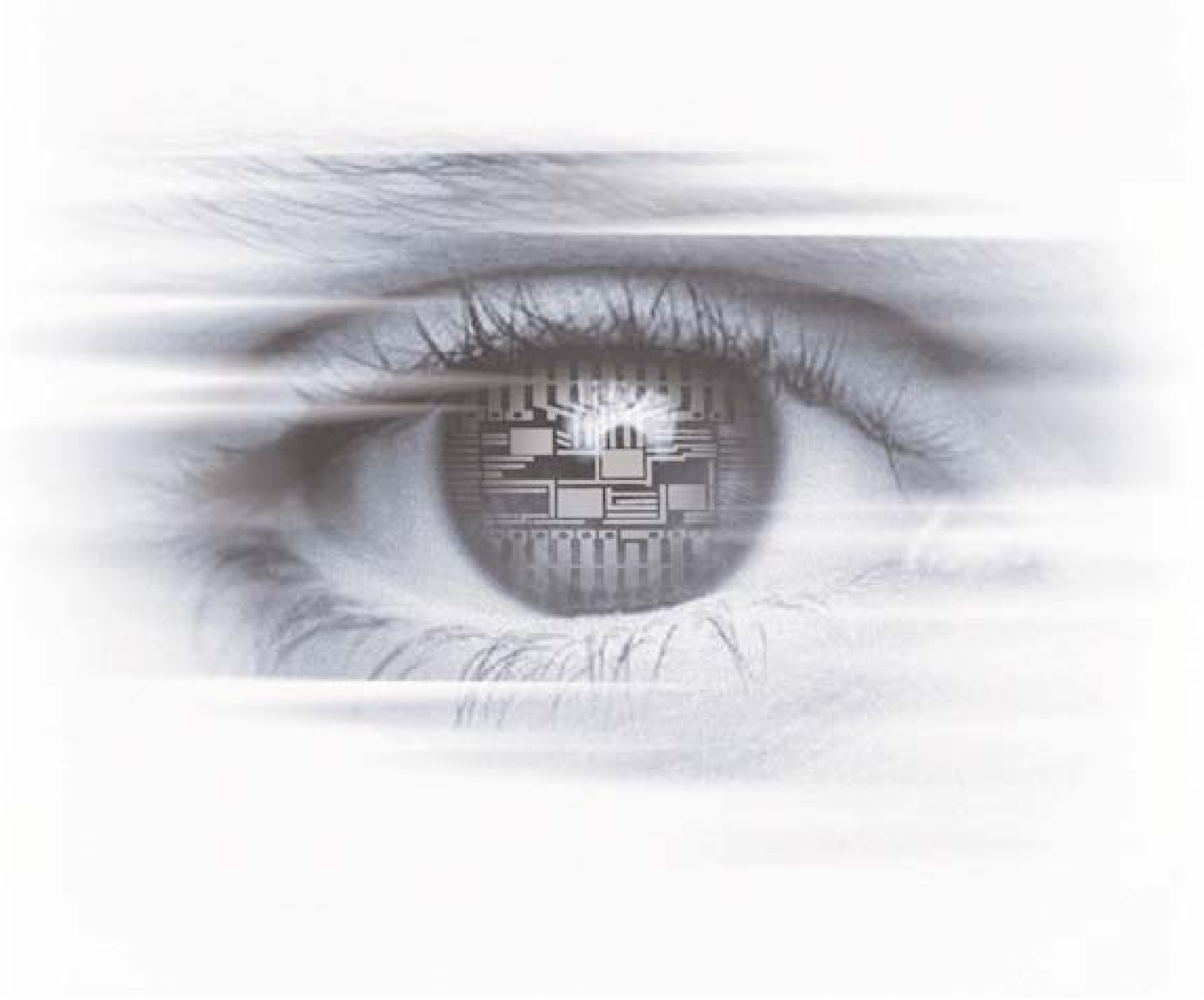
User Manual

MV1-D1312(I) CameraLink® Series

CMOS Area Scan Camera



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1 Preface

1.1 About Photonfocus

The Swiss company Photonfocus is one of the leading specialists in the development of CMOS image sensors and corresponding industrial cameras for machine vision, security & surveillance and automotive markets.
Photonfocus is dedicated to making the latest generation of CMOS technology commercially available. Active Pixel Sensor (APS) and global shutter technologies enable high speed and high dynamic range (120 dB) applications, while avoiding disadvantages like image lag, blooming and smear.
Photonfocus has proven that the image quality of modern CMOS sensors is now appropriate for demanding applications. Photonfocus' product range is complemented by custom design solutions in the area of camera electronics and CMOS image sensors.
Photonfocus is ISO 9001 certified. All products are produced with the latest techniques in order to ensure the highest degree of quality.

1.2 Contact

Photonfocus AG, Bahnhofplatz 10, CH-8853 Lachen SZ, Switzerland

Sales	Phone: +41 55 451 07 45	Email: sales@photonfocus.com
Support	Phone: +41 55 451 01 37	Email: support@photonfocus.com

Table 1.1: Photonfocus Contact

1.3 Sales Offices

Photonfocus products are available through an extensive international distribution network and through our key account managers. Details of the distributor nearest you and contacts to our key account managers can be found at www.photonfocus.com.

1.4 Further information

☞ Photonfocus reserves the right to make changes to its products and documentation without notice. Photonfocus products are neither intended nor certified for use in life support systems or in other critical systems. The use of Photonfocus products in such applications is prohibited.

Photonfocus can not be held responsible for any technical or typographical errors.

1.5 Legend

In this documentation the reader's attention is drawn to the following icons:

Important note

Alerts and additional information

Attention, critical warning

Notification, user guide

2

How to get started (CameraLink®)

1. Install a suitable frame grabber in your PC.

   To find a compliant frame grabber, please see the frame grabber compatibility list at www.photonfocus.com.

2. Install the frame grabber software.

   Without installed frame grabber software the camera configuration tool PFRemote will not be able to communicate with the camera. Please follow the instructions of the frame grabber supplier.

3. Remove the camera from its packaging. Please make sure the following items are included with your camera:

   - Power supply connector (7-pole power plug)
   - Camera body cap

   If any items are missing or damaged, please contact your dealership.

4. Remove the camera body cap from the camera and mount a suitable lens.

   When removing the camera body cap or when changing the lens, the camera should always be held with the opening facing downwards to prevent dust or debris falling onto the CMOS sensor.

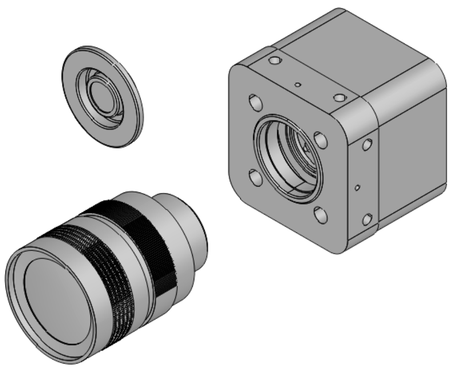

Figure 2.1: Camera with protective cap and lens.

Do not touch the sensor surface. Protect the image sensor from particles and dirt!

The sensor has no cover glass, therefore dust on the sensor surface may resemble to clusters or extended regions of dead pixel.

To choose a lens, see the Lens Finder in the 'Support' area at www.photonfocus.com.

5. Connect the camera to the frame grabber with a suitable CameraLink® cable (see Fig. 2.2). CameraLink® cables can be purchased from Photonfocus directly (www.photonfocus.com). Please note that Photonfocus provides appropriate solutions for your advanced vision applications.

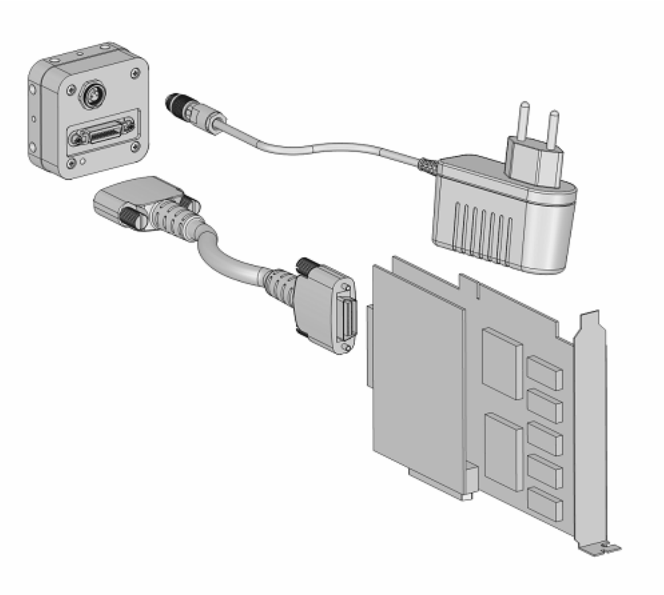

Figure 2.2: Camera with frame grabber, power supply and cable.

Do not connect or disconnect the CameraLink® cable while camera power is on! For more information about CameraLink® see Section 4.8.

6. Connect a suitable power supply to the provided 7-pole power plug. For the connector assembly see Fig. A.1. The pinout of the connector is shown in Appendix A.

Check the correct supply voltage and polarity! Do not exceed the maximum operating voltage of +12V DC ($\pm$ 10%).

7. Connect the power supply to the camera (see Fig. 2.2).

The status LED on the rear of the camera will light red for a short moment, and then flash green. For more information see Section 5.1.4.

8. Download the camera software PFRemote to your computer.

   You can find the latest version of PFRemote on the support page at www.photonfocus.com.

9. Install the camera software PFRemote. Please follow the instructions of the PFRemote setup wizard.

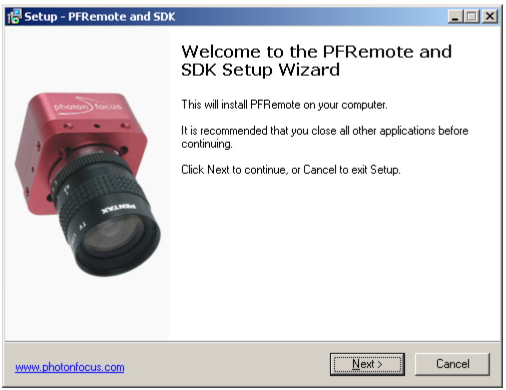

Figure 2.3: Screen shot PFremote setup wizard

10. Start the camera software PFRemote and choose the communication port.

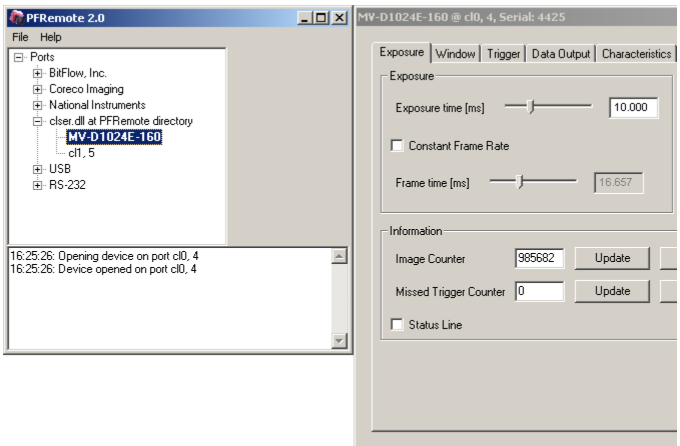

Figure 2.4: PFRemote start window

11. Check the status LED on the rear of the camera.

   The status LED lights green when an image is being produced, and it is red when serial communication is active. For more information see Section 5.1.4.

12. You may display images using the software that is provided by the frame grabber manufacturer.

3

Product Specification

3.1 Introduction

The MV1-D1312(I) CMOS camera series is built around the monochrome A1312(I) CMOS image sensor from Photonfocus, that provides a resolution of 1312 x 1082 pixels at a wide range of spectral sensitivity. It is aimed at standard applications in industrial image processing. The principal advantages are:

- Resolution of 1312 x 1082 pixels.
- Wide spectral sensitivity from 320 nm to 1030 nm.
- Enhanced near infrared (NIR) sensitivity with the A1312I CMOS image sensor.
- High quantum efficiency (> 50%).
- High pixel fill factor (> 60%).
- Superiour signal-to-noise ratio (SNR).
- Low power consumption at high speeds.
- Very high resistance to blooming.
- High dynamic range of up to 120 dB.
- Ideal for high speed applications: Global shutter.
- Greyscale resolution of up to 12 bit.
- On camera shading correction.
- 3x3 Convolver included on camera (not available on MV1-D1312-160-CL).
- Software provided for setting and storage of camera parameters.
- The camera has a digital CameraLink® interface.
- The compact size of 60 x 60 x 40 mm^3 make the MV1-D1312(I) CMOS cameras the perfect solution for applications in which space is at a premium.

The general specification and features of the camera are listed in the following sections.

3.2 Feature Overview

Characteristics	MV1-D1312(I) Series
Interfaces	CameraLink® base configuration
Camera Control	PFRemote (Windows GUI) or programming library
Configuration Interface	CLSERIAL (9’600 baud or 57’600 baud, user selectable)
Trigger Modes	Interface Trigger / External opto isolated trigger input
Features	Greyscale resolution 12 bit / 10 bit / 8 bit
	Region of Interest (ROI)
	Test pattern (LFSR and grey level ramp)
	Shading Correction (Offset and Gain)
	3x3 Convolver included on camera (not available on MV1-D1312-160-CL)
	High blooming resistance
	Opto isolated trigger input and opto isolated strobe output

Table 3.1: Feature overview (see Chapter 4 for more information)

Figure 3.1: MV1-D1312(I) CMOS camera series with C-mount lens.

3.3 Technical Specification

Technical Parameters	MV1-D1312(I) Series
Technology	CMOS active pixel (APS)
Scanning system	Progressive scan
Optical format / diagonal	1” (13.6 mm diagonal) @ maximum resolution
	2/3” (11.6 mm diagonal) @ 1024 x 1024 resolution
Resolution	1312 x 1082 pixels
Pixel size	8 μm x 8 μm
Active optical area	10.48 mm x 8.64 mm (maximum)
Random noise	< 0.3 DN @ 8 bit [1)]
Fixed pattern noise (FPN)	3.4 DN @ 8 bit / correction OFF [1)]
Fixed pattern noise (FPN)	< 1DN @ 8 bit / correction ON [1)2)]
Dark current	0.65 fA / pixel @ 27 °C
Full well capacity	~ 100 ke^{-}
Spectral range MV1-D1312	350 nm ... 980 nm (see Fig. 3.2)
Spectral range MV1-D1312I	350 nm ... 1100 nm (see Fig. 3.3)
Responsivity MV1-D1312	210 x10^{3} DN/(J/m^{2}) @ 625 nm / 8 bit
Responsivity MV1-D1312I	300 x10^{3} DN/(J/m^{2}) @ 850 nm / 8 bit
Quantum Efficiency	> 50 %
Optical fill factor	> 60 %
Dynamic range	Up to 120 dB
Colour format	Monochrome
Characteristic curve	Linear, LinLog®
Shutter mode	Global shutter
Greyscale resolution	12 bit / 10 bit / 8 bit

Table 3.2: General specification of the MV1-D1312(I) camera series (Footnotes: [1)] Indicated values are typical values. [2)] Indicated values are subject to confirmation.)

	MV1-D1312(I)-40	MV1-D1312(I)-80	MV1-D1312(I)-160
Exposure Time	10 μs ... 1.68 s	10 μs ... 1.68 s	10 μs ... 0.41 s
Exposure time increment	100 ns	50 ns	25 ns
Frame rate[3)] (T_{int} = 10 μs)	27 fps	54 fps	108 fps
Pixel clock frequency	40 MHz	40 MHz	80 MHz
Pixel clock cycle	25 ns	25 ns	12.5 ns
Camera taps	1	2	2
Read out mode	sequential or simultaneous		

Table 3.3: Model-specific parameters (Footnote: [3)]Maximum frame rate @ full resolution)

	MV1-D1312(I)-40	MV1-D1312(I)-80	MV1-D1312(I)-160
Operating temperature	0°C ... 50°C		
Camera power supply	+12 V DC ($\pm$ 10 %)		
Trigger signal input range	+5 .. +15 V DC		
Max. power consumption	< 2.5 W	< 3.0 W	< 3.3 W
Lens mount	C-Mount (CS-Mount optional)		
Dimensions	60 x 60 x 40 mm^3		
Mass	265 g		
Conformity	CE / RoHS / WEE		

Table 3.4: Physical characteristics and operating ranges

Fig. 3.2 shows the quantum efficiency and the responsivity of the A1312 CMOS sensor, displayed as a function of wavelength. For more information on photometric and radiometric measurements see the Photonfocus application notes AN006 and AN008 available in the support area of our website www.photonfocus.com.

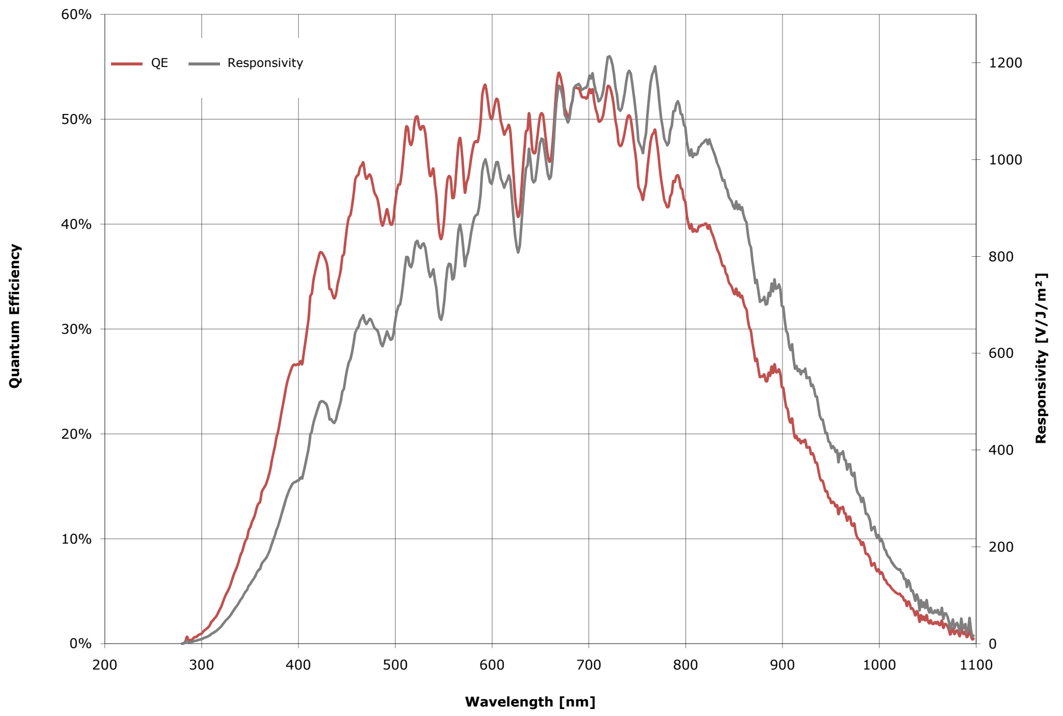

Figure 3.2: Spectral response of the A1312 CMOS image sensor (standard) in the MV1-D1312 camera series (Hint: the red-shiftet curve corresponds to the responsivity curve.)

Fig. 3.3 shows the quantum efficiency and the responsivity of the A1312I CMOS sensor, displayed as a function of wavelength.

