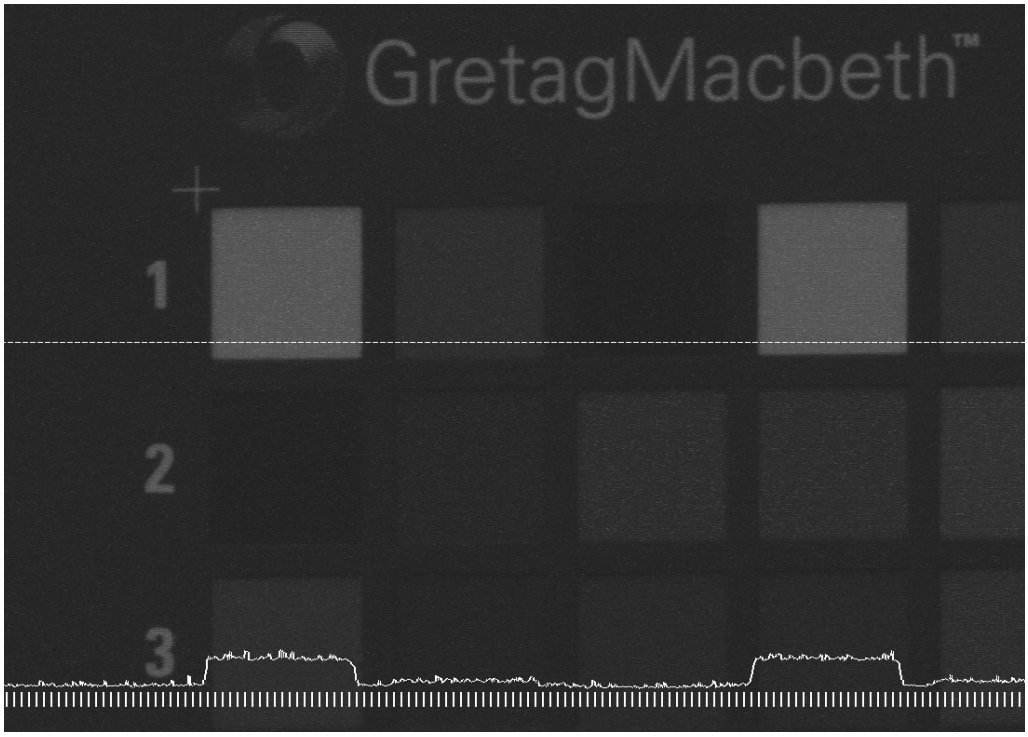


Image with Corrected Hot pixels

Hot Pixel Correction

EMC (51, 65, 103)

Shading Introduction

Shade correction (Shading) uses a gain value for a group of pixels called a block (typically 16x16). This gain value is calculated by finding the brightest block within an image and uses this block value to perform a gain calculations for each block with in an image on the following image.

Gain calculations for each block are stored into external high speed flash to be retrieved during the following frames. These values are retrieved as the frame progresses in groups of 16 lines. The gain values are buffered previous of the lines the gains are performed.

All shading calculation along with all other internal camera functions are performed on 12 bit pixel values. The pixels inside the camera are 12 bit until they hit the output module. 8 bit pixel are the upper 8 bits of a 12 bit pixel. 10 bit pixels are the upper 10 bits of s 12 bit pixel.

Shading Blocks

Shading area is defined by programmable registers in the camera. Typical shading area is broken into 16x16 blocks. The drawing below is the top of a sensor with 16x16 blocks. The blocks start from the top of the sensor at a register defined start row. This row does not have to be a product of 16. The left start position is determine by the value in the column start column.

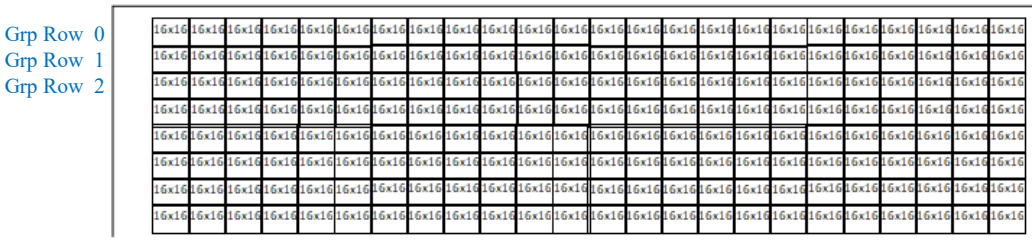
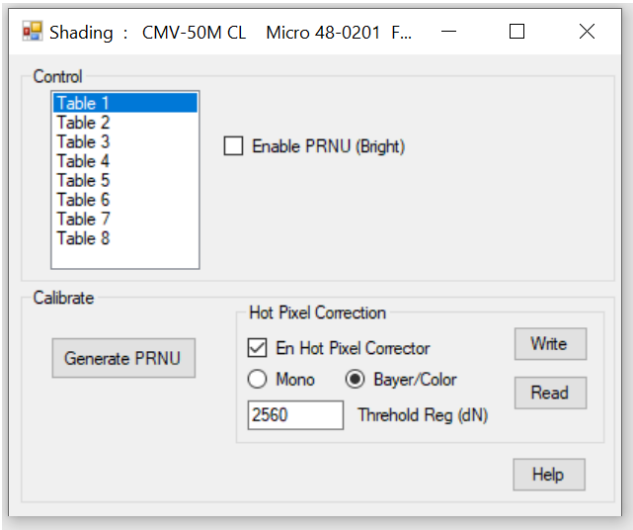


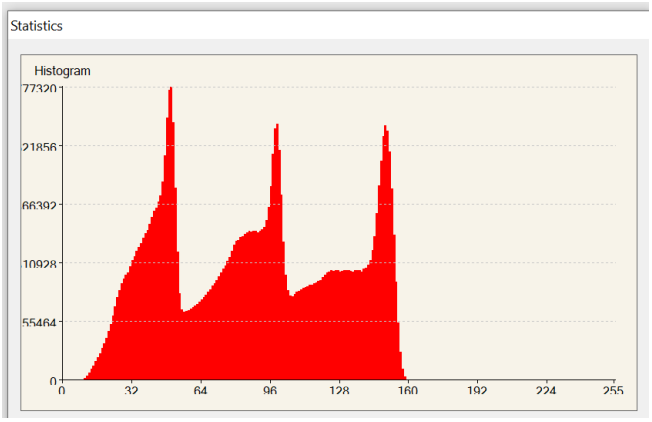
Figure 2 Top area of a sensor.

