User Manual

Photonfocus D/L-2048 CameraLink® Series

CMOS Area Scan Camera

MAN054 11/2013 V1.3

Contents

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 00 00	Email: sales@photonfocus.com
Support	Phone: +41 55 451 00 00	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

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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 Introduction

This manual describes standard Photonfocus 2048 series cameras that have a CameraLink® interface. The cameras contain CMV2000 or CMV4000 sensors from CMOSIS. The Photonfocus 2048 CameraLink® series has the following camera model families:

L-cameras Cameras that contain a dedicated line scan mode to acquire up to 4 rows at very high speeds (27300 fps for 2048x1 pixels), making it a cost-effective replacement for line scan cameras.

D-cameras Standard area scan cameras.

There are camera models in every camera family with the following sensor types:

Monochrome Standard monochrome sensor

Color Colour sensor

NIR Cameras with NIR enhanced CMV2000/CMV4000 E12 image sensor

2.1 Camera Naming convention

The naming convention of the D2048 camera series is summarized in Fig. 2.1.

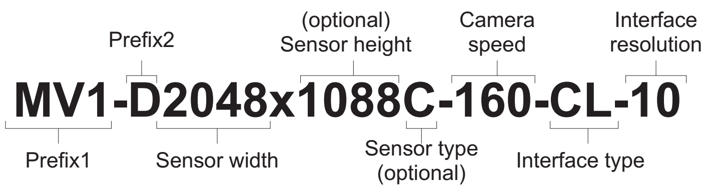

Figure 2.1: Camera naming convention

Prefix1 All cameras covered in this manual have `MV1` as Prefix1.

Prefix2 Camera family specifier. The following specifiers are used in this manual: "D": standard area scan cameras; "L": cameras with dedicated line scan mode

Sensor width All cameras covered in this manual use sensors with a width of 2048 pixels.

Sensor height This indication is optional to avoid ambiguity. The D-cameras that use the 2 MPix CMV2000 sensor have a height indicator of "1088". The D-cameras that use the 4 MPix CMV4000 sensor don't have a height indication.

Sensor type Available sensor types are: "I": NIR enhanced sensors, "C": colour cameras. Cameras without sensor type specifier have a standard monochrome sensor.

Camera speed The camera speed is usually the product of the camera interface clock in MHz and the number of parallel interface channels (taps).

Interface type All cameras covered by this manual have a CameraLink® interface denoted by "CL".

Interface resolution Resolution (bit width) of the camera interface.

2.2 Camera list

A list of all cameras covered in this manual is shown in Table 2.1 (see also Table 4.2).

Abbreviated camera names are used in this manual to increase readability. The following abbreviations are used (see also Table 2.1):

2048 camera series All cameras covered in this manual

D-camera Cameras that don't have a line scan mode. These cameras have Prefix2="D" (see also Fig. 2.1).

L-camera Cameras that have a line scan mode. These cameras have Prefix2="L" (see also Fig. 2.1).

D-xxx D-cameras with camera speed = xxx, e.g. D-160.

L-xxx L-cameras with camera speed = xxx, e.g. L-160.

NIR enhanced Cameras that have a Near Infrared (NIR) enhanced sensor.

Color Cameras that have a colour sensor.

Name	Resolution	Camera Family	Abbreviation	NIR	Color
MV1-D2048x1088-160-CL-10	2 MPix	D-camera	D-160	no	no
MV1-D2048x1088I-160-CL-10	2 MPix	D-camera	D-160	yes	no
MV1-D2048x1088C-160-CL-10	2 MPix	D-camera	D-160	no	yes
MV1-D2048x1088-240-CL-8	2 MPix	D-camera	D-240	no	no
MV1-D2048x1088I-240-CL-8	2 MPix	D-camera	D-240	yes	no
MV1-D2048x1088C-240-CL-8	2 MPix	D-camera	D-240	no	yes
MV1-D2048-160-CL-10	4 MPix	D-camera	D-160	no	no
MV1-D2048I-160-CL-10	4 MPix	D-camera	D-160	yes	no
MV1-D2048C-160-CL-10	4 MPix	D-camera	D-160	no	yes
MV1-D2048-240-CL-8	4 MPix	D-camera	D-240	no	no
MV1-D2048I-240-CL-8	4 MPix	D-camera	D-240	yes	no
MV1-D2048C-240-CL-8	4 MPix	D-camera	D-240	no	yes
MV1-L2048-160-CL-10	2 MPix	L-camera	L-160	no	no
MV1-L2048I-160-CL-10	2 MPix	L-camera	L-160	yes	no
MV1-L2048C-160-CL-10	2 MPix	L-camera	L-160	no	yes

