illunis

Operations Manual

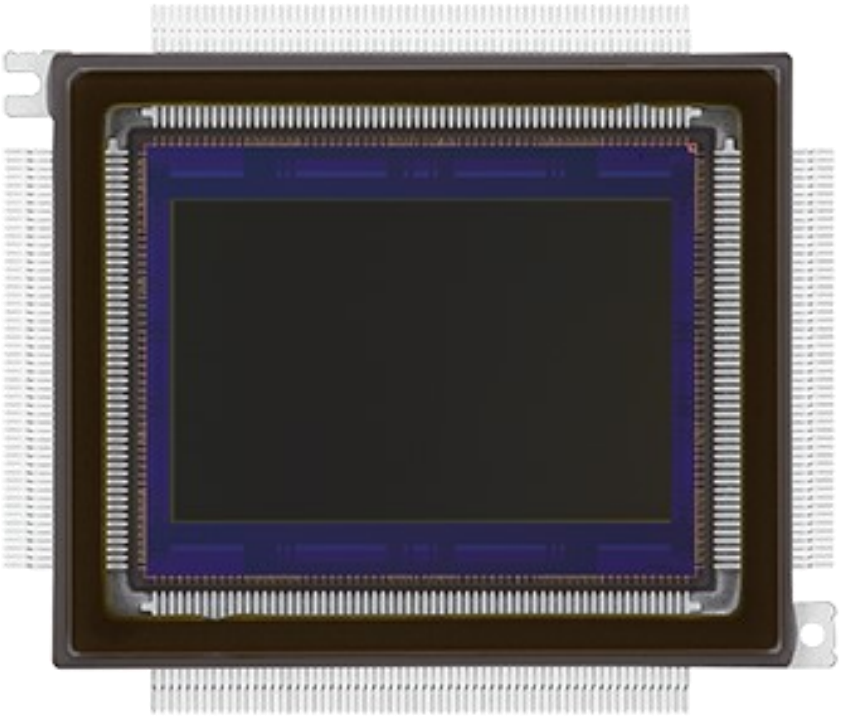
19,568 x 12,588 Rolling Shutter CMOS

CMV-250

Wednesday, March 24, 2022
Rev C

Rev	Date	Modification
A	02/18/22	CMV-250 Original Document
B	02/21/22	Added exploded drawing, date, edits.
C	03/23/22	Updated Images, edits. Fixed Analog gain description (1,2,4,8x). Added minimum exposure 1ms Added Functional test report. Updated Dialog Images, added revisions Updated power consumption to 6.5W Added Teledyne DALSA capture card details

Canon LI8020SA(M/C) 250 Mega Pixel Sensor



Revisions

CMV-250

Firmware Releases

040622	Micro 0xFA, 0x21E FPGA 0xFA, 0x222

Precautions

CMV-250

CMV-250 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.

The maximum Camera Link data rate is 85Mhz.

PoCL cables are compatible with the CMV-250 camera. PoCL camera power is supported.

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Contents

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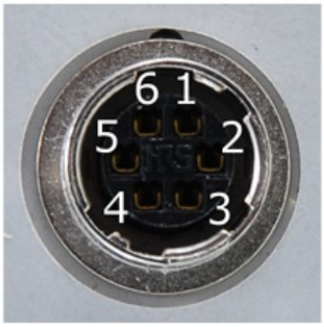
Table of Contents	Page

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

PIN	SIGNAL NAME
1	+12V DC
2	DC Ground
3	Trigger In
4	Strobe Out
5	No Connect
6	No Connect



View from Camera Back

Capture Card
Medium/Full Mode Camera Link capture card supporting
Camera Link (80 bit) Deca 8x8 or 8x10
Such as: Teledyne Dalsa Xtium-CL MX4 OR-Y4CO-XMX00.

Imaging SDK
Available from your capture card supplier.

Camera Link Cables
Two Camera Link cables (Mini HDR to SDR) **must be** rated at 85Mhz or more.

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

http://www.componentsexpress.com/Configurator.aspx?cnfi=1

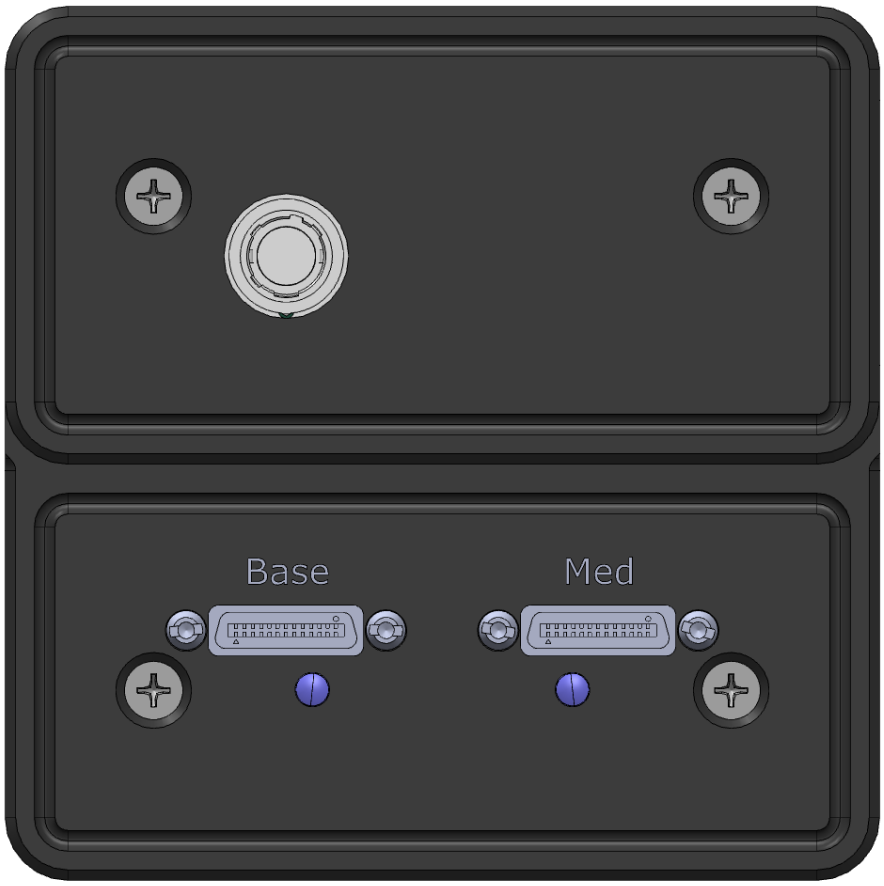
Camera Communication Software
illunis Camera Control Application (GUI)
Download at: https://www.illunis.com/help-center/

To start imaging with the CMV-250 CL:

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

Connect the CMV-250 Camera Link cables paying attention to the base and medium connections

The CMV-250 ONLY supports 8x8bit and 8x10bit Camera link Full.

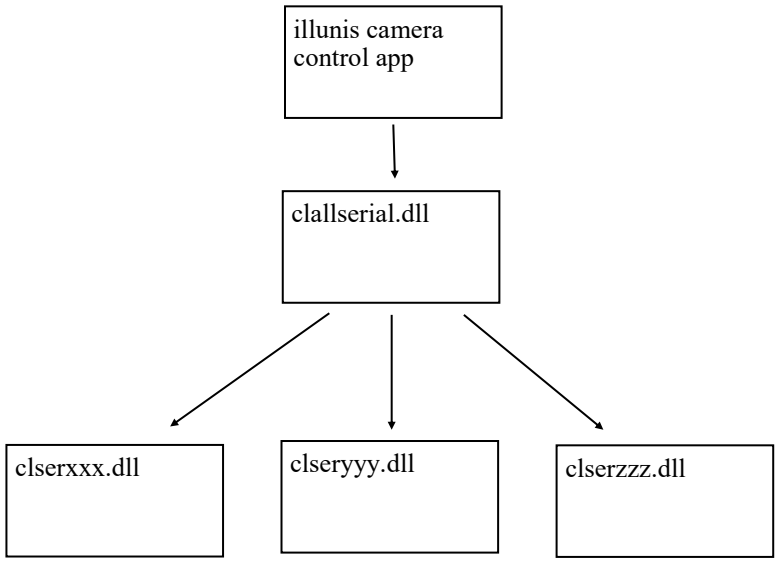


Installing the illunis Camera Serial Communication Software:

Download and install the illunis Camera Control Application (GUI) from https://www.illunis.com/help-center/

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.

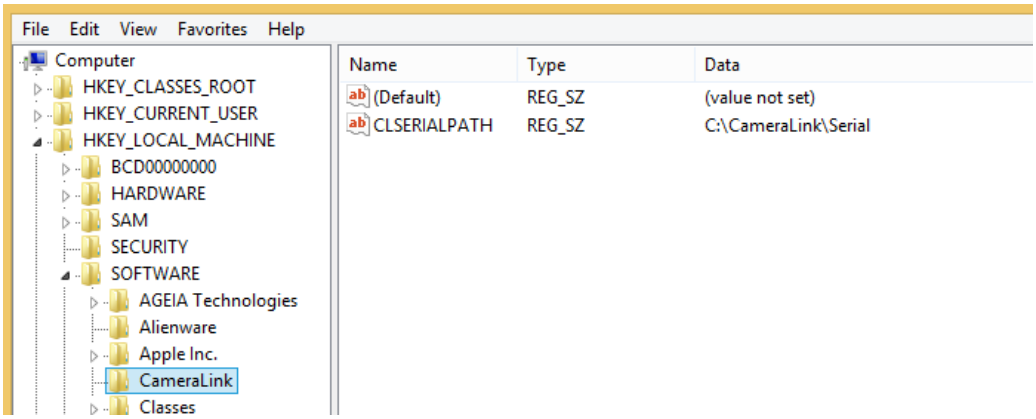


The registry:

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

HKEY_LOCAL_MACHINE\SOFTWARE\Cameralink CLSERIALPATH.

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



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

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

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

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

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** to be installed from:

   https://www.microsoft.com/en-us/download/details.aspx?id=48130

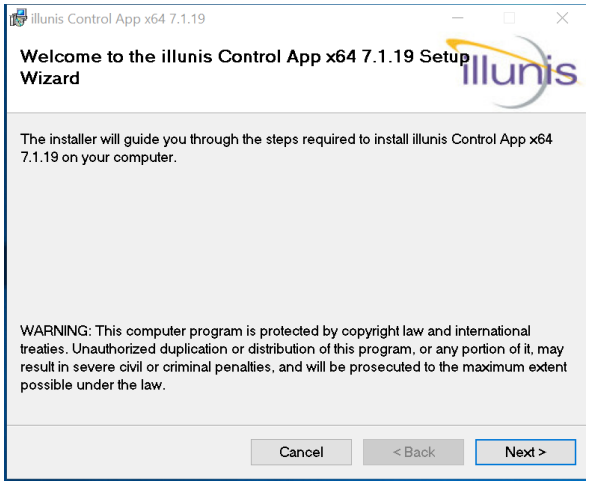
2. **Visual C++ 2010 Redistributable** from:

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

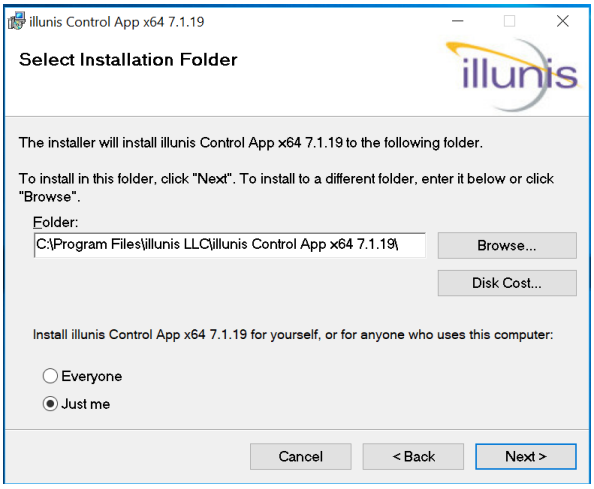
3. **Visual C++ 2013 Redistributable** from:

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

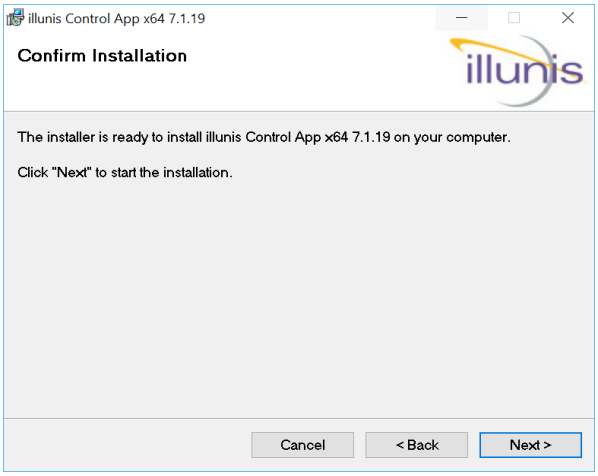
Install the Camera Serial Communication Software:



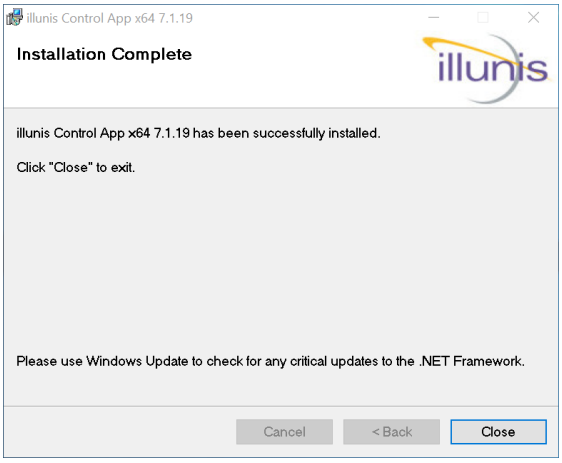
Launch the installer



Select the installation folder...



Confirm...



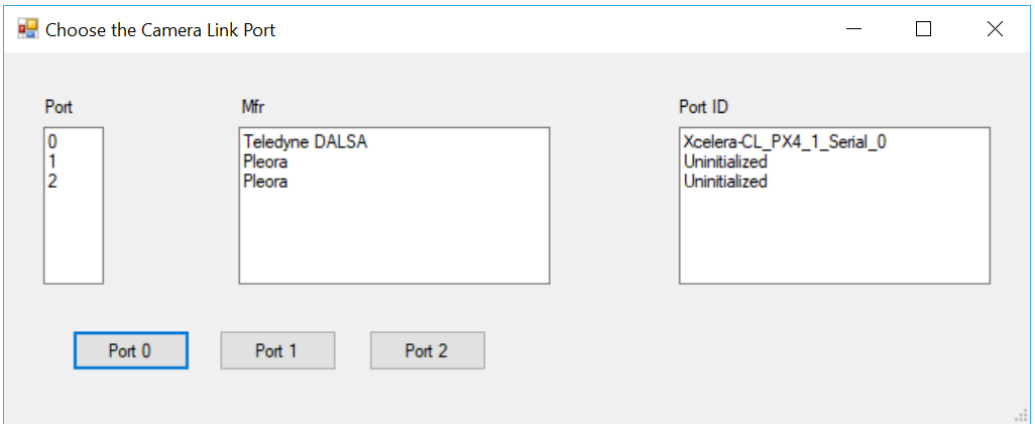
Install complete…

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

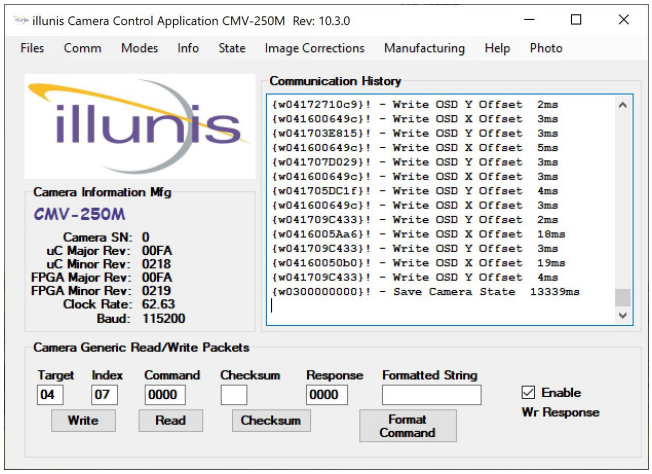
Power up the camera and run the illunis Camera Serial Communication Software.

