





## **EMC Embedded Machine Camera**

EMC-51 EMC-65 EMC-103



| Rev | Date     | Modification    |
|-----|----------|-----------------|
| Α   | 01/06/23 | Initial Release |
|     |          |                 |
|     |          |                 |
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|     |          |                 |
|     |          |                 |
|     |          |                 |
|     |          |                 |
|     |          |                 |
|     |          |                 |

#### Camera Communication Default Baud Rate is 115,200





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.

Precautions EMC (51, 65, 103)



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Started Epix

# **Camera Power Epix** 6-12V DC Power to the JST ZHR-7 connector. - Power F GND F Trigger In (LVTTL) - Strobe out (LVTTL) - GND - Shell Power

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) <u>Digi-Key</u> (other lengths available)

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#### 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: <u>Help Center – illunis</u>

Started GigE/USB3 00 S **EMC** Operations Manual



# Camera Link Started m S 6

#### 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







Started Camera Link Seria

#### **Camera Link Serial Overview**

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

#### **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.



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Started Camera Link Serial

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#### **Camera Link Serial Epix**

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

| Di EPIX® XCAP V3.8 |        |         |         |                           |                      |  |  |
|--------------------|--------|---------|---------|---------------------------|----------------------|--|--|
| File               | Images | Scripts | Utility | Utility PIXCI® Help       |                      |  |  |
|                    |        |         |         | PIXCK                     | ® Open/Close         |  |  |
|                    |        |         |         | PIXCK                     | ® Video Setup        |  |  |
|                    |        |         |         | PIXCI® Export Video Setup |                      |  |  |
|                    |        |         |         | PIXCK                     | B Import Video Setup |  |  |

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

| http://www.common.com/text/text/file/file/file/file/file/file/file/file | n/Close ×                         |  |  |  |  |  |
|---|-----------------------------------|--|--|--|--|--|
| Options<br>Multiple Devices   | Options Multiple Devices Advanced |  |  |  |  |  |
| Camera & Format   | Driver Assistant                  |  |  |  |  |  |
| Open Close C  | Open Close Cancel Board Info      |  |  |  |  |  |

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

#### 5. Then "Install"

| ो PIXCI® Driver Assistant   | Х   |
|---|---|
| Install PIXCI® Driver     Set PIXCI® Frame Buffer Memory Size   | Install PXXIB Camera Link® Serial DLL-  |
| Set PIXCI® Driver Advanced Options     Install PIXCI® Camera Link® Serial DLL   | The Camera Link® Serial DLL is required when using camera manufacturer's software to configure a camera via serial commands. It is not needed<br>when XCAP provides its own integrated serial control GUI for the camera of interest. Installation requires Administrator privileges. |
| Install PKCIB Serial (COM Port) Driver Install PKCIB TWAIN Driver Install PKCIB ImagePro Driver Install PKCIB Frame Server Driver Install Authorization Green Key Driver Install Authorization Green Key Driver | For Camera Manufacturer's Application:  Requiring the Camera Link 1.0 API  Requiring the Camera Link 1.1/2.0 API Application is 32 bit 1.64 bit 1  For Application expecting DLL Location:  Default or pre Resistry   |
| <ul> <li>Download &amp; Update Program</li> </ul>   | Log Activity of Camera Link® Serial DLL<br>Activity Log File Name   |
|   | Install Uninstall Cancel  |

#### Note: Epix Camera Link dll is names clserEPX.dll

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#### Camera Link Serial Pleora (GigE/USB3)

- 1. Download and install Pleora eBUS Player or eBUS SDK. <u>eBUS SDK</u> <u>and eBUS Player (pleora.com)</u>
- 2. The Camera Link serial dll will be installed in C:\Program Files\Common Files\Pleora\eBUS SDK\ by default
- 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).

This PC > System (C:) > Program Files > Common Files > Pleora > eBUS SDK

|   | Name              | Date modified      | Туре              | Size  |
|---|-------------------|--------------------|-------------------|-------|
|   | GenlCam           | 2/4/2021 6:06 AM   | File folder       |       |
| π | log4cxx           | 2/4/2021 6:06 AM   | File folder       |       |
| * | NDIS6             | 2/4/2021 6:06 AM   | File folder       |       |
| * | U3V               | 2/4/2021 6:06 AM   | File folder       |       |
| * | 🗟 clserpte.dll    | 7/24/2020 11:53 AM | Application exten | 66 KB |
| * | Sciserpte_w64.dll | 7/24/2020 11:53 AM | Application exten | 66 KB |

Started Camera Link Serial m 65 ,**1**, S ...





#### 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.

| App     |             |
|---------|-------------|
| Control |             |
| Started |             |
| ting    | l, 65, 103) |
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| File Edit View Favorites Help   |                                 |                  |   |
|---|---------------------------------|------------------|---|
| Computer  | Name                            | Туре             | Data                                    |
| <ul> <li>HKEY_CLASSES_ROOT</li> <li>HKEY_CURRENT_USER</li> <li>HKEY_LOCAL_MACHINE</li> <li>BCD0000000</li> <li>HARDWARE</li> <li>SAM</li> <li>SECURITY</li> <li>SOFTWARE</li> <li>AGEIA Technologies</li> <li>Alienware</li> <li>Apple Inc.</li> <li>CameraLink</li> <li>Classes</li> </ul> | 환) (Default)<br>환) CLSERIALPATH | REG_SZ<br>REG_SZ | (value not set)<br>C:\CameraLink\Serial |
|   |                                 |                  |   |