Table 2.1: Camera models covered by this manual

3

How to get started (CameraLink®)

The following items are required to operate your Photonfocus 2048 CameraLink® camera:

- PC
- Suitable CameraLink® frame grabber card to be installed in the PC. All Photonfocus CameraLink® cameras are fully compatible with the CameraLink® standard 1.1 and later. Therefore, all framegrabbers complying with the standard will be compatible with Photonfocus cameras if they meet the interface and speed specifications of the cameras. Note that some framegrabbers use CameraLink® chipsets limited to 66 MHz pixel clocks. These framegrabbers are not compatible with Photonfocus 2048 series CameraLink® cameras. If you have compatibility questions concerning your framegrabber, please contact our support team via support@photonfocus.com. Suitable CameraLink® frame grabbers can be purchased from Photonfocus directly (www.photonfocus.com) in some countries.
- CameraLink® cable. The cable length should not be too big for the camera. The camera includes test images 5.9 to measure the transmission quality of the system. CameraLink® cables can be purchased from directly Photonfocus (www.photonfocus.com) in some countries.
- A suitable power supply. A suitable power supply can be purchased at your Photonfocus dealership.
- C-Mount camera lens. Note that if you plan to use your NIR enhanced camera in the near infrared region (NIR), then you should use SWIR camera lenses.

1. Install a suitable frame grabber in your PC.
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.

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

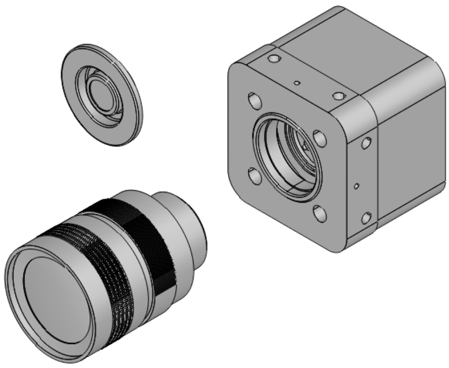

Figure 3.1: Camera with protective cap and lens.

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. 3.2).

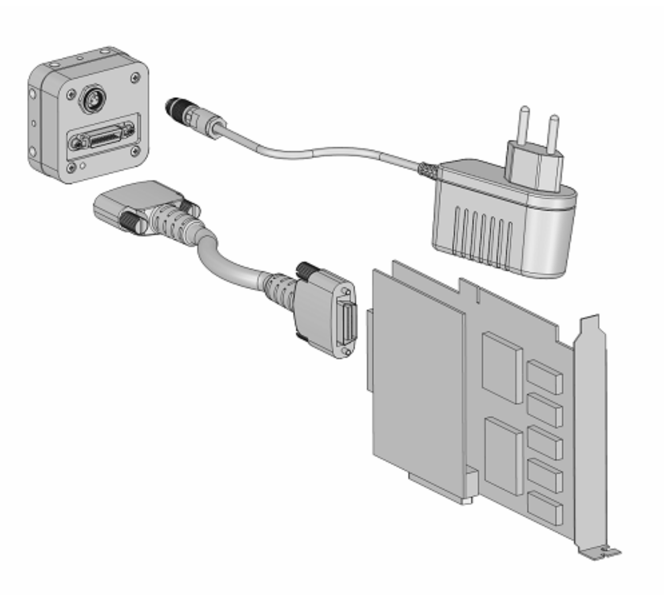

Figure 3.2: Camera with frame grabber, power supply and cable.

Do not connect or disconnect the CameraLink® cable while camera power is on! For more information about CameraLink® see Section 5.10.

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 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. 3.2).

   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 6.1.4.

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.