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

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



illunis Camera Serial Communication Software Main Window:

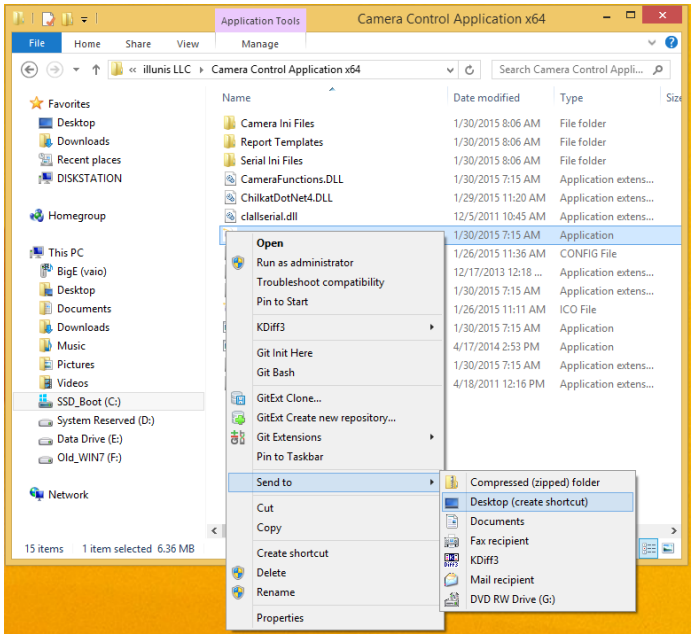


Disabled Menus

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

First, delete the desktop shortcut created by the installer.

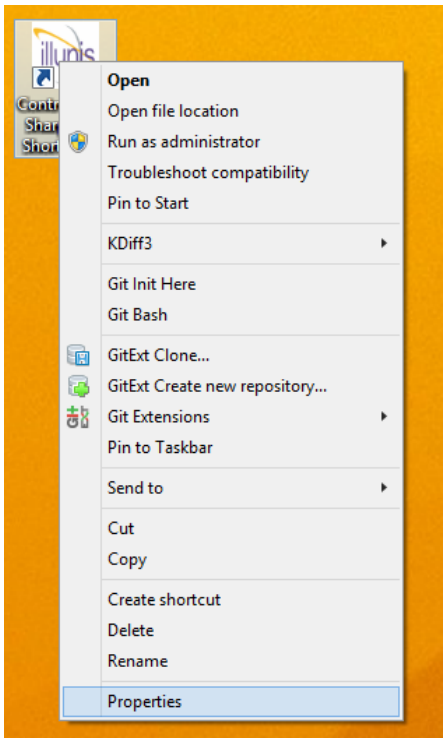
Creating a new shortcut for program options:



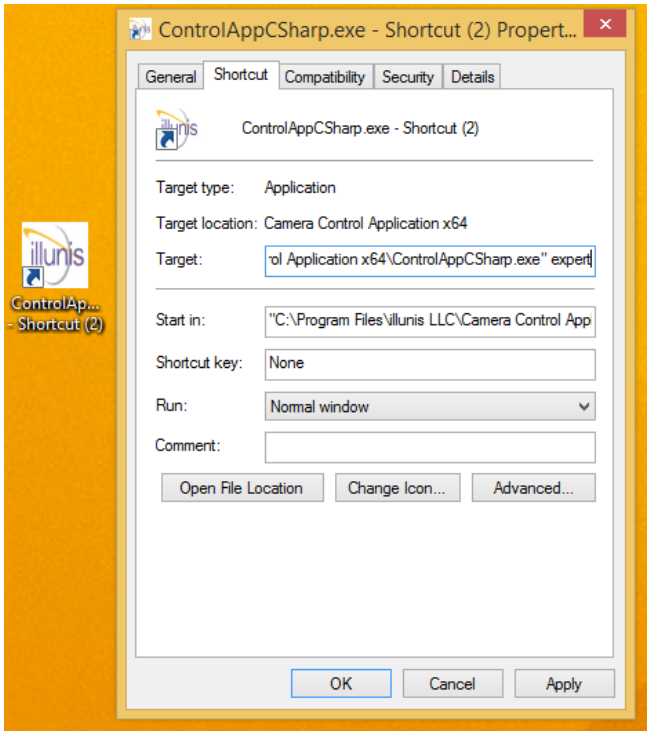
Create a new Shortcut

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

Adding options to the shortcut command line:



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

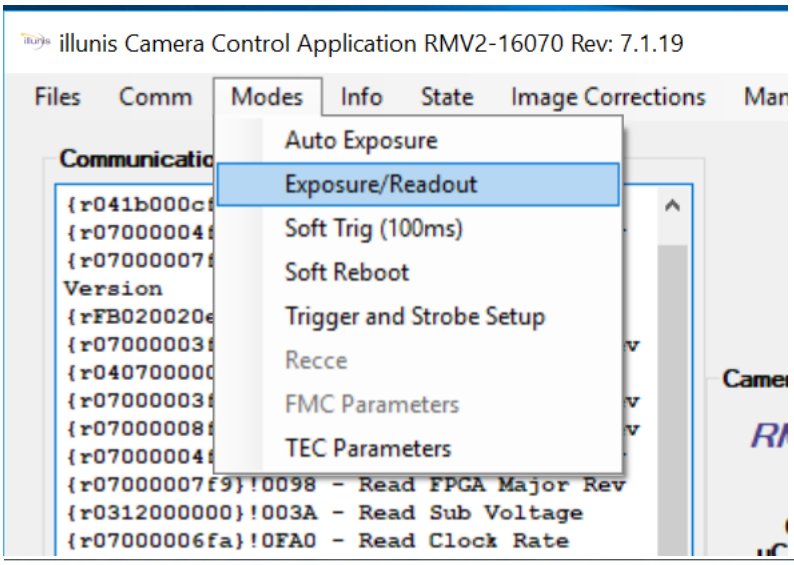


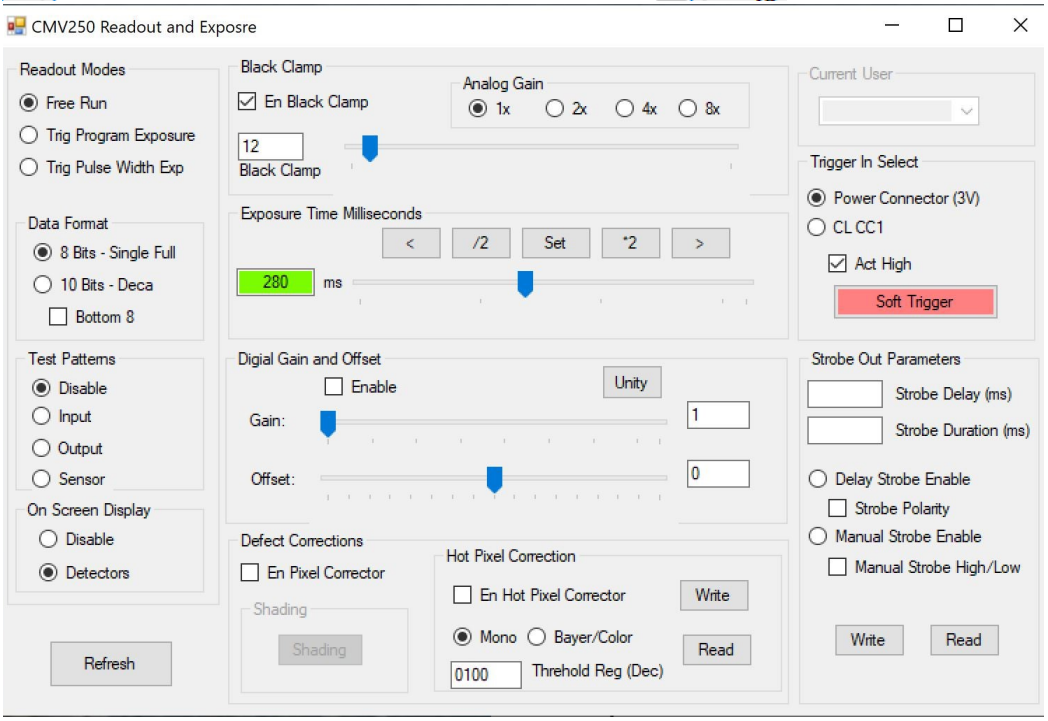
Add a space and the word **expert** after the close quote on the Target: line of the dialog box: .exe" expert

Choose OK.
When the program is launched, all menus will be enabled. **NOTE: Use care with all menus enabled as some changes cannot be undone and may require the camera be returned to the factory for remedy.**

Exposure / Readout:

Start with this dialog box.

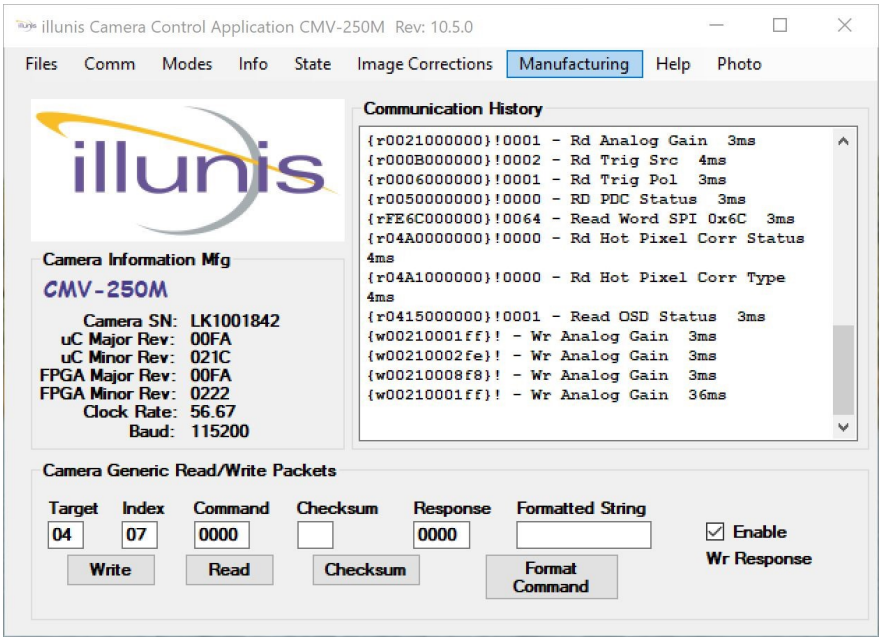




Camera Control Application Details:

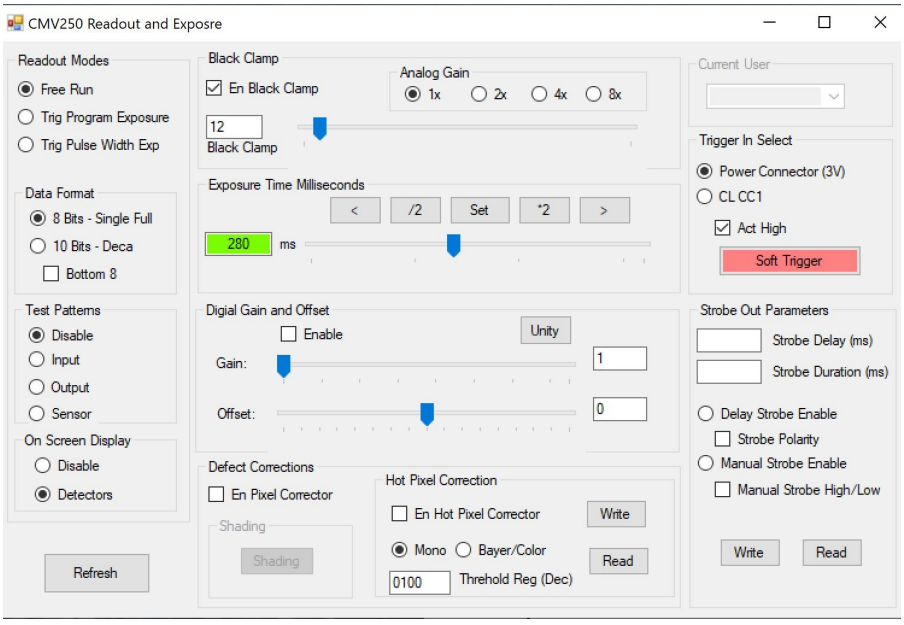
Main Dialog

The main dialog box provides access to the various functions of the camera. Menus are used to access sub-dialogs. A generic camera register read/write feature is provided. In addition, a history of communication is also provided in this dialog box.



Modes->Exposure and Readout

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

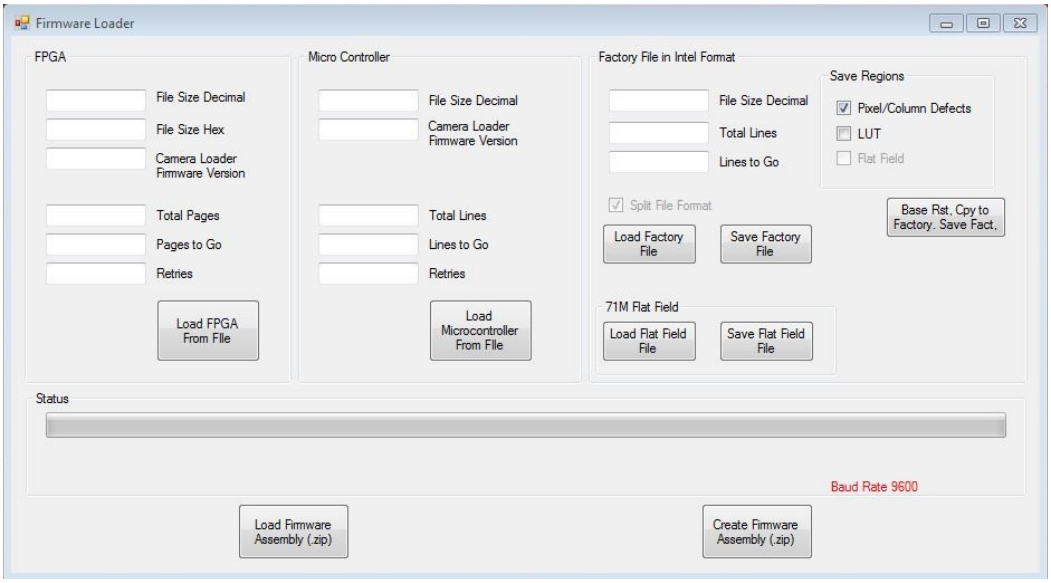


Camera Control Application Details:

Firmware Loader

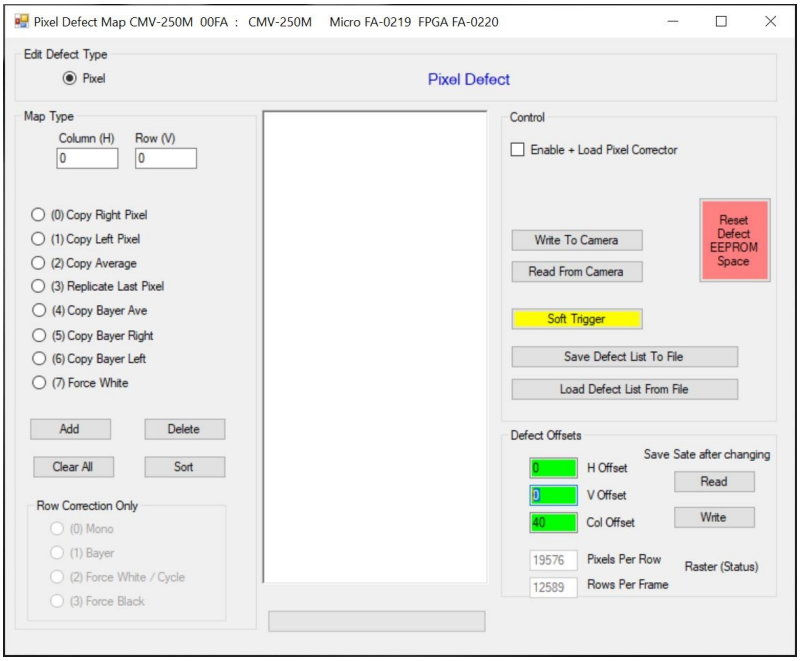
The firmware loader dialog is used to load FPGA and Microprocessor code as well as the EEPROM configuration data.

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.