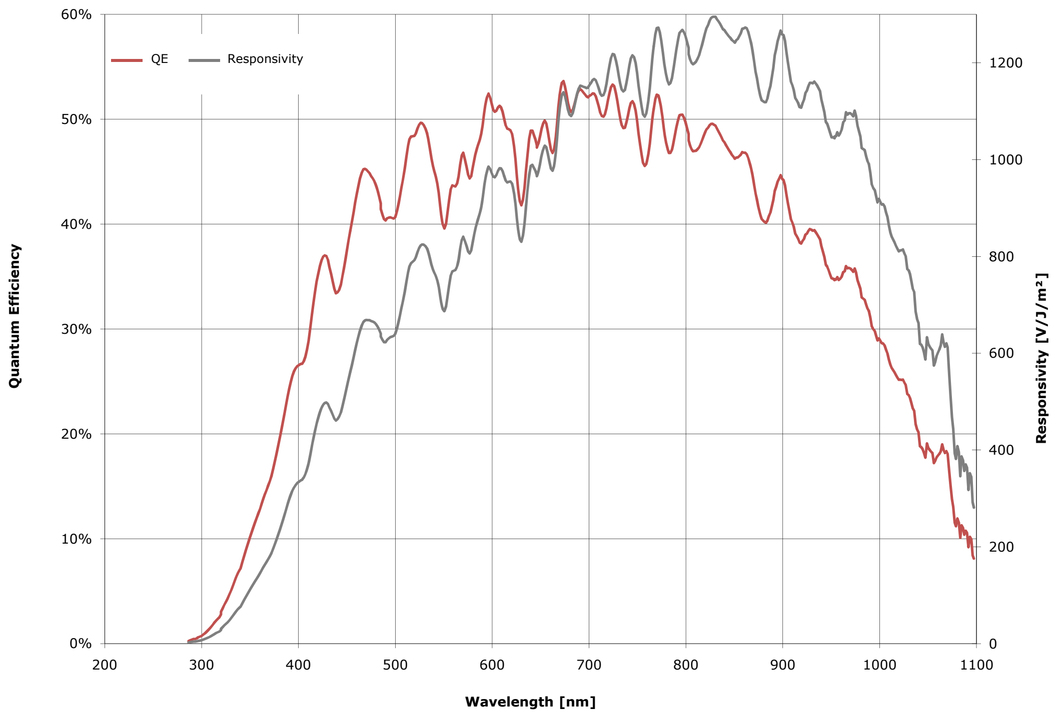

Figure 3.3: Spectral response of the A1312I image sensor (NIR) in the MV1-D1312I camera series (Hint: the red-shiftet curve corresponds to the responsivity curve.)

3.4 Frame Grabber relevant Configuration

The parameters and settings, which are essential to configure the frame grabber are shown in the following table. The timing diagrams of the camera are given in Section 5.3.

	MV1-D1312(I)-40	**MV1-D1312(I)-80**	**MV1-D1312(I)-160**
Pixel Clock per Tap	40 MHz	40 MHz	80 MHz
Number of Taps	1	2	2
Greyscale resolution	12 bit / 10 bit / 8 bit	12 bit / 10 bit / 8 bit	12 bit / 10 bit / 8 bit
Line pause	36 clock cycles	18 clock cycles	18 clock cycles
CC1	EXSYNC	EXSYNC	EXSYNC
CC2	not used	not used	not used
CC3	not used	not used	not used
CC4	not used	not used	not used

Table 3.5: Summary of parameters needed for frame grabber configuration

CameraLink® port and bit assignments are compliant with the CameraLink® standard (see [CL]).

Bit	Tap 0	Tap 0	Tap 0
	8 Bit	10 Bit	12 Bit
0 (LSB)	A0	A0	A0
1	A1	A1	A1
2	A2	A2	A2
3	A3	A3	A3
4	A4	A4	A4
5	A5	A5	A5
6	A6	A6	A6
7 (MSB of 8 Bit)	A7	A7	A7
8	-	B0	B0
9 (MSB of 10 Bit)	-	B1	B1
10	-	-	B2
11 (MSB of 12 Bit)	-	-	B3

Table 3.6: CameraLink® 1 Tap port and bit assignments for the MV1-D1312(I)-40 camera

Bit	Tap 0	Tap 1	Tap 0	Tap 1	Tap 0	Tap 1
	8 Bit	8 Bit	10 Bit	10 Bit	12 Bit	12 Bit
0 (LSB)	A0	B0	A0	C0	A0	C0
1	A1	B1	A1	C1	A1	C1
2	A2	B2	A2	C2	A2	C2
3	A3	B3	A3	C3	A3	C3
4	A4	B4	A4	C4	A4	C4
5	A5	B5	A5	C5	A5	C5
6	A6	B6	A6	C6	A6	C6
7 (MSB of 8 Bit)	A7	B7	A7	C7	A7	C7
8	-	-	B0	B4	B0	B4
9 (MSB of 10 Bit)	-	-	B1	B5	B1	B5
10	-	-	-	-	B2	B6
11 (MSB of 12 Bit)	-	-	-	-	B3	B7

Table 3.7: CameraLink® 2 Tap port and bit assignments for the MV1-D1312(I)-80 camera and for the MV1-D1312(I)-160 camera

4

Functionality

This chapter serves as an overview of the camera configuration modes and explains camera features. The goal is to describe what can be done with the camera. The setup of the MV1-D1312(I) series cameras is explained in later chapters.

4.1 Image Acquisition

4.1.1 Free-running and Trigger Mode

The MV1-D1312(I) CMOS cameras provide two different readout modes:

Sequential readout Frame time is the sum of exposure time and readout time. Exposure time of the next image can only start if the readout time of the current image is finished.

Simultaneous readout (interleave) The frame time is determined by the maximum of the exposure time or of the readout time, which ever of both is the longer one. Exposure time of the next image can start during the readout time of the current image.

	MV1-D1312(I) Series
Sequential readout	available
Simultaneous readout	available

Table 4.1: Readout mode of MV1-D1312 Series camera

The following figure illustrates the effect on the frame rate when using either the sequential readout mode or the simultaneous readout mode (interleave exposure).

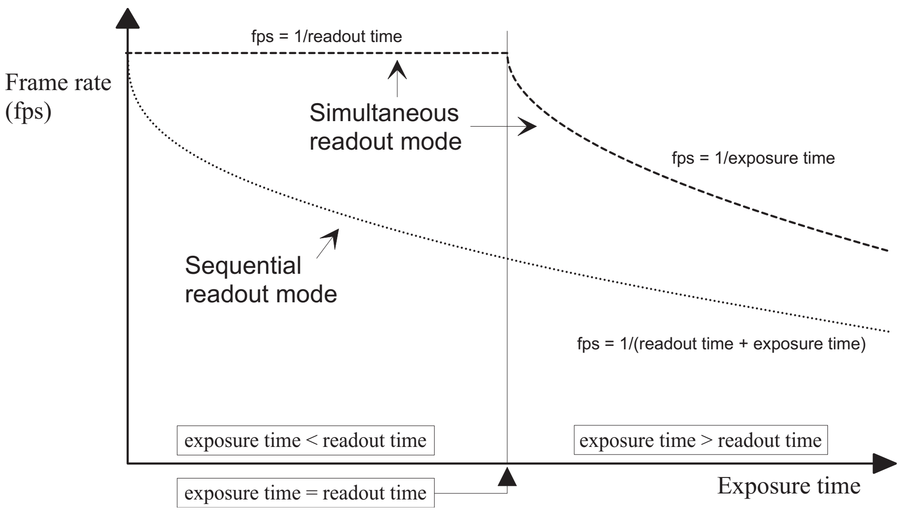

Figure 4.1: Frame rate in sequential readout mode and simultaneous readout mode

Sequential readout mode For the calculation of the frame rate only a single formula applies: frames per second equal to the invers of the sum of exposure time and readout time.

Simultaneous readout mode (exposure time < readout time) The frame rate is given by the readout time. Frames per second equal to the invers of the readout time.

Simultaneous readout mode (exposure time > readout time) The frame rate is given by the exposure time. Frames per second equal to the invers of the exposure time.

The simultaneous readout mode allows higher frame rate. However, if the exposure time strongly exceeds the readout time, then the effect on the frame rate is neglectable.

In simultaneous readout mode image output faces minor limitations. The overall linear sensor reponse is partially restricted in the lower grey scale region.

When changing readout mode from sequential to simultaneous readout mode or vice versa, new settings of the BlackLevelOffset and of the image correction are required.

Sequential readout

By default the camera continuously delivers images as fast as possible ("Free-running mode") in the sequential readout mode. Exposure time of the next image can only start if the readout time of the current image is finished.

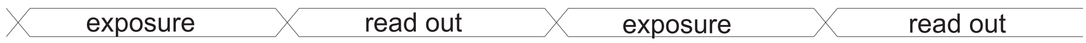

Figure 4.2: Timing in free-running sequential readout mode

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 4.6 and to Section 5.4). In this mode, the camera is idle until it gets a signal to capture an image.

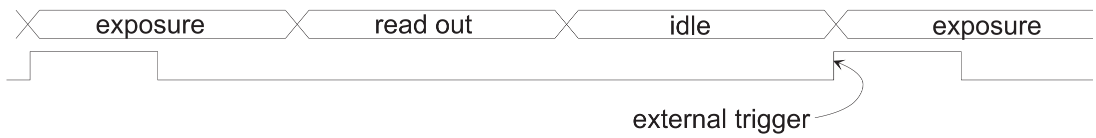

Figure 4.3: Timing in triggered sequential readout mode

Simultaneous readout (interleave exposure)

To achieve highest possible frame rates, the camera must be set to "Free-running mode" with simultaneous readout. The camera continuously delivers images as fast as possible. Exposure time of the next image can start during the readout time of the current image.

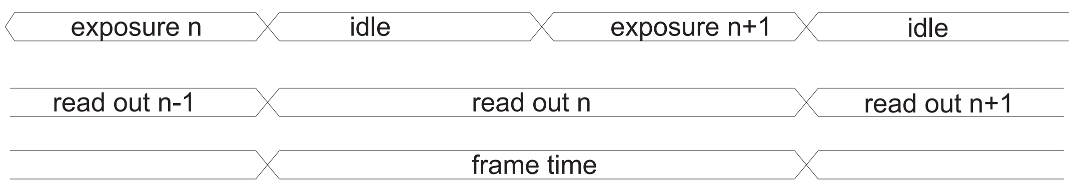

Figure 4.4: Timing in free-running simultaneous readout mode (readout time> exposure time)

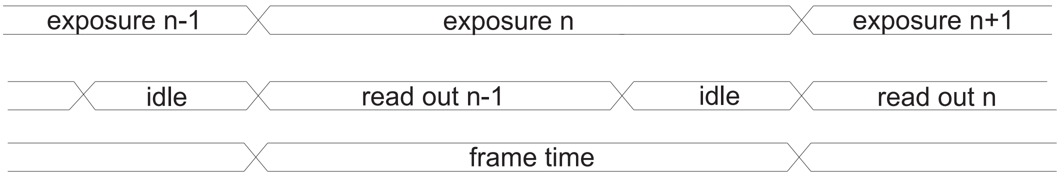

Figure 4.5: Timing in free-running simultaneous readout mode (readout time< exposure time)

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 4.6 and to Section 5.4). In this mode, the camera is idle until it gets a signal to capture an image.

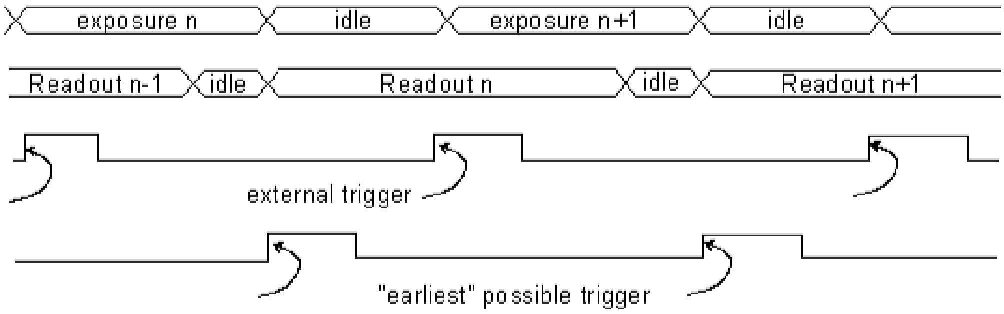

Figure 4.6: Timing in triggered simultaneous readout mode

4.1.2 Exposure Control

The exposure time defines the period during which the image sensor integrates the incoming light. Refer to Table 3.3 for the allowed exposure time range.

4.1.3 Maximum Frame Rate

The maximum frame rate depends on the exposure time and the size of the image (see Section 4.5.)

4.2 Pixel Response

4.2.1 Linear Response

The camera offers a linear response between input light signal and output grey level. This can be modified by the use of LinLog®as described in the following sections. In addition, a linear digital gain may be applied, as follows. Please see Table 3.2 for more model-dependent information.

Gain x1, x2, x4

Gain x1, x2 and x4 are digital amplifications, which means that the digital image data are multiplied in the camera by a factor 1, 2 or 4, respectively.

Black Level Adjustment

The black level is the average image value at no light intensity. It can be adjusted by the software by changing the black level offset. Thus, the overall image gets brighter or darker. Use a histogram to control the settings of the black level.

4.2.2 LinLog®

Overview

The LinLog® technology from Photonfocus allows a logarithmic compression of high light intensities inside the pixel. In contrast to the classical non-integrating logarithmic pixel, the LinLog® pixel is an integrating pixel with global shutter and the possibility to control the transition between linear and logarithmic mode.
In situations involving high intrascene contrast, a compression of the upper grey level region can be achieved with the LinLog® technology. At low intensities each pixel shows a linear response. At high intensities the response changes to logarithmic compression (see Fig. 4.7). The transition region between linear and logarithmic response can be smoothly adjusted by software and is continuously differentiable and monotonic.

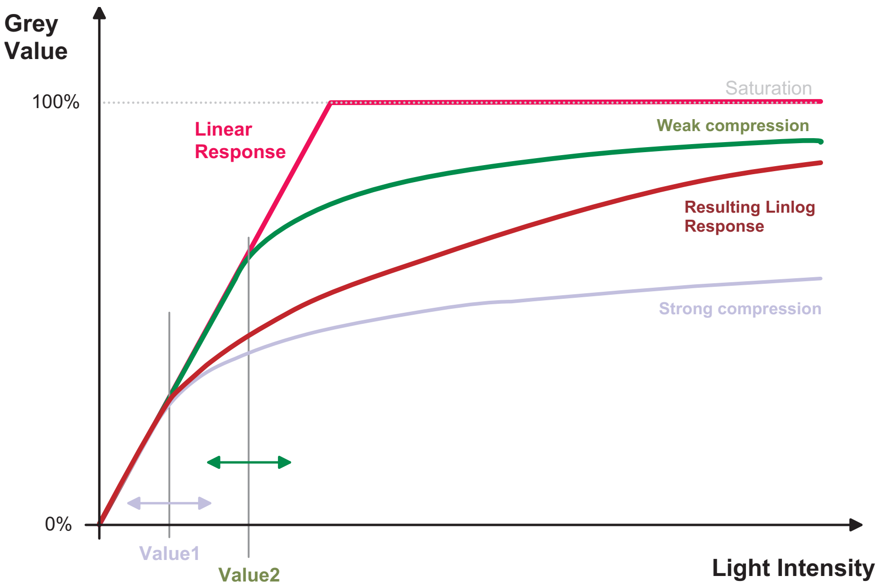

Figure 4.7: Resulting LinLog2 response curve

LinLog® is controlled by up to 4 parameters (`Time1`, `Time2`, `Value1` and `Value2`). `Value1` and `Value2` correspond to the LinLog® voltage that is applied to the sensor. The higher the parameters `Value1` and `Value2` respectively, the stronger the compression for the high light intensities. `Time1` and `Time2` are normalised to the exposure time. They can be set to a maximum value of 1000, which corresponds to the exposure time.
Examples in the following sections illustrate the LinLog® feature.

LinLog1

In the simplest way the pixels are operated with a constant LinLog® voltage which defines the knee point of the transition.This procedure has the drawback that the linear response curve changes directly to a logarithmic curve leading to a poor grey resolution in the logarithmic region (see Fig. 4.9).

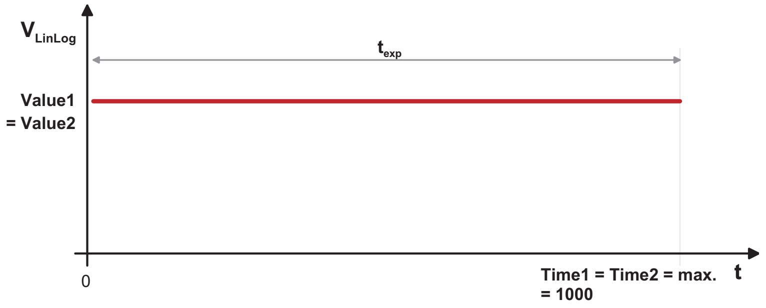

Figure 4.8: Constant LinLog voltage in the Linlog1 mode

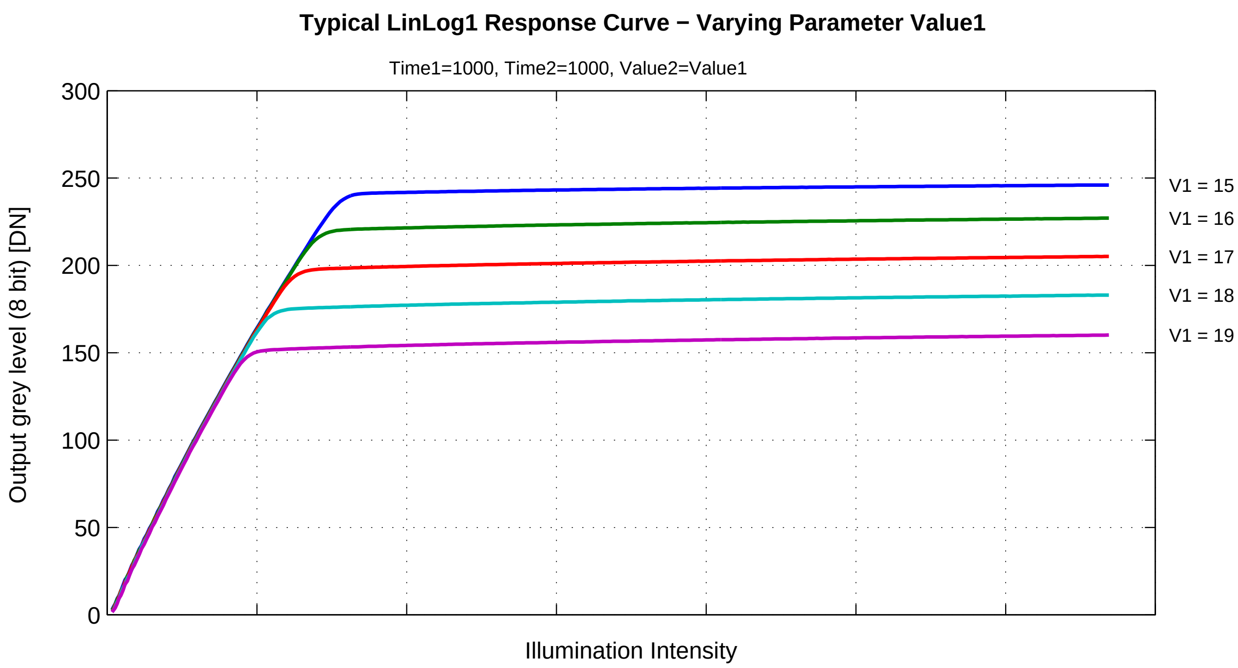

Figure 4.9: Response curve for different LinLog settings in LinLog1 mode

LinLog2

To get more grey resolution in the LinLog® mode, the LinLog2 procedure was developed. In LinLog2 mode a switching between two different logarithmic compressions occurs during the exposure time (see Fig. 4.10). The exposure starts with strong compression with a high LinLog®voltage (`Value1`). At `Time1` the LinLog®voltage is switched to a lower voltage resulting in a weaker compression. This procedure gives a LinLog®response curve with more grey resolution. Fig. 4.11 and Fig. 4.12 show how the response curve is controlled by the three parameters `Value1`, `Value2` and the LinLog®time `Time1`.

☞ Settings in LinLog2 mode, enable a fine tuning of the slope in the logarithmic region.