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

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Started Control App

#### Install the Camera Serial Communication Software: 🕞 illunis Control App x64 7.1.19 Launch the installer Welcome to the illunis Control App x64 7.1.19 Setup 11S Wizard The installer will guide you through the steps required to install illunis Control App x64 7.1.19 on your computer WARNING: This computer program is protected by copyright law and international treaties. Unauthorized duplication or distribution of this program, or any portion of it, may result in severe civil or criminal penalties, and will be prosecuted to the maximum extent possible under the law. Cancel < Back Next > 🕼 illunis Control App x64 7.1.19 Select Installation Folder Select the installation illunis folder... The installer will install illunis Control App x64 7.1.19 to the following folder. To install in this folder, click "Next". To install to a different folder, enter it below or click "Browse". Folder: C:\Program Files\illunis LLC\illunis Control App x64 7.1.19\ Browse... Disk Cost.. Install illunis Control App x64 7.1.19 for yourself, or for anyone who uses this computer: OEveryone Just me Cancel < Back Next > 时 illunis Control App x64 7.1.19 × **Confirm Installation** illunis Confirm... The installer is ready to install illunis Control App x64 7.1.19 on your computer. Click "Next" to start the installation. Cancel < Back Next >

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| 🕼 illunis Control App x64 7.1.19      |                       |                    |              |
|---------------------------------------|-----------------------|--------------------|--------------|
| Installation Complete                 |                       |                    | illunis      |
| illunis Control App x64 7.1.19 has be | en successfully i     | nstalled.          |              |
| Click "Close" to exit.                |                       |                    |              |
|                                       |                       |                    |              |
|                                       |                       |                    |              |
|                                       |                       |                    |              |
|                                       |                       |                    |              |
| Please use Windows Update to chec     | ck for any critical ( | updates to the .NE | T Framework. |
|                                       |                       |                    |              |
|                                       | Cancel                | < Back             | Close        |

Install complete...

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

| App                         | Please use Windows Update to  | check for any oritical updates to the .NET Framework. Cancel < Back Close  | ]  |   |
|-----------------------------|---|--|--|---|
| Control                     | Power up the ca<br>Communication<br>If there are mult<br>possible connect<br>If there is only a<br>application will s | amera and run the illunis C<br>Software.<br>iple clserxxx.dll's for multi<br>ctions will be presented.<br>single capture board pres<br>simply connect to that carc | Camera Serial<br>ple cards installed, a choice of<br>sent and one clserxxx.dll, the<br>J/port. |   |
| ting Started<br>1, 65, 103) | Choose the Camera Li Port 0 1 2 Port 0  | nk Port<br>Mfr<br>Teledyne DALSA<br>Pleora<br>Pleora<br>Port 1 Port 2  | Port ID<br>Xcelera-CL_PX4_1_Serial_0<br>Uninitialized<br>Uninitialized                         | × |
| Get<br>EMC (5:              |   |  |  |   |





#### illunis Camera Control Application CMV-250M Rev: 10.3.0 X Files Comm Modes Info State Image Corrections Manufacturing Help Photo Communication History Communication History [w04172710c9]! - Write OSD Y Offaet [w0412002463]! - Write OSD X Offaet [w0412002463]! - Write OSD X Offaet [w0412002463]! - Write OSD X Offaet [w0412002463]! - Write OSD Y Offaet [w0412002463]! - Write OSD Y Offaet [w0412002433]! - Write OSD Y Offaet [w0412002433]! - Write OSD X Offaet [w0412002433]! - Write OSD X Offaet [w0412032433]! - Write OSD X Offaet [w041203243]! - Write OSD X Offaet [w04120324]! 2ms ^ 3ms 3ms 5ms 3ms 3ms 4ms 3ms 2ms 18ms ш Jľ CMV-250M a SN 00FA 0218 3ms 19ms 0218 00FA 0219 62.63 115200 4ms Rev 13339ms Baud-Camera Generic Read/Write Packets Target Index Command Checksum Response Formatted String Enable 07 0000 0000 04 Wr Respon Write Read Checksum Format Command

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.

| I App                             | Camera SN: 0<br>uC Major Rev: 00FA<br>uC Major Rev: 00FA<br>Grinor Rev: 0218<br>FPGA Major Rev: 0218<br>FPGA Major Rev: 0219<br>Clock Rate: 62.63<br>Baud: 115200<br>Camera Generic Read/Wri<br>Target Index Comma<br>04 07 0000<br>Write Read  | ite Packets<br>Ind Check  | (w041709C433)! - Wi<br>(w041605As6)! - Wi<br>(w041709C433)! - Wi<br>(w041709C433)! - Wi<br>(w041709C433)! - Wi<br>(w0300000000)! - Si<br>(w000000000)! - Si<br>(w000000000)! - Si<br>(w000000000)! - Si<br>(w000000000)! - Si<br>(w0000000000)! - Si<br>(w0000000000)! - Si<br>(w00000000000)! - Si<br>(w00000000000000)! - Si<br>(w00000000000000000000000)! - Si<br>(w0000000000000000000000000000)! - Si<br>(w000000000000000000000000000000000000   | rite 05<br>rite 05<br>rite 05<br>rite 05<br>rite 05<br>ave Car<br>matted 5   | SD Y Offset<br>SD X Offset<br>SD X Offset<br>SD X Offset<br>SD Y Offset<br>SD Y Offset<br>sera State  | 2ms<br>18ms<br>3ms<br>19ms<br>4ms<br>13339ms<br>2 Enable<br>Vr Response  | •  <br>•   |
|-----------------------------------|---|---|---|--|---|--|--|
| Contro                            |   |   |   | nmand  |   |  |  |
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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.





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Open file location

Pin to Start KDiff3

Git Init Here Git Bash

GitExt Clone...

Pin to Taskbar Send to

Create shortcut Delete Rename Properties

😸 Git Extensions

Cut Copy

Run as administrator

Troubleshoot compatibility

GitExt Create new repository...