Defect Corrector Editor

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



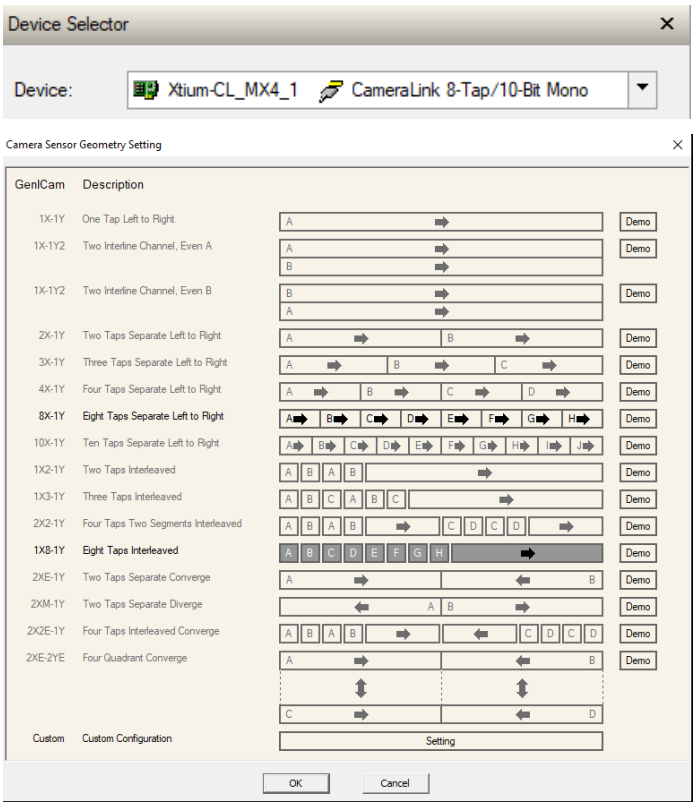
General Comments:

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

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

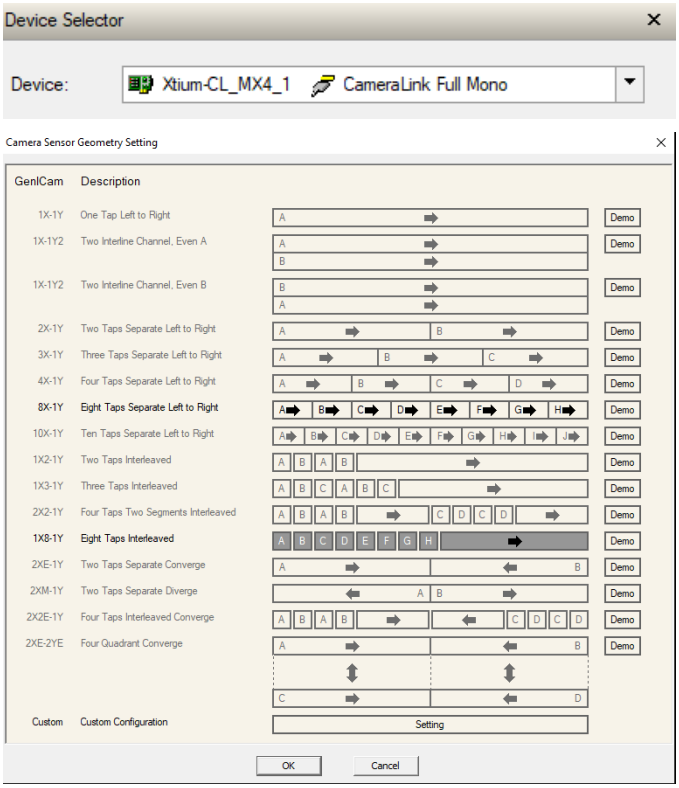
NOTE: If a camera mode is changed, the corresponding change in the capture environment will have to be made as they are independent.

Teledyne Dalsa CamExpert 80 bit Setup 8 tap/10 bit



8 Taps Interleaved

Teledyne Dalsa CamExpert Full Setup 8 tap/8 bit

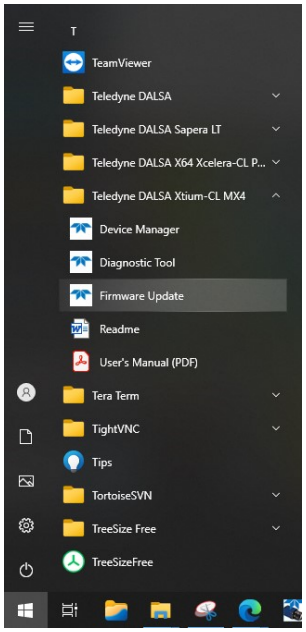


8 Taps Interleaved

Teledyne Dalsa Changing Capture Card Mode

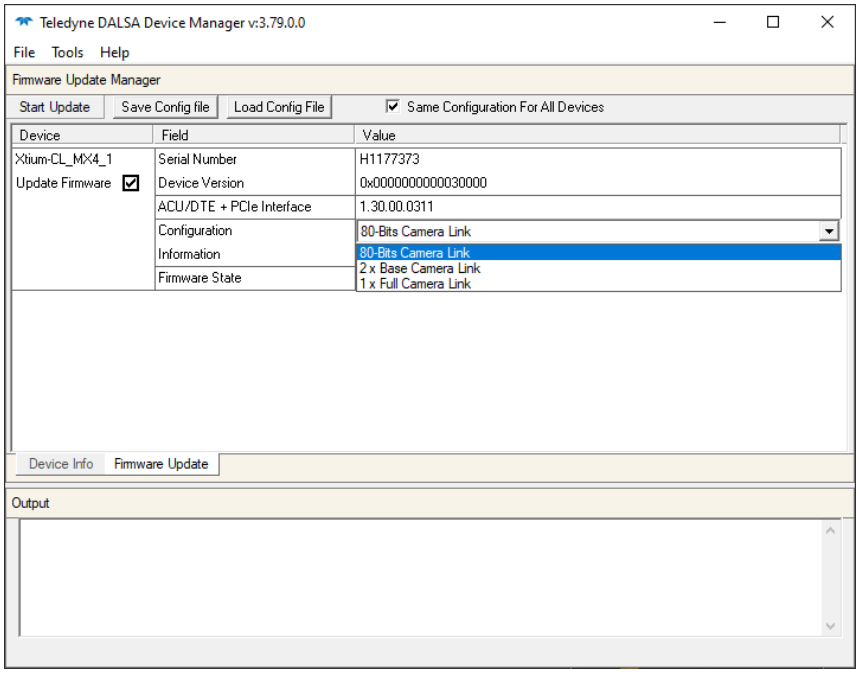
Teledyne Dalsa capture cards require a firmware update to switch between Full and DECA (80-bit) modes.

1) Close CamExpert and the illunis Camera Control App.

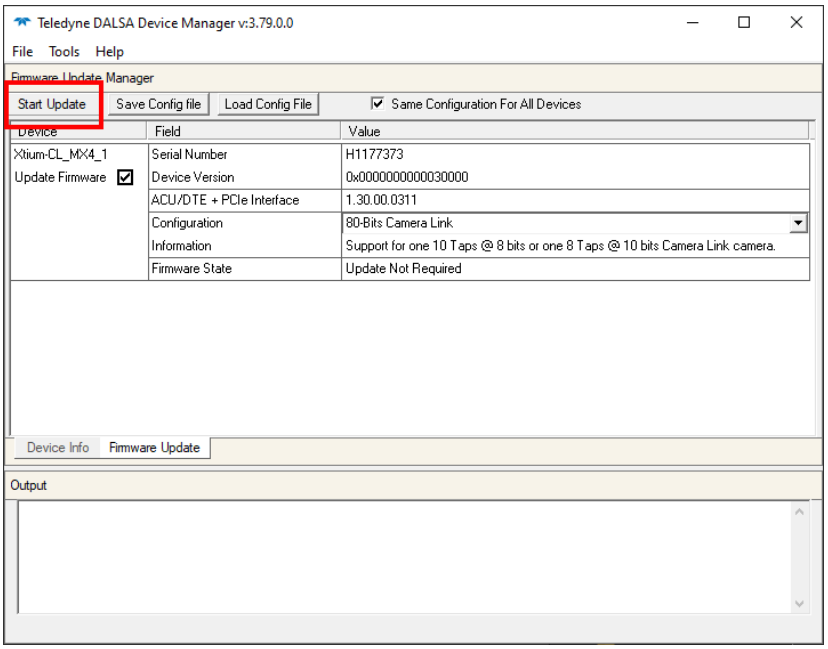


2) Open the Firmware Update tool for your capture card.

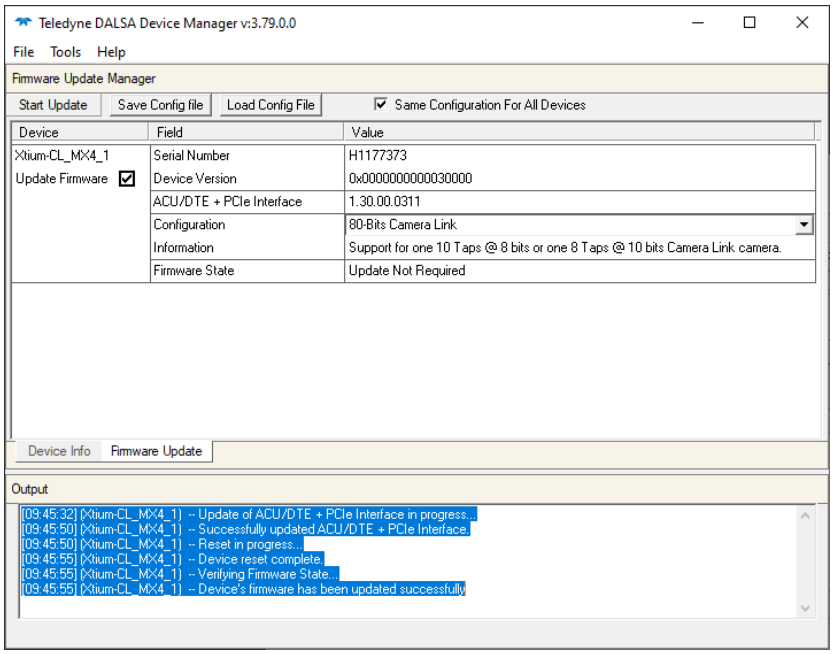
3) Choose the desired capture card configuration.



Teledyne Dalsa Changing Capture Card Mode

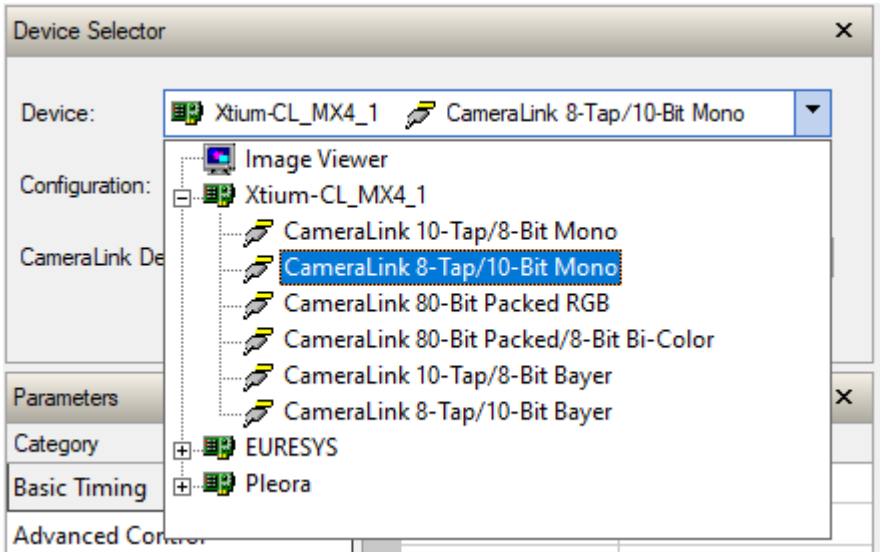


4) Click **Start Update**.



5) The app can be closed when the update is complete.

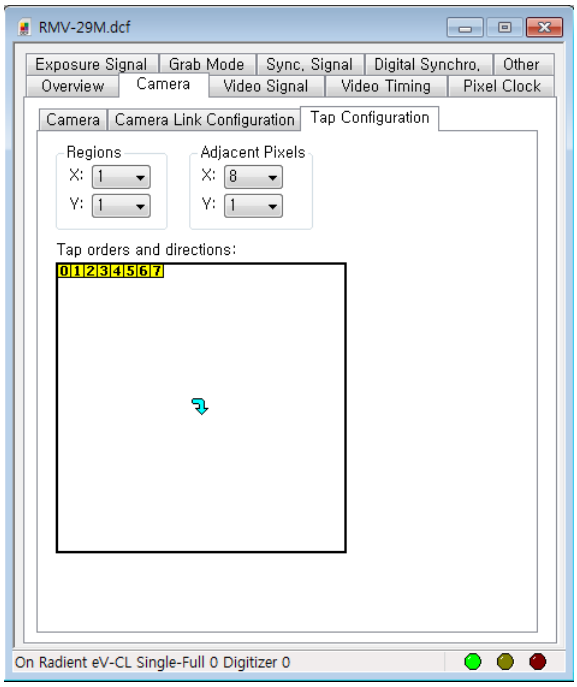
Teledyne Dalsa Changing Capture Card Mode

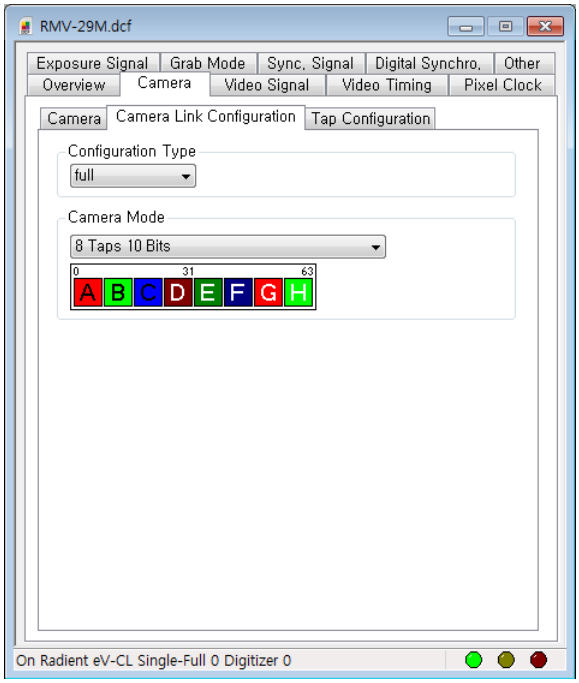


6) In CamExpert choose the correct Device type.