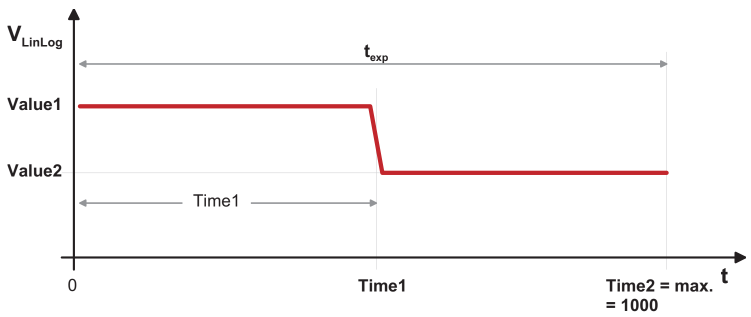

Figure 4.10: Voltage switching in the Linlog2 mode

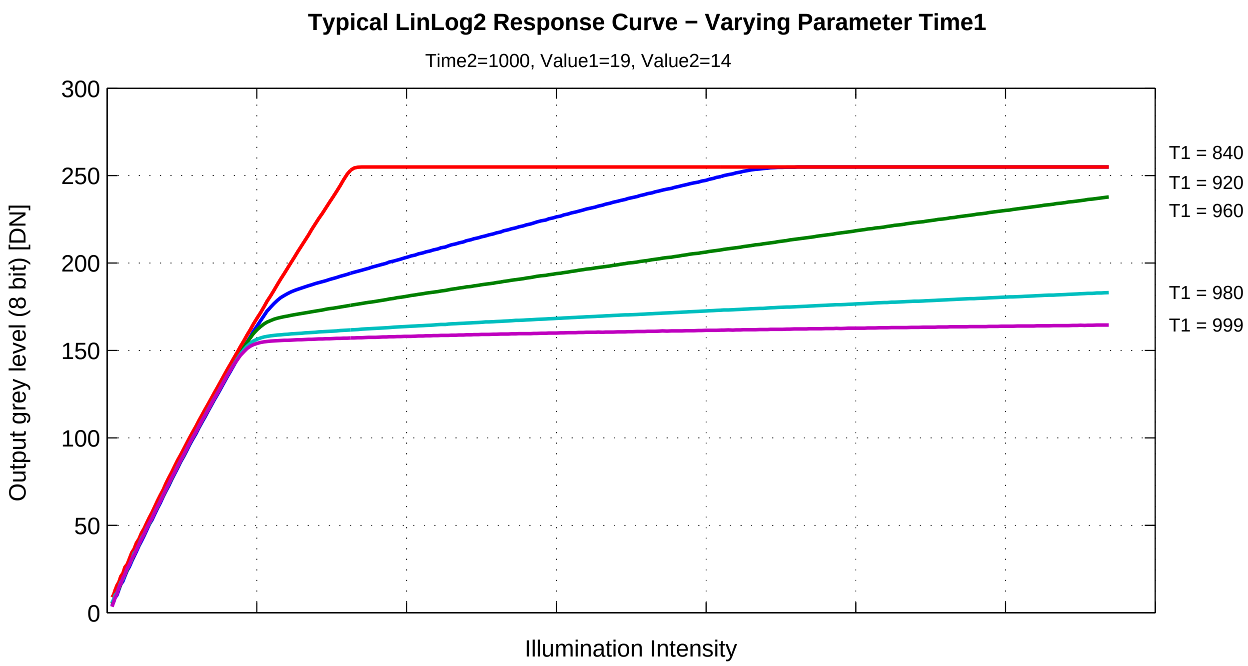

Figure 4.11: Response curve for different LinLog settings in LinLog2 mode

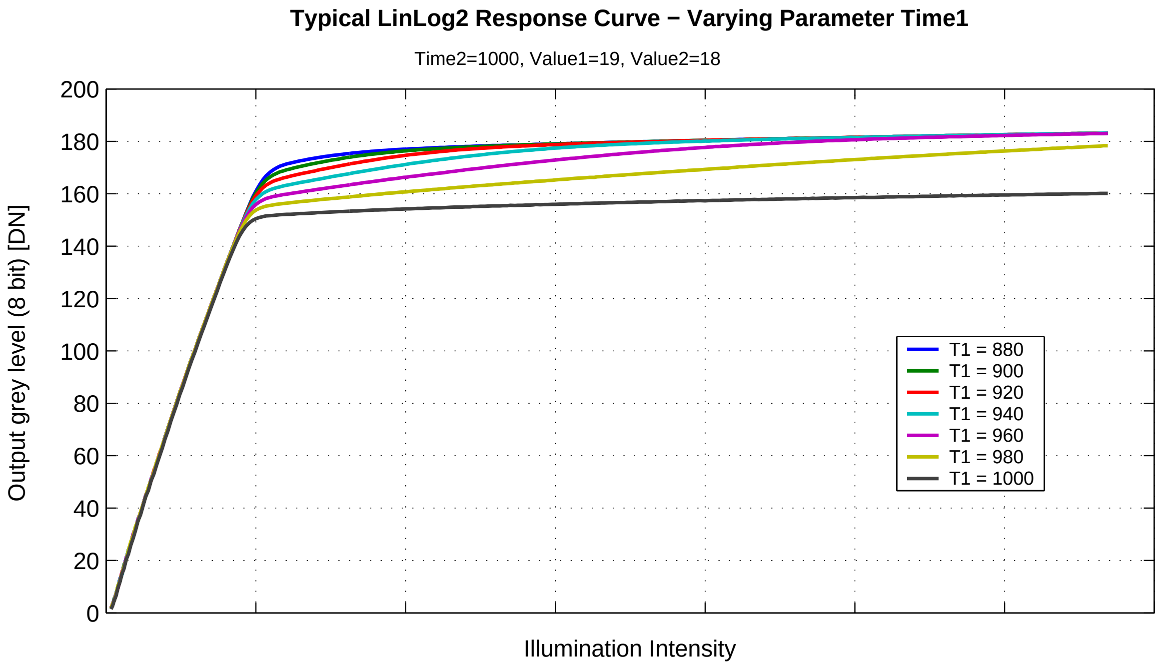

Figure 4.12: Response curve for different LinLog settings in LinLog2 mode

LinLog3

To enable more flexibility the LinLog3 mode with 4 parameters was introduced. Fig. 4.13 shows the timing diagram for the LinLog3 mode and the control parameters.

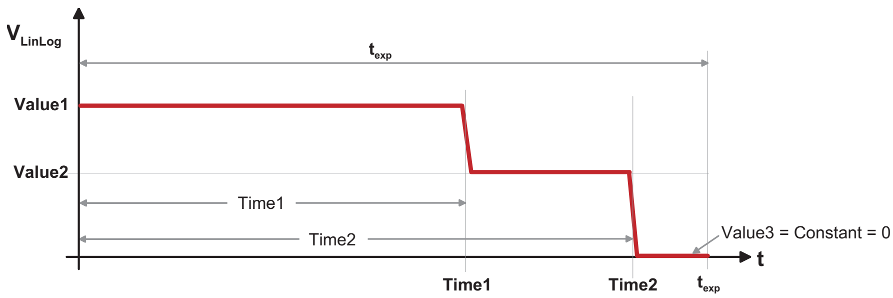

Figure 4.13: Voltage switching in the LinLog3 mode

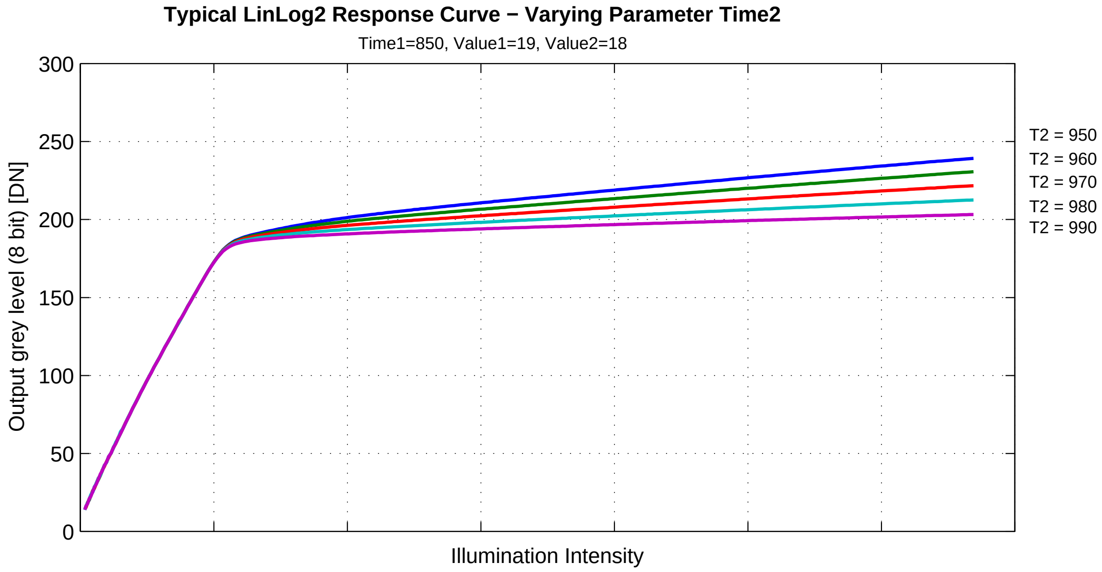

Figure 4.14: Response curve for different LinLog settings in LinLog3 mode

4.3 Test Images

Test images are generated in the camera FPGA, independent of the image sensor. They can be used to check the transmission path from the camera to the frame grabber. Independent from the configured grey level resolution, every possible grey level appears the same number of times in a test image. Therefore, the histogram of the received image must be flat.

A test image is a useful tool to find data transmission errors that are caused most often by a defective cable between camera and frame grabber.

The analysis of the test images with a histogram tool gives the correct result at full resolution only.

4.3.1 Ramp

Depending on the configured grey level resolution, the ramp test image outputs a constant pattern with increasing grey level from the left to the right side (see Fig. 4.15).

4.3.2 LFSR

The LFSR (linear feedback shift register) test image outputs a constant pattern with a pseudo-random grey level sequence containing every possible grey level that is repeated for every row. The LFSR test pattern was chosen because it leads to a very high data toggling rate, which stresses the interface electronic and the cable connection.
In the histogram you can see that the number of pixels of all grey values are the same.
Please refer to application note [AN026] for the calculation and the values of the LFSR test image.

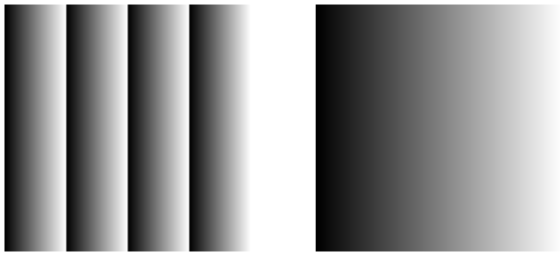

Figure 4.15: Ramp test images: 8 bit output (left), 10 bit output (right)

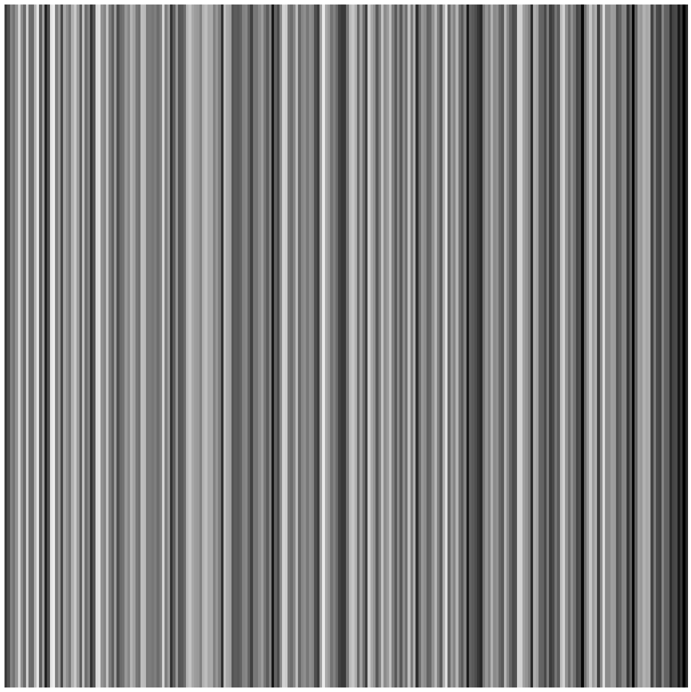

Figure 4.16: LFSR (linear feedback shift register) test image

4.3.3 Troubleshooting using the LFSR

To control the quality of your complete imaging system enable the LFSR mode and check the histogram at full resolution. If your frame grabber application does not provide a real-time histogram, store the image and use a graphic software tool to display the histogram.
In the LFSR (linear feedback shift register) mode the camera generates a constant pseudo-random test pattern containing all grey levels. If the data transmission is error free, the histogram of the received LFSR test pattern will be flat (Fig. 4.17). On the other hand, a non-flat histogram (Fig. 4.18) indicates problems, that may be caused either by the cable, by the connectors or by the frame grabber.

A possible origin of failure message can be caused by the CameraLink® cable which exceeds the maximum length. Also, CameraLink® cables may suffer either from stress due to wrong installation or from severe electromagnetic interference.

Some thinner CameraLink® cables have a predefined direction. In these cables not all twisted pairs are separately shielded to meet the RS644 standard. These pairs are used for the transmission of the RX/TX and for the CC1 to CC4 low frequency control signals.

Figure 4.17: LFSR test pattern received at the frame grabber and typical histogram for error-free data transmission

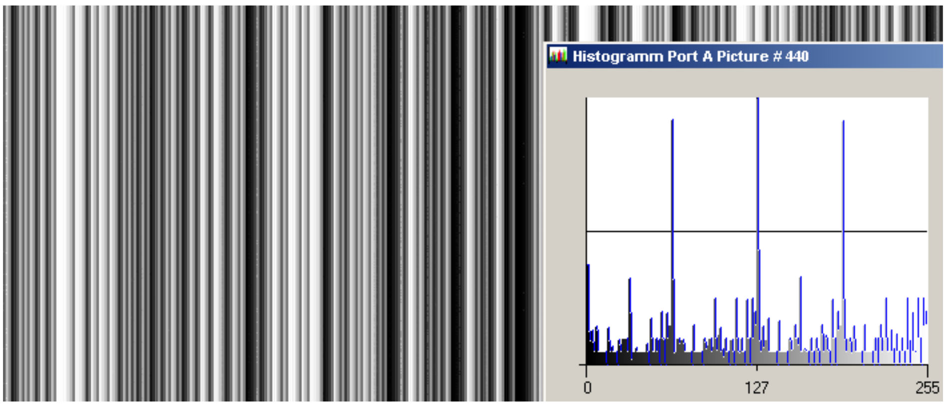

Figure 4.18: LFSR test pattern received at the frame grabber and histogram containing transmission errors

CameraLink® cables contain wire pairs, which are twisted in such a way that the cable impedance matches with the LVDS driver and receiver impedance. Excess stress on the cable results in transmission errors which causes distorted images. Therefore, please do not stretch and bend a CameraLink cable.

In robots applications, the stress that is applied to the CameraLink® cable is especially high due to the fast movement of the robot arm. For such applications, special drag chain capable cables are available. Please contact the Photonfocus Support for consulting expertise. Appropriate CameraLink® cable solutions are available from Photonfocus.

4.4 Image Correction

4.4.1 Overview

The camera possesses image pre-processing features, that compensate for non-uniformities caused by the sensor, the lens or the illumination. This method of improving the image quality is generally known as 'Shading Correction' or 'Flat Field Correction' and consists of a combination of offset correction, gain correction and pixel interpolation.

Since the correction is performed in hardware, there is no performance limitation of the cameras for high frame rates.

The offset correction subtracts a configurable positive or negative value from the live image and thus reduces the fixed pattern noise of the CMOS sensor. In addition, hot pixels can be removed by interpolation. The gain correction can be used to flatten uneven illumination or to compensate shading effects of a lens. Both offset and gain correction work on a pixel-per-pixel basis, i.e. every pixel is corrected separately. For the correction, a black reference and a grey reference image are required. Then, the correction values are determined automatically in the camera.

Do not set any reference images when gain or LUT is enabled! Read the following sections very carefully.

Correction values of both reference images can be saved into the internal flash memory, but this overwrites the factory presets. Then the reference images that are delivered by factory cannot be restored anymore.

4.4.2 Offset Correction (FPN, Hot Pixels)

The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimise the static noise.

Offset correction algorithm

After configuring the camera with a black reference image, the camera is ready to apply the offset correction:

1. Determine the average value of the black reference image.
2. Subtract the black reference image from the average value.
3. Mark pixels that have a grey level higher than 252 DN (@ 10 bit) as hot pixels.
4. Store the result in the camera as the offset correction matrix.
5. During image acquisition, subtract the correction matrix from the acquired image and interpolate the hot pixels (see Section 4.4.2).

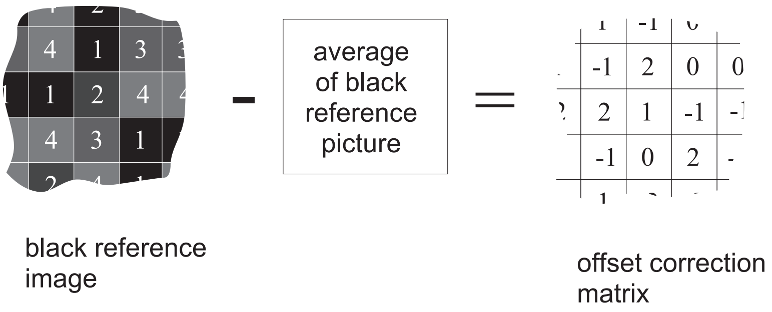

Figure 4.19: Schematic presentation of the offset correction algorithm

How to Obtain a Black Reference Image

In order to improve the image quality, the black reference image must meet certain demands.

- The black reference image must be obtained at no illumination, e.g. with lens aperture closed or closed lens opening.
- It may be necessary to adjust the black level offset of the camera. In the histogram of the black reference image, ideally there are no grey levels at value 0 DN after adjustment of the black level offset. All pixels that are saturated black (0 DN) will not be properly corrected (see Fig. 4.20). The peak in the histogram should be well below the hot pixel threshold of 252 DN @ 10 bit.
- Camera settings may influence the grey level. Therefore, for best results the camera settings of the black reference image must be identical with the camera settings of the image to be corrected.

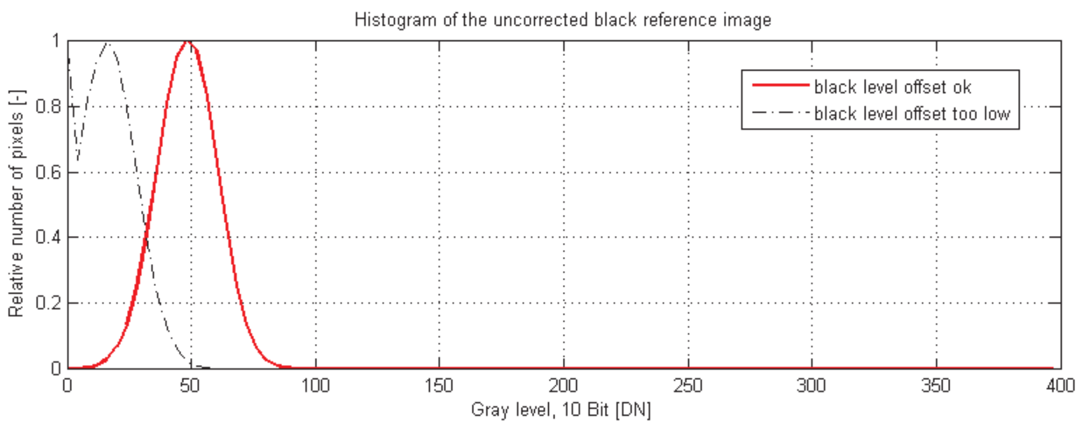

Figure 4.20: Histogram of a proper black reference image for offset correction

Hot pixel correction

Every pixel that exceeds a certain threshold in the black reference image is marked as a hot pixel. If the hot pixel correction is switched on, the camera replaces the value of a hot pixel by an average of its neighbour pixels (see Fig. 4.21).

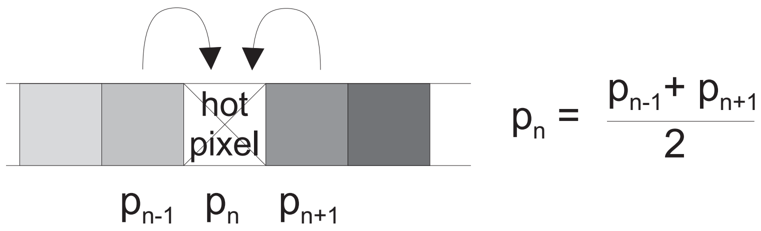

Figure 4.21: Hot pixel interpolation

4.4.3 Gain Correction

The gain correction is based on a grey reference image, which is taken at uniform illumination to give an image with a mid grey level.

Gain correction is not a trivial feature. The quality of the grey reference image is crucial for proper gain correction.

Gain correction algorithm

After configuring the camera with a black and grey reference image, the camera is ready to apply the gain correction:

1. Determine the average value of the grey reference image.
2. Subtract the offset correction matrix from the grey reference image.
3. Divide the average value by the offset corrected grey reference image.
4. Pixels that have a grey level higher than a certain threshold are marked as hot pixels.
5. Store the result in the camera as the gain correction matrix.
6. During image acquisition, multiply the gain correction matrix from the offset-corrected acquired image and interpolate the hot pixels (see Section 4.4.2).