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#### Adding options to the shortcut command line:

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| Target type:    | Application                                       |     |
|-----------------|---|-----|
| Target location | illunis Control App x64 7.0.5                     |     |
| Target:         | .0.5\ControlAppCSharp.exe" expert baud=1152       | 00  |
| Start in:       | "C:\Program Files\illunis LLC\illunis Control App | x6- |
| Shortcut key:   | None  |     |
| Run:            | Normal window                                     | ~   |
| Comment:        |   |     |
| Open File L     | ocation Change Icon Advanced                      | 8   |

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.





g Started Control App

#### Exposure / Readout:

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

× illunis Camera Control Application CMV-65M Rev: 9.6.0 Files Modes Info State Image Corrections Manufacturing Help Photo Comm Exposure/Readout ation History Soft Trig (100ms) 00000}!0000 - Read Hot Pixel Type ٨ Soft Reboot 00000}!0000 - Read Dig Gain 00000}!0000 - Read Dig Offset Recce 00000}!0000 - CL Output Config FMC Parameters 00000}!0000 - Read Test Patteren Status 00000}!0000 - Read Manufacture BIT **TEC Parameters** Camera Inform {r0060000000}!0001 - SPI Read Corr CMV-65M {r0005000000}!61AA - Read Current Exp us {r0003000000}!0000 - Read Readout Mode Camera SN: CMV-65 Beta 1 {r0004000000}!0001 - Rd Strb Pol uC Major Rev: uC Minor Rev: 0065 0161 {r000F000000}!0000 - Rd Man Level {r000B000000}!0002 - Rd Trig Src FPGA Major Rev: 0065 {r0006000000}!0001 - Rd Trig Pol FPGA Minor Rev: 0123 Clock Rate: 0.00 ÷ XXXX Type: Camera Generic Read/Write Packets Index Command Checksum Formatted String Target Response Enable 04 07 0000 0000 Wr Response Write Format Read Checksum Command 🖳 Exposure/Readout × Readout Modes Exposure Trigger In Select Free Run Manual Exposure Parameters Power Connector (3V) Trig Program Exposure /2 Set •2 O CLACC1 O Trig Manual Exposure Act High 25.002 ms Soft Trigger Strobe Out Polarity Active High Data Format Active Low Gain and Offset 12 Bits - Med Unity Enable 🔘 10 Bits - Med 1 Gain 0 8 Bits - Full 80 Bits - 8x10bits Offset 12 Bits - Base 10 Bits - Base Corrections 8 Bits - Base En Pixel Corrector Bottom 8 Test Patterns Hot Pixel Correction Disable En Hot Pixel Corrector Threhold Reg (Hex) A00 O Input Mono O Bayer Read Write Output Refresh Sensor

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Started Control App

#### **Camera Control Application Details:**

| 🦗 illunis Camera Control Application Cl   | /IV-65M Rev: 9.6.0 — □ >  | < |  |  |  |
|---|---|---|--|--|--|
| Files Comm Modes Info Stat  | te Image Corrections Manufacturing Help Photo   |   |  |  |  |
| Communication History (r07000004fc)!0065 - Read FPGA Major Rev (r043900000)!0202 - Read Variant (r07000008fd)!0065 - Read uCTLR Major Rev (r07000008fd)!0165 - Read uCTLR Minor Rev (r07000008fd)!0165 - Read uLTLR Minor Rev |   |   |  |  |  |
| Camera Information<br>CMV-65M<br>Camera SN: CMV-65 Beta 1<br>uC Major Rev: 0065<br>uC Minor Rev: 0065<br>FPGA Minor Rev: 0065<br>FPGA Minor Rev: 0123<br>Clock Rate: 0.00<br>Type: XXXX                                       | <pre>(r07000004fc)!0051 Read HFCA Major Rev<br/>(r07000000fc)!0055 - Read FFCA Major Rev<br/>(r07000006fa)!0000 - Read FFCA Major Rev<br/>(r07000006fa)!0000 - Read Sub Voltage<br/>(r07000000ff)!0055 - Read FFCA Major Rev<br/>(r07000000ff)!0055 - Read FFCA Minor Rev<br/>(r07000000ff)!0065 - Read UCTLR Major Rev<br/>(r07000000ff)!0161 - Read UCTLR Minor Rev</pre> |   |  |  |  |
| Camera Generic Read/Write Packe<br>Target Index Command Ch<br>04 07 0000<br>Write Read  | ts<br>ecksum Response Formatted String<br>0000 Enable<br>Checksum Format<br>Command   |   |  |  |  |

#### 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.

| Exposure/Readout   |  | >   |
|--|--|---|
| Readout Modes<br>Free Run<br>Trig Program Exposure<br>Trig Manual Exposure<br>Seft Tricoge | Exposure<br>Manual Exposure Parameters<br>< /2 Set *2 ><br>25.002 ms | Trigger In Select    Power Connector (3  CLA CC1  Act High  Stroke Out Polarity |
| Data Format  |  | Active High   |
| <ul> <li>12 Bits - Med</li> <li>10 Bits - Med</li> </ul>                                   | Gain and Offset Unity Enable Unity                                   | O Active Low  |
| 8 Bits - Full     80 Bits - 8x10bits     13 Bits - Barro                                   | Gain:  |   |
| 12 Bits - Base     10 Bits - Base     8 Bits - Base  | Corrections  |   |
| Bottom 8   | En Pixel Corrector   |   |
| Test Patterns  | Hot Pixel Correction   |   |
| <ul> <li>Disable</li> <li>Input</li> </ul>   | En Hot Pixel Corrector A00 Threhold Reg (Hex)                        |   |
| Output   | Mono Bayer Read Write  | Refresh   |

#### 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.

**EMC** Operations Manual

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#### **Camera Control Application Details:**

| rmware Load | er  |                        |  |   |   |   |
|-------------|---|------------------------|--|---|---|---|
| GA          |   | Micro Controller       |  | Factory File in Intel F                 | ormat   | Cause Decisions                         |
|             | File Size Decimal<br>File Size Hex<br>Camera Loader<br>Firmware Version |                        | File Size Decimal<br>Camera Loader<br>Firmware Version |   | File Size Decimal<br>Total Lines<br>Lines to Go | V Pixel/Column Defects LUT Rat Reid     |
|             | Total Pages<br>Pages to Go<br>Retries                                   |                        | Total Lines<br>Lines to Go<br>Retries                  | Split File Forma                        | Save Factory<br>File                            | Base Rst, Cpy to<br>Factory. Save Fact, |
|             | Load FPGA<br>From File  |                        | Load<br>Microcontroller<br>From File                   | 71M Rat Field<br>Load Rat Field<br>File | Save Flat Field<br>File                         |   |
| atus        |   |                        |  |   |   |   |
|             |   |                        |  |   |   | Baud Rate 9600                          |
|             | Load<br>Asser   | Rimware<br>nbly (.zip) |  | [                                       | Create Firmware<br>Assembly (.zip)              |   |