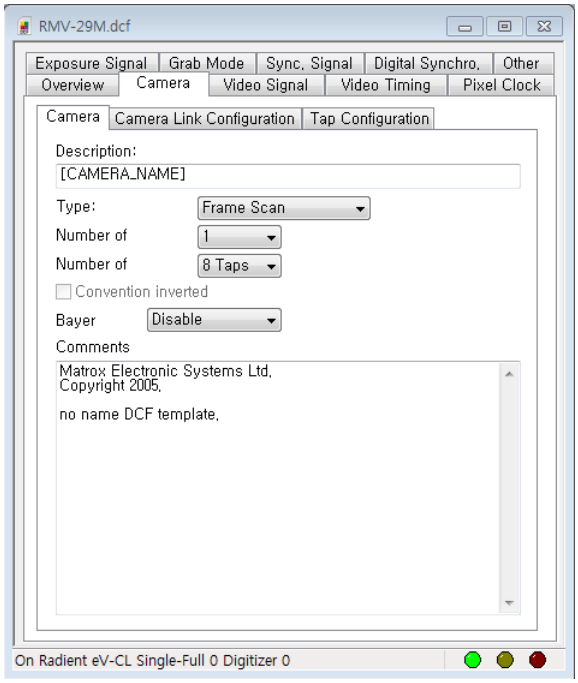
For illunis Cameras:
DECA - **CameraLink 8-Tap/10-Bit**
Full - **CameraLink Full**

Matrox Intellicam Full Setup 8 tap/8 bit





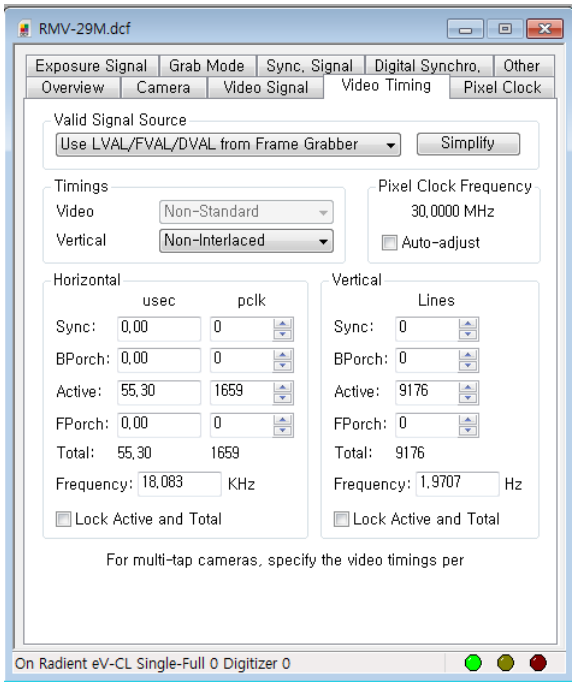
Matrox Intellicam Full Setup 8 tap/8 bit Continued

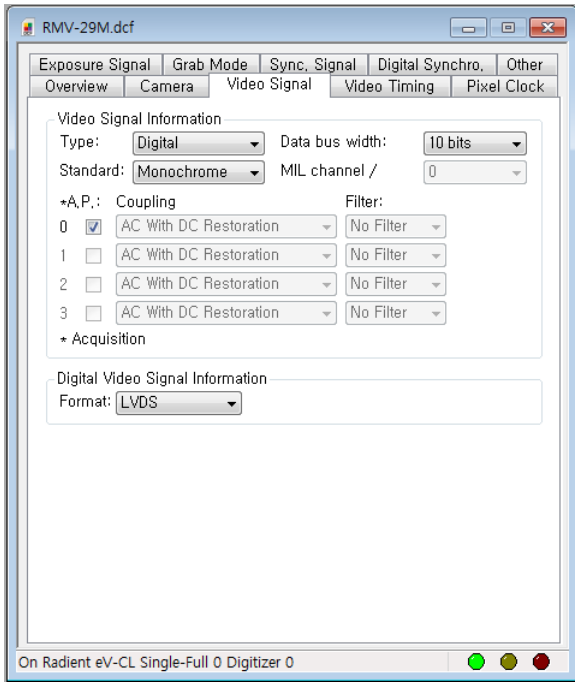


RadientPro PN: RP2GSF340300

RP2GSF340300*	Matrox RadientPro single-Medium/Full Camera Link® PCIe® 2.0 x8 frame grabber with 2 GB DDR3 SDRAM, Altera Stratix V 5SGXA3 FPGA and no SRAM

Matrox Intellicam Full Setup 8 tap/8 bit Continued





CMV-250 Specifications:

Item	CMV-250
Active Image	19,568 x 12,588
Sensor Type	Canon LI8020SA (M mono, C RGB)
Pixel Size	1.5µm x 1.5µm
Sensor Output	16 data lanes
Video Output	8/10 bits
Output Format	Mono, Bayer
Camera Interface	Full or Deca Camera Link
Electronic Shutter	Rolling shutter with Global reset
CL Data rate	2.4 fps (Full 8x8 or Deca 8x10 CL)
Pixel Clock	Up to 63Mhz
Shutter Speed	Increments of line time.
Windowing	TBD
Black Level	Auto Clamp, Offset Adjustable
Analog Gain	1.0x, 2.0x, 4.0x, 8.0X
Digital Gain	1X-16X (1/4096 step)
Exposure Modes	Programmed Free Run, Programmed Triggered, Triggered Pulse Width
External Trigger	3.3-5.0V TTL
Software Trigger	Per Camera API
Dynamic Range	60dB
Defect Correction	Pixel + Hot Pixel
Flat Field Correction	Block Based Shading Correction
Lens Mount	OEM/M58, Nikon F, M72, Canon EF
Power - varies with mode and data interface	7-12V DC @ 6.5W with Fan
Environmental	Operating –30C to +70C, Storage –40C to +85C
Vibration/Shock	10G (20-200Hz) XYZ 70G 10ms

CMV-250 Sensor Specifications:

The CMV-250 Digital Camera incorporates the Canon LI8020SA-sensor.

https://canon-cmos-sensors.com/canon-li8020sa-250mp-cmos-sensor/

Sensor Features

- APS-H (29.35 mm x 18.88 mm)
- 19,568 x 9,176 active pixels with a 1.5µm pitch.
- Frame rate at full resolution is 2.4 frames /sec.
- 16 digital LVDS outputs and 4 clocks
- Analog gain 1.0x, 2.0x, 4.0x, 8.0X
- On chip timing for Free Run and Trigger Modes.
- Mono, Bayer pattern output.
- High Grade (No row or column defects)

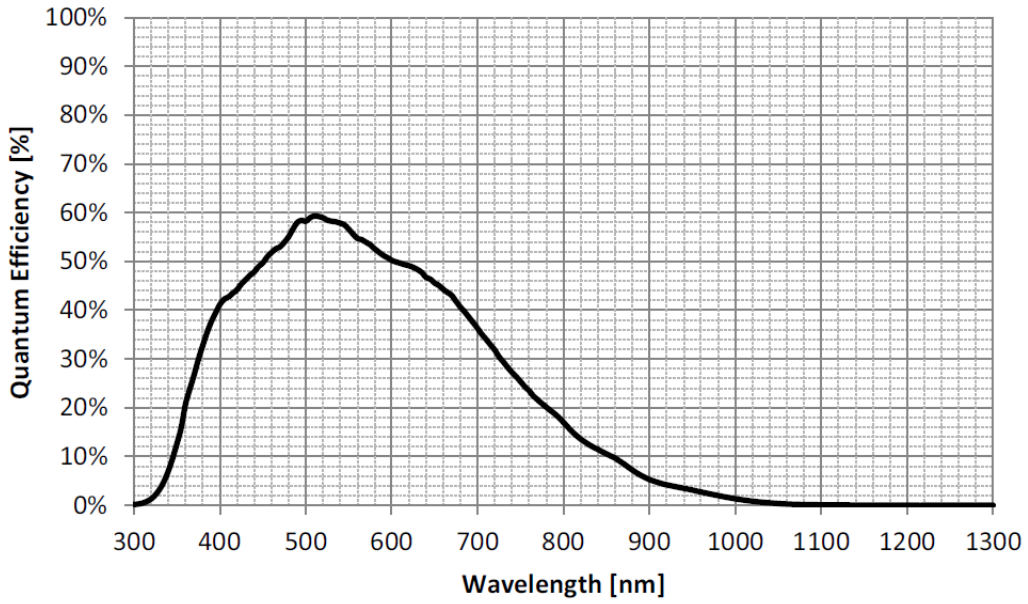
Sensor Specifications

- Full well charge: 5,400 e
- Sensitivity: 11,000 e/Lux/Sec
- Extremely low dark current: 0.1e/sec @ 0C, 13 e/sec @ 60C
- Extremely low dark random noise: 3.8e rms at @ 12dB.

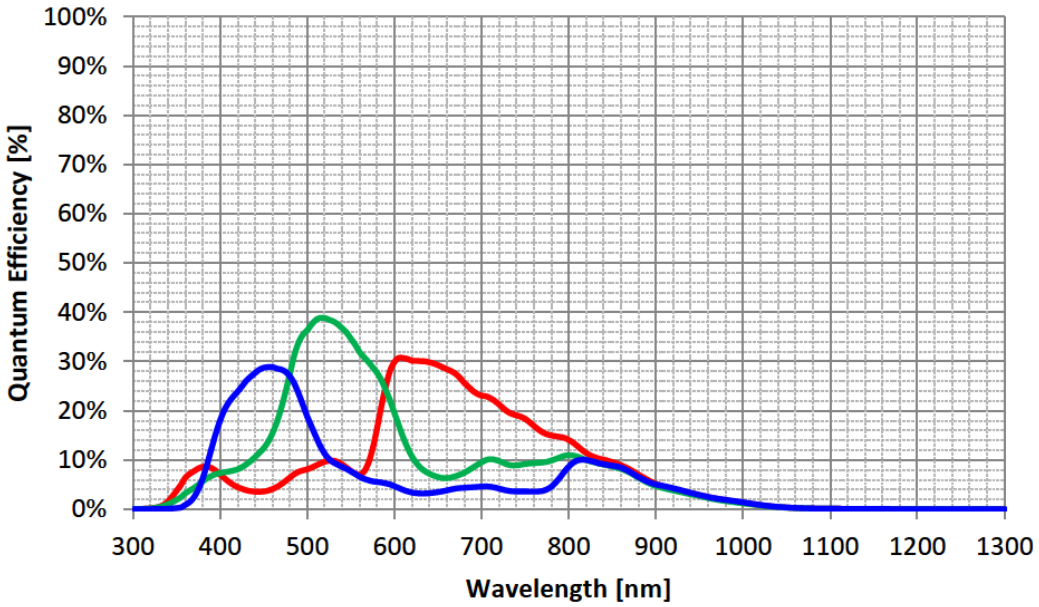
Sensor Operation

- CMOS rolling shutter
- Operating mode: 12 bit data readout
- Data Range: 10 bits centered within 12bits
- Internal data path: 12 bits
- Readout Speed: 2.4fps (limited by camera link data rate)

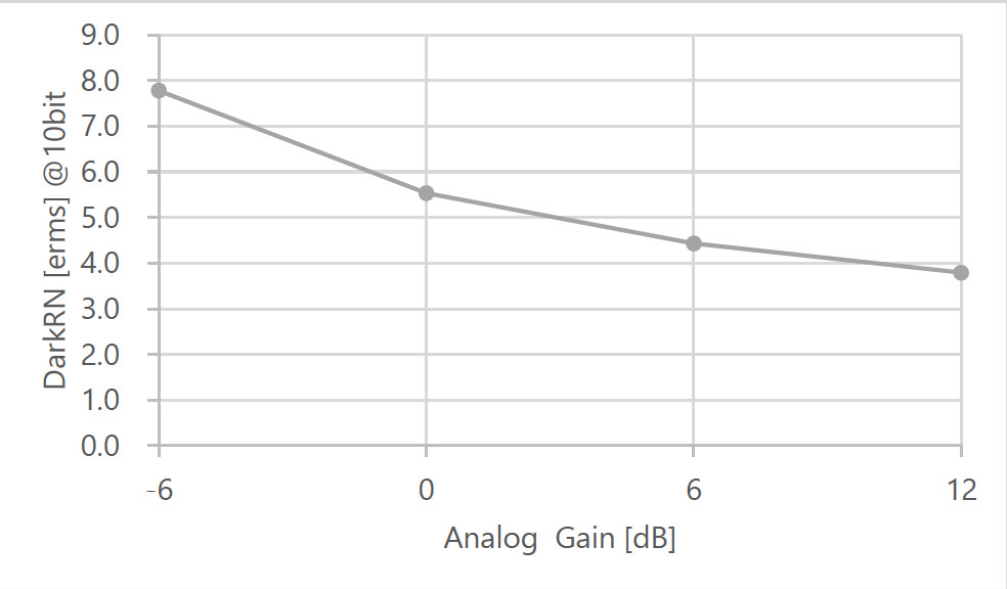
CMV-250 Sensor Pixel Response: Mono



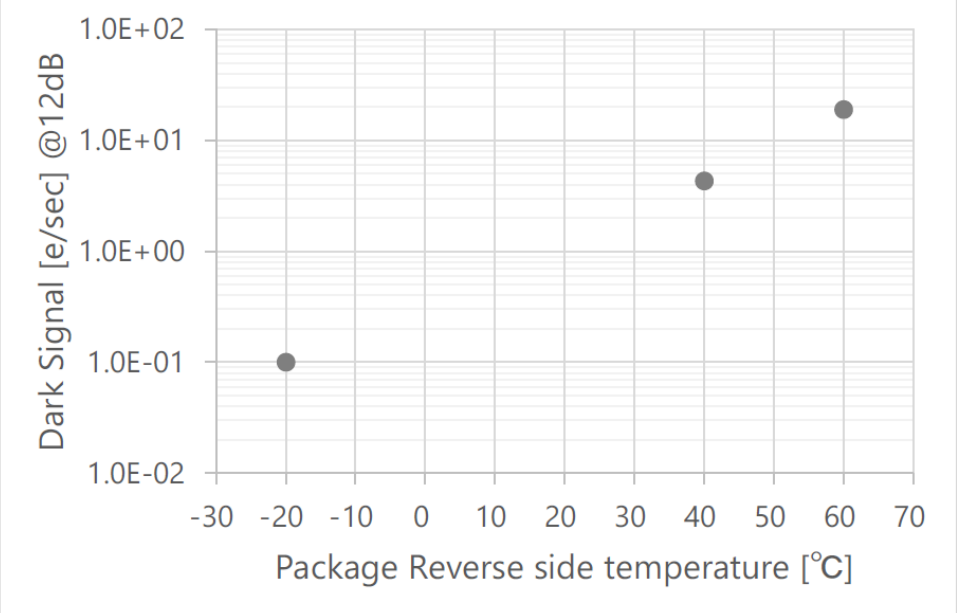
CMV-250 Sensor Pixel Response: RGB



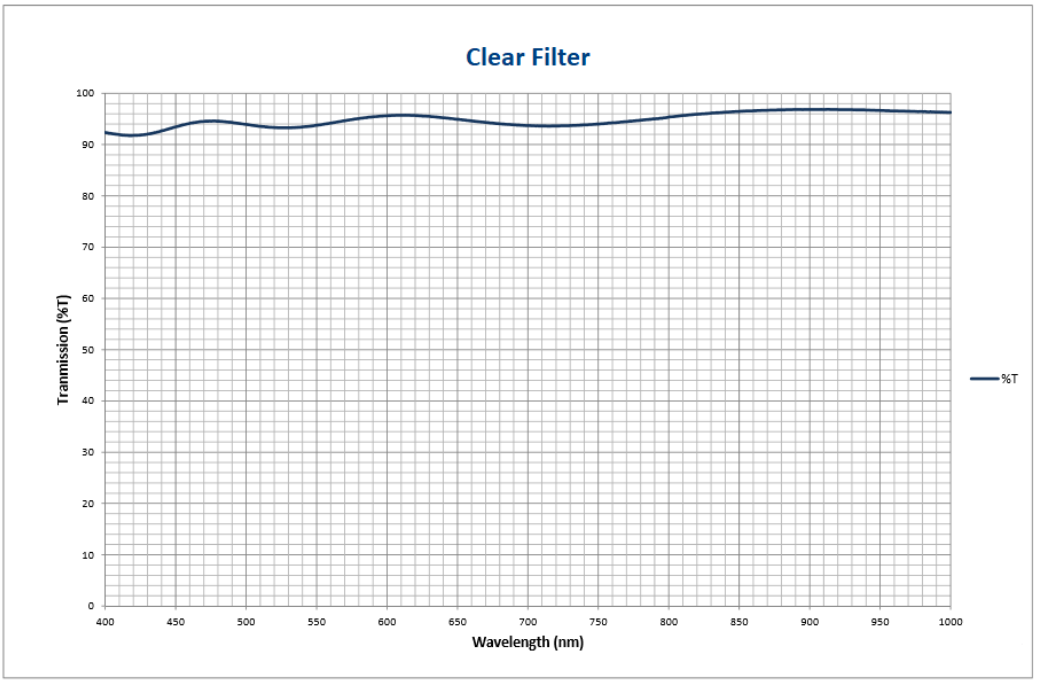
CMV-250 Sensor Dark Random Noise at Each Gain Setting