Gain correction is not a trivial feature. The quality of the grey reference image is crucial for proper gain correction.

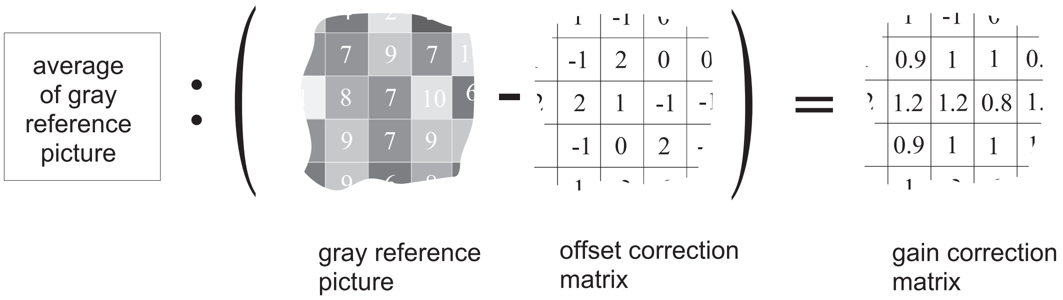

Figure 4.22: Schematic presentation of the gain correction algorithm

Gain correction always needs an offset correction matrix. Thus, the offset correction always has to be performed before the gain correction.

How to Obtain a Grey Reference Image

In order to improve the image quality, the grey reference image must meet certain demands.

- The grey reference image must be obtained at uniform illumination.

  Use a high quality light source that delivers uniform illumination. Standard illumination will not be appropriate.

- When looking at the histogram of the grey reference image, ideally there are no grey levels at full scale (1023 DN @ 10 bit). All pixels that are saturated white will not be properly corrected (see Fig. 4.23).
- Camera settings may influence the grey level. Therefore, the camera settings of the grey reference image must be identical with the camera settings of the image to be corrected.

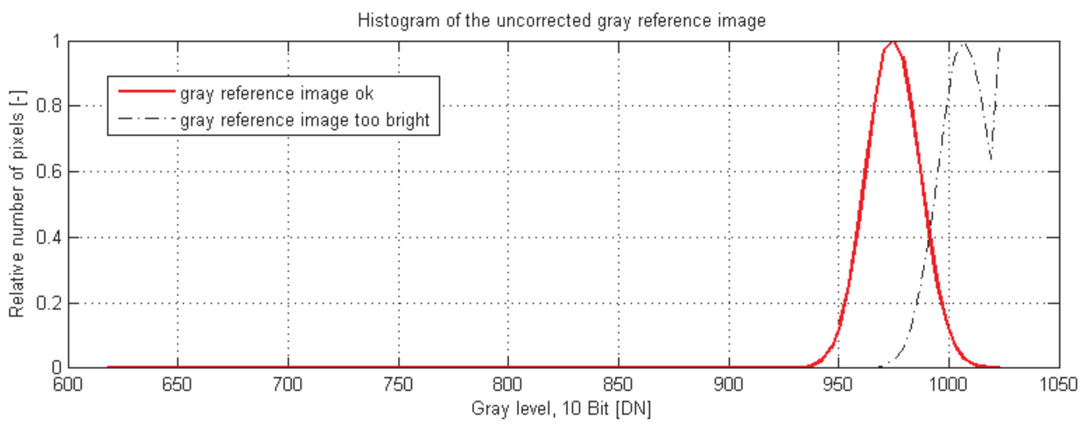

Figure 4.23: Proper grey reference image for gain correction

4.4.4 Corrected Image

Offset, gain and hot pixel correction can be switched on separately. The following configurations are possible:

- No correction
- Offset correction only
- Offset and hot pixel correction
- Hot pixel correction only
- Offset and gain correction
- Offset, gain and hot pixel correction

In addition, the black reference image and grey reference image that are currently stored in the camera RAM can be output.

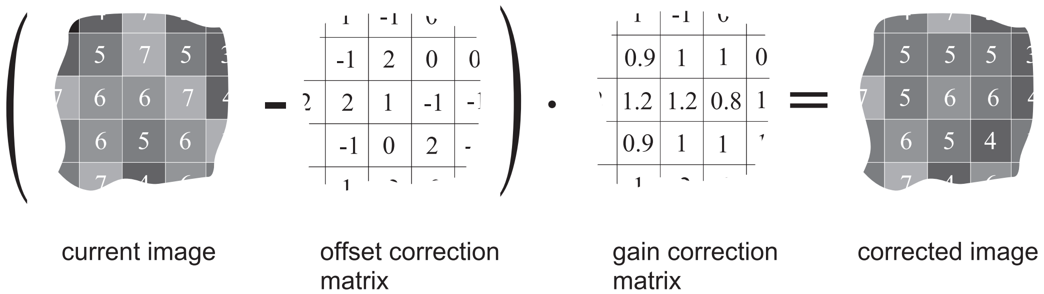

Figure 4.24: Schematic presentation of the corrected image using gain correction algorithm

Table 4.2 shows the minimum and maximum values of the correction matrices, i.e. the range that the offset and gain algorithm can correct.

	Minimum	Maximum
Offset correction	-127 DN @ 10 bit	+127 DN @ 10 bit
Gain correction	0.42	2.67

Table 4.2: Offset and gain correction ranges

4.5 Reduction of Image Size

With Photonfocus cameras there are several possibilities to focus on the interesting parts of an image, thus reducing the data rate and increasing the frame rate. The most commonly used feature is Region of Interest (ROI).

4.5.1 Region of Interest (ROI)

Some applications do not need full image resolution (e.g. 1312 x 1082 pixels). By reducing the image size to a certain region of interest (ROI), the frame rate can be drastically increased. A region of interest can be almost any rectangular window and is specified by its position within the full frame and its width (W) and height (H). Fig. 4.26 and Fig. 4.27 shows possible configurations for the region of interest, and Table 4.3 presents numerical examples of how the frame rate can be increased by reducing the ROI.

☞ Both reductions in x- and y-direction result in a higher frame rate.

Any region of interest may NOT be placed outside of the center of the sensor. Examples shown in Fig. 4.25 illustrate configurations of the ROI that are NOT allowed.

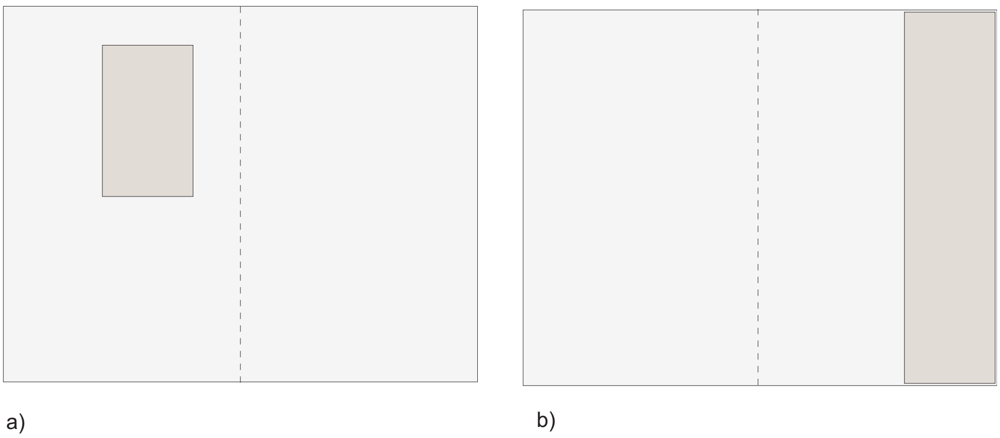

Figure 4.25: ROI configuration examples that are NOT allowed

The minimum width of the region of interest depends on the model of the MV1-D1312(I) camera series. For more details please consult Table 4.5 and Table 4.6.

The minimum width must be positioned symmetrically towards the vertical center line of the sensor as shown in Fig. 4.26 and Fig. 4.27). A list of possible settings of the ROI for each camera model is given in Table 4.6.

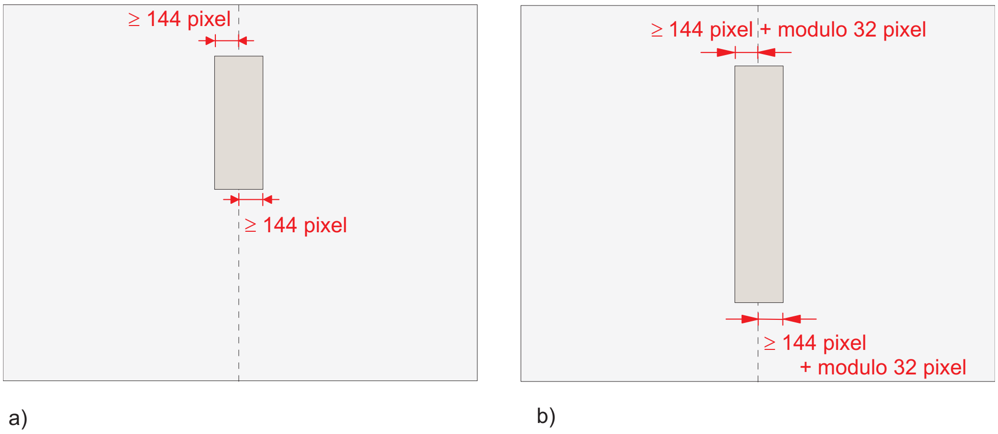

Figure 4.26: Possible configuration of the region of interest for the MV1-D1312(I)-40 CMOS camera

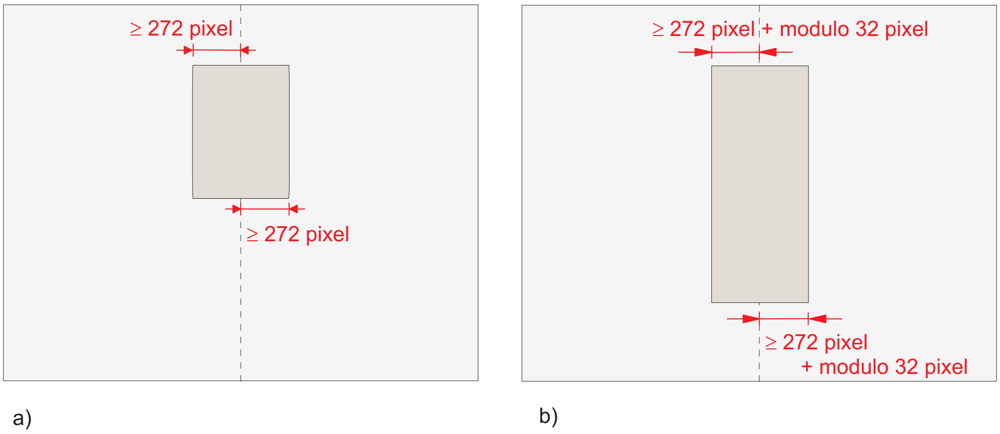

Figure 4.27: Possible configuration of the region of interest with MV1-D1312(I)-160 CMOS camera

It is recommended to re-adjust the settings of the shading correction each time a new region of interest is selected.

ROI Dimension [Standard]	MV1-D1312(I)-40	MV1-D1312(I)-80	MV1-D1312(I)-160
1312 x 1082 (full resolution)	27 fps	54 fps	108 fps
288 x 1 (minimum resolution)	10245 fps	10863 fps	not allowed ROI setting
1280 x 1024 (SXGA)	29 fps	58 fps	117 fps
1280 x 768 (WXGA)	39 fps	78 fps	156 fps
800 x 600 (SVGA)	79 fps	157 fps	310 fps
640 x 480 (VGA)	121 fps	241 fps	472 fps
544 x 1	9615 fps	10498 fps	11022 fps
544 x 1082	63 fps	125 fps	249 fps
1312 x 544	54 fps	107 fps	214 fps
1312 x 256	114 fps	227 fps	445 fps
544 x 544	125 fps	248 fps	485 fps
1024 x 1024	36 fps	72 fps	145 fps
1312 x 1	8116 fps	9537 fps	10468 fps

Table 4.3: Frame rates of different ROI settings (exposure time 10 μs; correction on, and sequential readout mode).

Exposure time	MV1-D1312(I)-40	MV1-D1312(I)-80	MV1-D1312(I)-160
10 μs	27 / 27 fps	54 / 54 fps	108 / 108 fps
100 μs	27 / 27 fps	54 / 54 fps	107 / 108 fps
500 μs	27 / 27 fps	53 / 54 fps	103 / 108 fps
1 ms	27 / 27 fps	51 / 54 fps	98 / 108 fps
2 ms	26 / 27 fps	49 / 54 fps	89 / 108 fps
5 ms	24 / 27 fps	42 / 54 fps	70 / 108 fps
10 ms	22 / 27 fps	35 / 54 fps	52 / 99 fps
12 ms	21 / 27 fps	33 / 54 fps	47 / 82 fps

Table 4.4: Frame rates of different exposure times, [sequential readout mode / simultaneous readout mode], resolution 1312 x 1082 pixel (correction on).

4.5.2 ROI configuration

In the MV1-D1312(I) camera series the following two restrictions have to be respected for the ROI configuration:

- The minimum width (w) of the ROI is camera model dependent, ranging from 288 pixel in the MV1-D1312(I)-40 camera to 544 pixel in the MV1-D1312(I)-160 camera.

- The region of interest must overlap a minimum number of pixels centered to the left and to the right of the vertical middle line of the sensor (ovl).

For any camera model of the MV1-D1312(I) camera series the allowed ranges for the ROI settings can be deduced by the following formula:

$$x_{min} = \max(0, 656 + ovl - w)$$
$$x_{max} = \min(656 - ovl, 1312 - w)$$

where "ovl" is the overlap over the middle line and "w" is the width of the region of interest.

Any ROI settings exceeding the minimum ROI width must be modulo 32.

	MV1-D1312(I)-40	MV1-D1312(I)-80	MV1-D1312(I)-160
ROI width (w)	288 ... 1312	416 ... 1312	544 ... 1312
overlap (ovl)	144	208	272
width condition	modulo 32	modulo 32	modulo 32

Table 4.5: Summary of the ROI configuration restrictions for the MV1-D1312(I) camera series indicating the minimum ROI width (w) and the required number of pixel overlap (ovl) over the sensor middle line

The settings of the region of interest in x-direction are restricted to modulo 32 (see Table 4.6).

There are no restrictions for the settings of the region of interest in y-direction.

4.5.3 Calculation of the maximum frame rate (CameraLink®)

The frame rate mainly depends on the exposure time and readout time. The frame rate is the inverse of the frame time.
$fps = \frac{1}{t_{frame}}$

Calculation of the frame time (sequential mode)

$$t_{frame} \geq t_{exp} + t_{ro}$$

Calculation of the frame time (simultaneous mode)

The calculation of the frame time in simultaneous read out mode requires more detailed data input and is skipped here for the purpose of clarity.

The formula for the calculation of the frame time in simultaneous mode is available from Photonfocus on request.

Width	ROI-X (MV1-D1312(I)-40)	ROI-X (MV1-D1312(I)-80)	ROI-X (MV1-D1312(I)-160)
288	512	not available	not available
320	480 ... 512	not available	not available
352	448 ... 512	not available	not available
384	416 ... 512	not available	not available
416	384 ... 512	448	not available
448	352 ... 512	416 ... 448	not available
480	320 ... 520	384 ... 448	not available
512	288 ... 512	352 ... 448	not available
544	256 ...512	320 ... 448	384
576	224 ... 512	288 ... 448	352 ... 384
608	192 ... 512	256 ... 448	320 ... 352
640	160 ... 512	224 ... 448	288 ... 384
672	128 ... 512	192 ... 448	256 ... 384
704	96 ... 512	160 ... 448	224 ... 384
736	64 ... 512	128 ... 448	192 ... 384
768	32 ... 512	96 ... 448	160 ... 384
800	0 ... 512	64 ... 448	128 ... 384
832	0 ... 480	32 ... 448	96 ... 384
864	0 ... 448	0 ... 448	64 ... 384
896	0 ... 416	0 ... 416	32 ... 384
...	...	...	...
1312	0	0	0

Table 4.6: Some possible ROI-X settings

ROI Dimension	MV1-D1312(I)-40	MV1-D1312(I)-80	MV1-D1312(I)-160
1312 x 1082	t_{ro} = 36.46 ms	t_{ro}= 18.23 ms	t_{ro} = 9.12 ms
1024 x 512	t_{ro} = 13.57 ms	t_{ro}= 6.78 ms	t_{ro} = 3.39 ms
1024 x 256	t_{ro} = 6.78 ms	t_{ro}= 3.39 ms	t_{ro} = 1.70 ms

Table 4.7: Read out time at different ROI settings for the MV1-D1312(I) CMOS camera series in sequential read out mode.

☞ A frame rate calculator for calculating the maximum frame rate is available in the support area of the Photonfocus website.

4.6 External Trigger

An external trigger is an event that starts an exposure. The trigger signal is either generated on the frame grabber (soft-trigger) or comes from an external device such as a light barrier. If a trigger signal is applied to the camera before the earliest time for the next trigger, this trigger will be ignored.

4.6.1 Trigger Source

The trigger signal can be configured to be active high or active low. One of the following trigger sources can be used:

Interface Trigger In the interface trigger mode, the trigger signal is applied to the camera by the CameraLink® interface.

Trigger In the trigger mode, the trigger signal is applied directly to the camera by the power supply connector (via an optocoupler).

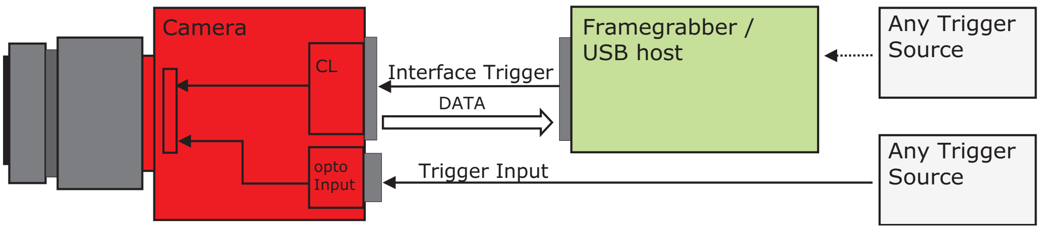

Figure 4.28: Trigger Inputs

4.7 Strobe Output

The strobe output is an opto-isolated output located on the power supply connector that can be used to trigger a strobe. The strobe output can be used both in free-running and in trigger mode. There is a programmable delay available to adjust the strobe pulse to your application.

☞ The strobe output needs a separate power supply. Please see Section 5.4 for more information.

4.8 Configuration Interface (CameraLink®)

A CameraLink® camera can be controlled by the user via a RS232 compatible asynchronous serial interface. This interface is contained within the CameraLink® interface as shown in Fig. 4.29 and is physically not directly accessible. Instead, the serial communication is usually routed through the frame grabber. For some frame grabbers it might be necessary to connect a serial cable from the frame grabber to the serial interface of the PC.

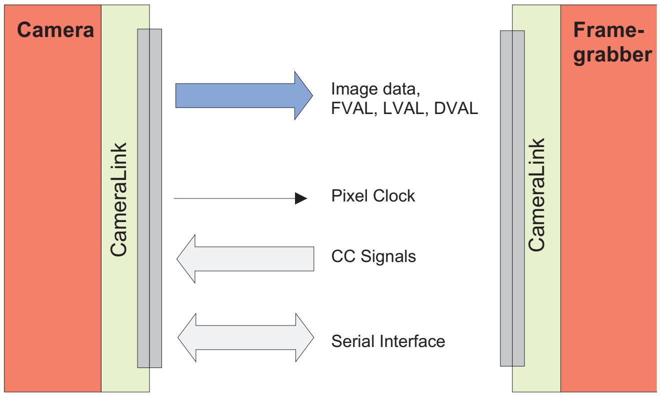

Figure 4.29: CameraLink serial interface for camera communication

4.9 Convolver (not available on MV1-D1312-160-CL)

4.9.1 Functionality

The "Convolver" is a discrete 2D convolution filter with a 3x3 convolution kernel. The kernel coefficients can be user-defined.
The M x N discrete 2D convolution $p_{out}(x,y)$ of pixel $p_{in}(x,y)$ with convolution kernel h, scale s and offset o is defined in Fig. 4.30.

$$p_{\mathrm{out}}(x,y)=\frac{1}{s}\left(\sum_{m^*=0}^{M-1}\sum_{n^*=0}^{N-1} h(m^*,n^*)\ p_{\mathrm{in}}\left(x-\frac{M-1}{2}+m^*,\ y-\frac{N-1}{2}+n^*\right)\right)+o$$

Figure 4.30: Convolution formula

4.9.2 Settings

The following settings for the parameters are available:

Offset Offset value o (see Fig. 4.30). Range: -4096 ... 4095

Scale Scaling divisor s (see Fig. 4.30). Range: 1 ... 4095

Coefficients Coefficients of convolution kernel h (see Fig. 4.30). Range: -4096 ... 4095. Assignment to coefficient properties is shown in Fig. 4.31.

$$\begin{bmatrix} Coeff0 & Coeff1 & Coeff2 \\ Coeff3 & Coeff4 & Coeff5 \\ Coeff6 & Coeff7 & Coeff8 \end{bmatrix}$$

Figure 4.31: Convolution coefficients assignment

5

Hardware Interface

5.1 Connectors

5.1.1 CameraLink® Connector

The CameraLink® cameras are interfaced to external components via

- a CameraLink® connector, which is defined by the CameraLink® standard as a 26 pin, 0.5" Mini Delta-Ribbon (MDR) connector to transmit configuration, image data and trigger.
- a subminiature connector for the power supply, 7-pin Binder series 712.