Generating Shade Tables

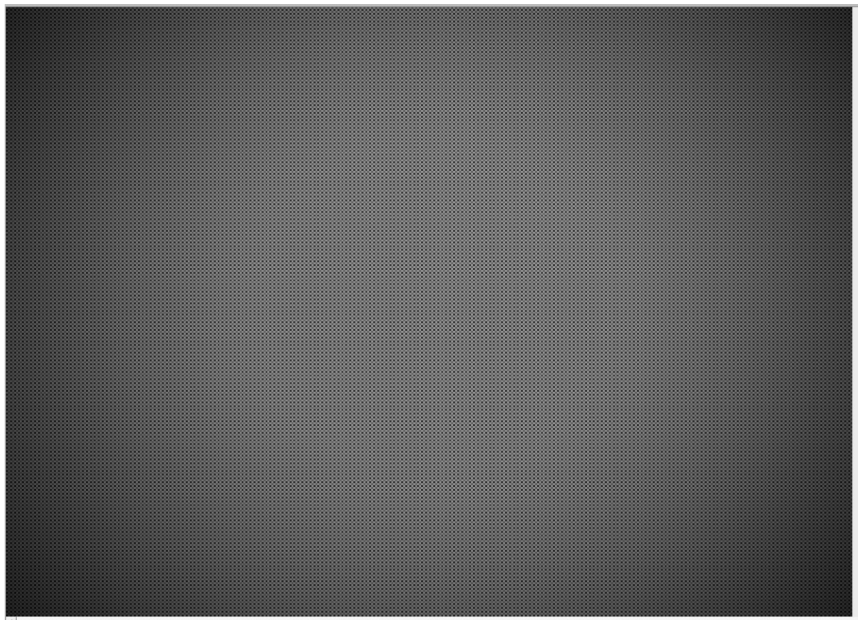
The dialog box below is a Illunis control application dialog box used generate and use shading tables. A list boxes allows the user to select a table to store or use. A check box to enables the use of the selected table. A button to generate a new table (PRNU) and a hot pixel correction to mask any hot pixels that may effect the table generation. This hot pixel correction control is the same control used in the exposure dialog box (Note, hot pixels correction is performed on 12 bit pixel value). Changes to hot pixel control in the shading dialog box will not update in the exposure dialog box until refreshed.



Shading gain values are calculated and stored in groups of row over many frames. The image must be constant during the shade generation function. A stable light panel or sphere is recommended for generating shade tables



Once you have a light source in place, the image should be between 50% and 75% brightness. In the histogram shown, we see a bayer pattern sensor showing the colors of the pattern darken from the brightest levels. This is the effect of the lens on the camera. The image is darker at the edge than the center. The brightness or right edge of this histogram is over 50% (note we ignore any pixels that may be hotter then the right edge or the graph).

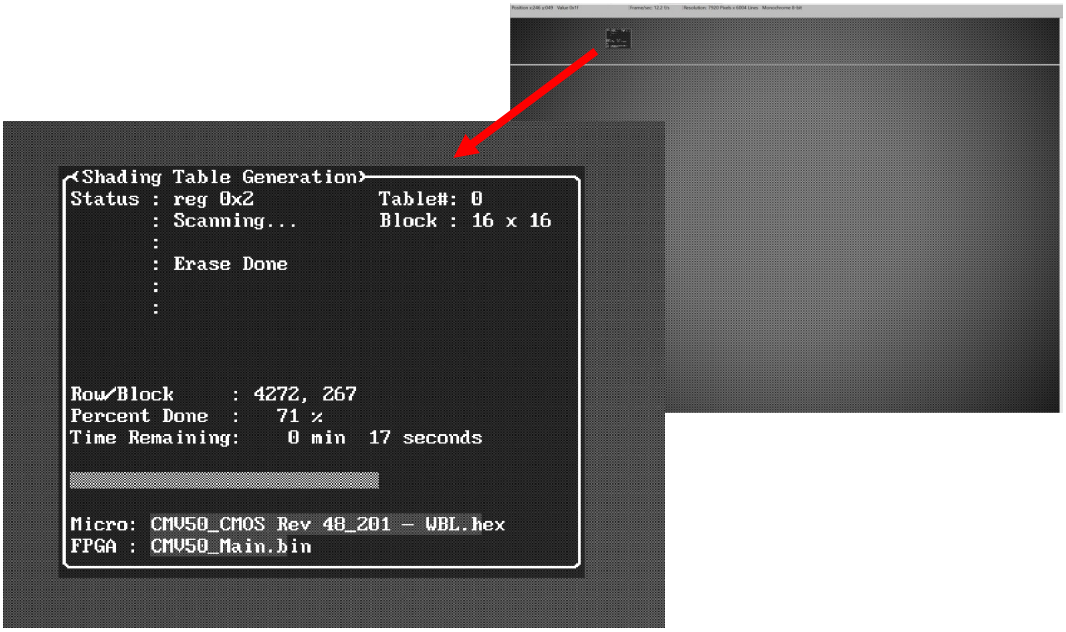


The image above is from a bayer pattern sensor the previous histogram was measuring. This sensor is looking at a stable light panel. Note the darker edges due to the lens on the camera.