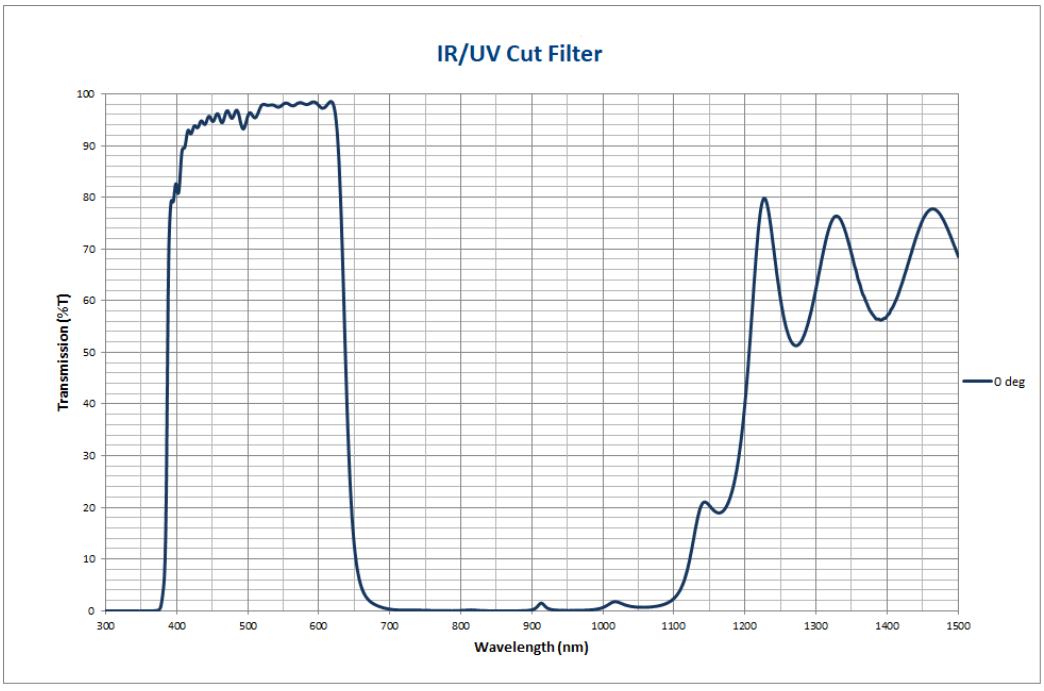
CMV-250 Sensor Dark Current at Each Temperature



CMV-250 Clear Filter response:



CMV-250 IR/UV Cut Filter response:



CMV-250 Sensor Imaging Characteristics

Evaluation results in 10bit All Pixel readout mode (5fps) at room temperature. (n=2)

Table 7-1. List of Imaging Characteristics

Item		Typ.	Unit	Remarks
Saturation		5,400	e-	@Analog gain -6dB
Sensitivity	Color Sensor LI8020SAC	4,600	e-/lx/sec	Green @Analog gain -6dB
	Monochrome Sensor LI8020SAM	11,000	e-/lx/sec	@Analog gain -6dB
Quantum Efficiency	Color Sensor LI8020SAC	39	%	Green Peak @wavelength 518 nm
		39	%	Green @wavelength 525nm
	Monochrome Sensor LI8020SAM	61	%	Peak @wavelength 513 nm
		60	%	@wavelength 525nm
Conversion Gain		0.1	LSB/e-	Charge Conversion Gain @Analog gain -6dB
Temporal Noise		3.8	e-rms	Dark RN*: Dark Random Noise @Analog gain 12dB
DSNU		1.3	e-rms	Dark Fixed-Pattern Noise @Analog gain 12dB
PRNU		1.6	%	Light Fixed-Pattern Noise @Analog gain -6dB

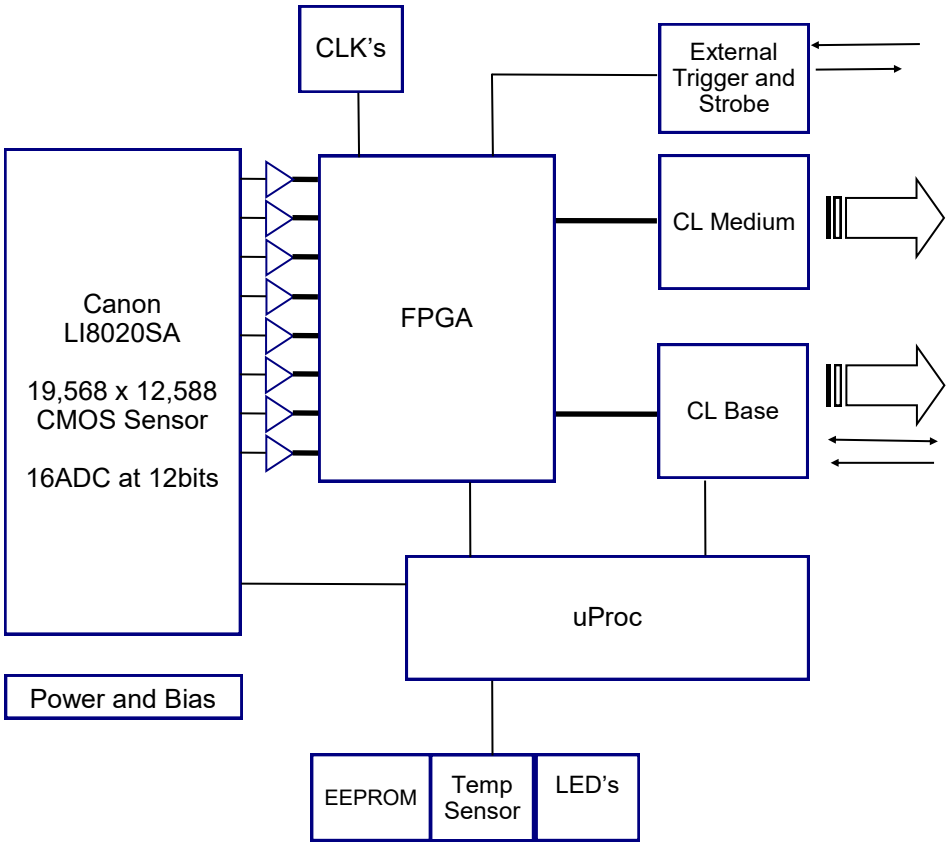
CMV-250 Sensor Pixel Defects:

Table 17-6. Pixel Defect Summary @10 bit

No.	Item Name	Conditions	Target Image	Limit		Unit
				Min.	Max.	
12	Light White Pixel Defect (Median)	Bright Field	LGT(-6dB) - Kuro	0	6000	Defects
13	Light Black Pixel Defect (Median)			0	6000	Defects
14	Total Pixel Defect (Major)	Dark Field, Bright Field	DARK1S(6dB), LGT(-6dB) - Kuro	0	26400	Defects
15	Total Pixel Defect (Minor)			0	52800	Defects
16	Cluster Defect 1			0	48	Defects
17	Cluster Defect 2			0	180	Defects
18	Cluster Defect A	Dark Field	DARK1S(6dB)	0	0	Defects
19	Cluster Defect B	Bright Field	LGT(-6dB) - Kuro	0	0	Defects
20	Cluster Defect C	Dark Field, Bright Field	DARK1S(6dB), LGT(-6dB) - Kuro	0	0	Defects

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

CMV-250 Camera Link output block diagram:



The sensor output data is 16 digital taps. Each tap is digitized with an analog to digital converter (ADC) with 12 bit precision.

The FPGA reorders the tap data into eight paths of pixels and outputs the pixels onto a Camera Link bus. The output data can be formatted to Camera Link Full Mode (8(8bit) pixels per clock) or Camera Link 80 Deca Mode (8 x10 bit) pixels per clock). The Camera Link interface includes trigger and serial communications.

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

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

Camera Link Overview

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 enables 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.

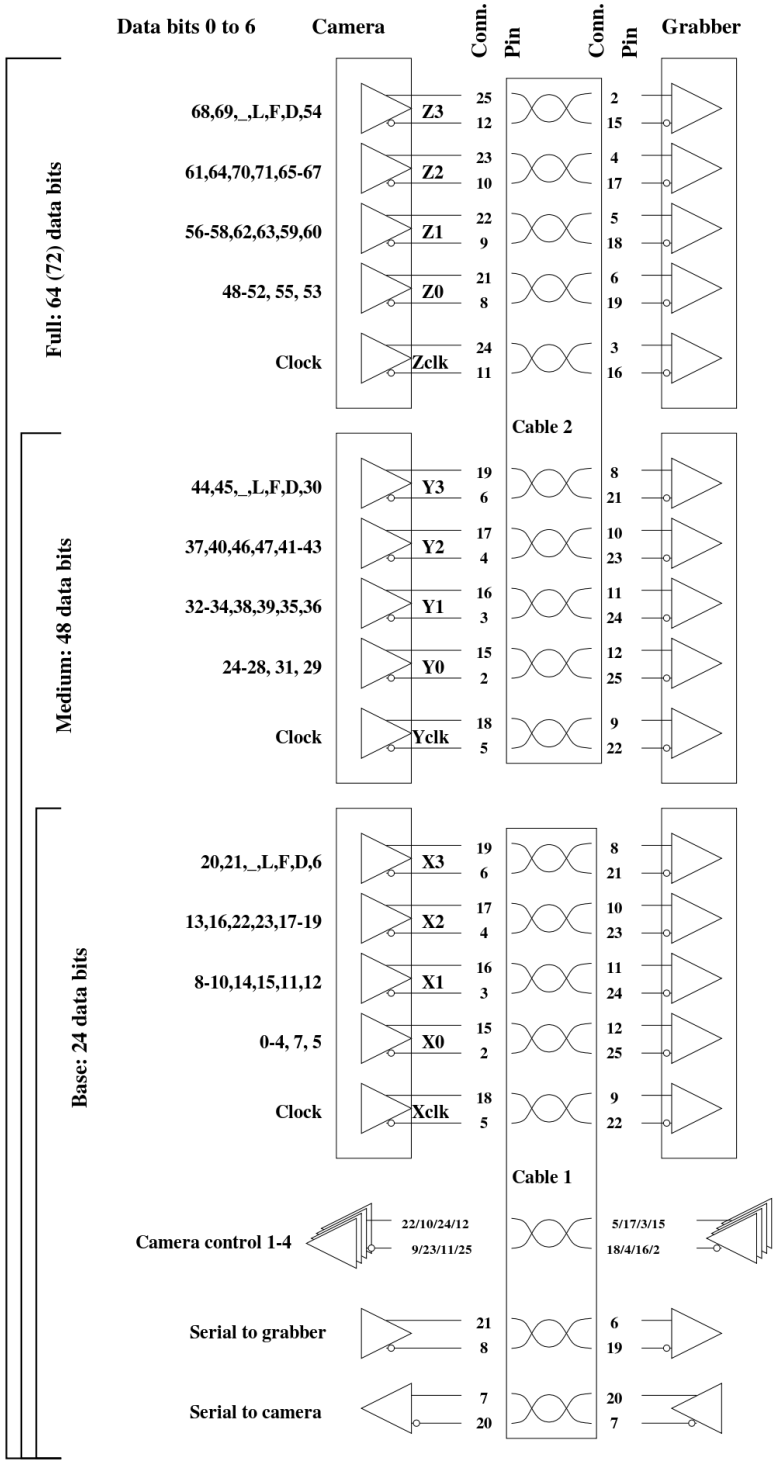
Four LVDS pairs are reserved for general purpose camera control. They are defined as camera inputs and frame grabber outputs. The signals are CC1, CC2, CC3, CC4. The CMV-250 uses CC1 as the trigger source.

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.
80bit Deca:	Three Channel Link chips, two cable connectors.

Note: CMV-250 can operate only in a **Full 8x8** or **Deca 8x10** Cameral Link configuration.

Camera Link


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

Pixel Format

The CMV-250 camera samples the sensor with 10 bit precision and processes the data throughout the FPGA at 12 bits.

During the data format stage, the 12 bit image data can be output as 10 or 8 bits. In addition, the bottom 8 bit data can be output as the top 8 (msb) of the 10 bit image sample.

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

Channel Format

The Camera Link Full Mode used on the CMV-250 camera, can transfer pixel data in 8 bit depths in 8 channels.

The Camera Link 80bit Deca Mode used on the CMV-250 camera, can transfer pixel data in 10 bit depths in 8 channels.

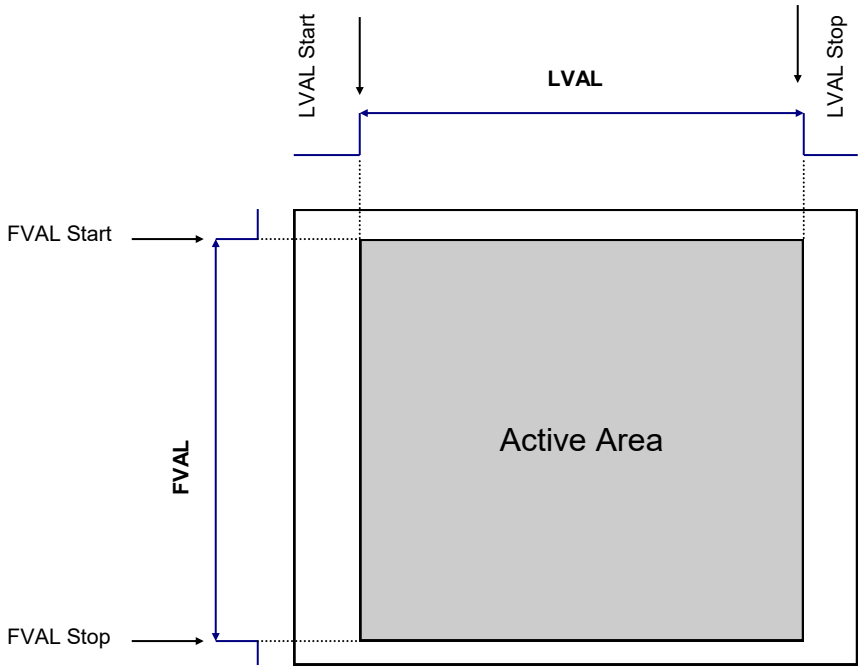
CMV-250 Frame Rate Table Camera Link:

Camera Link Mode	Cables	Bits/Pixel	Frame Rate
Camera Link Full	2	8x8	5.2
Camera Link Deca	2	8x10	5.2

Camera Link Raster Control

The CMV-250 camera samples and processes the entire area of the image sensor. In the standard operating mode, only the active image area is output on the Camera Link as valid data. The LVAL/FVAL signals, which define the valid pixel data, can be programmed to output any part of the image, including the optical black clamping areas. FVAL start/stop are specified in lines. LVAL start is x8 columns.

You must save the camera state to retain values.



Target	Index	Command	R/W	Description
0x04	0x60	0x0000	R/W	LVAL Start in x8 columns
0x04	0x61	0x0000	R/W	LVAL Stop in x8 columns
0x04	0x62	0x0000	R/W	FVAL Start
0x04	0x63	0x0000	R/W	FVAL Stop

See the section 'Serial Communication' for the use of these commands

Drawings and CAD Models:

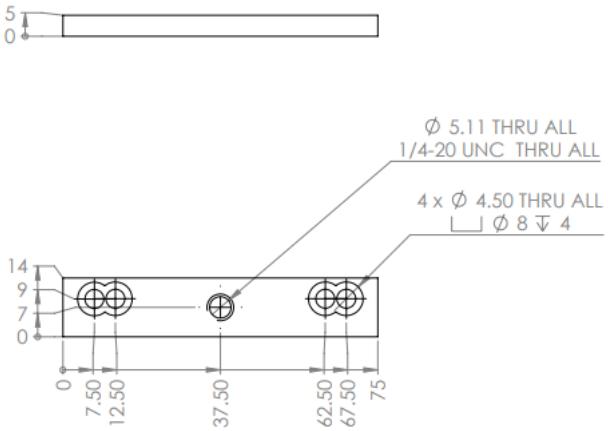
The CMV-250 case dimensions are available on the illunis web site under the camera and interface of interest. See the web page for the most current mechanical drawings.

CAD Models are available by request to info@illunis.com.