The connectors are located on the back of the camera. Fig. 5.1 shows the plugs and the status LED which indicates camera operation.

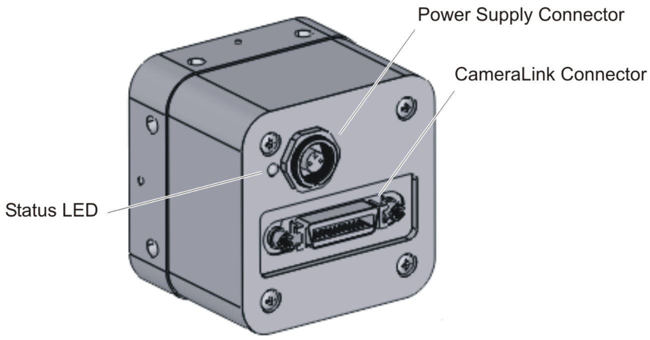

Figure 5.1: Rear view of the CameraLink camera

The CameraLink® interface and connector are specified in [CL]. For further details including the pinout please refer to Appendix A. This connector is used to transmit configuration, image data and trigger signals.

5.1.2 Power Supply

The camera requires a single voltage input (see Table 3.4). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear power supplies provide optimum performance.

It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage the camera.

For further details including the pinout please refer to Appendix A.

5.1.3 Trigger and Strobe Signals

The power connector contains an external trigger input and a strobe output.

The trigger input is equipped with a constant current diode which limits the current of the optocoupler over a wide range of voltages. Trigger signals can thus directly get connected with the input pin and there is no need for a current limiting resistor, that depends with its value on the input voltage. The input voltage to the `TRIGGER` pin must not exceed +15V DC, to avoid damage to the internal ESD protection and the optocoupler!

In order to use the strobe output, the internal optocoupler must be powered with 5 .. 15 V DC. The `STROBE` signal is an open-collector output, therefore, the user must connect a pull-up resistor (see Table 5.1) to `STROBE_VDD` (5 .. 15 V DC) as shown in Fig. 5.2. This resistor should be located directly at the signal receiver.

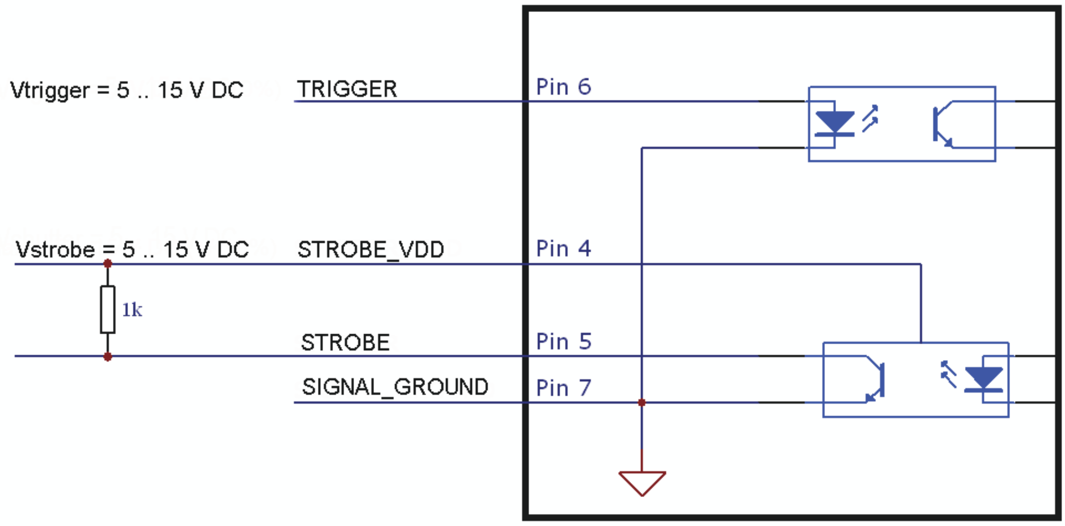

Figure 5.2: Circuit for the trigger input signals

The maximum sink current of the `STROBE` pin is 8 mA. *Do not connect inductive or capacitive loads*, such loads may result in damage of the optocoupler! If the application requires this, please use voltage suppressor diodes in parallel with this components to protect the optocoupler.

STROBE_VDD	Pull-up Resistor
15 V	> 3.9 kOhm
10 V	> 2.7 kOhm
8 V	> 2.2 kOhm
7 V	> 1.8 kOhm
5 V	> 1.0 kOhm

Table 5.1: Pull-up resistor for strobe output and different voltage levels

5.1.4 Status Indicator (CameraLink® cameras)

A dual-color LED on the back of the camera gives information about the current status of the CameraLink® cameras.

LED Green	Green when an image is output. At slow frame rates, the LED blinks with the `FVAL` signal. At high frame rates the LED changes to an apparently continuous green light, with intensity proportional to the ratio of readout time over frame time.
LED Red	Red indicates an active serial communication with the camera.

Table 5.2: Meaning of the LED of the CameraLink® cameras

5.2 CameraLink® Data Interface

The CameraLink® standard contains signals for transferring the image data, control information and the serial communication.

Data signals: CameraLink® data signals contain the image data. In addition, handshaking signals such as `FVAL`, `LVAL` and `DVAL` are transmitted over the same physical channel.

Camera control information: Camera control signals (CC-signals) can be defined by the camera manufacturer to provide certain signals to the camera. There are 4 CC-signals available and all are unidirectional with data flowing from the frame grabber to the camera. For example, the external trigger is provided by a CC-signal (see Table 5.3 for the CC assignment).

`CC1`	`EXSYNC`	External Trigger. May be generated either by the frame grabber itself (software trigger) or by an external event (hardware trigger).
`CC2`	`CTRL0`	Control0. This signal is reserved for future purposes and is not used.
`CC3`	`CTRL1`	Control1. This signal is reserved for future purposes and is not used.
`CC4`	`CTRL2`	Control2. This signal is reserved for future purposes and is not used.

Table 5.3: Summary of the Camera Control (CC) signals as used by Photonfocus

Pixel clock: The pixel clock is generated on the camera and is provided to the frame grabber for synchronisation.

Serial communication: A CameraLink® camera can be controlled by the user via a RS232 compatible asynchronous serial interface. This interface is contained within the CameraLink® interface and is physically not directly accessible. Refer to Section 4.8 for more information.

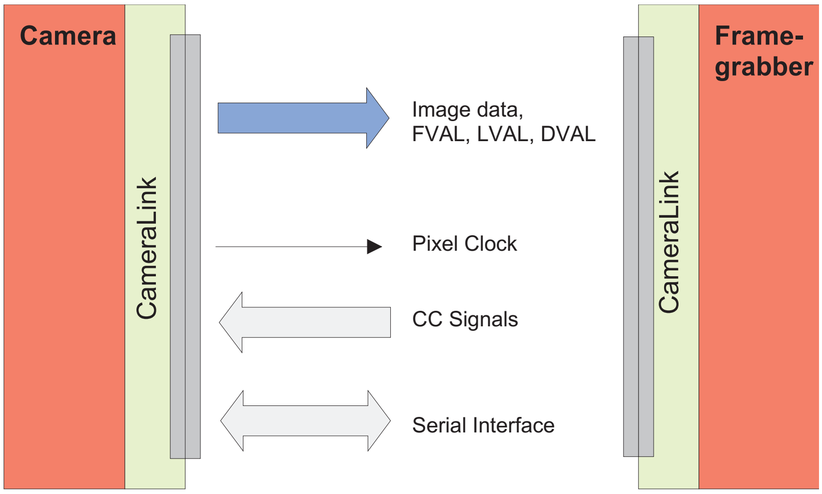

Figure 5.3: 1-tap CameraLink system

The frame grabber needs to be configured with the proper tap and resolution settings, otherwise the image will be distorted or not displayed with the correct aspect ratio. Refer to Table 3.3 and to Section 3.4 for a summary of frame grabber relevant specifications. Fig. 5.3 shows symbolically a 1-tap system. For more information about taps refer to the relevant application note [AN021] on the Photonfocus website.

5.3 Read-out Timing

5.3.1 Free running Mode

Sequential readout timing

By default, the camera is in free running mode and delivers images without any external control signals. The sensor is operated in sequential readout mode, which means that the sensor is read out after the exposure time. Then the sensor is reset, a new exposure starts and the readout of the image information begins again. The data is output on the rising edge of the pixel clock. The signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER indicates the active exposure period of the sensor and is shown for clarity only.

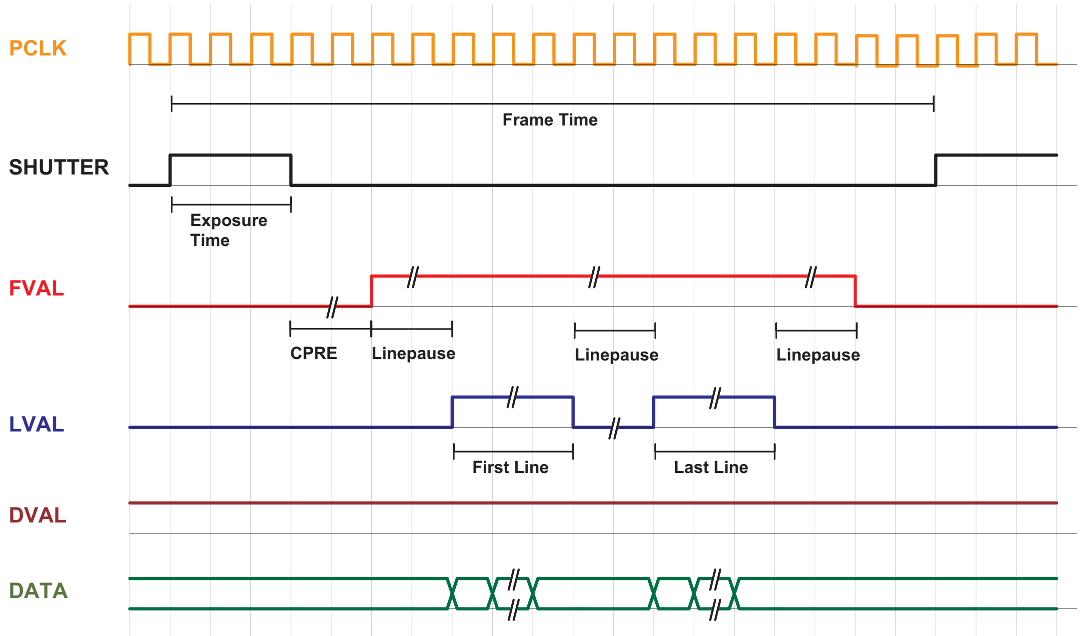

Figure 5.4: Timing diagram sequential readout mode

Simultaneous readout timing

To achieve highest possible frame rates, the camera must be set to "Free-running mode" with simultaneous readout. The camera continuously delivers images as fast as possible. Exposure time of the next image can start during the readout time of the current image. The data is output on the rising edge of the pixel clock. The signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER indicates the active integration phase of the sensor and is shown for clarity only.

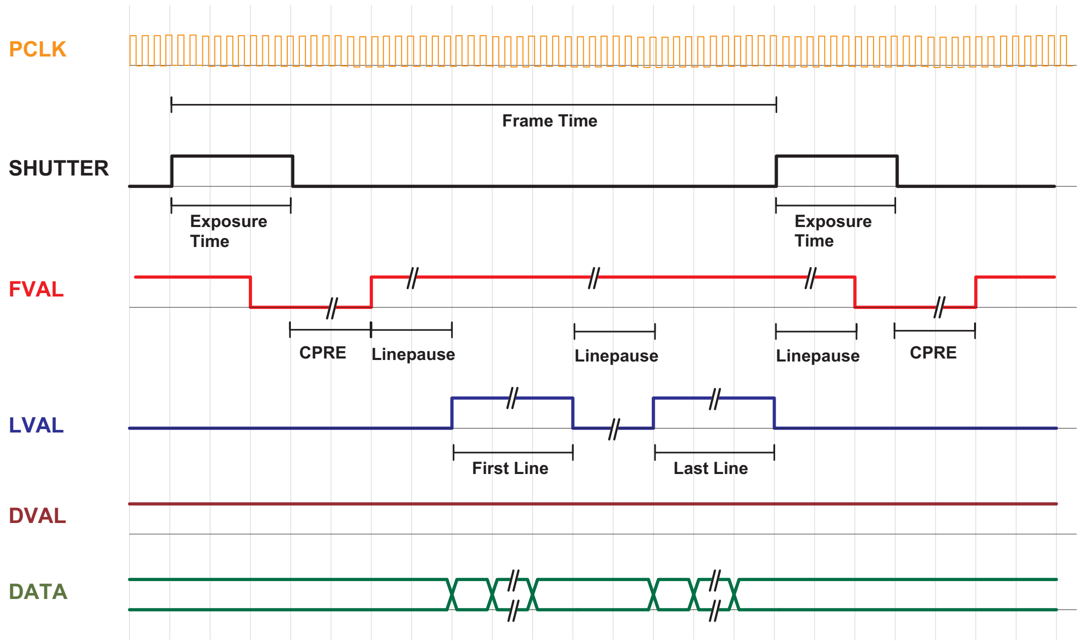

Figure 5.5: Timing diagram simultaneous readout mode (readout time > exposure time)

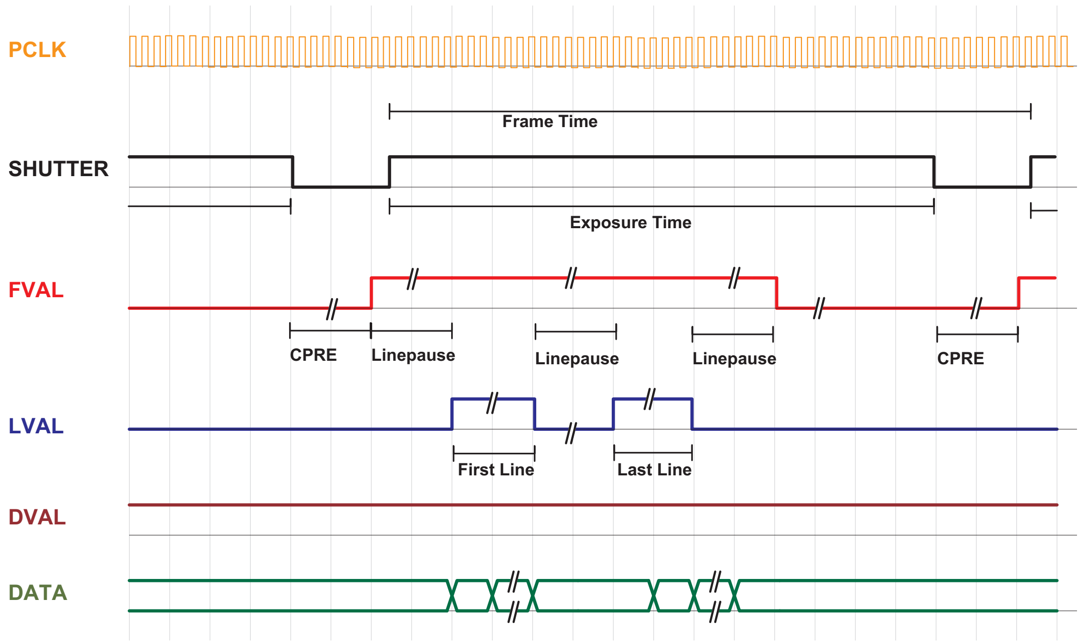

Figure 5.6: Timing diagram simultaneous readout mode (readout time < exposure time)

Frame time	Frame time is the inverse of the frame rate.
Exposure time	Period during which the pixels are integrating the incoming light.
PCLK	Pixel clock on CameraLink® interface.
SHUTTER	Internal signal, shown only for clarity. Is 'high' during the exposure time.
FVAL (Frame Valid)	Is 'high' while the data of one complete frame are transferred.
LVAL (Line Valid)	Is 'high' while the data of one line are transferred. Example: To transfer an image with 640x480 pixels, there are 480 LVAL within one FVAL active high period. One LVAL lasts 640 pixel clock cycles.
DVAL (Data Valid)	Is 'high' while data are valid.
DATA	Transferred pixel values. Example: For a 100x100 pixel image, there are 100 values transferred within one LVAL active high period, or 100*100 values within one FVAL period.
Line pause	Delay before the first line and after every following line when reading out the image data.

Table 5.4: Explanation of control and data signals used in the timing diagram

These terms will be used also in the timing diagrams of Section 5.4.

5.4 Trigger

5.4.1 Trigger Modes

The following sections show the timing diagram for the trigger modes. The signal ExSync denotes the trigger signal that is provided either by the interface trigger or the I/O trigger (see Section 4.6). The other signals are explained in Table 5.4. For an active high trigger signal, the image acquisition begins with the rising edge of the trigger signal. The image is read out after the pre-configured exposure time. After the readout, the sensor returns to the reset state and the camera waits for a new trigger pulse (see Fig. 5.7).
The data is output on the rising edge of the pixel clock, the handshaking signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER in Fig. 5.7 indicates the active integration phase of the sensor and is shown for clarity only.

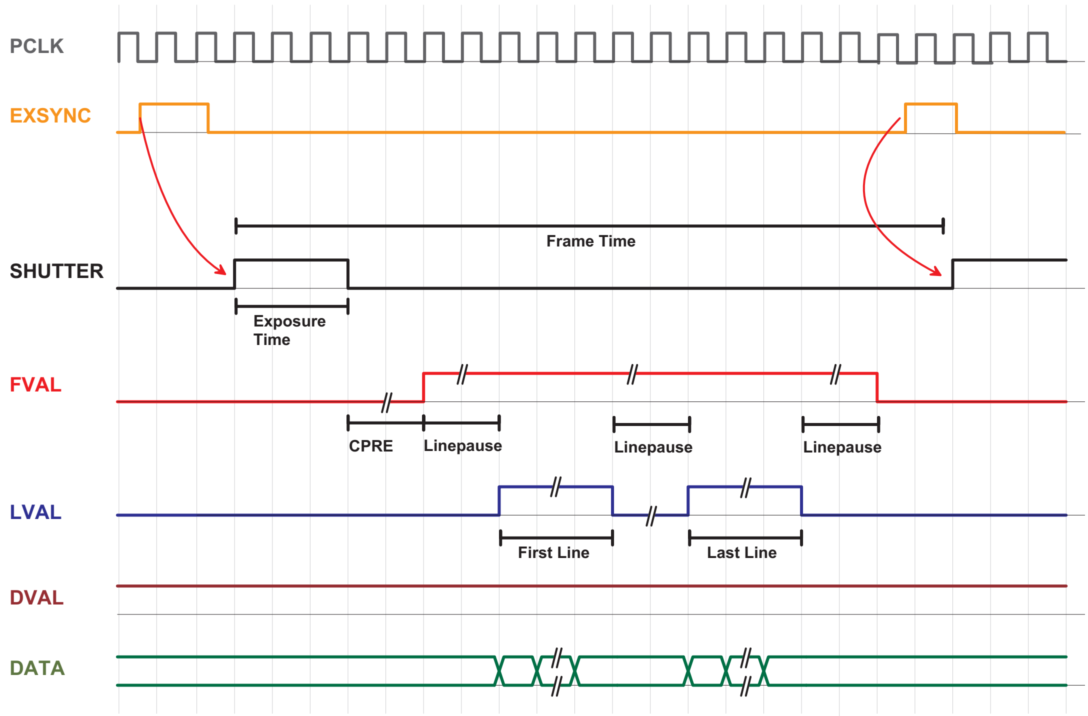

Figure 5.7: Trigger timing diagram for camera controlled exposure

5.4.2 Trigger Delay

The total delay between the trigger edge and the camera exposure consists of the delay in the frame grabber and the camera (Fig. 5.8). Usually, the delay in the frame grabber is relatively large to avoid accidental triggers caused by voltage spikes (see Fig. 5.9).