### 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.

| Edit Defect Type   |                       |  |        |   |
|--|-----------------------|--|--------|---|
| O Pixel  | O Column              | O Row  | Defect |   |
| Map Type<br>Column (H) Rov<br>(I) Copy Right Pixel<br>(I) Copy Left Pixel<br>(I) Copy Left Pixel<br>(I) Copy Bayer Ave<br>(I) Copy Bayer Right<br>(I) Copy Bayer Right<br>(I) Copy Bayer Right<br>(I) Copy Bayer Right<br>(I) Copy Bayer Left<br>(I) Copy Bayer Left<br>(I) Copy Bayer Left<br>(I) Copy Bayer Left<br>(I) Copy Bayer Right<br>(I) Copy Bayer | (V)<br>el Delete Sort | Sensor Readout<br>O V Rip Off, H Rip Off<br>O V Rip Off, H Rip On<br>O V Rip On, H Rip Off<br>O V Rip On, H Rip On |        | Correction Control  Enable Pixel Corrector Enable Row Corrector Write To Camera Soft Tragger Save Defect List To File Load Defect List From File Defect Offsets Read Write Raster (Status) Pixels Per Row |
| (2) Force White<br>(3) Force Black   | / Cycle               |  |        | Rows Per Frame       PCD Default Maps       X Hair     O White       L Form     O Black       Splatter Form   |

#### Image Corrections->Sensor Defects->Defect Editor

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

Started Control App 65 **EMC Operations Manual** 





#### **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.

Started Control App 65





#### Epix XCAP Setup



#### **Base Format**

10 and 8-bit also available



#### Medium Format

10-bit also available



) Started Camera Link tting 65 S

#### Epix XCAP Setup



#### **Full Format**

8-bit Only

#### **DECA** Format

10-bit only

**EMC Operations Manual** 

Live

Unlive

Snap

Repet

Tips

Driver Assistant

----





#### Teledyne Dalsa CamExpert Setup





#### Teledyne Dalsa CamExpert Setup



#### **Full Format**

8 pixels per clock Left to Right, Top to Bottom



#### 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 <sup>-</sup> @PGA x3.5<br>12.5ke <sup>-</sup> @PGA x5 | Dark noise           | 9.5e <sup>-</sup> @PGA x3.5<br>7.6e <sup>-</sup> @PGA x5 |
| Dynamic range      | 65.8@PGA x3.5<br>64.3@PGA x5                               | Dark current         | 6e <sup>-</sup> /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   |



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EMC-51

8424 x 6032 (Windowing optional) Active Image 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 10.1 fps: Full 8/8bit, DECA 8x10bit 8 bits/pixel 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 1/16th to 16X Digital Gain 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

J Overview 103 е Га 65, Ļ Ŋ C Σ ш **EMC Operations Manual** 



| 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<br>1.7% RMS typical @ PGA gain x3.5 |
| QE              | 67.1%@510nm   |

EMC-5 Overview -Camera -EMC (51, 65, 103)



#### **EMC-51 Sensor Pixel Defects:**

MC-5 Overview 103 nera 65, Ļ, **9** 10 C Σ ш **EMC Operations Manual** 

| Mono                 | Lir     | nit     |
|----------------------|---------|---------|
|                      | 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<br>(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.

|   | GMAX4651 sensor (38.75x27.75mm)         |
|---|---|
| Γ | Full Frame 35mm format sensor (36x24mm) |
| L |   |
| L |   |
| L |   |
| L |   |
|   |   |

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EMC-5 Camera - Overview EMC (51, 65, 103) **EMC** Operations Manual

20% 10% 0%

-20

-15

-10

-5

0

Angle(degree)

5

10

15

20



#### 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 doublesided ARC D263 glass lid.

| Resolution         | 9344 × 7000                   | Optical format            | 2.3"(Ø37.4 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                       |
|                    | 7.7e <sup>-</sup> @ PGA x0.75 |                           | 11ke <sup>-</sup> @PGA x0.75   |
| Dark noise@12bit   | 5e <sup>-</sup> @PGA x1.25    | Full well capacity@12bit  | 10ke <sup>-</sup> @PGA x1.25   |
|                    | 1.9e <sup>-</sup> @PGA x6     |                           | 2ke- @PGA x6                   |
| Dark poice@10bit   | 11.8e <sup>-</sup> @PGA x0.75 | Full well conseits @10hit | 10.6ke <sup>-</sup> @PGA x0.75 |
| Dark Hoise@1001    | 7.5e <sup>-</sup> @PGA x1.25  | Full well capacity@100it  | 9.8ke <sup>-</sup> @PGA x1.25  |
| Max Dunamic range  | 62.3dB @ 10bit                | Eramo rato                | 71fps @ 10bit                  |
| Max. Dynamic range | 66dB @ 12bit                  | Framerate                 | 31fps @ 12bit                  |
| Output interface   | 56 pairs of sub-LVDS          | Channel multiplexing      | 56/28/14/7/4/2/1               |
| Dark current       | <1e <sup>-</sup> /p/s @ 25°C  | Power consumption         | 2.2W @ 10bit / 2W @ 12bit      |
| Chroma             | Mono & RGB Color              | Package                   | 239-pin micro-PGA              |
|                    |                               |                           |                                |



EMC Operations Manual

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#### **EMC-65 Specifications:**

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#### EMC-65

9344 x 7000 (Windowing optional) Active Image 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 2.4 Base CL, 4.9 Medium CL, 9.4 Full CL, 8 bits/pixel **9.4 DECA** Windowing V increments of 1 rows Black Level Adjustable .75, 1, 1.25, 1.5, 6x Analog Gain **Digital Gain** 1/16th to 16X **Exposure Modes** Free Run, Program Triggered, Pulse Width Triggered 3.3-5.0V TTL External Trigger 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