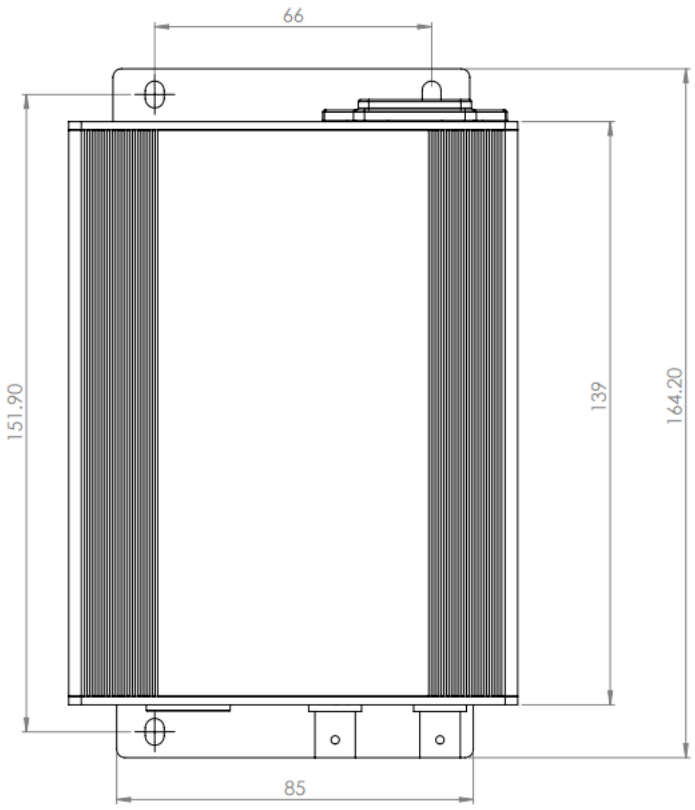
Lens Interfaces:

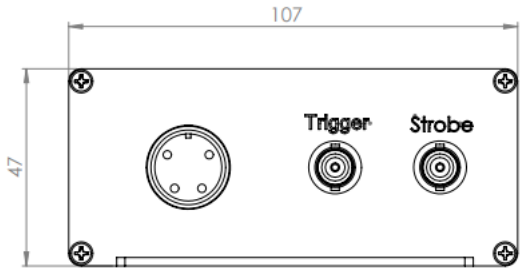
The CMV-250 base configuration for all data interfaces is an M58/OEM mount. Optional mounts include Nikon F, M72 and Canon EF.

Tripod Adapter



12V Universal Power Supply





The CMV-250 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 frame grabber to the CMV-250 is through the Camera Link cable. The Camera Link committee has specified that devices connected must first communicate at 9600 baud, but the CMV-250 has a selectable baud rate for faster communication speeds.

The CMV-250 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, 9600 baud.

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

Protocol

The CMV-250 camera is controlled through command packets. The CMV-250 camera is considered a slave device and never generates data without a read request. The data packet formatting is described in detail below. ***Note:*** the checksum is calculated only on the 4 ascii characters comprising the Data.

Data Packets

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

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

Start:

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

Command:

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

Target:

Command descriptor
Size = 2 ascii characters

Index:

Command descriptor
Size = 2 ascii characters

Data:

The data transferred
Size = 4 ascii characters

Checksum of Data

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

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

End:

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

Ack/Nack:

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

COMMAND DESCRIPTIONS

Read Command Structure

The CMV-250 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 CMV-250 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 CMV-250 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 CMV-250 camera micro-controller uses a hardware watchdog timer that will time out if the time between bytes are longer than 500ms. When sending command frames to the camera, the host must not have significant delays between bytes sent.

Camera Control

Target	Index	Description	Read Write	Modes
0x00	0x00	Bit Depth	R/W	0x0000 = 8x8 Full 0x0001 = 8x10 Deca
0x00	0x01	Exposure MS	R/W	Exposure in milliseconds.
0x00	0x03	Readout Mode	R/W	0x0000 = Free Run 0x0001 = Triggered Program Exposure (TPE) 0x0002 = Triggered Pulse Width Exposure (TME)
0x00	0x05	Exposure US	R/W	Exposure in microseconds Minimum trigger exposure 1000us.
0x00	0x04	Trigger pulse width scaling factor	R/W	Pulse width scale 0x0001 = 1x, 0x03E8 = 1000x
0x00	0x06	Trigger Polarity	R/W	0x0000 = Active Low 0x0001 = Active High
0x00	0x07	Test Pattern	R/W	0x0000 = Inactive 0x0001 = Input 0x0002 = Output 0x0003 = Sensor
0x00	0x08	Black Clamp Enable	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x09	Black Clamp Value	R/W	10bit dN space
0x00	0x0B	Trigger Source	R/W	0x0000 = Camera Link 0x0002 = Power Cable
0x00	0x0C	Software Trigger	W	Exposure in milliseconds
0x00	0x0C	Triggers missed	R	# of triggers ignored
0x00	0x0D	Strobe Status	R/W	BIT0 = manual Strobe EN BIT1 = Manual Strobe BIT2 = Strobe Polarity
0x00	0x0E	Strobe Delay	R/W	In milliseconds
0x00	0x0F	Strobe Duration	R/W	In milliseconds
0x00	0x12	Pure Black	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x50	Pixel Defect Correction	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x51	Shading Correction	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x52	Image Display	R/W	0x0000 = Inactive 0x0001 = Active
0x00	0x21	Analog Gain	R/W	0x0001 = 1.0x 0x0002 = 2.0x 0x0004 = 4.0x 0x0008 = 8.0x
0x00	0x41	Y Window Start	R/W	0 to 12,588
0x00	0x42	Y Window End	R/W	4 to 12,588
0x04	0xA0	Hot Pixel Corrector (HPC)	R/W	0x0000 = Inactive 0x0001 = Active
0x04	0xA1	**HPC** Type	R/W	0x0000 = Bayer 0x0001 = Mono
0x00	0x70	Brightness	R	Depends on image
0x00	0x71	Sharpness	R	Depends on image
0x00	0x72	Saturated pixels %	R	# = data / 100
0x00	0x73	Read Detectors	R	

Target	Index	Description	Read Write	Modes
0x00	0x60	Calculate Sensor Times	W	Internal operation generates data
0x00	0x61	Calculate SNR Values	W	Internal operation generates data
0x00	0x60	Well Depth (est)	R	Data in e-
0x00	0x61	Std Dev	R	Data * 100 in dN
0x00	0x62	DR	R	Data * 100 in dN
0x00	0x63	SNR	R	Data * 100 in dB
0x00	0x64	ENOB	R	Data in dN
0x00	0x65	Max Pixel	R	Data in dN
0x00	0x66	Trigger time	R	Data in ms Valid only in TME mode
0x00	0x67	Frames per second	R	Data * 100
0x00	0x68	Line time	R	Data * 100 in us
0x00	0x69	Frame time	R	Data in ms
0x00	0x6A	System Error	R	NOERROR 0 ERROR_BROWN_OUT 1 ERROR_WDT 2 ERROR_JTAG_UART 3 ERROR_SENSOR 4 ERROR_DATA_FLASH 5 ERROR_FPGA_CONFIG 6 ERROR_SPI_BIT 7 ERROR_EEPROM_BIT 8 ERROR_VOLTAGE 9 ERROR_I2C A ERROR_FFC B ERROR_POST F
0x00	0x6B	Sync Status LW	R	Any ‘1’ bits are error
0x00	0x6C	Sync Status HW	R	Any ‘1’ bits are error
0x00	0x6D	Pixel Clock Rate	R	Data * 100 Mhz
0x00	0x6E	Frame Count LW	R	Frame Counter (bottom 16 bits)
0x00	0x6F	Frame Count HW	R	Frame Counter (top 16 bits)
0x04	0x07	Internal Temperature	R	In Celsius (Signed Value)

Communication BAUD Rates

The Camera Link 1.0 specification allows for serial communication at 9600 baud only. The 1.1 specification (and later) provides for faster rates.

The CMV-250 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 CMV-250 camera allows the user the option of saving the communication speed in the camera EEPROM. This can cause communication with the camera to be lost if the command is not used carefully. ***Note:*** only one of the baud rates will be used so that if communication is lost it can be restored by trying the other baud rates.

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

Target	Index	Description	Read Write	Modes
0x04	0x09	Set Current Baud Rate	W	0x0000 = 9600 0x0001 = 19200 0x0002 = 38400 0x0003 = 57600 0x0004 = 115200 0x0005 = 230400 0x0006 = 460800 0x0007 = 921600
0x04	0xD2	Set Camera Link Boot Baud Rate (Requires reboot)	R/W	0x0000 = 9600 0x0001 = 19200 0x0002 = 38400 0x0003 = 57600 0x0004 = 115200 0x0005 = 230400 0x0006 = 460800 0x0007 = 921600
0xFF	0xFF	Power Up	W	Resets camera and powers up circuits

The Default Baud Rate of the CMV-250 is 115200 baud

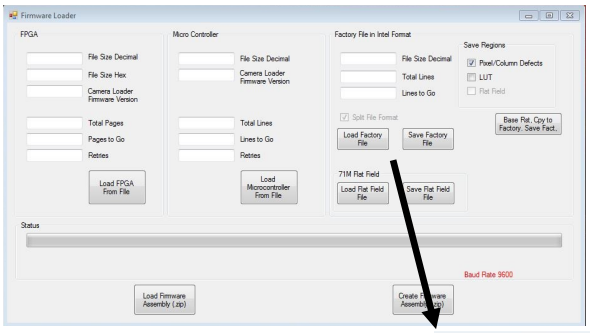
Backup/Restore

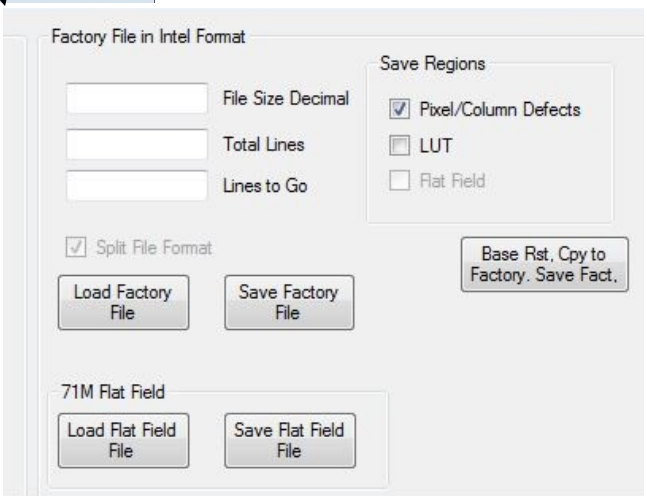
The CMV-250 camera control program provides features for saving and restoring the camera state. Please save the camera state before changing the default state of the camera.

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

1) Camera state with optional defect tables.
2) Flat Field Calibration data.

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.

Trigger and Strobe Timing

TPE Mode = Triggered Programmed Exposure (exposure is set in camera) In this mode the exposure sequence starts on the rising edge of the trigger pulse.

TME Mode = Triggered Manual Exposure (exposure is set with trigger pulse width)
In this mode the exposure is calculated from the trigger pulse width, then the exposure sequence is started on the falling edge of the trigger pulse (Since exposure and pulse width measurement can overlap, timing can be optimized for the fastest cycle time).

Triggers can be set active high or low in the application.

The strobe can be operated as

Manual (forced) mode = register sets strobe.
Programmed mode = registers define delay from trigger and duration in ms.

TPE Timing

Yellow = Trigger Sequence begins on rising edge of trigger.

Blue = Strobe Out (delay=0ms, strobe=100ms)

Green = Exposure and Readout

Red = NA

TME Timing

100ms Pulse Width

Yellow = **Trigger Sequence begins on falling edge of trigger.**

Blue = Strobe Out (delay = 0ms, Strobe = 100ms)

Green = Exposure and Readout (Debug signal)

Red = Exposure calculation from trigger pulse (Debug signal)

TME Timing

300ms Pulse Width

Yellow = **Trigger Sequence begins on falling edge of trigger.**

Blue = Strobe Out (delay = 0ms, Strb = 32ms)

Green = Exposure and Readout (Debug signal)

Red = Exposure calculation from trigger pulse (Debug signal)

TME Timing Optimization

Trigger pulse can be scaled to minimize timing overhead. For example set the trigger factor to 1000x and send a TME trigger pulse of 200us, the exposure is 200ms !

Trigger Timing

The CMV-250 is a rolling shutter sensor. Usually this type of sensor requires an exposure frame followed by a readout frame thus effectively reducing trigger timing to 1/2 of free run timing for short exposure.

The Canon sensors, used in the CMV-120 and CMV-250, require software communication to the sensor on every frame, this is used to instruct the sensor what mode operate in.

The CMV-250 exploits these modes to reduce the exposure frame time to the exposure itself. Thus increasing the triggered frame rate by up to 50% for very short exposures.

Because of the need for the software communication to the sensor, a minimum exposure time of 1ms is needed to allow for the commutation.

Firmware Update

CMV-250 firmware is updated using the illunis control application by following these steps:

(1) Update to the recommended control application.

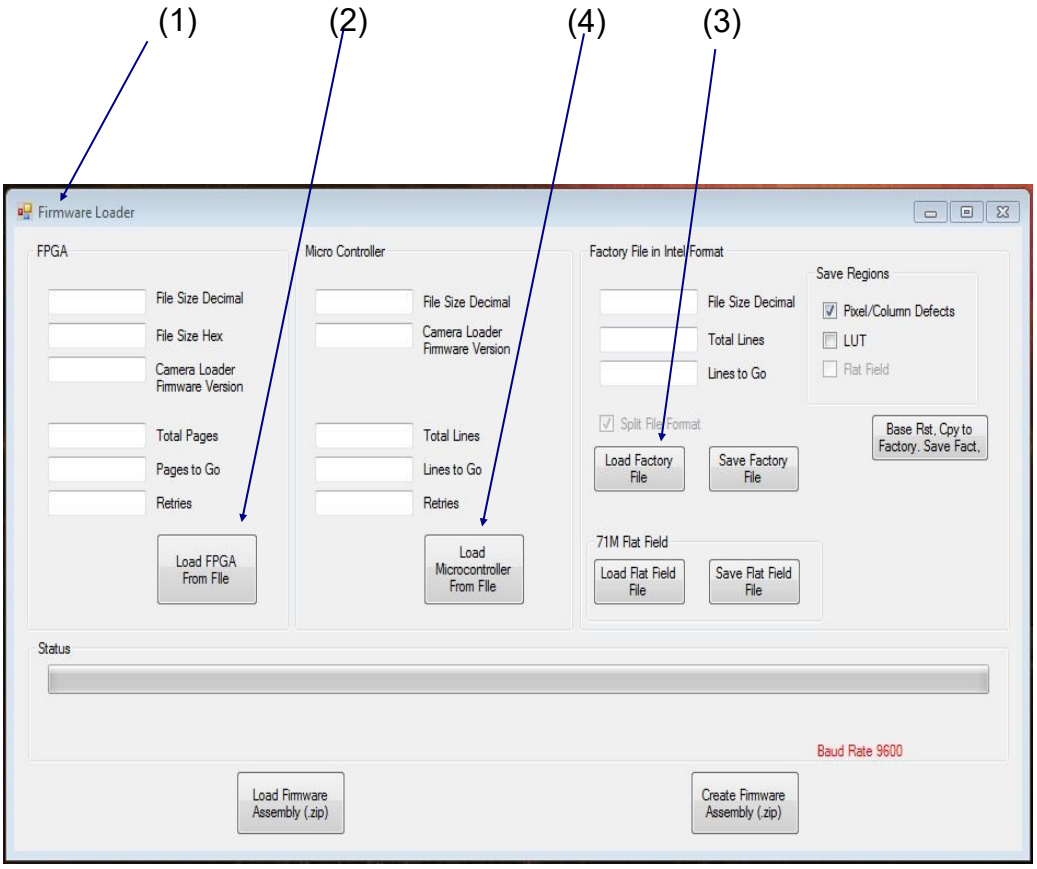
(2) Update the FPGA file with the ***.bin** file and the firmware loader dialog

(3) Update the EEPROM configuration with the ***.fca** file

(4) Update the microprocessor with the ***.hex** file

(5) Repower the camera, reopen the control app, reconfigure the camera settings.