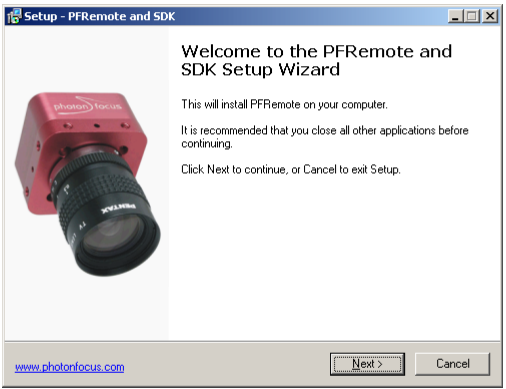

Figure 3.3: Screen shot PFremote setup wizard

10. Start the camera software PFRemote and choose the communication port.
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 6.1.4.

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

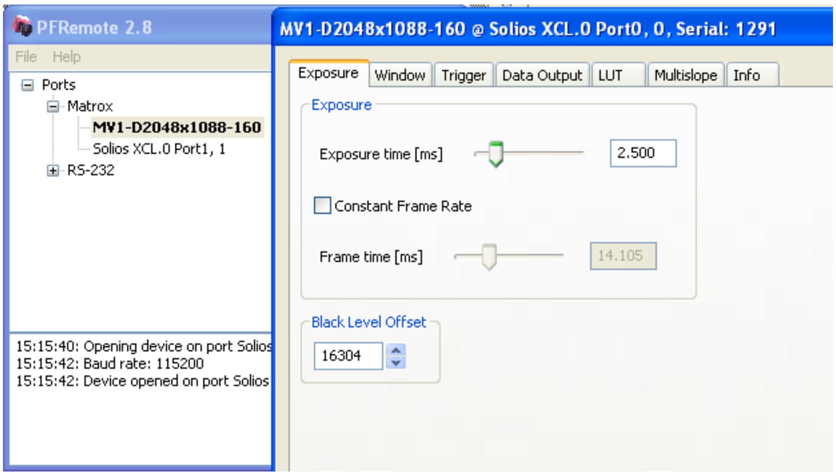

Figure 3.4: PFRemote start window

4 Product Specification

4.1 Introduction

The Photonfocus 2048 CMOS camera series is built around the CMOS image sensors CMV2000 and CMV4000 from CMOSIS, that provide a resolution of 2048 x 1088 (CMV2000) or 2048 x 2048 pixels (CMV4000). The cameras are optimized for low light conditions and there are standard monochrome, NIR enhanced monochrome (I) and colour (C) models. The cameras are aimed at standard applications in industrial image processing where high sensitivity and high frame rates are required.

The L-160 cameras contain a dedicated line scan mode where up to 4 rows can be acquired at very high speeds (27300 fps for 2048x1 pixels), making it a cost-effective replacement for line scan cameras.

The principal advantages are:

- Resolution of 2048 x 1088 or 2048 x 2048 pixels
- Optimized for low light conditions
- Spectral range: monochrome standard; 350 - 900 nm, NIR enhanced: 350 ... 950 nm
- Global shutter, correlated double sampling (CDS) in the pixel
- Micro lenses
- Colour cameras: Bayer pattern filter and cut off filter @ 660nm
- CameraLink® base interface.
- Frame rates of the D-160 camera series: 37 fps (2048 x 2048 pixel, 4 MPix camera only), 71 fps (2048 x 1088), 150 fps (1024 x 1024), 318 fps (640 x 480)
- Frame rates of the D-240 camera series: 45 fps (2046 x 2048 pixel, 4 MPix camera only), 85 fps (2046 x 1088), 180 fps (1020 x 1024), 755 fps (636 x 480)
- L-series line scan frame rates: 27300 fps (2048 x 1), 25400 fps (2048 x 2)
- Opto isolated trigger input and opto isolated strobe output
- Up to 8 regions of interest (MROI)
- 2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT)
- Crosshairs overlay on the image
- Image information and camera settings inside the image (status line)
- Software provided for setting and storage of camera parameters
- The rugged housing at a compact size of 55 x 55 x 42 mm^3 makes the Photonfocus 2048 camera familiy 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.

4.2 Feature Overview

The general specification and features of the camera are listed in the following sections. The detailed description of the camera features is given in Chapter 5.