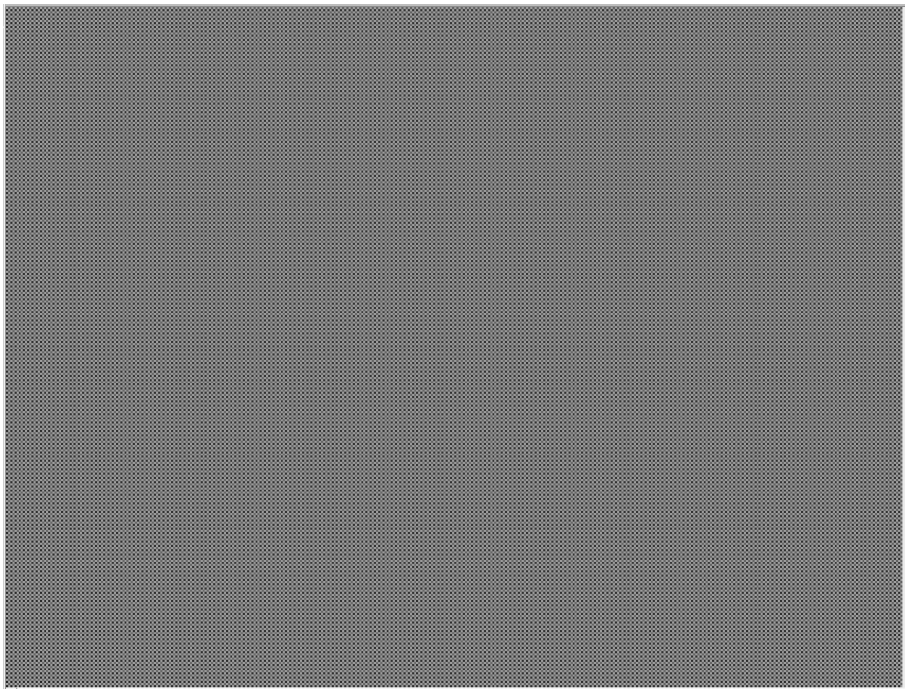
To generate the shade table for this camera, we click the “Generate PRNU” button. This starts a process of erasing the table location, then scanning the image from top to bottom to generate the new shade table.

The control application will displays a progress status bar displaying the table generation progress. The camera’s on screen display (OSD) also shows shade progress in a OSD box and a bar moving down the live image.

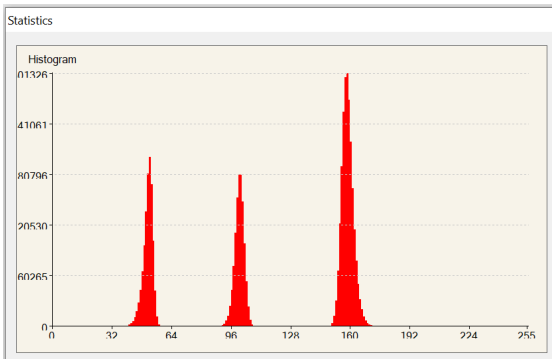
Once the table is generated, the control application automatically enables the table (sets “Enable PRNU).



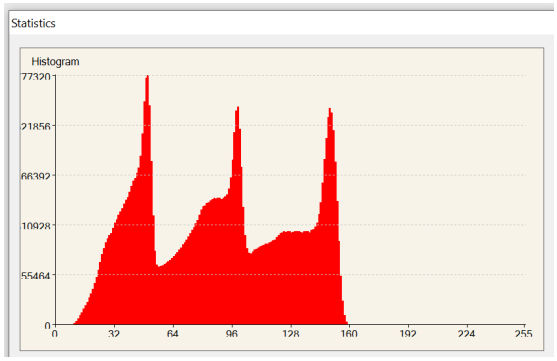
If the light source is stable and the brightness level is within 50%-75%, the shade table generation should give you results similar to below.



The before and after histograms show the result of the shade table.



Histogram with shading.



Histogram without shading.

Shade Table Controls

Below is a list of important controls for setting up and using block shade correction.
NOTE All commands numeric values are in Hexadecimal:

Table Select (Read/Write)
Multiple tables can be stored and recalled. Depending on the camera set up and storage will determine the number of tables available.

Target	Index	Command	Description
6A	00	0x0000—0x0007	Table Select (R/W) xAE

Enable/Disable Shade Table (Read/Write)
This command enables or disables the shading function. The shade table used when enabled is selected using the Table Select command.

Target	Index	Command	Description
6A	04	0000	Disable Shade Function
6A	04	0001	Enable Shade Function

Generate Shade Table (Read/Write)
This command generates a new shade table. The shade table location (0, 1, 2, …) is selected using the Table Select command. When generating a shade table, the camera will use an OSD to display the generation progress.

Target	Index	Command	Description
6A	05	0001	Generate Shade Table

Shade Status

Below is a list of status commands that can be used to determine shade generation progress:

Current Generation position (Read Only)
This command returns the current position of the shade generation scan. The value is related to the position of the OSD bar traveling down the frame as the table is being generated. The approximate row in the image can be estimated at 16x this number.

Shade Status

This command can be used to read to shade generation see if the generation is in progress. When this read command returns a value of 0000, the shade generation is complete.

Current Generation position (Read Only)
This command returns the current position of the shade generation scan. The value is related to the position of the OSD bar traveling down the frame as the table is being generated. The approximate row in the image can be estimated at 16x this number.

Target	Index	Command	Description
6A	16	0000	Returns current row position during the generation scan.

Note that when the shade generation starts, there is a delay between the start command and the status register being updated. If you use this read to determine when a shade generation is complete, do the following steps.

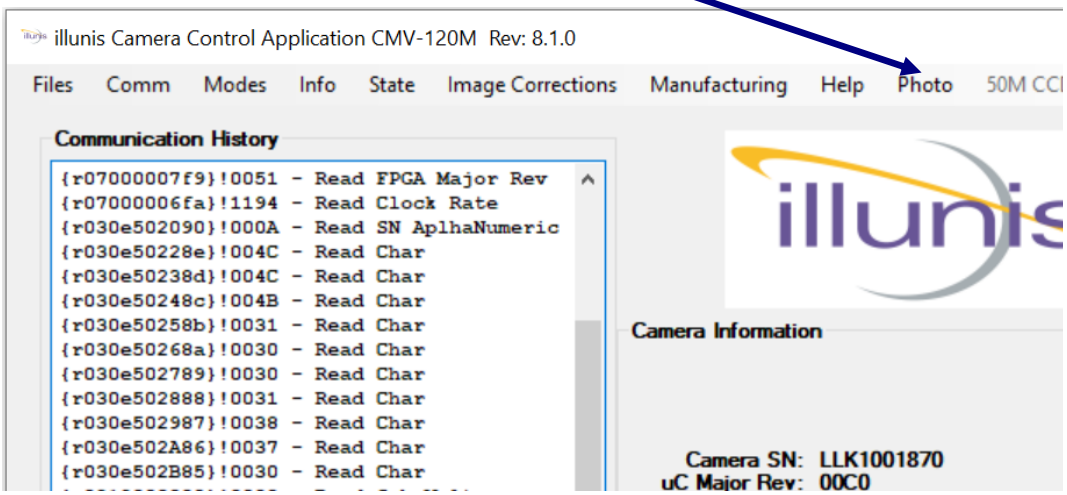
1) Start Generation.
2) Read status until shade generation in progress is not 0000 (shade gen is in progress).
3) Read status until shade generation in progress is 0000 (once in progress, read to see when progress is compete).