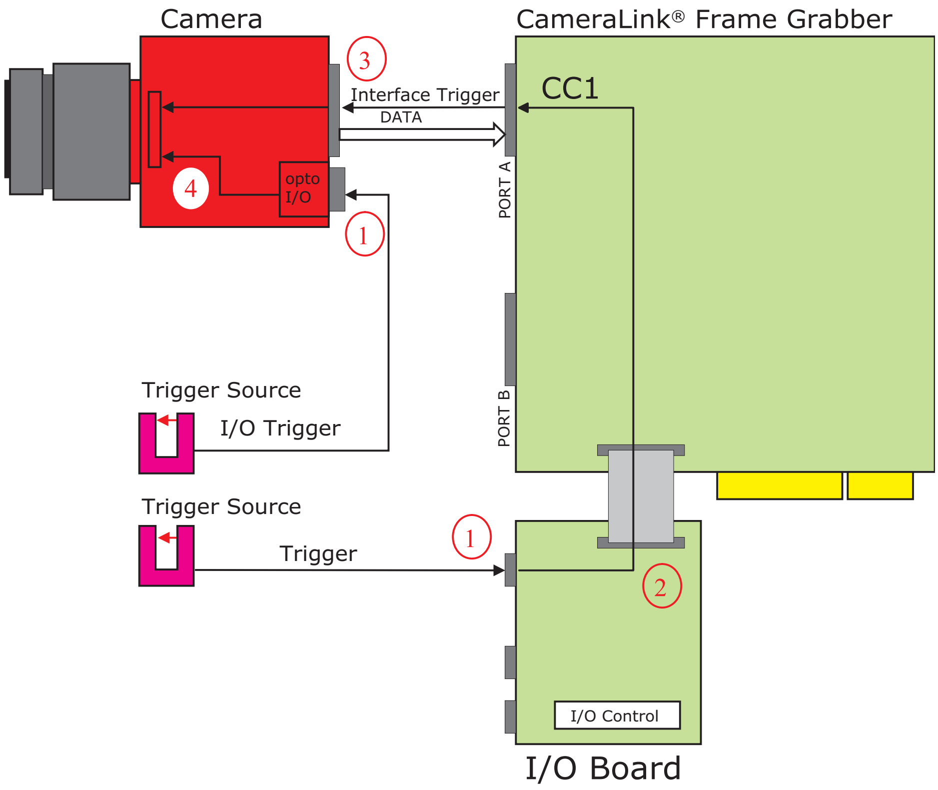

Figure 5.8: Trigger Delay visualisation from the trigger source to the camera

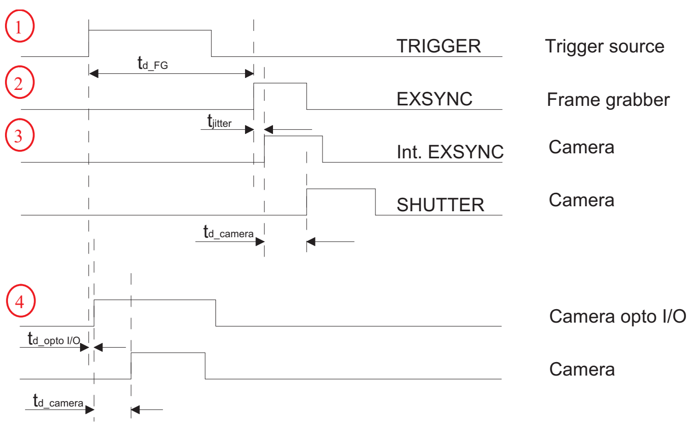

Figure 5.9: Timing Diagram for Trigger Delay

For the delay in the frame grabber, please ask your frame grabber manufacturer. The camera delay consists of a constant trigger delay and a variable delay (jitter), due to the sampling of the trigger signal by the clocked camera electronic. The trigger delay and the jitter are specified in Table 5.6 and shown in Fig. 5.9. The description of the parameters is summarized in Table 5.5.

Trigger delay type	**Description**
t_{d-FG}	Trigger delay of the frame grabber, refer to frame grabber manual
t_{jitter}	Variable camera trigger delay
$t_{d-camera}$	Constant camera trigger delay
t_{d-opto}	Variable trigger delay of opto coupler

Table 5.5: Trigger Delay Parameters

Trigger delay type	**MV1-D1312(I)-40**	**MV1-D1312(I)-80**	**MV1-D1312(I)-160**
t_{jitter}	100 ns	50 ns	25 ns
$t_{d-camera}$	600 ns	300 ns	150 ns

Table 5.6: Trigger Delay for the MV1-D1312(I) camera series in sequential read out mode

Delay type	**MV1-D1312(I) Series**
Trigger t_{d-opto}	90 ns
Strobe t_{d-opto} (min/max)	(0.2 / 1.4) μs

Table 5.7: Interface Strobe/Trigger Delay for the MV1-D1312(I) camera series

In simultaneous read out mode trigger delay times may exceed indicated trigger delay times of the sequential read out mode (see Table 5.6).

Trigger multiple cameras with strobe output only with an additional buffer.

✎ Please contact Photonfocus for further information on trigger delay times in simultaneous read out mode.

6 The PFRemote Control Tool

6.1 Overview

PFRemote is a graphical configuration tool for Photonfocus cameras. The latest release can be downloaded from the support area of www.photonfocus.com.
All Photonfocus cameras can be either configured by PFRemote, or they can be programmed with custom software using the PFLib SDK ([PFLIB]).

6.2 PFRemote and PFLib

As shown in Fig. 6.1, the camera parameters can be controlled by PFRemote and PFLib respectively. To grab an image use the software or the SDK that was delivered with your frame grabber.

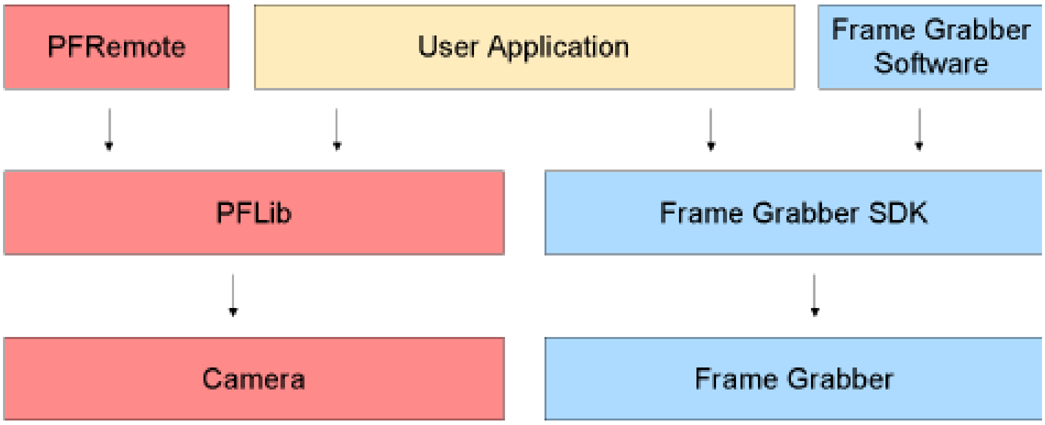

Figure 6.1: PFRemote and PFLib in context with the CameraLink frame grabber software

6.3 Operating System

The PFRemote GUI is available for Windows OS only. For Linux or QNX operating systems, we provide the necessary libraries to control the camera on request, but there is no graphical user interface available.

If you require support for Linux or QNX operating systems, you may contact us for details of support conditions.

6.4 Installation Notes

Before installing the required software with the PFInstaller, make sure that your frame grabber software is installed correctly.
Several DLLs are necessary in order to be able to communicate with the cameras:

- `PFCAM.DLL`: The main DLL file that handles camera detection, switching to specific camera DLL and provides the interface for the SDK.
- `'CAMERANAME'.DLL`: Specific camera DLL, e.g. mv_d1024e_3d01_160.dll.
- `COMDLL.DLL`: Communication DLL. This COMDLL is not necessarily CameraLink® specific, but may depend on a CameraLink® API compatible DLL, which should also be provided by your frame grabber manufacturer.
- `CLALLSERIAL.DLL`: Interface to CameraLink® frame grabber which supports the clallserial.dll.
- `CLSER_USB.DLL`: Interface to USB port.

More information about these DLLs is available in the SDK documentation [SW002].

6.5 Graphical User Interface (GUI)

PFRemote consists of a main window (Fig. 6.2) and a configuration dialog. In the main window, the camera port can be opened or closed, and log messages are displayed at the bottom. The configuration dialog appears as a sub window as soon as a camera port was opened successfully. In the sub window of PFRemote the user can configure the camera properties.
The following sections describe the general structure of PFRemote.

6.5.1 Port Browser

On start, PFRemote displays a list of available communication ports in the main window.

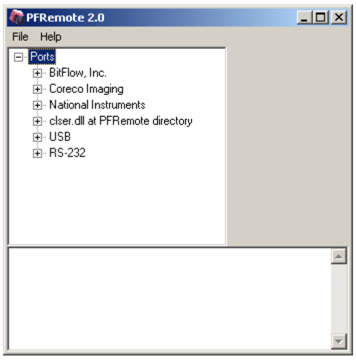

Figure 6.2: PFRemote main window with PortBrowser and log messages

To open a camera on a specific port double click on the port name (e.g. USB). Alternatively right click on the port name and choose **Open & Configure...**. The port is then queried for a compatible Photonfocus camera.
In the PFRemote main window, there are two menus with the following entries available:

File Menu

Clear Log: Clears the log file buffer

Quit: Exit the program

Help Menu

About: Copyright notice and version information

Help F1: Invoke the online help (PFRemote documentation)

6.5.2 Ports, Device Initialization

After starting **PFRemote**, the main window as shown in Fig. 6.2 will appear. In the PortBrowser in the upper left corner you will see a list of supported ports.

☞ Depending on the configuration, your port names may differ, and not every port may be functional.

If your frame grabber supports clallserial.dll version 1.1 (CameraLink® compliant standard Oct 2001), the name of the manufacturer is shown in the PortBrowser.

If your frame grabber supports clallserial.dll version 1.0 (CameraLink® compliant standard Oct 2000), the PortBrowser shows either the name of the dll or the manufacturer name or displays "Unknown".

If your frame grabber does not support clallserial.dll, copy the clserXXXX.dll of your frame grabber in the PFRemote directory and rename it to clser.dll. The PortBrowser will then indicate this DLL as "clser.dll at PFRemote directory".

After connecting the camera, the device can be opened with a double click on the port name or by right-clicking on the port name and choosing **Open & Configure**. If the initialisation of the camera was successful, the configuration dialog will open. The device is closed when PFRemote is closed. Alternatively, e.g. when connecting another camera or evaluation kit, the device can also be closed explicitely by right clicking on the port name and choosing **Close**. Make sure that the configuration dialog is closed prior to closing the port.

✎ Errors, warnings or other important activities are logged in a log window at the bottom of the main window.

If the device does not open, check the following:

- Is the power LED of the camera active? Do you get an image in the display software of your frame grabber?
- Verify all cable connections and the power supply.
- Check the communication LED of the camera: do you see some activity when you try to access the camera?

6.5.3 Main Buttons

The buttons on the right side of the configuration dialog store and reset the camera configuration.

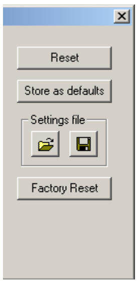

Figure 6.3: Main buttons

Reset: Reset the camera and load the default configuration.

Store as defaults: Store the current configuration in the camera flash memory as the default configuration. After a reset, the camera will load this configuration by default.

Settings file - File Load: Load a stored configuration from a file.

Settings file - File Save: Save current configuration to a file.

Factory Reset: Reset camera and reset the configuration to the factory defaults.

6.6 Device Properties

Cameras or sensor devices are generally addressed as ’device’ in this software. These devices have properties that are accessed by a property name. These property names are translated into register accesses on the driver DLL. The property names are reflected in the GUI as far as practicable. A property name normally has a special mark up throughout this document, for example: `ExposureTime`. Some properties are grouped into a structure whose member is accessed via dot notation, e.g. `Window.X` (for the start X value of a region of interest). When changing a property, the property name can always be seen in the log window of the main program window.

7

Graphical User Interface (GUI)

7.1 MV1-D1312-160

This section describes the parameters of the following camera:

- MV1-D1312-160-CL, CameraLink interface

The following sections are grouped according to the tabs in the configuration dialog.

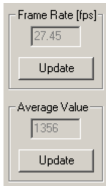

Figure 7.1: MV1-D1312-160 frame rate and average value

Frame Rate [fps :] Shows the actual frame rate of the camera in frames per second.

Update: To update the value of the frame rate, click on this button.

Average Value: Greyscale average of the actual image. This value is in 12bit (0...4095).

Update: To update the value of the average, click on this button.

7.1.1 Exposure

This tab contains exposure settings.

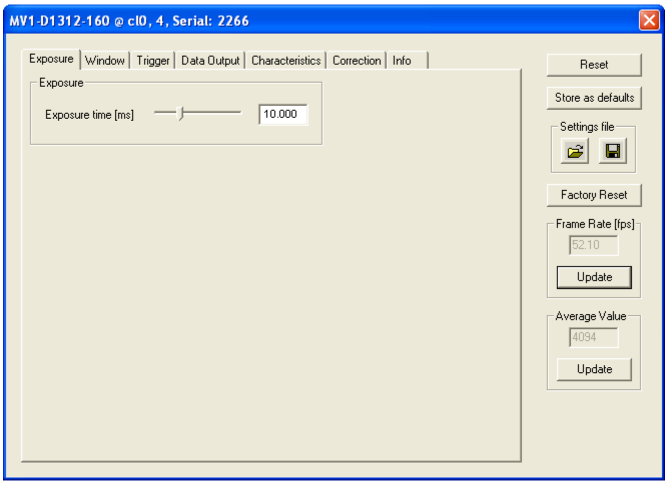

Figure 7.2: MV1-D1312-160 exposure panel

Exposure

Exposure time [ms :] Configure the exposure time in milliseconds.

7.1.2 Window

This tab contains the settings for the region of interest.

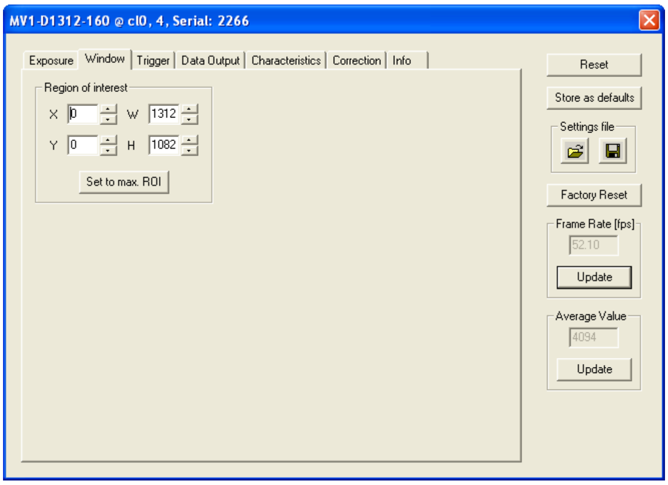

Figure 7.3: MV1-D1312-160 window panel

Region of Interest

The region of interest (ROI) is defined as a rectangle (X, Y), (W, H) where

X: X - coordinate, starting from 0 in the upper left corner.

Y: Y - coordinate, starting from 0 in the upper left corner.

W: Window width (in steps of 32 pixel).

H: Window height.

Set to max ROI: Set Window to maximal ROI (X=0; Y=0; W=1312; H=1082).

☞ Window width is only available in steps of 32 pixel.

7.1.3 Trigger

This tab contains trigger and strobe settings.

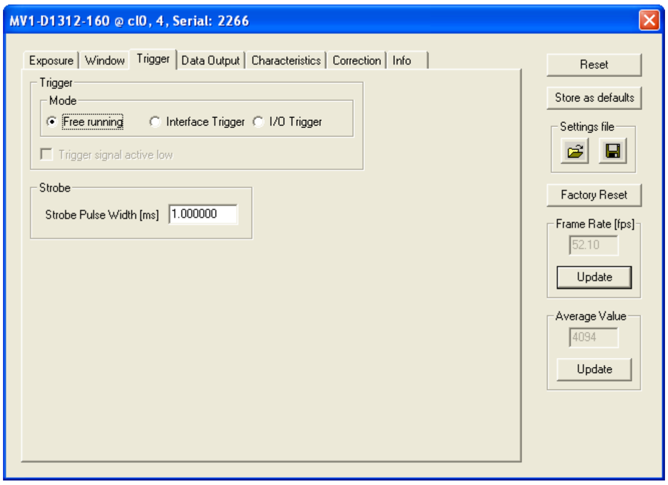

Figure 7.4: MV1-D1312-160 trigger panel

Trigger

Trigger Source:

Free running: The camera continuously delivers images with a certain configurable frame rate.

Interface Trigger: The Trigger signal is applied to the camera by the CameraLink frame grabber or the USB interface respectively.

I/O Trigger: The trigger signal is applied directly to the camera on the power supply connector.

Further trigger settings:

Trigger signal active low: Define the trigger signal to be active high (default) or active low.

Strobe

The camera generates a strobe output signal that can be used to trigger a strobe. The pulse width can be defined by software. To turn off strobe output, set StrobePulseWidth to 0.

Strobe Pulse Width [ms :] The pulse width of the strobe trigger in milliseconds.

7.1.4 Data Output

This tab contains image data settings.

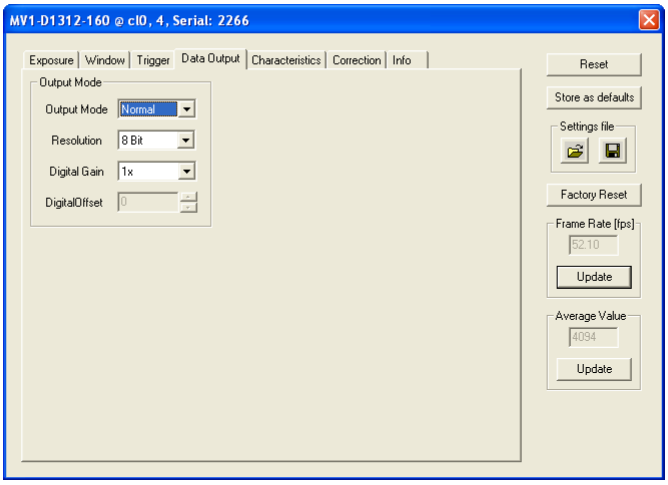

Figure 7.5: MV1-D1312-160 data output panel

Output Mode

Output Mode:

Normal: Normal mode.

LFSR: Test image. Linear feedback shift register (pseudo-random image). The pattern depends on the grey level resolution.

Ramp: Test image. Values of pixel are incremented by 1, starting at each row. The pattern depends on the grey level resolution.

Resolution:

8 Bit: Grey level resolution of 8 bit.

10 Bit: Grey level resolution of 10 bit.

12 Bit: Grey level resolution of 12 bit.

Digital Gain:

1x: No digital gain, normal mode.

2x: Digital gain 2.

4x: Digital gain 4.

Digital Offset: Substracts an offset from the data. Only available in gain mode.

7.1.5 Characteristics

This tab contains LinLog and Skimming settings.

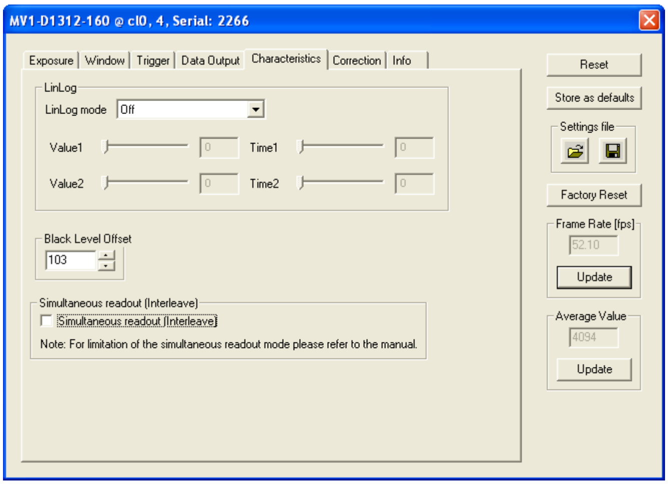

Figure 7.6: MV1-D1312-160 characteristics panel

LinLog

The LinLog technology from Photonfocus allows a logarithmic compression of high light intensities. In contrast to the classical non-integrating logarithmic pixel, the LinLog pixel is an integrating pixel with global shutter and the possibility to control the transition between linear and logarithmic mode (Section 4.2.2). There are 3 predefined LinLog settings available. Alternatively, custom settings can be defined in the `User defined` Mode.