Characteristics	Photonfocus 2048 CameraLink® Series
Interface	CameraLink® base configuration
Camera Control	PFRemote (Windows GUI) or programming library
Configuration Interface	CLSERIAL (9'600 baud up to 1.5Mbaud, user selectable)
Trigger Modes	Interface Trigger / External opto isolated trigger input
Image pre-processing	2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT)
Features	Greyscale / colour resolution 10 [1] bit / 8 bit
	Region of Interest (ROI)
	Up to 8 regions of interest (MROI)
	Fast line scan mode (L-series only)
	Test pattern (LFSR and grey level ramp)
	Image information and camera settings inside the image (status line)
	Crosshairs overlay on the image
	Opto isolated trigger input and opto isolated strobe output

Table 4.1: Feature overview (see Chapter 5 for more information). (Footnotes: [1] D-160 and L-160 only)

Figure 4.1: Photonfocus 2048 CMOS camera series with C-mount lens.

4.3 Available Camera Models

☞ Please check the availability of a specific camera model on our website www.photonfocus.com.

Name	**Resolution**	**FPS**	**NIR** [4]	**Color**	**Line Scan**
MV1-D2048x1088-160-CL-10	2048 x 1088	71 fps [1]	no	no	no
MV1-D2048x1088I-160-CL-10	2048 x 1088	71 fps [1]	yes	no	no
MV1-D2048x1088C-160-CL-10	2048 x 1088	71 fps [1]	no	yes	no
MV1-D2048x1088-240-CL-8	2046 x 1088	85 fps [1]	no	no	no
MV1-D2048x1088I-240-CL-8	2046 x 1088	85 fps [1]	yes	no	no
MV1-D2048x1088C-240-CL-8	2046 x 1088	85 fps [1]	no	yes	no
MV1-D2048-160-CL-10	2048 x 2048	37 fps [1]	no	no	no
MV1-D2048I-160-CL-10	2048 x 2048	37 fps [1]	yes	no	no
MV1-D2048C-160-CL-10	2048 x 2048	37 fps [1]	no	yes	no
MV1-D2048-240-CL-8	2046 x 2048	45 fps [1]	no	no	no
MV1-D2048I-240-CL-8	2046 x 2048	45 fps [1]	yes	no	no
MV1-D2048C-240-CL-8	2046 x 2048	45 fps [1]	no	yes	no
MV1-L2048-160-CL-10	2048 x 1088	27300 fps [2]	no	no	yes
MV1-L2048I-160-CL-10	2048 x 1088	27300 fps [2]	yes	no	yes
MV1-L2048C-160-CL-10	2048 x 1088	25400 fps [3]	no	yes	yes

Table 4.2: Available Photonfocus 2048 camera models (Footnotes: [1] frame rate at at full resolution, [2] line scan mode 2048x1 pixels, [3] line scan mode 2048x2 pixels, [4] NIR enhanced camera with CMV2000/CMV4000 E12 image sensor)

4.4 Technical Specification

	D-160 / L-160	D-240
Sensor	CMOSIS CMV2000	
Technology	CMOS active pixel	
Scanning system	progressive scan	
Optical format / diagonal	2/3" (12.75 mm diagonal)	
Resolution	2048 x 1088 pixels	2046 x 1088 pixels
Pixel size	5.5 μm x 5.5 μm	
Active optical area	11.26 mm x 5.98 mm	
Full well capacity	~11 ke^-	
Spectral range standard sensor	< 350 to 900 nm (to 10 % of peak responsivity)	
Spectral range of (I) models	< 350 to 970 nm (to 10 % of peak responsivity)	
Spectral range of colour models	390 to 670 nm (to 10 % of peak responsivity)	
Conversion gain	0.075 LSB/e^-	
Sensitivity	5.56 V / lux.s (with micro lenses @ 550 nm)	
Optical fill factor	42 % (without micro lenses)	
Dark current	125 e^-/s @ 25°C	
Dynamic range	60 dB	
Micro lenses	Yes	
Colour format (C) cameras	RGB Bayer Raw Data Pattern	
Characteristic curve	Linear, Piecewise linear (multiple slope)	
Shutter mode	global shutter	
Sensor bit depth	10 bit	
Maximal Frame rate	70.9 fps [1)], 27300 fps [2)]	85.1 fps [1)]
Camera pixel formats	10 / 8 bit	8 bit
Pixel clock frequency	80 MHz	80 MHz
CameraLink® taps	2	3
Digital Gain	0.1 to 15.99 (Fine Gain)	
Exposure Time D-series	15 μs ... 0.42 s / 25 ns steps	13 μs ... 0.349 s / 20.8 ns steps
Exposure Time L-series	13 μs ... 0.349 s / 20.8 ns steps	n/a