Image Storage and Display

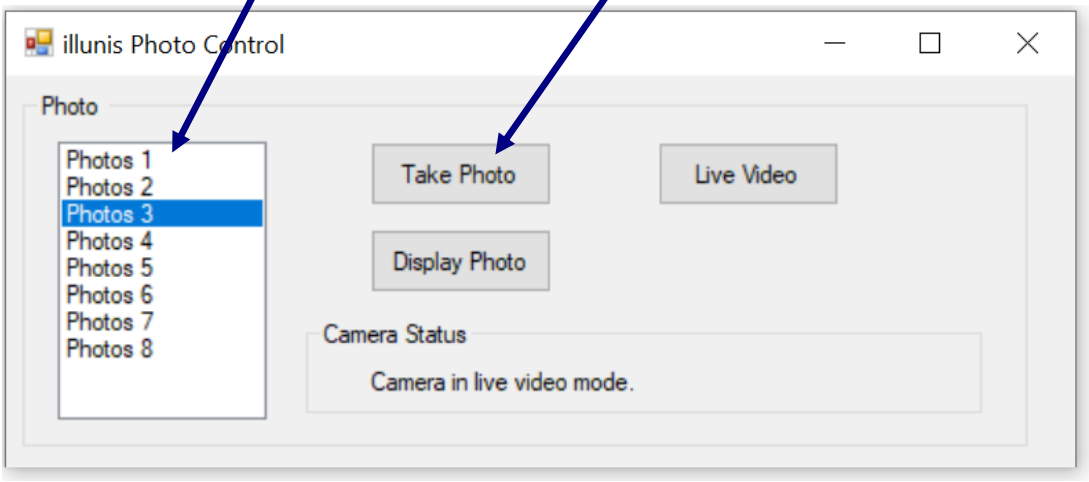
Up to 8 images may be stored and displayed by the camera. These images are stored in internal 128 Mbit memory in block format. The images remain in permanent memory and can be displayed after the camera power has been removed and re-applied.

The storage and display of stored images is accomplished through the Camera Control Application.

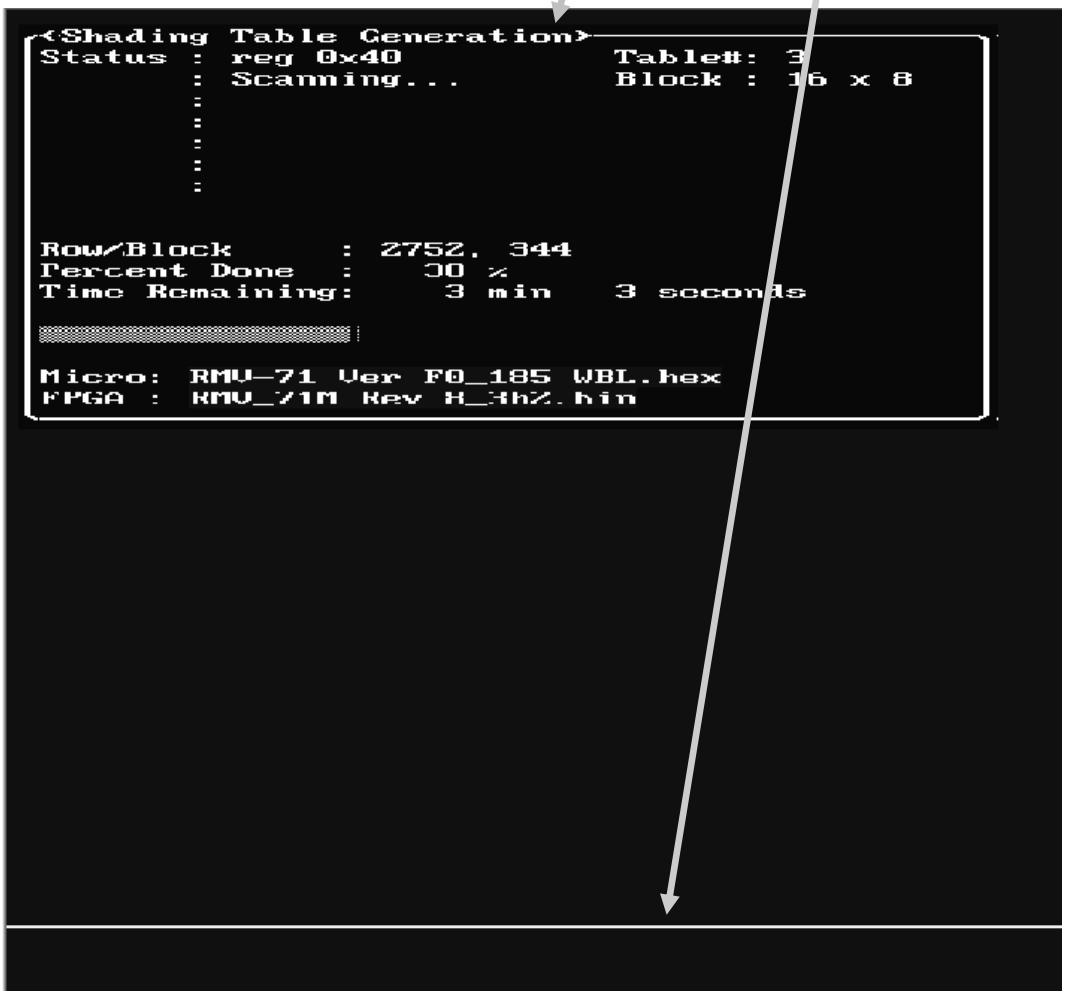
Choose the Photo menu item to open the image store and display dialog box.



Choose the Image number to store and press Take Photo to begin storing the image to memory.