LinLog Mode: Off: LinLog is disabled. Low/Normal/High compression: Three LinLog presettings. User defined: `Value1`, `Time1`, `Value2` and `Time2`. The Linlog times are per thousand of the exposure time. Time 800 means 80% of the exposure time.

Black Level Offset

It may be necessary to adjust the black level offset of the camera.

Black Level Offset: Black level offset value. Use this to adjust the black level.

Simultaneous readout (Interleave)

The simultaneous readout mode allows higher frame rate.

Simultaneous readout (Interleave): Enable the simultaneous readout mode.

7.1.6 Correction

This tab contains correction settings.

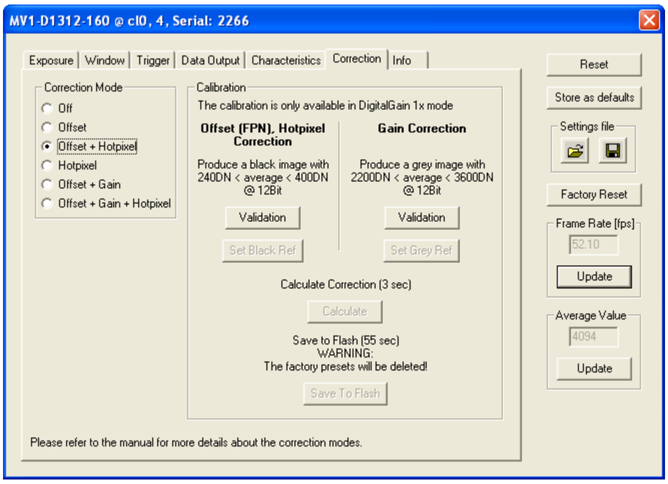

Figure 7.7: MV1-D1312-160 correction panel

Correction Mode

This camera has image pre-processing features, that compensate for non-uniformities caused by the sensor, the lens or the illumination.

Off: No correction.

Offset: Activate offset correction

Offset + Hotpixel: Activate offset and hot pixel correction.

Hotpixel: Activate hot pixel correction.

Offset + Gain: Activate offset and gain correction.

Offset + Gain + Hotpixel: Activate offset, gain and hot pixel correction.

Calibration

Offset (FPN), Hotpixel Correction: The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimize the static noise. Close the lens of the camera. Click on the Validation button. If the Set Black Ref - button is still inactive, the average of the image is out of range. Change to panel Charateristics and change the Property `BlackLevelOffset` until the average of the image is between 160 and 400DN. Click again on the Validation button and then on the Set Black Ref Button.

If only offset and hot pixel correction is needed it is not necessary to calibrate a grey image. (see Calculate)

Gain Correction: The gain correction is based on a grey reference image, which is taken at uniform illumination to give an image with a mid grey level.

Gain correction is not a trivial feature. The quality of the grey reference image is crucial for proper gain correction.

Produce a grey image with an average between 2200 and 3600DN. Click on the Validation button to check the average. If the average is in range, the Set Grey Ref button is active.

Calculate: Calculate the correction values into the camera RAM. To make the correction values permanent, use the 'Save to Flash' button.

Save to Flash: Save the current correction values to the internal flash memory.

This will overwrite the factory presets.

7.1.7 Info

This panel shows camera specific information such as type code, serial number and firmware revision of the FPGA and microcontroller and the description of the camera interface.

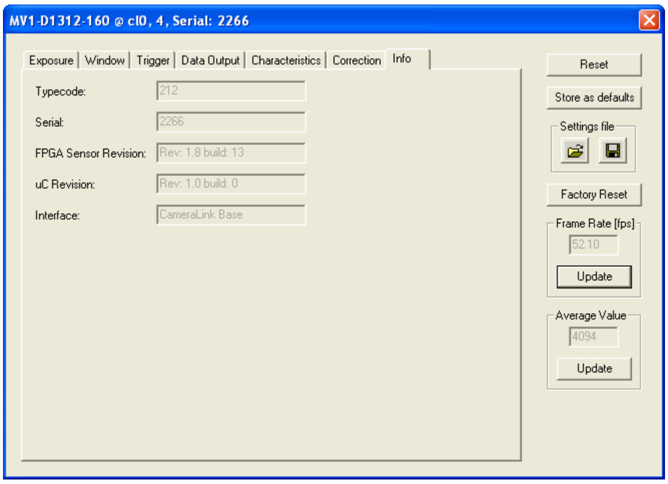

Figure 7.8: MV1-D1312-160 info panel

Typecode: Type code of the connected camera.

Serial: Serial number of the connected camera.

FPGA Sensor Revision: Firmware revision of built-in Sensor FPGA of the connected camera.

uC Revision: Firmware revision of built-in microcontroller of the connected camera.

Interface: Description of the camera interface.

☞ For any support requests, please enclose the information provided on this tab.

7.2 MV1-D1312-40, MV1-D1312I-40, MV1-D1312-80, MV1-D1312I-80, MV1-D1312I-160

This section describes the parameters of the following cameras:

- MV1-D1312-40-CL, CameraLink interface,
- MV1-D1312I-40-CL, CameraLink interface,
- MV1-D1312-80-CL, CameraLink interface,
- MV1-D1312I-80-CL, CameraLink interface,
- MV1-D1312I-160-CL, CameraLink interface.

The following sections are grouped according to the tabs in the configuration dialog.

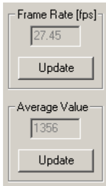

Figure 7.9: MV1-D1312-40 frame rate and average value

Frame Rate [fps :] Shows the actual frame rate of the camera in frames per second.

Update: To update the value of the frame rate, click on this button.

Average Value: Greyscale average of the actual image. This value is in 12bit (0...4095).

Update: To update the value of the average, click on this button.

7.2.1 Exposure

This tab contains exposure settings.

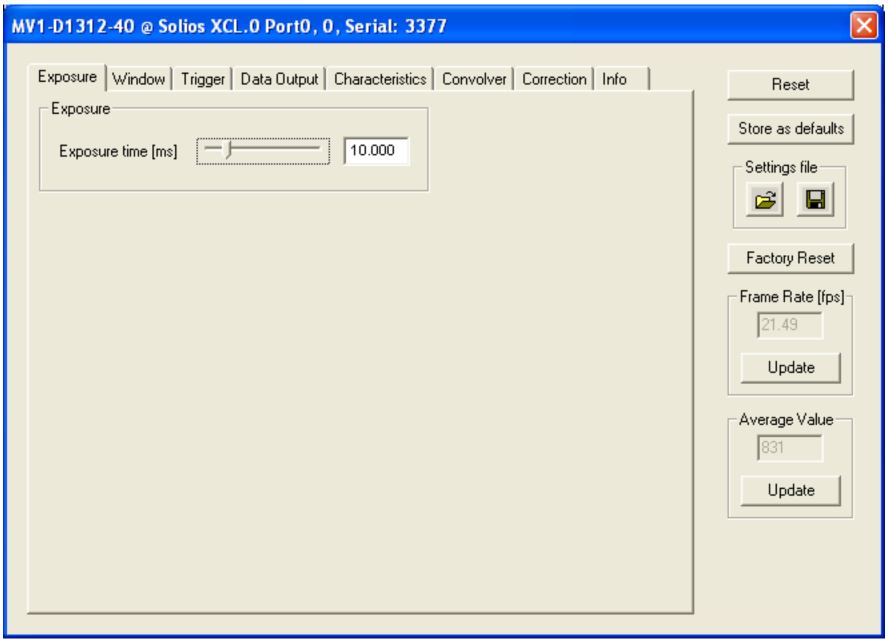

Figure 7.10: MV1-D1312-40 exposure panel

Exposure

Exposure time [ms :] Configure the exposure time in milliseconds.

7.2.2 Window

This tab contains the settings for the region of interest.

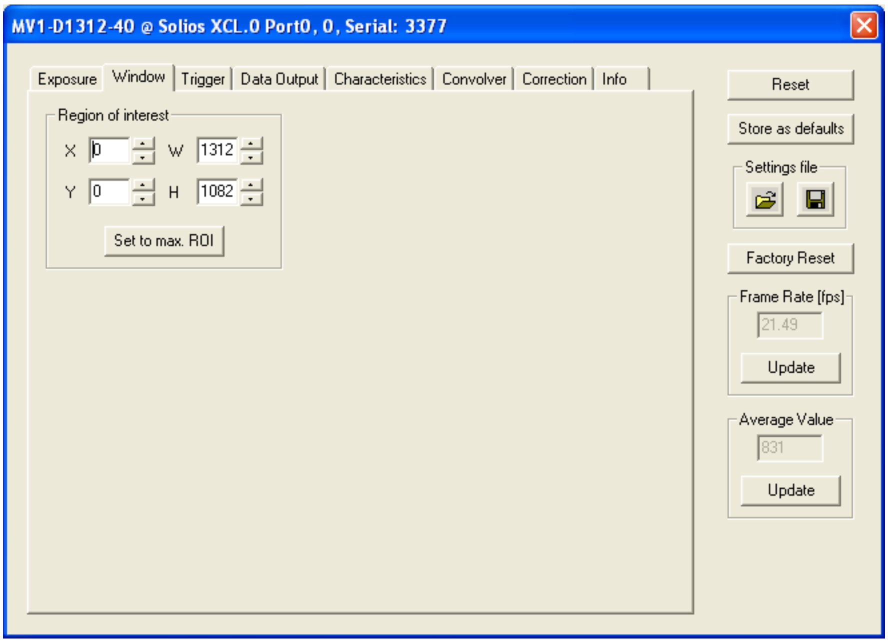

Figure 7.11: MV1-D1312-40 window panel

Region of Interest

The region of interest (ROI) is defined as a rectangle (X, Y), (W, H) where

X: X - coordinate, starting from 0 in the upper left corner.

Y: Y - coordinate, starting from 0 in the upper left corner.

W: Window width (in steps of 32 pixel).

H: Window height.

Set to max ROI: Set Window to maximal ROI (X=0; Y=0; W=1312; H=1082).

Window width is only available in steps of 32 pixel.

7.2.3 Trigger

This tab contains trigger and strobe settings.

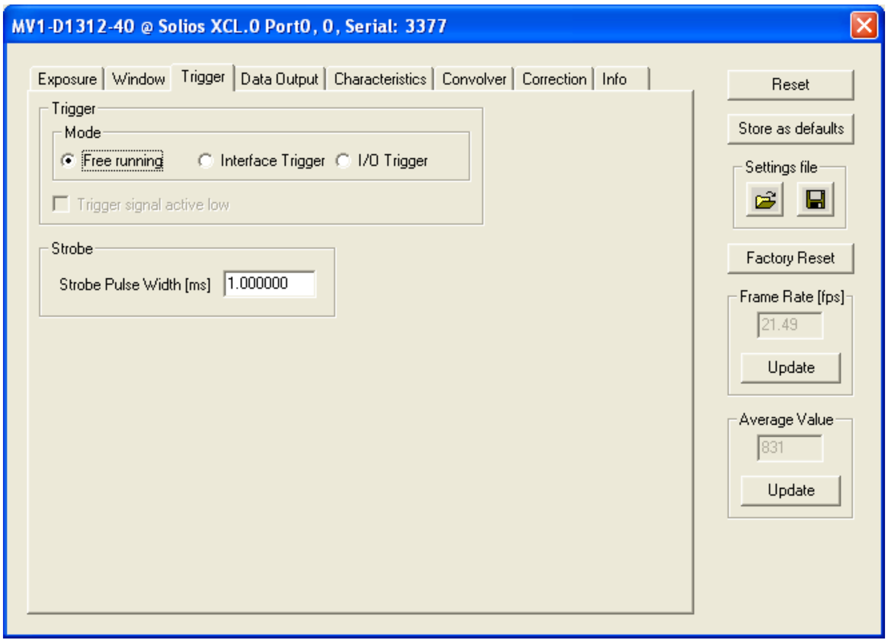

Figure 7.12: MV1-D1312-40 trigger panel

Trigger

Trigger Source:

Free running: The camera continuously delivers images with a certain configurable frame rate.

Interface Trigger: The Trigger signal is applied to the camera by the CameraLink frame grabber or the USB interface respectively.

I/O Trigger: The trigger signal is applied directly to the camera on the power supply connector.

Further trigger settings:

Trigger signal active low: Define the trigger signal to be active high (default) or active low.

Strobe

The camera generates a strobe output signal that can be used to trigger a strobe. The pulse width can be defined by software. To turn off strobe output, set StrobePulseWidth to 0.

Strobe Pulse Width [ms :] The pulse width of the strobe trigger in milliseconds.

7.2.4 Data Output

This tab contains image data settings.

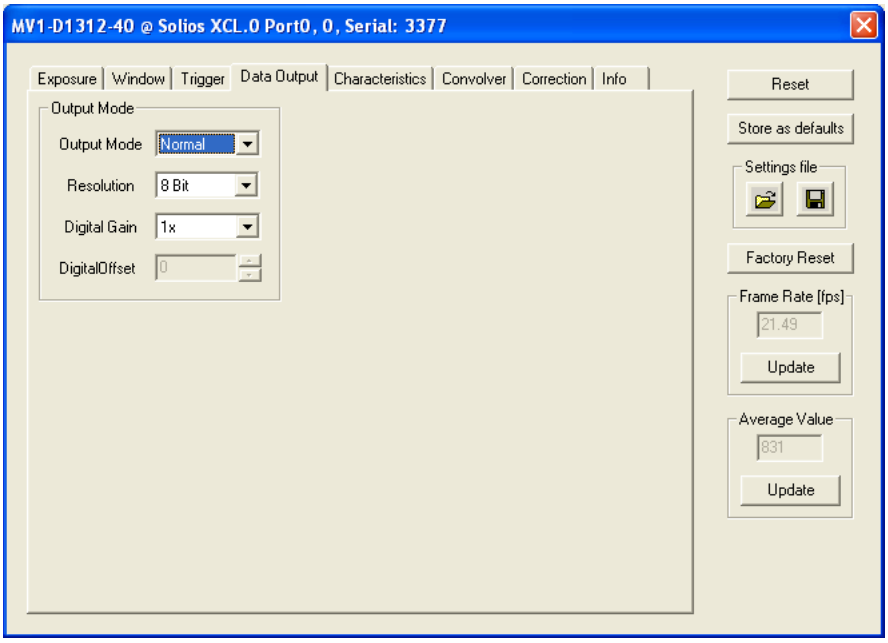

Figure 7.13: MV1-D1312-40 data output panel

Output Mode

Output Mode:

Normal: Normal mode.

LFSR: Test image. Linear feedback shift register (pseudo-random image). The pattern depends on the grey level resolution.

Ramp: Test image. Values of pixel are incremented by 1, starting at each row. The pattern depends on the grey level resolution.

Resolution:

8 Bit: Grey level resolution of 8 bit.

10 Bit: Grey level resolution of 10 bit.

12 Bit: Grey level resolution of 12 bit.

Digital Gain:

1x: No digital gain, normal mode.

2x: Digital gain 2.

4x: Digital gain 4.

Digital Offset: Substracts an offset from the data. Only available in Gain Mode.

7.2.5 Characteristics

This tab contains LinLog and Skimming settings.

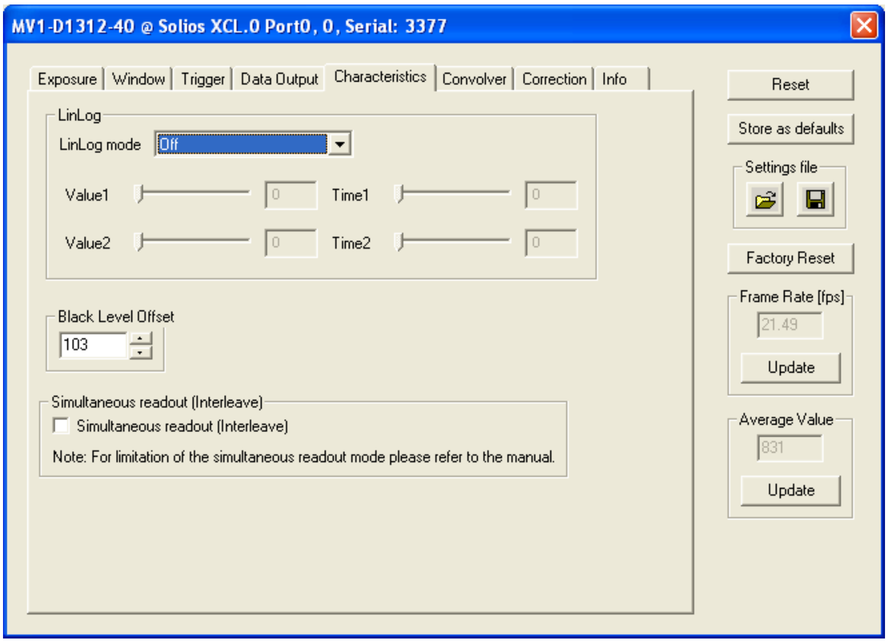

Figure 7.14: MV1-D1312-40 characteristics panel

LinLog

The LinLog technology from Photonfocus allows a logarithmic compression of high light intensities. In contrast to the classical non-integrating logarithmic pixel, the LinLog pixel is an integrating pixel with global shutter and the possibility to control the transition between linear and logarithmic mode (Section 4.2.2). There are 3 predefined LinLog settings available. Alternatively, custom settings can be defined in the `User defined` Mode.

LinLog Mode: Off: LinLog is disabled. Low/Normal/High compression: Three LinLog presettings. User defined: `Value1`, `Time1`, `Value2` and `Time2`. The Linlog times are per thousand of the exposure time. Time 800 means 80% of the exposure time.

Black Level Offset

It may be necessary to adjust the black level offset of the camera.

Black Level Offset: Black level offset value. Use this to adjust the black level.

Simultaneous readout (Interleave)

The simultaneous readout mode allows higher frame rate.

Simultaneous readout (Interleave): Enable the simultaneous readout mode.

7.2.6 Convolver

This tab contains the Convolver settings.

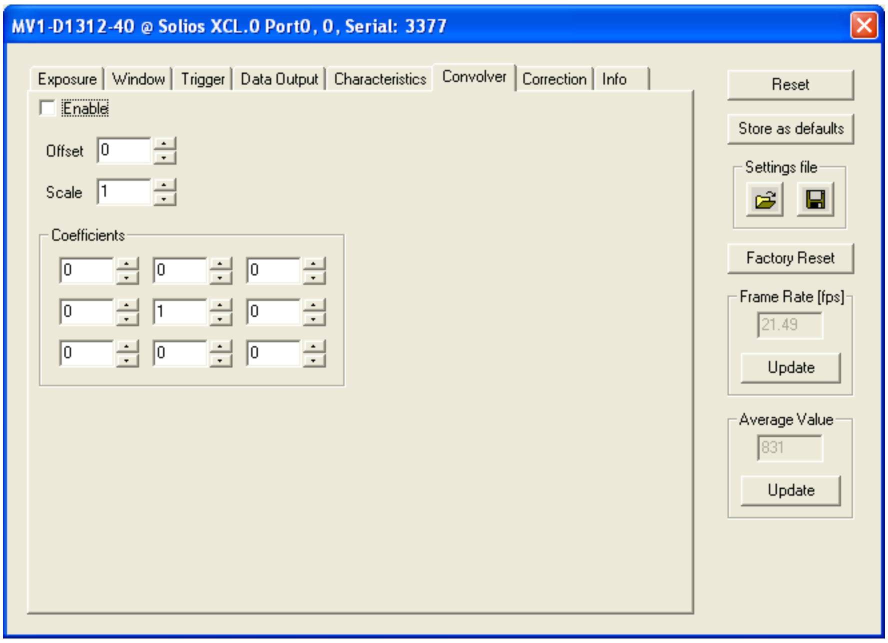

Figure 7.15: MV1-D1312-40 convolver panel

Offset

Offset: Offset value o. Range: -4096 ... 4095.

Scale

Scale: Scale value s. Range: 1 ... 4095.

Coefficients

Coefficents: Coefficients of the convolution kernel h. Range: -4096 ... 4095.