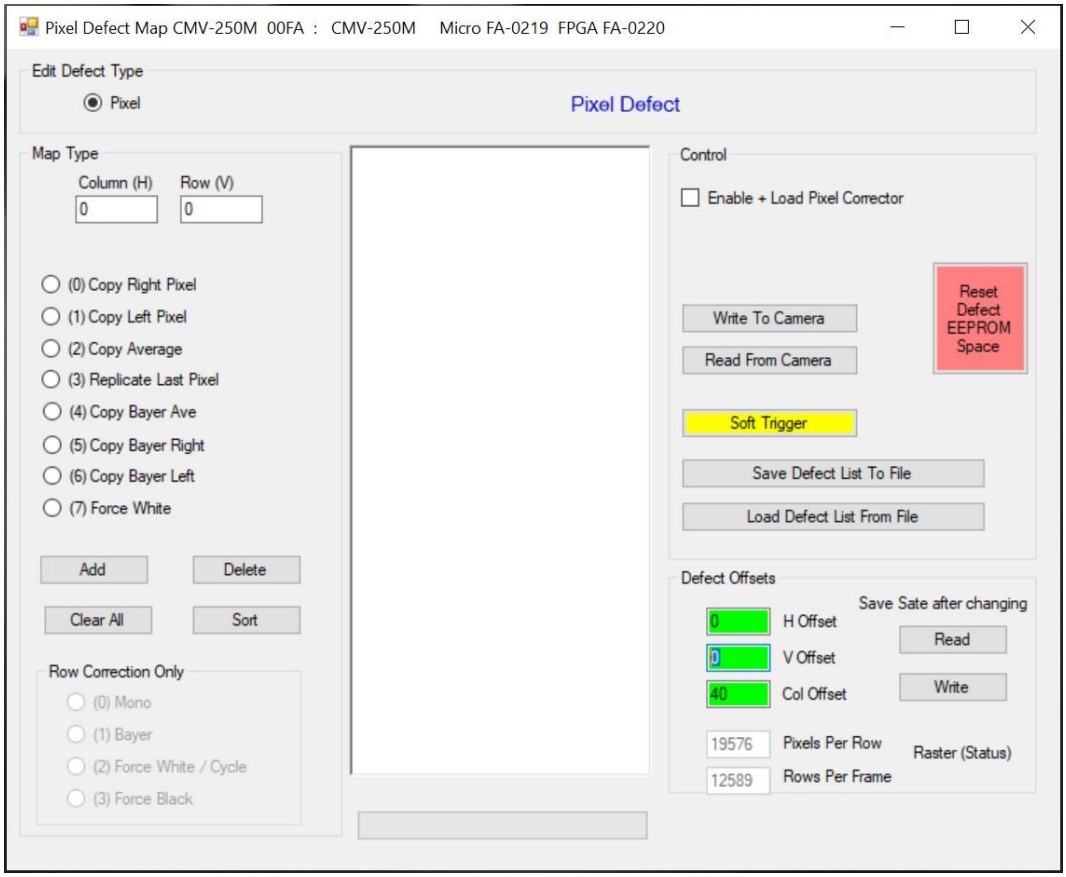
(6) If needed recalibrate the black offset and bright FFC.



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	Index	Description	Read Write	Modes
0x04	0x1c	Defect Correction (DC)	Write	0x0000 = Load/Enable Pixel DC 0x0001 = Load/Enable Column DC 0x000A = Load/Enable Row DC 0x0005 = Disable Pixel DC 0x0004 = Disable Column DC 0x000B = Disable Row DC



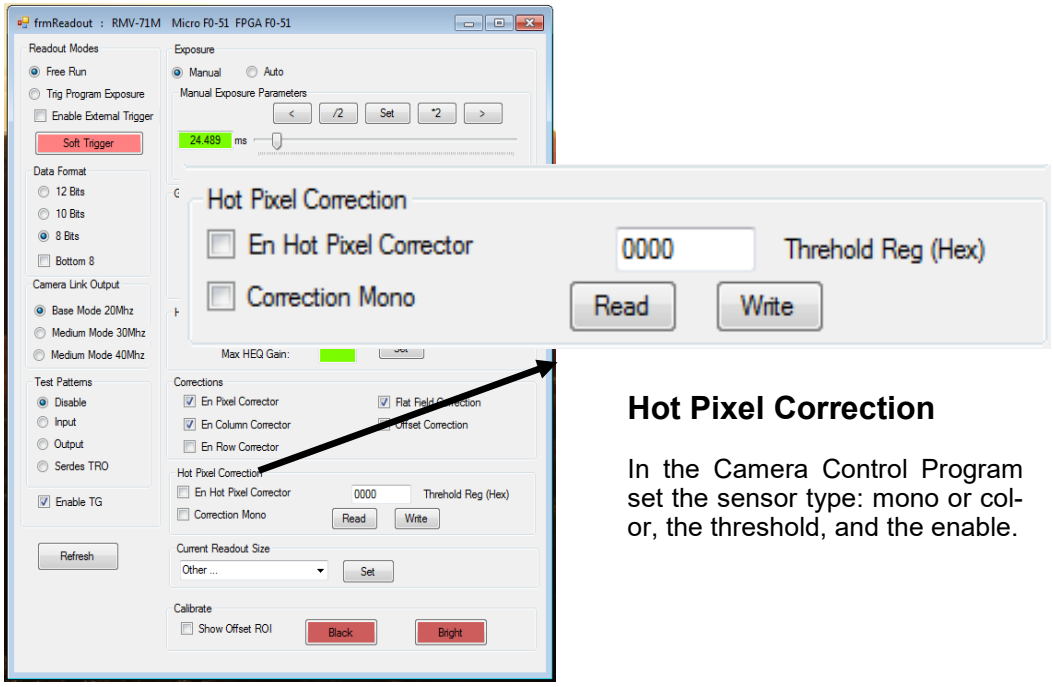
Hot Pixel Correction

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

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

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

Target	Index	Description	Read Write	Modes
0x04	0xA0	Hot Pixel Corrector	R/W	0x0000 = Disabled 0x0001 = Enabled
0x04	0xA1	Hot Pixel Correction Type	R/W	0x0000 = Color Bayer 0x0001 = Monochrome
0x04	0xA2	Hot Pixel Threshold	R/W	Threshold in dn Recommended > 0x0010 Bottom 4 bits are used. 10 bit range is (12:2)

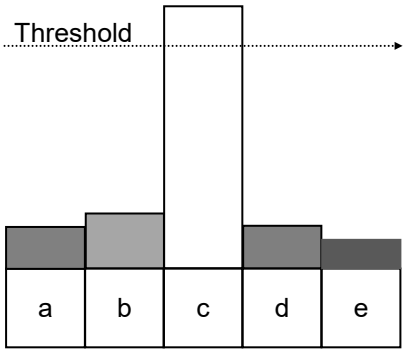


Hot Pixel Correction

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

Hot Pixel Correction

Simplified Correction Algorithm
For horizontal pixel data only



Mono Correction Algorithm

```
If(  ((Pix(c) - Pix(b))  > Threshold) AND
     ((Pix(c) - Pix(d))  > Threshold))
     Pix( c ) = (Pix(b) + Pix(d))/2;   // average
```

Bayer Correction Algorithm

```
If(  ((Pix(c) - Pix(a))  > Threshold) AND
     ((Pix(c) - Pix(e))  > Threshold))
     Pix( c ) = (Pix(a) + Pix(e))/2;   // average
```

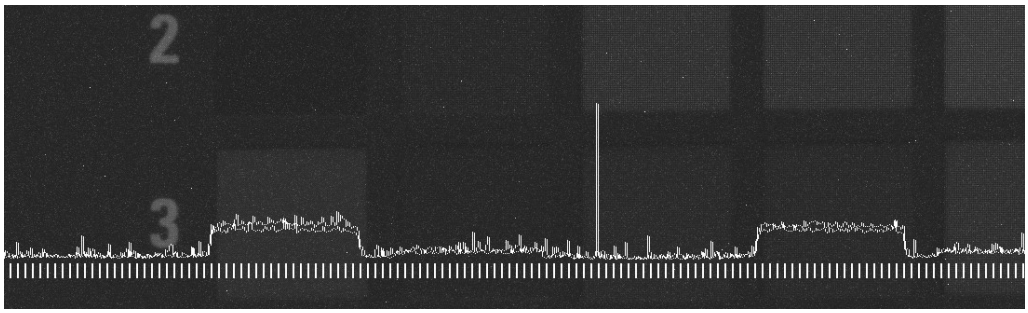


Image with Hot pixels

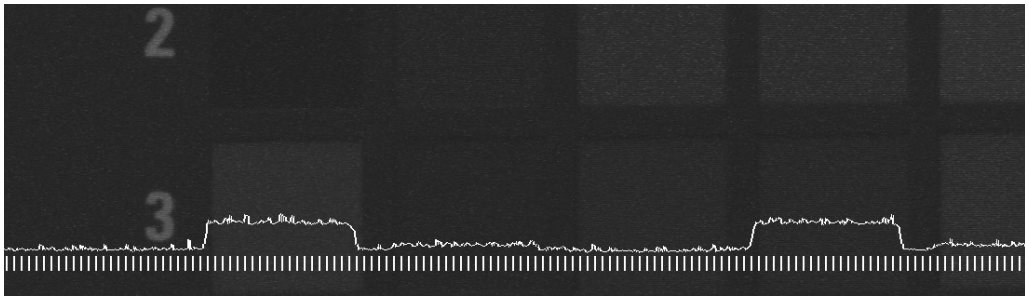


Image with Corrected Hot pixels

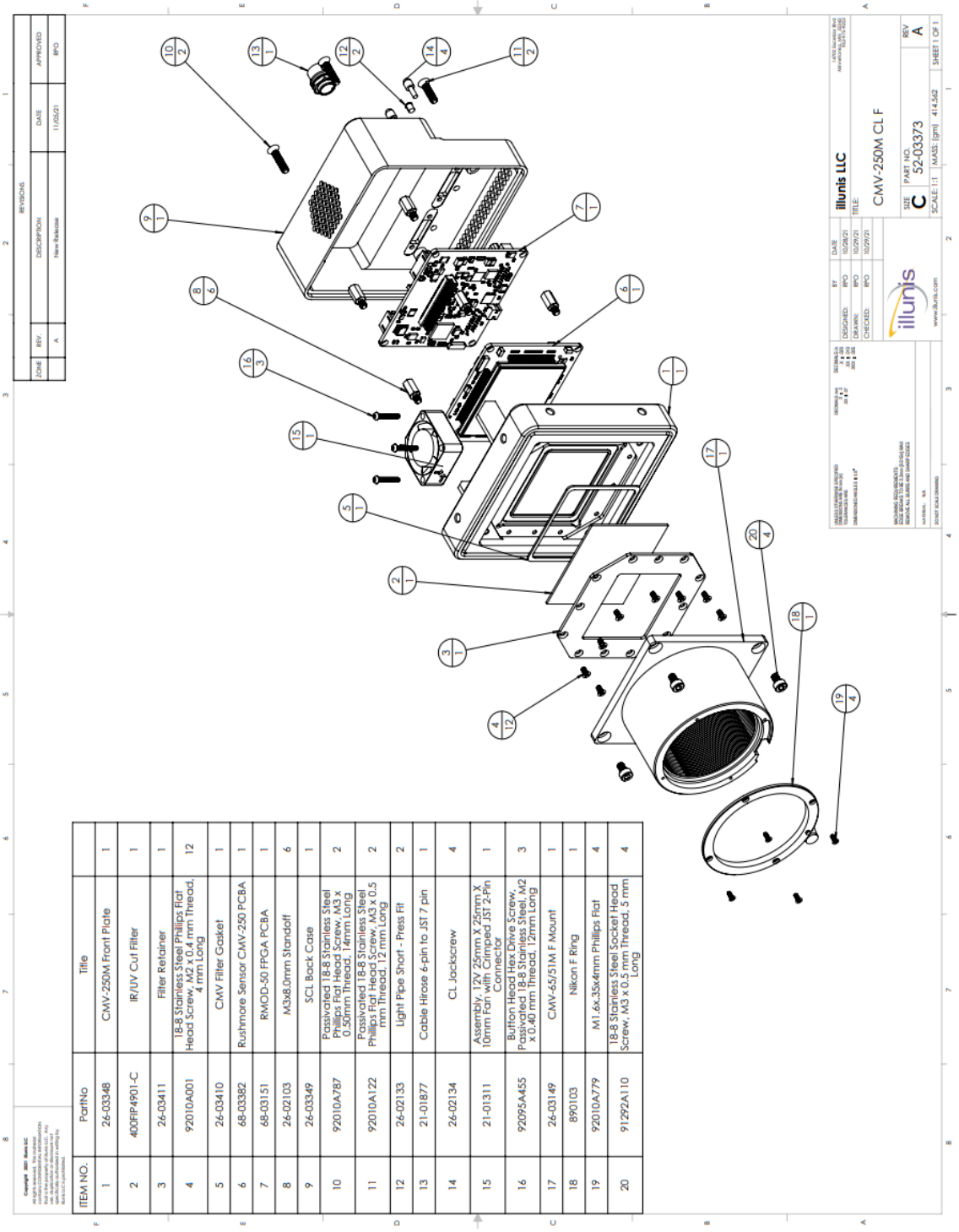
Long Exposures

The CMV-250 uses the Canon LI8020SA CMOS sensor. This sensor is implemented in a DLSR CMOS process with 1.5 µm pixels, and as such does perform as well as or better than CCD sensors with larger pixels. In particular the dark current performance is approximately 4.5x better than a typical Interline CCD sensor with 5.5µm pixels.

These are the recommended techniques to minimize the dark current:

1) Reduce the camera and sensor operating temperature.
2) Utilize a dark frame subtraction algorithm.
3) Break longer exposures into many short exposures, subtract a dark frame and sum the images.
4) Use the Hot Pixel Corrector feature.

Mechanical Exploded Drawing

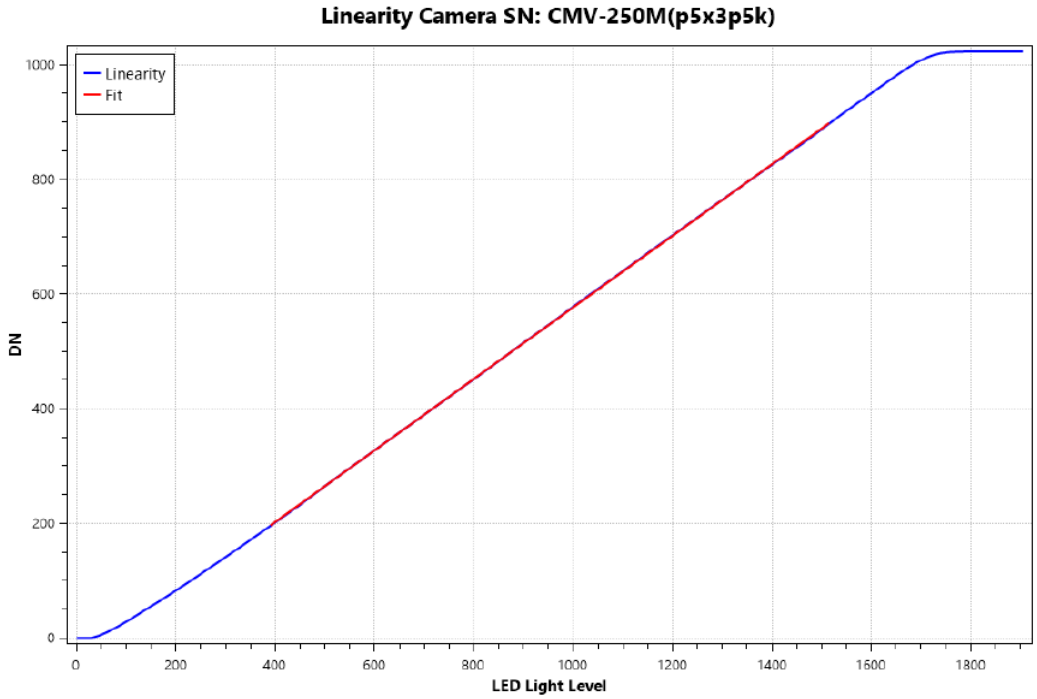


ITEM NO.	PartNo	Title	
1	26-03348	CMV-250M Front Plate	1
2	400FIP4901-C	IR/UV Cut Filter	1
3	26-03411	Filter Retainer	1
4	920110A001	18-8 Stainless Steel Phillips Flat Head Screw, M2 x 0.4 mm Thread, 4 mm Long	12
5	26-03410	CMV Filter Gasket	1
6	68-03382	Rushmore Sensor CMV-250 PCBA	1
7	68-03151	RMOD-50 FPGA PCBA	1
8	26-02103	M3x8.0mm Standoff	6
9	26-03349	SCL Back Case	1
10	920110A787	Passivated 18-8 Stainless Steel Phillips Flat Head Screw, M3 x 0.50mm Thread, 14mm Long	2
11	920110A122	Passivated 18-8 Stainless Steel Phillips Flat Head Screw, M3 x 0.5 mm Thread, 12 mm Long	2
12	26-02133	Light Pipe Short - Press Fit	2
13	21-01877	Cable Hirose 6-pin to JST 7 pin	1
14	26-02134	CL Jackscrew	4
15	21-01311	Assembly, 12V 25mm X 25mm X 10mm Fan with Crimped JST 2-Pin Connector	1
16	92095A455	Button Head Hex Drive Screw, Passivated 18-8 Stainless Steel, M2 x 0.40 mm Thread, 12mm Long	3
17	26-03149	CMV-65/51M F Mount	1
18	890103	Nikon F Ring	1
19	920110A779	M1.6x.35x4mm Phillips Flat	4
20	91292A110	18-8 Stainless Steel Socket Head Screw, M3 x 0.5 mm Thread, 5 mm Long	4