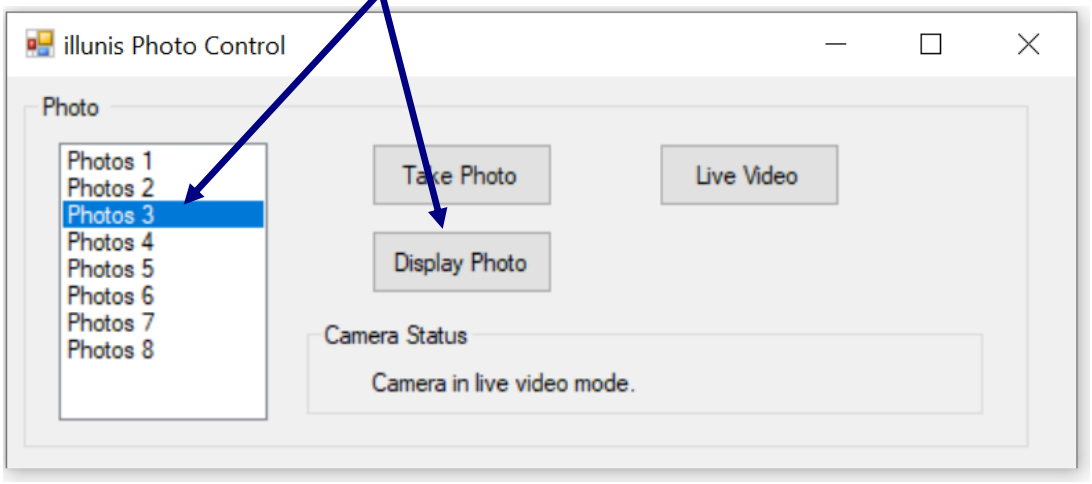


The camera will display an On Screen Display and a progress bar that moves down the image as the image is stored.



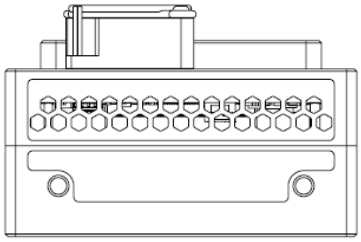
When the image storage is complete a dialog box appears indicating the process is complete.

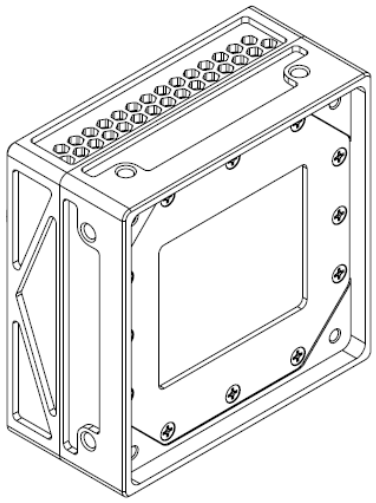
Any stored image can be displayed by selecting the image to display and then pressing Display Photo.

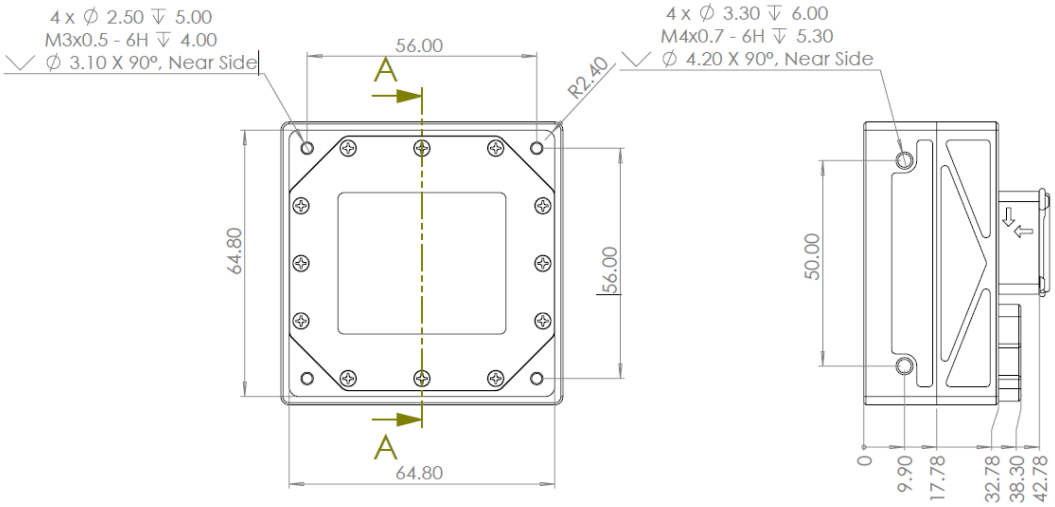


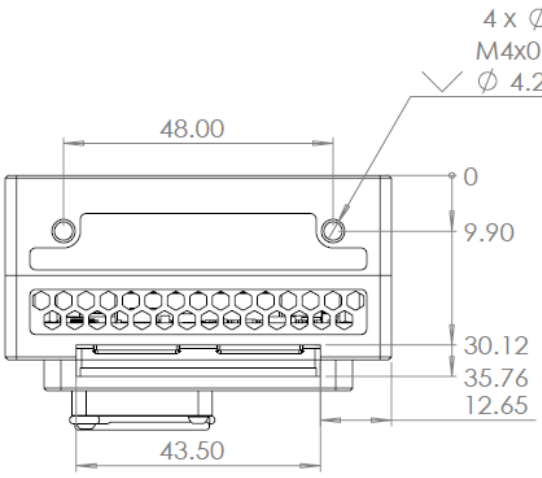
The image will be displayed without a delay.