Table 4.3: General specification of the 2 MPix models of the Photonfocus 2048 series (Footnotes: [1)]D-cameras at full resolution, [2)]L-cameras at 2048x1 in line scan mode)

	D-160	D-240
Sensor	CMOSIS CMV4000	
Technology	CMOS active pixel	
Scanning system	progressive scan	
Optical format / diagonal	1” (15.92 mm diagonal)	
Resolution	2048 x 2048 pixels	2046 x 2048 pixels
Pixel size	5.5 μm x 5.5 μm	
Active optical area	11.26 mm x 11.26 mm	
Full well capacity	~11 ke$^-$	
Spectral range standard sensor	< 350 to 900 nm (to 10 % of peak responsivity)	
Spectral range of (I) models	< 350 to 970 nm (to 10 % of peak responsivity)	
Spectral range of colour models	390 to 670 nm (to 10 % of peak responsivity)	
Conversion gain	0.075 LSB/e$^-$	
Sensitivity	5.56 V / lux.s (with micro lenses @ 550 nm)	
Optical fill factor	42 % (without micro lenses)	
Dark current	125 e$^-$/s @ 25°C	
Dynamic range	60 dB	
Micro lenses	Yes	
Colour format (C) cameras	RGB Bayer Raw Data Pattern	
Characteristic curve	Linear, Piecewise linear (multiple slope)	
Shutter mode	global shutter	
Sensor bit depth	10 bit	
Maximal Frame rate [1)]	37.7 fps	45.3 fps
Camera pixel formats	10 / 8 bit	8 bit
Pixel clock frequency	80 MHz	80 MHz
CameraLink® taps	2	3
Digital Gain	0.1 to 15.99 (Fine Gain)	
Exposure Time	28 μs ... 0.42 s / 25 ns steps	26 μs ... 0.349 s / 20.8 ns steps

Table 4.4: General specification of the 4 MPix models of the Photonfocus 2048 series (Footnotes: [1)] at full resolution)

	Photonfocus 2048 CameraLink® Series
Operating temperature / moisture	0°C ... 50°C / 20 ... 80 %
Storage temperature / moisture	-25°C ... 60°C / 20 ... 95 %
Camera power supply	+12 V DC (± 10 %)
Trigger signal input range	+5 .. +15 V DC
Maximal power consumption	4.2 W
Lens mount	C-Mount, CS-Mount (optional)
Dimensions	55 x 55 x 42 mm^3
Mass	215 g
Conformity	RoHS, WEEE

Table 4.5: Physical characteristics and operating range

Fig. 4.2 shows the quantum efficiency curve of the monochrome CMV2000/4000 sensors from CMOSIS measured in the wavelength range from 400 nm to 1000 nm.