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#### **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<br>1.3% RMS typical @ PGA gain x1.25 |
| QE              | 65.3% @ 500nm  |

EMC-65 Overview Camera -EMC (51, 65, 103)



#### **EMC-65 Sensor Pixel Defects:**

EMC-65 Overview 80 era Ē 65, ÷, Ŋ C Σш

| 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<br>(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.

|    | Full Frame 35mm format sensor (36x24mm) |
|----|---|
|    | GMAX3265 sensor (29.9x22.4mm)           |
| L. |   |
|    |   |
|    |   |
|    |   |
|    |   |
|    |   |



#### **EMC-65 Sensor Pixel Response:**

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#### EMC-65 Sensor Microlens Angular Response:




### EMC-103 Sensor Specifications:

### EMC-103 Overview 103 era П

### 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 (Ø 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 <sup>-</sup> (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<br>Dedicated pixel supplies | Power consumption    | 2.47 W                  |

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**EMC Operations Manual** 



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### **EMC-103 Specifications:**

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### 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<br>8 bits/pixel | 6.1 fps: Full 8/8bit, Deca 8x10bit<br>3.0fps: Medium, 12/10/8 bits<br>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<br>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<br>Clamp   |
| Lens Mount                                  | M58, Nikon F, Canon EF, M72  |
| Power                                       | 7-12V DC   |
| Environmental                               | Operating 0C to 60C, Storage –40C to +85C<br>Camera Link tested to –30C to 70C.                  |
| Vibration/Shock                             | 10G (20-200Hz) XYZ 70G 10ms  |
|   |  |

EMC-103 Overview Camera -Emc (51, 65, 103)



### **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<br>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** Overview - ECA - 65, 103) (51, U Σ Ш



### **EMC-103 Sensor Pixel Defects:**

**EMC-103** Overview M 0 e La 60 (51, C Σш

| 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<br>(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.

| _ | GMAX32103 sensor (36.1x29.4mm)          |  |  |  |  |
|---|---|--|--|--|--|
|   | Full Frame 35mm format sensor (36x24mm) |  |  |  |  |
|   |   |  |  |  |  |
|   |   |  |  |  |  |
|   |   |  |  |  |  |
|   |   |  |  |  |  |
|   |   |  |  |  |  |
|   |   |  |  |  |  |



### **EMC-103 Sensor Specifications:**

**EMC-103** Overview Camera -Emc (51, 65, 103)



Angular response





### Skylight Filter response:



# R/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 - Overview EMC (51, 65, 103)



### 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 - Overview EMC (51, 65, 103)



### Camera Link



Camera - Overview EMC (51, 65, 103)



### **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      |  |  |  |
| <b>5</b> 5>5                                   |           | 5>3       | 5>1      |  |  |  |
| 4  | 4>4       | 4>2       | 4>0      |  |  |  |
| 3  | 3>3       | 3>1       |          |  |  |  |
| <b>2</b> 2>2                                   |           | 2>0       |          |  |  |  |
| 1  | 1>1       |           |          |  |  |  |
| 0  | 0>0       |           |          |  |  |  |

Camera - Overview EMC (51, 65, 103)



### **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 |                    |     | Description  |
|--------|-------------------------------|--------------------|-----|--|
| 0x00   | 0x02                          | Camera Link Output | R/W | 0x0000 = 12 bit Medium<br>0x0001 = 10 bit Medium<br>0x0003 = 8x8 Full<br>0x0004 = 8x10 Deca 80bit<br>0x0005 = 12 bit Base<br>0x0006 = 10 bit Base<br>0x0007 = 8 bit Base |

Camera - Overview EMC (51, 65, 103)



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).

Serial Communication EMC (51, 65, 103)

| 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/<br>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 Acknowledge - Negative acknowledge Size = 1 ascii character Ack Value = 33 Decimal (ascii ! ) Nack Value = 63 Decimal (ascii ?)

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### **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.

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### **Camera Control**

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

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Serial Commands EMC (51, 65, 103)



### **Camera Control Continued**

| Target | Index | Description                  | Read<br>Write | Modes   |
|--------|-------|------------------------------|---------------|---|
| 0x00   | 0x60  | Pixel Corrector              | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled   |
| 0x00   | 0x61  | Column Corrector             | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled   |
| 0x00   | 0x62  | Row Corrector                | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled   |
| 0x00   | 0x64  | Set H Flip                   | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled   |
| 0x00   | 0x65  | Set V Flip                   | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled   |
| 0x00   | 0xA0  | Hot Pixel Corrector<br>(HPC) | R/W           | 0x0000 = Inactive<br>0x0001 = Active  |
| 0x00   | 0xA1  | Hot Pixel Corrector<br>Type  | R/W           | 0x0000 = Mono<br>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<br>0x0001 - Detectors OSD<br>0x0005 - Raster OSD<br>0x0006 - Revision OSD<br>0x0007 - Frame Counter OSD<br>0x000C - Serdes OSD |

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### 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<br>Write | Modes  |
|--------|-------|-----------------------------------|---------------|--|
| 0x00   | 0x0E  | Enable Digital Gain<br>and Offset | R/W           | 0x0000 = Inactive<br>0x0001 = Active                                       |
| 0x00   | 0x13  | Digital Gain                      | R/W           | In units of 1/4096 gain<br>Example 0x1000 = 1X gain<br>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<br>0x0001 = Active (default)                             |
| 0x00   | 0x21  | Set "Analog" Gain                 | R/W           | Varies, see following pages  |

Serial Commands EMC (51, 65, 103)



### 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    |

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### **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  |

## Serial Commands EMC (51, 65, 103)



### Fast Meter and AE Commands

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

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|        | munis 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<br>Window (32bit)<br>Brightness | R   | Data = 0 Returns bottom 16bits<br>Data = 1 Returns top 16 bits |  |  |  |  |
| 0x00   | 0xB2                    | Sharpness<br>Window (32bit)                         | R   | Data = 0 Returns bottom 16bits<br>Data = 1 Returns top 16 bits |  |  |  |  |
| 0x00   | 0xB3                    | # pixels in AE Win-<br>dow (32bit)                  | R   | Data = 0 Returns bottom 16bits<br>Data = 1 Returns top 16 bits |  |  |  |  |
| 0x00   | 0xB4                    | # saturated pixels in AE Window (32bit)             | R   | Data = 0 Returns bottom 16bits<br>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-<br>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 pix-<br>els (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)