7.2.7 Correction

This tab contains correction settings.

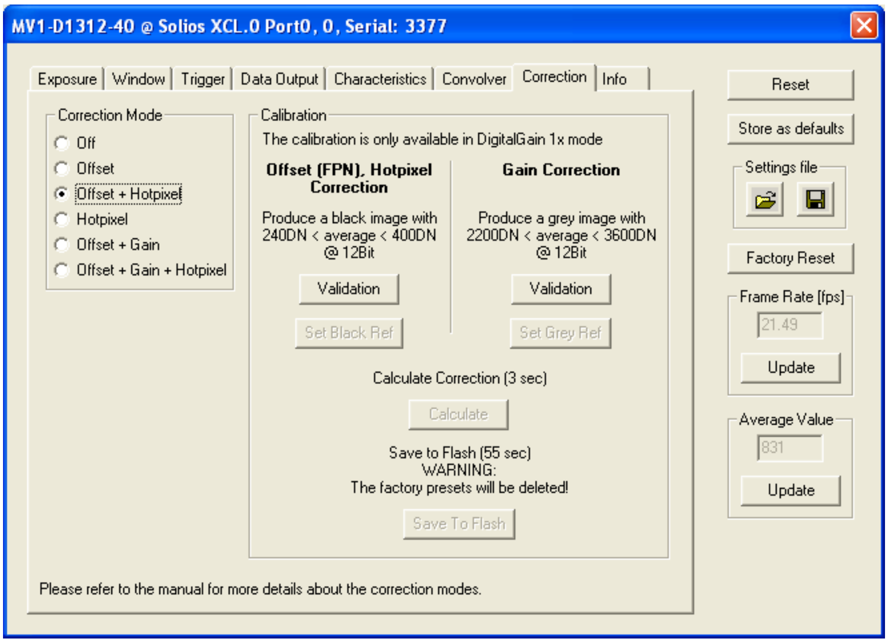

Figure 7.16: MV1-D1312-40 correction panel

Correction Mode

This camera has image pre-processing features, that compensate for non-uniformities caused by the sensor, the lens or the illumination.

Off: No correction.

Offset: Activate offset correction

Offset + Hotpixel: Activate offset and hot pixel correction.

Hotpixel: Activate hot pixel correction.

Offset + Gain: Activate offset and gain correction.

Offset + Gain + Hotpixel: Activate offset, gain and hot pixel correction.

Calibration

Offset (FPN), Hotpixel Correction: The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimize the static noise. Close the lens of the camera. Click on the Validation button. If the Set Black Ref - button is still inactive, the average of the image is out of range. Change to panel Charateristics and change the Property `BlackLevelOffset` until the average of the image is between 160 and 400DN. Click again on the Validation button and then on the Set Black Ref Button.

If only offset and hot pixel correction is needed it is not necessary to calibrate a grey image. (see Calculate)

Gain Correction: The gain correction is based on a grey reference image, which is taken at uniform illumination to give an image with a mid grey level.

Gain correction is not a trivial feature. The quality of the grey reference image is crucial for proper gain correction.

Produce a grey image with an average between 2200 and 3600DN. Click on the Validation button to check the average. If the average is in range, the Set Grey Ref button is active.

Calculate: Calculate the correction values into the camera RAM. To make the correction values permanent, use the 'Save to Flash' button.

Save to Flash: Save the current correction values to the internal flash memory.

This will overwrite the factory presets.

7.2.8 Info

This panel shows camera specific information such as type code, serial number and firmware revision of the FPGA and microcontroller and the description of the camera interface.

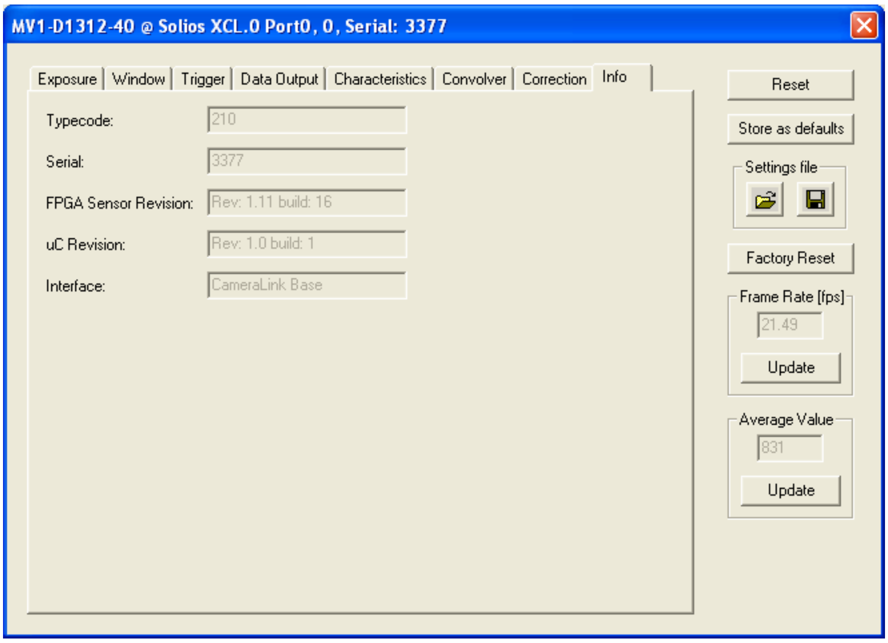

Figure 7.17: MV1-D1312-40 info panel

Typecode: Type code of the connected camera.

Serial: Serial number of the connected camera.

FPGA Sensor Revision: Firmware revision of built-in Sensor FPGA of the connected camera.

uC Revision: Firmware revision of built-in microcontroller of the connected camera.

Interface: Description of the camera interface.

☞ For any support requests, please enclose the information provided on this tab.

8

Mechanical and Optical Considerations

8.1 Mechanical Interface

During storage and transport, the camera should be protected against vibration, shock, moisture and dust. The original packaging protects the camera adequately from vibration and shock during storage and transport. Please either retain this packaging for possible later use or dispose of it according to local regulations.

8.1.1 Cameras with CameraLink® Interface

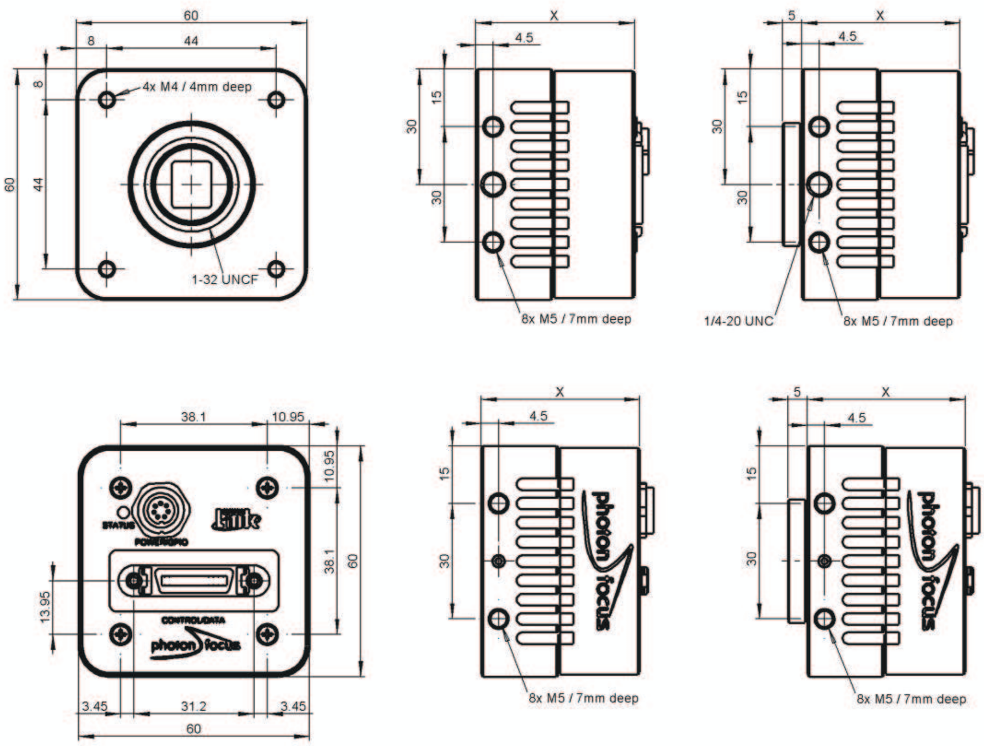

Figure 8.1: Mechanical dimensions of the CameraLink model, displayed without and with C-Mount adapter

Fig. 8.1 shows the mechanical drawing of the camera housing for the MV1-D1312(I) CMOS cameras. The depth of the camera housing is given in Table 8.1 (all values in [mm]).

	MV1-D1312(I) Series
X (housing depth)	40 mm

Table 8.1: Model-specific parameters

8.2 Optical Interface

8.2.1 Cleaning the Sensor

The sensor is part of the optical path and should be handled like other optical components: **with extreme care**.
Dust can obscure pixels, producing dark patches in the images captured. Dust is most visible when the illumination is collimated. Dark patches caused by dust or dirt shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

1. The camera should only be cleaned in ESD-safe areas by ESD-trained personnel using wrist straps. Ideally, the sensor should be cleaned in a clean environment. Otherwise, in dusty environments, the sensor will immediately become dirty again after cleaning.
2. Use a high quality, low pressure air duster (e.g. Electrolube EAD400D, pure compressed inert gas, www.electrolube.com) to blow off loose particles. This step alone is usually sufficient to clean the sensor of the most common contaminants.

   Workshop air supply is not appropriate and may cause permanent damage to the sensor.

3. If further cleaning is required, use a suitable lens wiper or Q-Tip moistened with an appropriate cleaning fluid to wipe the sensor surface as described below. Examples of suitable lens cleaning materials are given in Table 8.2. Cleaning materials must be ESD-safe, lint-free and free from particles that may scratch the sensor surface.

   Do not use ordinary cotton buds. These do not fulfil the above requirements and permanent damage to the sensor may result.

4. Wipe the sensor carefully and slowly. First remove coarse particles and dirt from the sensor using Q-Tips soaked in 2-propanol, applying as little pressure as possible. Using a method similar to that used for cleaning optical surfaces, clean the sensor by starting at any corner of the sensor and working towards the opposite corner. Finally, repeat the procedure with methanol to remove streaks. It is imperative that no pressure be applied to the surface of the sensor or to the black globe-top material (if present) surrounding the optically active surface during the cleaning process.

Product		Supplier	Remark
EAD400D	Airduster	Electrolube, UK	www.electrolube.com
Anticon Gold 9"x 9"	Wiper	Milliken, USA	ESD safe and suitable for class 100 environments. www.milliken.com
TX4025	Wiper	Texwipe	www.texwipe.com
Transplex	Swab	Texwipe	
Small Q-Tips SWABS BB-003	Q-tips	Hans J. Michael GmbH, Germany	www.hjm.de
Large Q-Tips SWABS CA-003	Q-tips	Hans J. Michael GmbH, Germany	
Point Slim HUBY-340	Q-tips	Hans J. Michael GmbH, Germany	
Methanol	Fluid	Johnson Matthey GmbH, Germany	Semiconductor Grade 99.9% min (Assay), Merck 12,6024, UN1230, slightly flammable and poisonous. www.alfa-chemcat.com
2-Propanol (Iso-Propanol)	Fluid	Johnson Matthey GmbH, Germany	Semiconductor Grade 99.5% min (Assay) Merck 12,5227, UN1219, slightly flammable. www.alfa-chemcat.com

Table 8.2: Recommended materials for sensor cleaning

For cleaning the sensor, Photonfocus recommends the products available from the suppliers as listed in Table 8.2.

✎ Cleaning tools (except chemicals) can be purchased directly from Photonfocus (www.photonfocus.com).

8.3 Compliance

CE Compliance Statement

We,

Photonfocus AG,
CH-8853 Lachen, Switzerland

declare under our sole responsibility that the following products

MV-D1024-28-CL-10, MV-D1024-80-CL-8, MV-D1024-160-CL-8

MV-D752-28-CL-10, MV-D752-80-CL-8, MV-D752-160-CL-8

MV-D640-33-CL-10, MV-D640-66-CL-10, MV-D640-48-U2-8
MV-D640C-33-CL-10, MV-D640C-66-CL-10, MV-D640C-48-U2-8

MV-D1024E-40, MV-D752E-40, MV-D750E-20 (CameraLink and USB2.0 Models), MV-D1024E-80, MV-D1024E-160

MV-D1024E-3D01-160

MV2-D1280-640-CL-8

SM2-D1024-80 / VisionCam PS

DS1-D1024-40-CL, DS1-D1024-40-U2,
DS1-D1024-80-CL, DS1-D1024-160-CL

DS1-D1312-160-CL
MV1-D1312(I)-40-CL, MV1-D1312(I)-80-CL, MV1-D1312(I)-160-CL

Digipeater CLB26

are in compliance with the below mentioned standards according to the provisions of European Standards Directives:

EN 61 000 - 6 - 3 : 2001
EN 61 000 - 6 - 2 : 2001
EN 61 000 - 4 - 6 : 1996
EN 61 000 - 4 - 4 : 1996
EN 61 000 - 4 - 3 : 1996
EN 61 000 - 4 - 2 : 1995
EN 55 022 : 1994

Photonfocus AG, April 2009

Figure 8.2: CE Compliance Statement

9 Warranty

The manufacturer alone reserves the right to recognize warranty claims.

9.1 Warranty Terms

The manufacturer warrants to distributor and end customer that for a period of two years from the date of the shipment from manufacturer or distributor to end customer (the "Warranty Period") that:

- the product will substantially conform to the specifications set forth in the applicable documentation published by the manufacturer and accompanying said product, and
- the product shall be free from defects in materials and workmanship under normal use.

The distributor shall not make or pass on to any party any warranty or representation on behalf of the manufacturer other than or inconsistent with the above limited warranty set.

9.2 Warranty Claim

The above warranty does not apply to any product that has been modified or altered by any party other than manufacturer, or for any defects caused by any use of the product in a manner for which it was not designed, or by the negligence of any party other than manufacturer.

10 References

All referenced documents can be downloaded from our website at www.photonfocus.com.

CL CameraLink® Specification, January 2004

SW002 PFLib Documentation, Photonfocus, August 2005

MAN025 User Manual "microDisplayUSB2.0", Photonfocus, November 2005

AN001 Application Note "LinLog", Photonfocus, December 2002

AN006 Application Note "Quantum Efficiency", Photonfocus, February 2004

AN007 Application Note "Camera Acquisition Modes", Photonfocus, March 2004

AN008 Application Note "Photometry versus Radiometry", Photonfocus, December 2004

AN010 Application Note "Camera Clock Concepts", Photonfocus, July 2004

AN021 Application Note "CameraLink®", Photonfocus, July 2004

AN026 Application Note "LFSR Test Images", Photonfocus, September 2005

AN030 Application Note "LinLog® Parameter Optimization Strategies", February 2009

A

Pinouts

A.1 Power Supply Connector

The power supply plugs are available from Binder connectors at www.binder-connector.de. Fig. A.2 shows the power supply plug from the solder side. The pin assignment of the power supply plug is given in Table A.2.

It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage or destroy the camera.

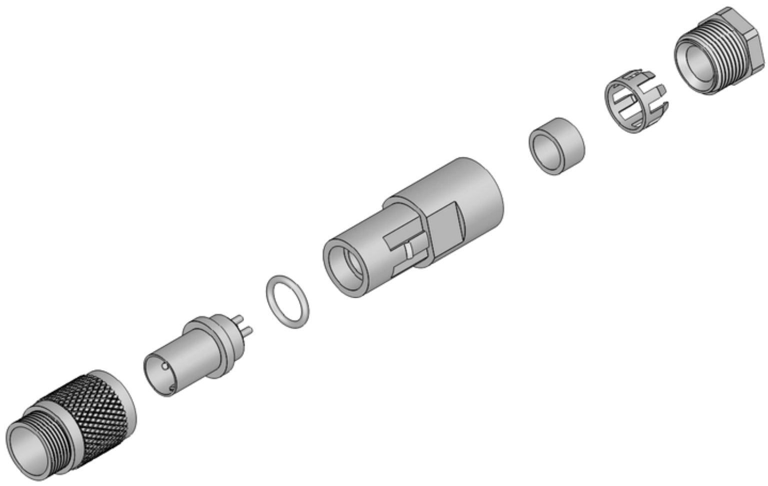

Figure A.1: Power connector assembly

Connector Type	Order Nr.
7-pole, plastic	99-0421-00-07
7-pole, metal	99-0421-10-07

Table A.1: Power supply connectors (Binder subminiature series 712)

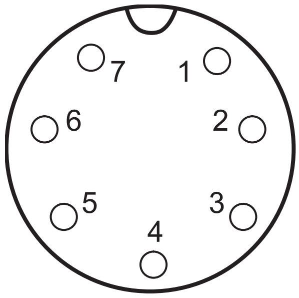

Figure A.2: Power supply plug, 7-pole (rear view of plug, solder side)

Pin	*I/O Type*	*Name*	*Description*
1	PWR	VDD	+12 V DC ($\pm$ 10%)
2	PWR	GND	Ground
3	O	RESERVED	Do not connect
4	PWR	STROBE-VDD	+5 .. +15 V DC
5	O	STROBE	Strobe control (opto-isolated)
6	I	TRIGGER	External trigger (opto-isolated), +5 .. +15V DC
7	PWR	GROUND	Signal ground (for opto-isolated strobe signal)

Table A.2: Power supply plug pin assignment

A.2 CameraLink® Connector

The pinout for the CameraLink® 26 pin, 0.5" Mini D-Ribbon (MDR) connector is according to the CameraLink® standard ([CL]) and is listed here for reference only (see Table A.3). The drawing of the CameraLink® cable plug is shown in Fig. A.3.

☞ CameraLink® cables can be purchased from Photonfocus directly (www.photonfocus.com).

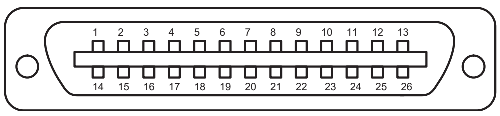

Figure A.3: CameraLink cable 3M MDR-26 plug (both ends)

PIN	IO	Name	Description
1	PW	SHIELD	Shield
2	O	N_XD0	Negative LVDS Output, CameraLink® Data D0
3	O	N_XD1	Negative LVDS Output, CameraLink® Data D1
4	O	N_XD2	Negative LVDS Output, CameraLink® Data D2
5	O	N_XCLK	Negative LVDS Output, CameraLink® Clock
6	O	N_XD3	Negative LVDS Output, CameraLink® Data D3
7	I	P_SERTOCAM	Positive LVDS Input, Serial Communication to the camera
8	O	N_SERTOFG	Negative LVDS Output, Serial Communication from the camera
9	I	N_CC1	Negative LVDS Input, Camera Control 1 (CC1)
10	I	N_CC2	Positive LVDS Input, Camera Control 2 (CC2)
11	I	N_CC3	Negative LVDS Input, Camera Control 3 (CC3)
12	I	P_CC4	Positive LVDS Input, Camera Control 4 (CC4)
13	PW	SHIELD	Shield
14	PW	SHIELD	Shield
15	O	P_XD0	Positive LVDS Output, CameraLink® Data D0
16	O	P_XD1	Positive LVDS Output, CameraLink® Data D1
17	O	P_XD2	Positive LVDS Output, CameraLink® Data D2
18	O	P_XCLK	Positive LVDS Output, CameraLink® Clock
19	O	P_XD3	Positive LVDS Output, CameraLink® Data D3
20	I	N_SERTOCAM	Negative LVDS Input, Serial Communication to the camera
21	O	P_SERTOFG	Positive LVDS Output, Serial Communication from the camera
22	I	P_CC1	Positive LVDS Input, Camera Control 1 (CC1)
23	I	N_CC2	Negative LVDS Input, Camera Control 2 (CC2)
24	I	P_CC3	Positive LVDS Input, Camera Control 3 (CC3)
25	I	N_CC4	Negative LVDS Input, Camera Control 4 (CC4)
26	PW	SHIELD	Shield
S	PW	SHIELD	Shield

Table A.3: Pinout of the CameraLink® connector

B

Revision History

Revision	Date	Changes
1.0	November 2008	First release
1.1	March 2009	Added camera models MV1-D1312I-160 and MV1-D1312(I)-40
		Added formula to calculate ROI-X
		Added description of optocoupler delay
		Added description of 3x3 convolver
1.2	April 2009	Added camera model MV1-D1312(I)-80