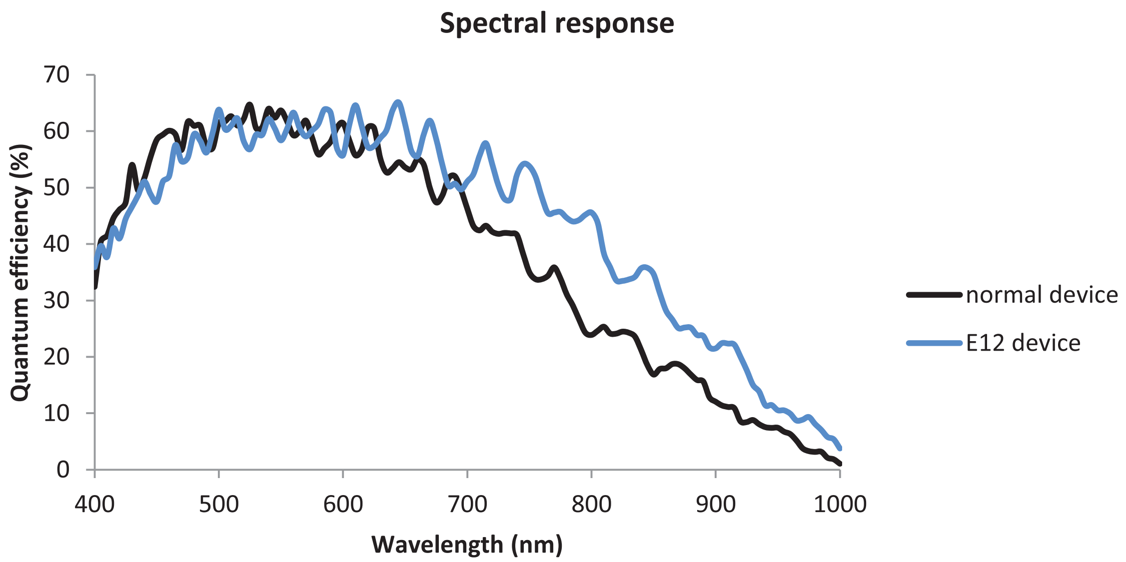

Figure 4.2: Spectral response of the CMV2000/4000 CMOS monochrome image sensors (with micro lenses); E12 device is contained in the (I) cameras

Fig. 4.3 shows the quantum efficiency curve of the colour CMV2000/4000 sensors from CMOSIS used in the Photonfocus 2048 colour cameras.

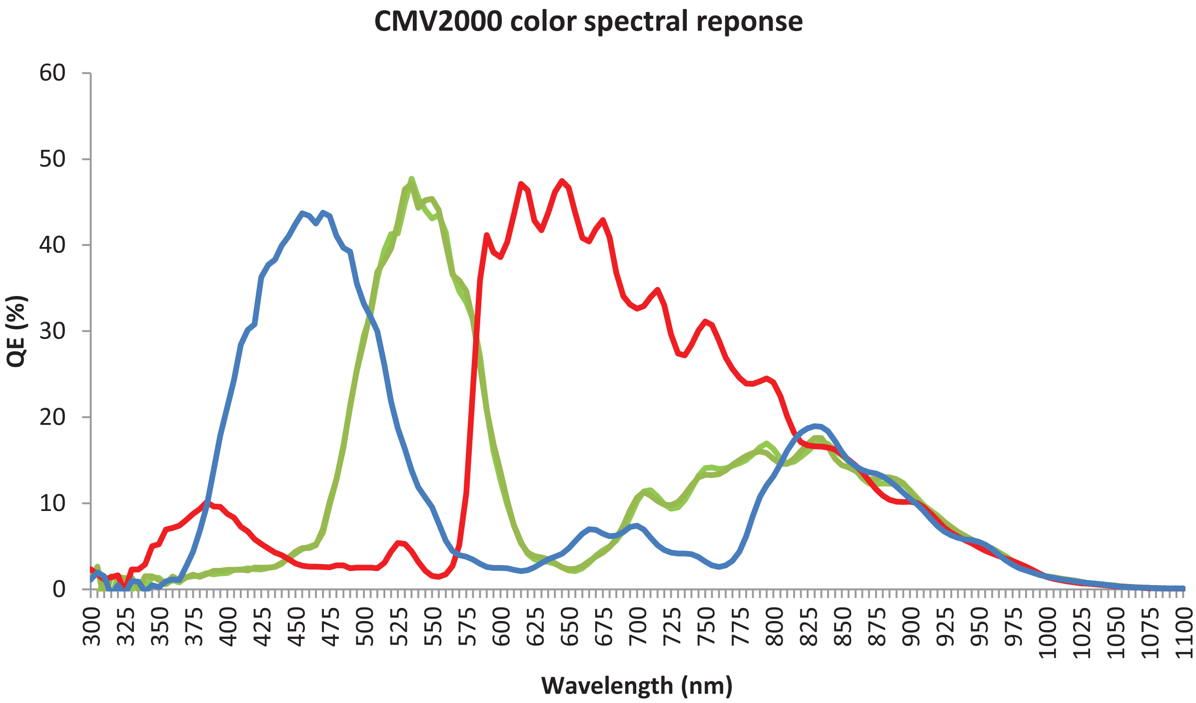

Figure 4.3: Spectral response of the CMV2000/4000 CMOS colour image sensors (with micro lenses)