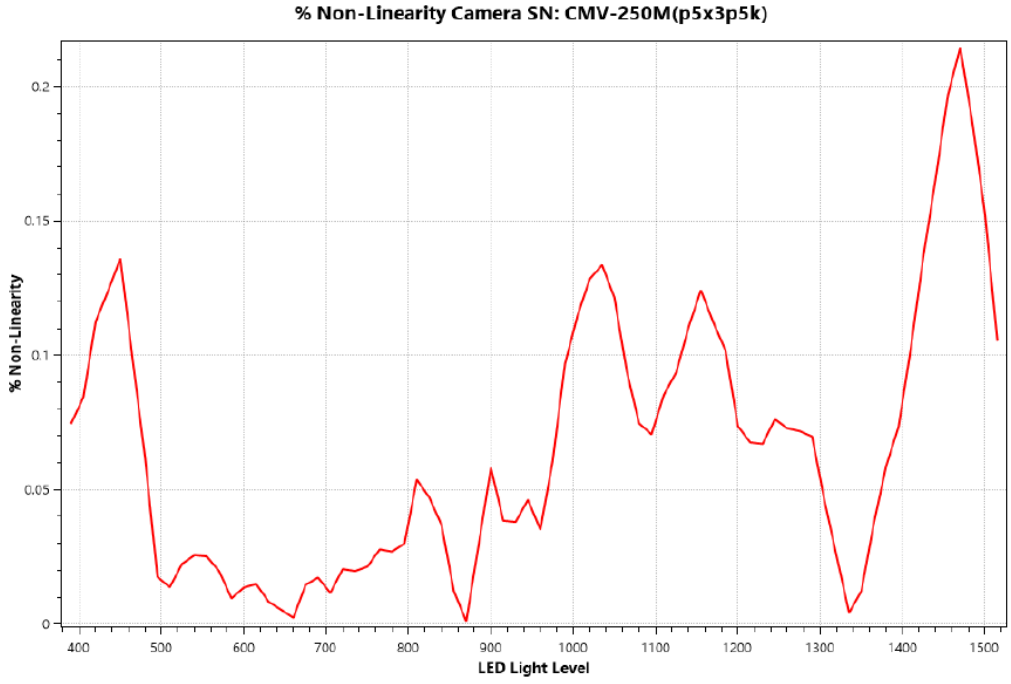
Performance Test

3/17/2022 1:56:00 PM CMV-250 Test Report illunis LLC

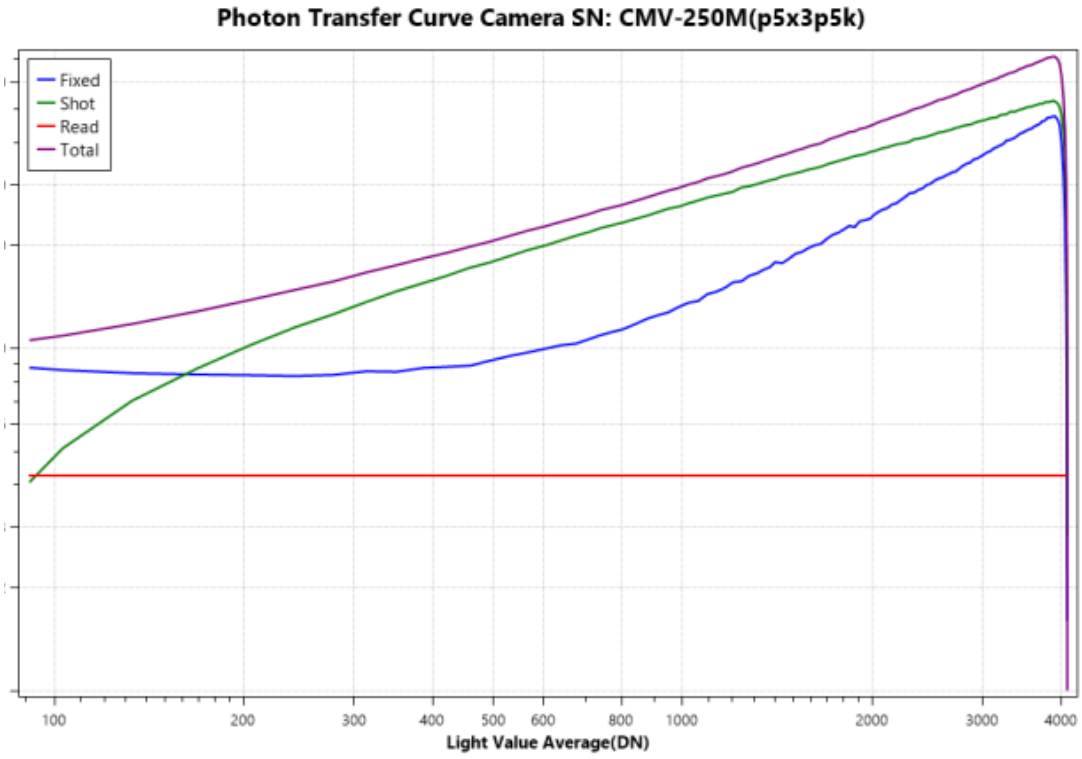
Test Summary	Value	Comments
Camera Model	CMV-250	Camera Tested
Serial Number	CMV-250M(p5x3p9k)	Camera Tested
Testing Date	3/17/2022 1:56:00 PM	Date of test
Clock Rate	56	As tested
Hardware Type	00FA	Illunis parameter
Bit Depth (bits)	10	Bit Depth of test
Defects Loaded	221 (1.2 per million)	
Defects Verified	6	Minimized
Camera Internal Temperature (°C)	40	As tested
Defect Test Level (DN)	600	Per Spec
Defect Test Dark Thresh (%) >= Avg + Thresh = Defect	19	Per Spec
Defect Test Bright Thresh (%) >= Avg +- Thresh = Defect	15%	Per Spec
Firmware Revisions	**Major**	**Minor**
Microcontroller Revision	00FA	021B
FPGA Revision	00FA	0222
C# Test Software Version	8	2
System Summary	**Value**	**Comments**
Full Well Capacity (e-)	5530	IEEE 1288
System Gain (e-/DN) Fit	1.35 (12bit equivalent)	IEEE 1288
Full Mean Value (DN)	1023	Verify Saturation
Dynamic Range (db)	59.7 (12bit equivalent)	Calculated from PTC
Read Noise (DN)	4.24 (12bit equivalent)	Calculated from PTC
Read Noise (e-)	5.72 (12bit equivalent)	Calculated from PTC
Effective Number of Bits	10.35	Calculated from PTC

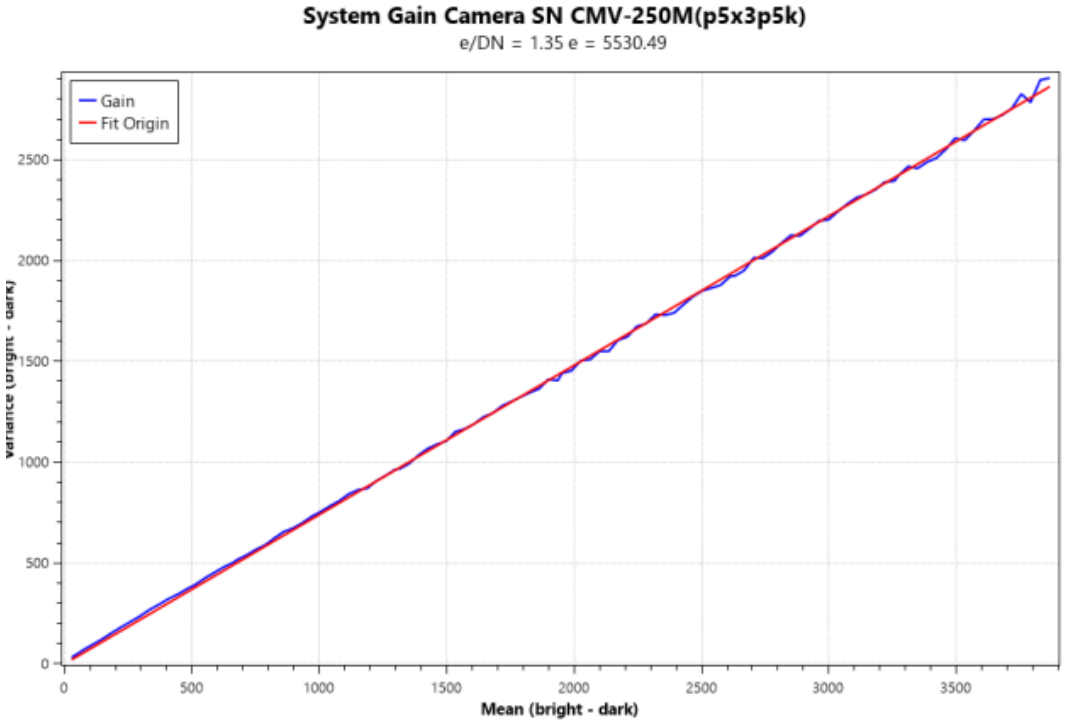


Linearity

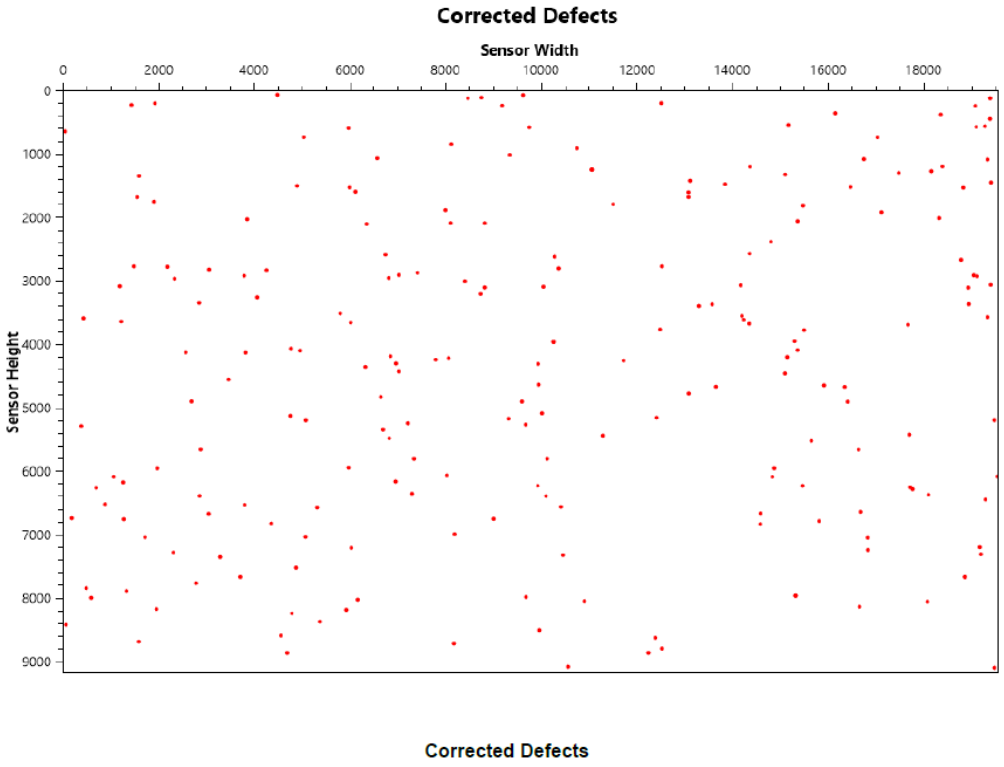


Percent Non-Linearity





Conversion Gain



Corrected Defects

CERTIFICATE OF CONFORMANCE

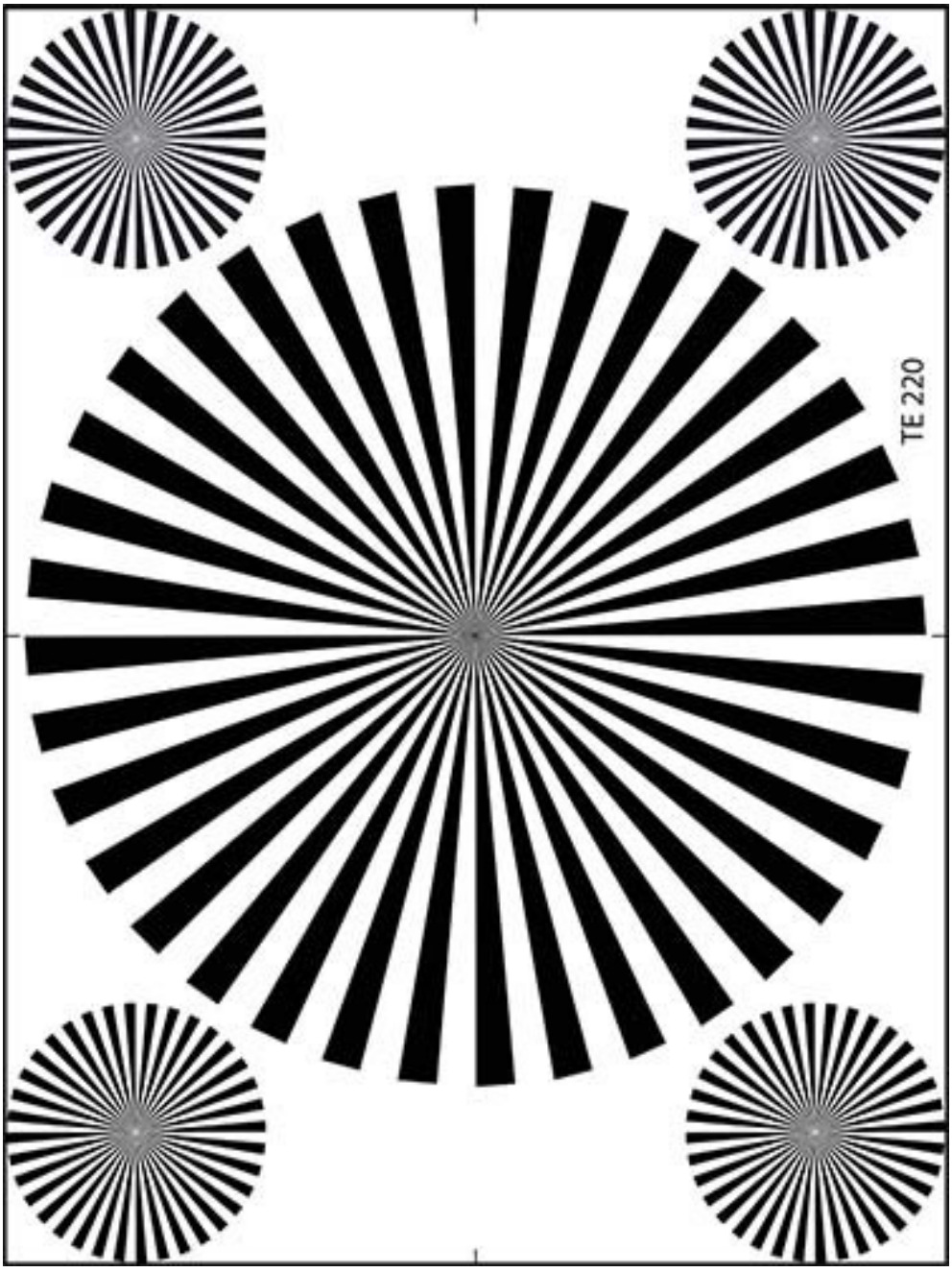
Unit Tested				
Camera Model	CMV-250			
Serial Number	CMV-250M(p5x3p9k)			
Camera Internal Temperature (°C)	40			
Microcontroller Revision Major/Minor	00FA	021B		
FPGA Revision Major/Minor	00FA	0222		
C# Test Software Version Major/Minor	8	2		

Firmware Rev Checks	Pass/Fail	Revision Expected
Microcontroller	Pass	00FA 021B
FPGA	Pass	00FA 0222

Performance Checks	Pass/Fail	Tolerance or Level
Internal Temperature	Pass	<47C
Dynamic Range (db)	Pass	±10%
Read Noise (e)	Pass	±10%
Percent Nonlinearity (%)	Pass	<2% 0%-80% full range
Data Path Checks		
Output TP CRC	Pass	Matches CRC in test file

CMOS Machine Vision

Advanced Digital Machine Vision Cameras



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