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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 (70)                  | DOSD FIFO    |
| 5     | Frame Cnt (158)                 | DOSD FIFO    |
| 6     | Frame Cnt (239)                 | DOSD FIFO    |
| 7     | Frame Cnt (3124)                | DOSD FIFO    |
| 8     | SNR Num of Pixels(70)           | DOSD FIFO    |
| 9     | SNR Num of Pixels(15.8)         | DOSD FIFO    |
| 10    | SNR Num of Pixels(2316)         | DOSD FIFO    |
| 11    | SNR Num of Pixels(3124)         | DOSD FIFO    |
| 12    | SNR Sum of Squares(70)          | DOSD FIFO    |
| 13    | SNR Sum of Squares(158)         | DOSD FIFO    |
| 14    | SNR Sum of Squares(2316)        | DOSD FIFO    |
| 15    | SNR Sum of Squares(3124)        | DOSD FIFO    |
| 16    | SNR Sum of Pixels(70)           | DOSD FIFO    |
| 17    | SNR Sum of Pixels(158)          | DOSD FIFO    |
| 18    | SNR Sum of Pixels(2316)         | DOSD FIFO    |
| 19    | SNR Sum of Pixels(3124)         | DOSD FIFO    |
| 20    | AEW Sharpness Detector(70)      | DOSD FIFO    |
| 21    | AEW Sharpness Detector(158)     | DOSD FIFO    |
| 22    | AEW Sharpness Detector(2316)    | DOSD FIFO    |
| 23    | AEW Sharpness Detector(3124)    | DOSD FIFO    |
| 24    | AEW Brightness Detector(114) *  | DOSD FIFO    |
| 25    | AEW Brightness Detector(1912) * | DOSD FIFO    |
| 26    | AEW Brightness Detector(2720) * | DOSD FIFO    |
| 27    | AEW Brightness Detector(3528) * | DOSD FIFO    |
| 28    | AEW Saturated Detector(70)      | DOSD FIFO    |
| 29    | AEW Saturated Detector(158)     | DOSD FIFO    |
| 30    | AEW Saturated Detector(2316)    | DOSD FIFO    |
| 31    | AEW Saturated Detector(3124)    | DOSD FIFO    |
| 32    | AEW Num of Pixels (70)          | DOSD FIFO    |
| 33    | AEW Num of Pixels (158)         | DOSD FIFO    |
| 34    | AEW Num of Pixels (2316)        | DOSD FIFO    |
| 35    | AEW Num of Pixels (3124)        | DOSD FIFO    |
| 36    | AEW Max Pixel(70)               | DOSD FIFO    |
| 37    | AEW Max Pixel(118)              | DOSD FIFO    |
| 38    | DOSD RAM(0)                     | Programmable |
| 39    | DOSD RAM(1)                     | Programmable |
| 40    | DOSD RAM(2)                     | Programmable |
|       |                                 |              |
| 549   | DOSD RAM(511)                   | Programmable |

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### 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.

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### Auto Exposure PBM Continued

|        | illunis AE/PBM Commands |   |     |   |  |  |
|--------|-------------------------|---|-----|---|--|--|
| Target | ln-<br>dex              | Description                               | R/W | Modes   |  |  |
| 0x06   | 0x00                    | AE/PBM Start                              | R/W | W: Starts AE/PBM<br>R: Returns current average dN   |  |  |
| 0x06   | 0x01                    | AE/PBM Disable                            | R/W | W: 0 = disable, 1 = enable<br>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<br>AE Loop<br>Date is imbedded in Meta Data.<br>Uses resources that reduce AE<br>rate by about one half. |  |  |
| 0x06   | 0x19                    | PBM Sat Count                             | R   | Returns current Pixel Burn Meter<br>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<br>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 pix-<br>els  |  |  |
| 0x06   | 0x1E                    | AE IRIS Flag                              | R/W | 0 = NOP<br>1 = CLOSE<br>2 = OPEN  |  |  |
| 0x06   | 0x1F                    | AE/PBM Status                             | R   | 1 = Enabled   |  |  |
| 0x06   | 0x20                    | AE Cycle Count                            | R   | # of AE measurements between<br>frame   |  |  |
| 0x06   | 0x21                    | PBM Cycle Count                           | R   | # of PBM measurements between<br>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<br>Write | Modes  |
|--------|-------|--------------------------|---------------|--|
| 0x04   | 0x09  | Set Current Baud<br>Rate | W             | 0x0000 = 9600<br>0x0001 = 19200<br>0x0002 = 38400<br>0x0003 = 57600<br>0x0004 = 115200<br>Save the state to EEPROM to retain baud rate |

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### 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<br>Write | Modes   |
|--------|-------|--------------|---------------|---|
| 0x00   | 0x03  | Readout Mode | R/W           | 0 = Free Run<br>1 = Trigger Program Exposure<br>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<br>Write | Modes  |
|--------|-------|-------------|---------------|--|
| 0x00   | 0x01  | Exposure ms | R/W           | Exposure time in milliseconds,<br>max is 0xFFFF = 65.535 seconds |
| 0x00   | 0x05  | Exposure us | R/W           | Exposure time in Microseconds,<br>max is 0xFFFF = 0.065 seconds  |