EMC-65 Epix No Mount





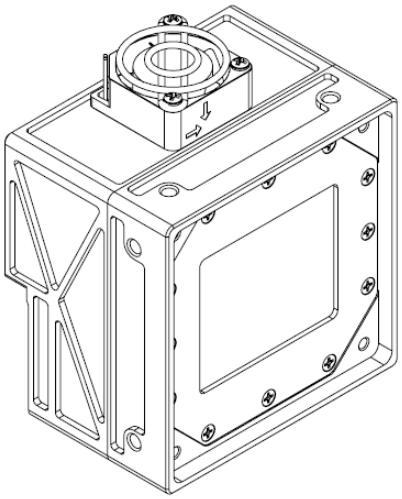


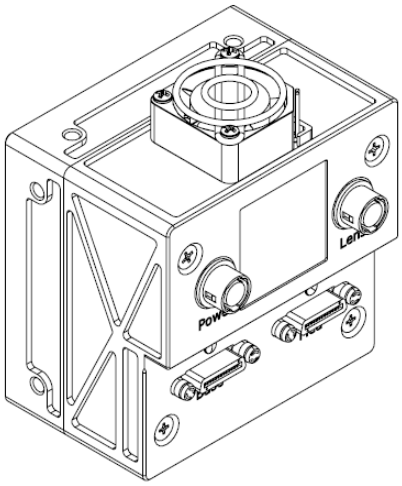


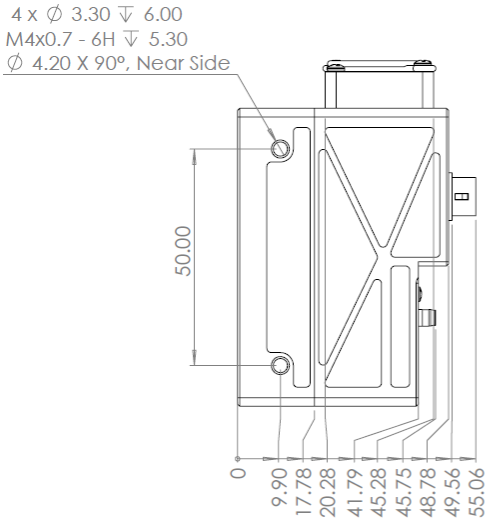
Camera Drawings

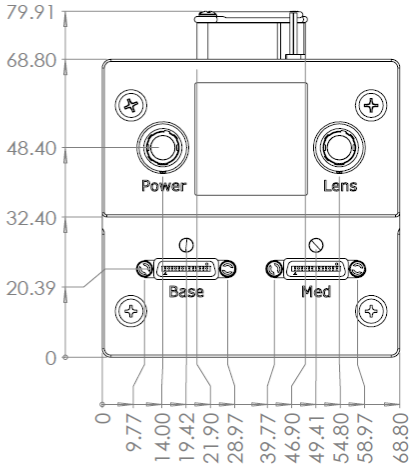
EMC (51, 65, 103)

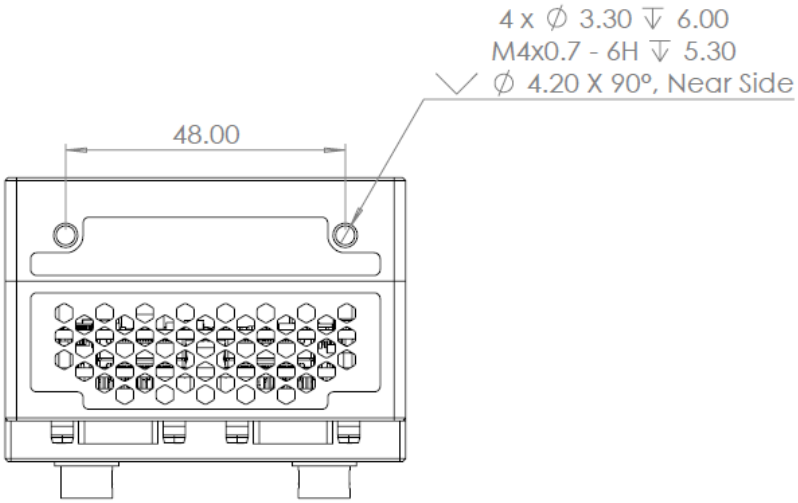
EMC-65 Camera Link No Mount







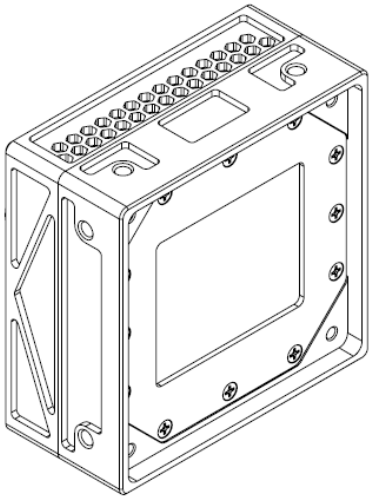


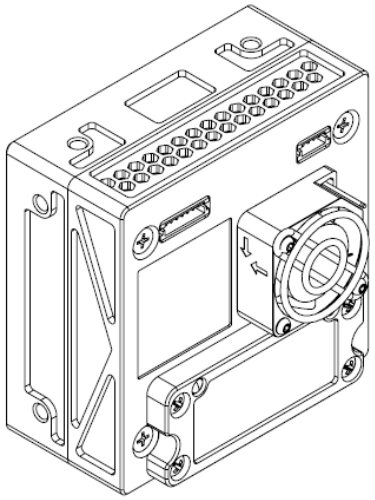


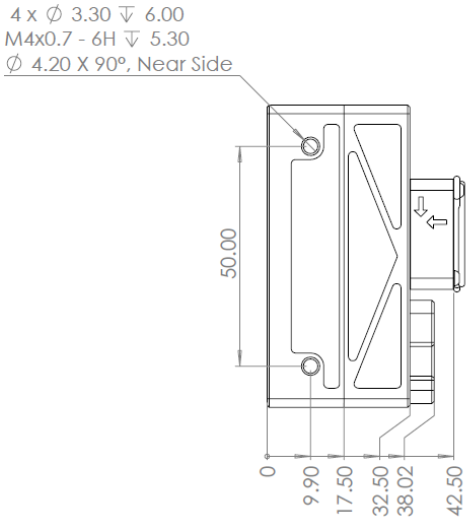
Camera Drawings

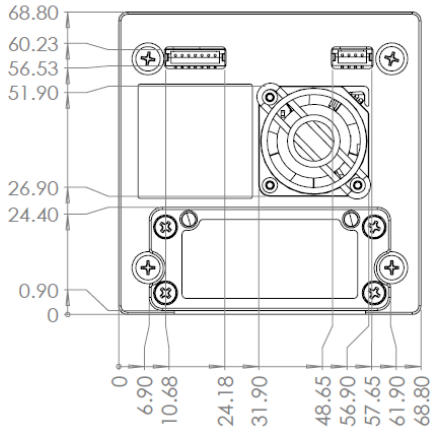
EMC (51, 65, 103)

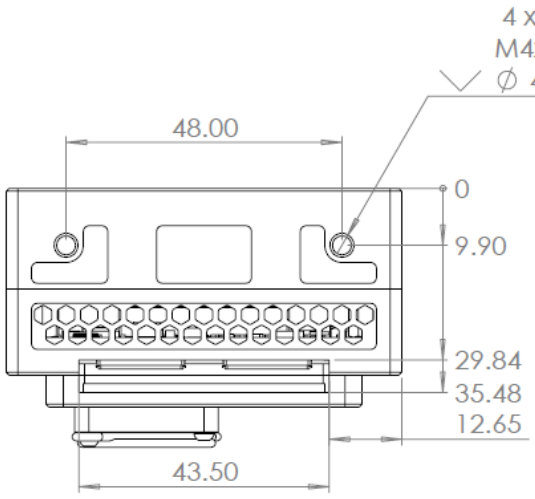
EMC-103 Epix No Mount



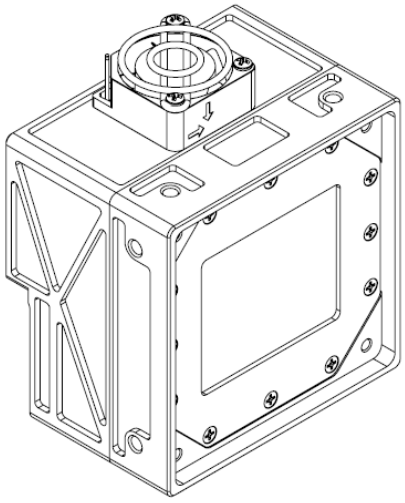


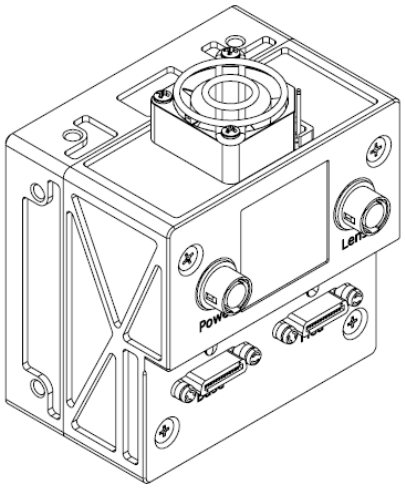


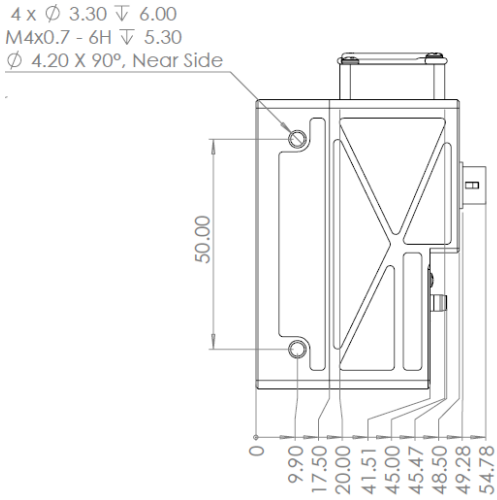


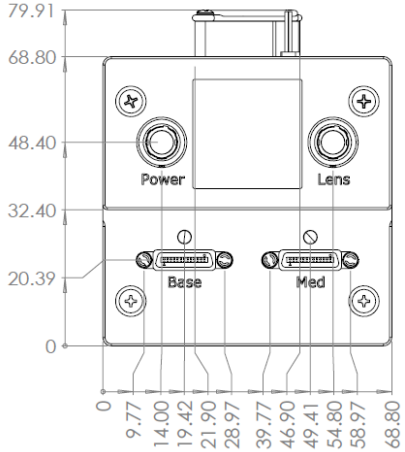


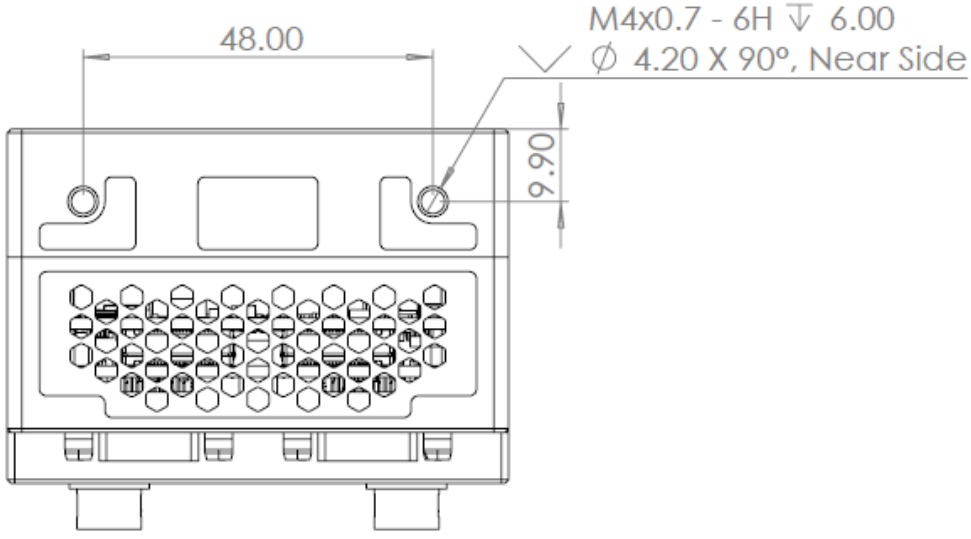
EMC-103 Camera Link No Mount







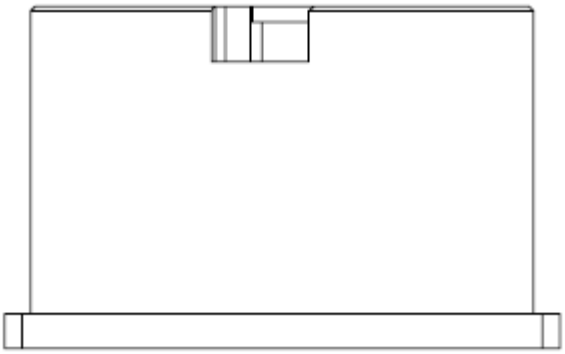