### Strobe Signal

| S        | Target   | Index   | Description   | Read   | Modes   |
|----------|--|---|---|--|---|
| σ        |  |   |   | Write  |   |
| Č        |  |   | _   | -  |   |
|          | 0x00   | 0x01  | Exposure ms   | R/W  | Exposure time in milliseconds,<br>max is 0xFFFF = 65.535 seconds  |
| J        | 0x00   | 0x05  | Exposure us   | R/W  | Exposure time in Microseconds,<br>max is 0xFFFF = 0.065 seconds   |
| <b>J</b> | •  | <u>.</u>  |   |  |   |
|          | Strobe   | Signal  |   |  |   |
| CO       | The EM<br>the sens<br>for analy<br>to activa<br>Signal c | C Strobe<br>sor is trig<br>zing an<br>ite an ille<br>annot de | e Signal is a 3.3V LVTT<br>ggered and exposing and<br>d optimizing imaging a<br>umination source. If us<br>rive significant current a | L signal<br>n image.<br>pplication<br>ed in this<br>and shou | that is active when<br>The Strobe Signal is useful<br>ns. The strobe can be used<br>s fashion, the Strobe<br>Ild be buffered. |
| J<br>J   |  |   |   |  |   |
| С<br>[5] | Target   | Index   | Description   | Read<br>Write  | Modes   |
|          | 0x00   | 0x04  | Strobe Control  | R/W  | 0x0000 = negative strobe polarity<br>0x0001 = positive strobe polarity  |

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### 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<br>Write | Modes                          |
|--------|-------|--------------|---------------|--------------------------------|
| 0x00   | 0x0C  | Soft Trigger | W             | Software trigger in ms 1-65535 |

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### **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<br>0x0001 = Input (CCD) Test Pattern<br>0x0002 = Output Test Pattern<br>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.

| File Size Decimal<br>File Size Hex<br>Camera Lader<br>Primware Version | File Size Decimal<br>Camera Loader<br>Firmware Version                        | File Size Decimal   | Save Regions V Pwel/Column Defects LUT Rat Reid |
|--|---|---|---|
| Total Pages<br>Pages to Go<br>Retries<br>Load FPCs<br>From File        | Total Lines<br>Lines to Go<br>Retries<br>Load<br>Microcontroller<br>From File | Sout He Format      Load Factory     File      71M Rat Reid      Load Rat Field      File      Save Rat Field      File | Base Rat, Coy to<br>Factory: Save Fact.         |
| Status   | Load Firmware<br>Assembly (zip)   | Create Firmware<br>Assembly (zp)  | Baud Rate 9600                                  |
| FPGA   | X   | Micro Controlle   | er  |
|  | File Size Decimal   |   | File Size Decimal<br>Camera Loader              |
|  | Camera Loader<br>Firmware Version   |   | Firmware Version                                |
|  | Total Pages   |   | Total Lines                                     |
| Ď,   | Pages to Go<br>Retries  |   | Lines to Go<br>Retries                          |
| т, со , т  | Load FPGA<br>From File  | ]   | Load<br>Microcontroller<br>From File            |
| <u>n</u>   |   |   |   |



### **Backup/Restore**

Firmwa

**FPG** 

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.

Came Save F include Load F in manu EMC Operations Manual



### **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-<br>dex | Description      | Read<br>Write | Modes                                 |
|--------|------------|------------------|---------------|---------------------------------------|
| 0x00   | 0x60       | Pixel Corrector  | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled |
| 0x00   | 0x61       | Column Corrector | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled |
| 0x00   | 0x62       | Row Corrector    | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled |

| Target               | In-<br>dex                | Descript  | ion       | Read<br>Write | Modes                                |
|----------------------|---------------------------|-----------|-----------|---------------|--------------------------------------|
| 0x00                 | 0x60                      | Pixel Cor | rector    | R/W           | 0x0000 = Disable                     |
| 0x00                 | 0x61                      | Column    | Corrector | R/W           | 0x0001 = Enabled<br>0x0000 = Disable |
|                      |                           |           | -         |               | 0x0001 = Enabled                     |
| 0x00                 | 0x62                      | Row Cor   | rector    | R/W           | 0x0000 = Disable<br>0x0001 = Enabled |
| 🖳 FrmCorre           | ction_CMV50               |           |           |               |                                      |
| Edit Defect T        | ype                       | 0.61      |           | D. (          | -                                    |
| Mar Tara             | IXei                      | Column    | O Row     | Detec         |                                      |
| Colum                | n (H) Row                 | (V)       |           |               | Enable Pixel Correcto                |
| 0                    | 0                         |           |           |               | Enable Column Corre                  |
| (0) No C             | Correction                |           |           |               | Enable Row Corrector                 |
| (1) Copy             | Right Pixel               |           |           |               | Write To Camera                      |
| (2) Copy<br>(3) Copy | / Left Pixel<br>/ Average |           |           |               | Read From Camera                     |
| (4) Force            | e White                   |           |           |               | Soft Trigger                         |
| (5) Force            | e Black                   |           |           |               | Save Defect Li                       |
| (6) XOR              | i<br>icate Last Pixe      | 1         |           |               | Load Defect List                     |
| (8) Copy             | / Bayer Ave               |           |           |               | Defect Offsets                       |
| (9) Copy             | / Bayer Right             |           |           |               | 128 H Offset                         |
| (10) Cop             | by Bayer Left             |           |           |               | 32 V Offset                          |
| (13) Cyc             | le Right                  |           |           |               | 112 Col Offset                       |
|                      |                           |           |           |               | 3960 H Split Po                      |
| Add                  |                           | Delete    |           |               | 3960 Col Split F                     |
| Clear A              | ll                        | Sort      |           |               | 0 PDC Base                           |
| - Row Corre          | ction Only                |           | ,         |               | PCD Default Map                      |
| (0)                  | Mono                      |           |           |               | X Hair                               |
| O (1) I              | Bayer                     |           |           |               | L Form                               |
| $\bigcirc$ (2)       | Force White /             | Cycle     |           |               | Splatter Form                        |