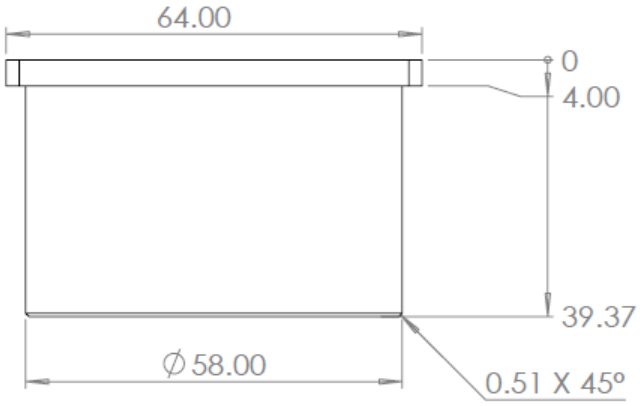


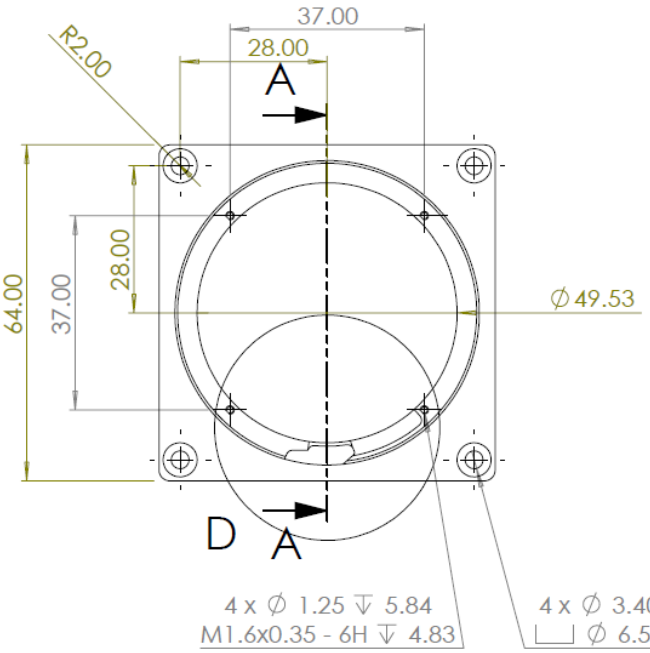
Camera Drawings

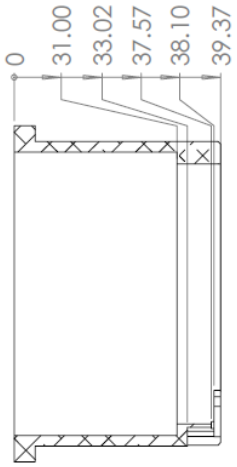
EMC (51, 65, 103)

EMC F-Mount









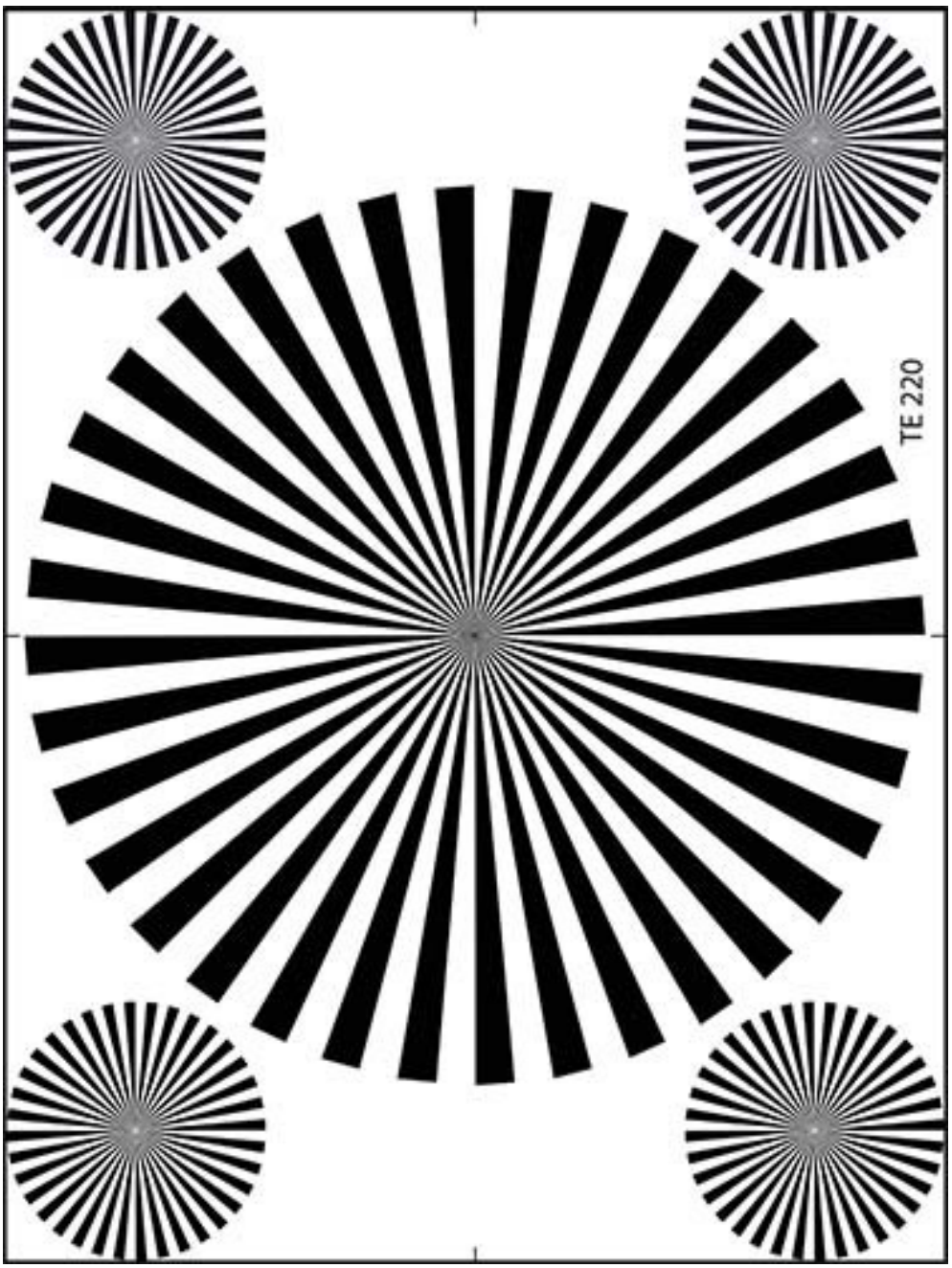
EMC Canon EF Mount

Camera Drawings

EMC (51, 65, 103)

CMOS Machine Vision

Advanced Digital Machine Vision Cameras



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