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### **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<br>Write | Modes                                       |
|--------|-------|---------------------------|---------------|---|
| 0x00   | 0xA0  | Hot Pixel Corrector       | R/W           | 0x0000 = Disabled<br>0x0001 = Enabled       |
| 0x00   | 0xA1  | Hot Pixel Correction Type | R/W           | 0x0000 = Monochrome<br>0x0001 = Color Bayer |
| 0x00   | 0xA2  | Hot Pixel Threshold       | R/W           | Threshold in dn<br>Recommended > 0x0100     |

| 🖳 Exposure/Readout  |   | - 🗆 ×   |
|---|---|---|
| Readout Modes  Free Run  Trig Program Exposure  Trig Manual Exposure  Soft Trigger  Data Format  12 Bits - Med  10 Bits - Med   | Exposure<br>Manual Exposure Parameters<br>< /2 Set *2 ><br>25 002 ms<br>Gain and Offset     | Trigger In Select <ul> <li>Power Connector (3V)</li> <li>CLA CC1</li> <li>Act High</li> </ul> Strobe Out Polarity <ul> <li>Active High</li> <li>Active Low</li> </ul> |
| <ul> <li>8 Bits - Full</li> <li>80 Bits - 8x10bits</li> <li>12 Bits - Base</li> <li>10 Bits - Base</li> <li>8 Bits - Base</li> <li>B Bits - Base</li> <li>B Bottom 8</li> </ul> | Gain:<br>Gain:<br>I En Hot Pixel Corrector<br>Offset<br>Correctiv<br>Mono Bayer<br>Read     | Threhold Reg (Hex)<br>Write   |
| Test Patterns     Disable     Input     Output     Sensor   | In Hot Pixel Corrector     A00     Threhold Reg (Hex)     Mono     Bayer     Read     Write | Refresh   |

### **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

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### **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.

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### **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.

| Grp Row 0 | 16x16 | 16×16 | 16×16 | 16×16 | 16x16 | 16x16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 | 16×16 | 16×16 | 16x16 |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Grp Row 1 | 16x16 | 16×16 | 16x16 |
| Grp Row 2 | 16x16 | 16×16 | 16x16 | 16×16 | 16×16 | 16x16 |
| -         | 16x16 | 16x16 | 16×16 | 16×16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 | 16×16 | 16×16 | 16x16 |
|           | 16x16 | 16×16 | 16x16 |
|           | 16x16 | 16×16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 | 16x16 | 16x16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 |
|           | 16x16 |
|           | 16x16 | 16x16 | 16×16 | 16x16 | 16x16 | 16x16 | 16×16 | 16×16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 | 16x16 | 16x16 | 16x16 | 16x16 | 16x16 | 16×16 | 16x16 |

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

and a not 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

| 骎 Shading : CMV-50   | DM CL Micro 48-0201 F —  |               | $\times$ |
|--|--|---------------|----------|
| Control<br>Table 1<br>Table 2<br>Table 3<br>Table 4<br>Table 5<br>Table 5<br>Table 6<br>Table 7<br>Table 8 | Enable PRNU (Bright)   |               |          |
| Calibrate<br>Generate PRNU   | Hot Pixel Correction<br>Fin Hot Pixel Corrector<br>Mono  Bayer/Color<br>2560 Threhold Reg (dN) | Write<br>Read |          |
|  |  | Help          |          |



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 ).

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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).

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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 The before Statistics (1306) (130

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



Histogram with shading.





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### **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    | 0x00000x0007 | 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.

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### **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 genera-<br>tion 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).

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### 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.

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| ituris | illun      | is Camera            | Control Ap           | plicati      | on CMV-            | 120M R | ev: 8.1.0 | )    |                        |            |   |
|--------|------------|----------------------|----------------------|--------------|--------------------|--------|-----------|------|------------------------|------------|---|
| Fi     | iles       | Comm                 | Modes                | Info         | State              | Image  | e Correc  | tion | s Manufacturing Help P | hoto 50M C | C |
|        | Соп        | municatio            | on History           |              |                    |        |           |      |                        |            |   |
|        | {r0        | 70000076             | [9]!0051             | - Re         | ad FPGA            | Major  | Rev       | ^    | 111                    |            |   |
|        | {r0        | 30e50209             | 00}!000A             | - Re         | ad SN A            | plhaNu | meric     |      | IIIU                   | Int        |   |
|        | {r0<br>{r0 | 30e50228<br>30e50238 | 3e}!004C<br>3d}!004C | - Re<br>- Re | ad Char<br>ad Char |        |           |      |                        |            |   |
|        | {r0<br>{r0 | 30e50248<br>30e50258 | 3c}!004B<br>3b}!0031 | - Re<br>- Re | ad Char<br>ad Char |        |           |      | Camera Information     |            |   |
|        | {r0<br>{r0 | 30e50268             | Ba}!0030             | - Re<br>- Re | ad Char<br>ad Char |        |           |      |                        |            |   |
|        | {r0        | 30e50288             | 38) ! 0031           | - Re         | ad Char            |        |           |      |                        |            |   |
|        | {r0        | 30e50298             | 36}!0037             | - Re         | ad Char            | •      |           |      | Camera SN: LLK1001     | 870        |   |
|        | {r0        | 30e502B8             | 5110030              | - Re         | ad Char            |        |           |      | uC Major Rev: 00C0     |            |   |

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

| illunis Photo Cont  | trol  |               |          | _   |  |
|---|---|---------------|----------|-----|--|
| Photo 1<br>Photos 1<br>Photos 2<br>Photos 3<br>Photos 4<br>Photos 5<br>Photos 6<br>Photos 7<br>Photos 8 | Take P<br>Display<br>Camera Status<br>Camera in | hoto<br>Photo | Live Vic | deo |  |



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

Shading Table Generation reg 0x40 Table#: Block : Status 1 Scanning.. 6 x 8 Row/Block E 275Z. 344 Percent Done **0**C ~ Time Remaining: з min 3 seconfis RMU-71 Ver F0\_185 WBL.hex RMU\_71M Rev 8\_3hZ.hin Micro: FPGA :

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

When the cess is of t





Any stored image can be displayed by selecting the image to display and then

The image will be displayed without a delay.

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### **EMC-65 Camera Link No Mount**



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### **EMC-103 Epix No Mount**







### **EMC-103 Camera Link No Mount**



**EMC F-Mount** 



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**EMC Canon EF Mount** 

# Camera DrawingS EMC (51, 65, 103)



## **I**SIO Machine **CMOS MACNI** Advanced Digital Machine Vision Cameras



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