The cover glass of the CMV2000/4000 image sensors is plain D263 glass with a transmittance as shown in Fig. 4.4. Refraction index of the glass is 1.52. Scratch, bubbles and digs shall be less than or equal to 0.02 mm

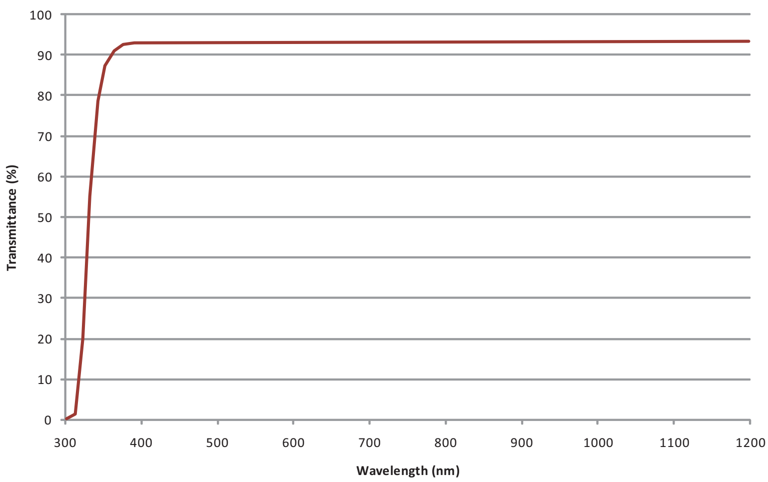

Figure 4.4: Transmittance curve of D263 cover glass

The colour cameras are equipped with a infra-red cut-off filter to avoid false colours arising when an infra-red component is present in the illumination. Fig. 4.5 shows the transmssion curve of the cut-off filter.

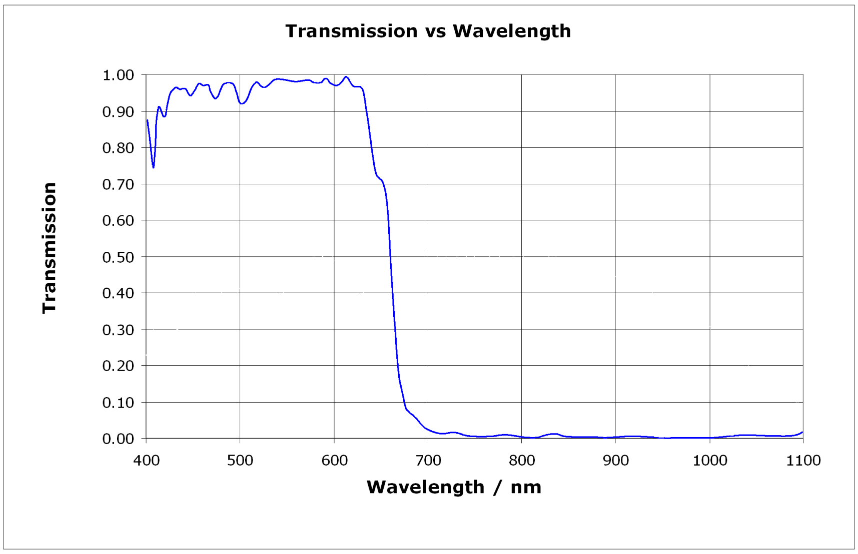

Figure 4.5: Transmission curve of the cut-off filter in the Photonfocus 2048 colour camera models

4.5 RGB Bayer Pattern Filter

Fig. 4.6 shows the bayer filter arrangement on the pixel matrix in the colour camera models which is often denoted as "Green - Blue" pattern.

The fixed bayer pattern arrangement has to be considered when the ROI configuration is changed or the MROI feature is used (see Section 5.1). It depends on the line number in which a ROI starts. A ROI can start at an even or an odd line number.

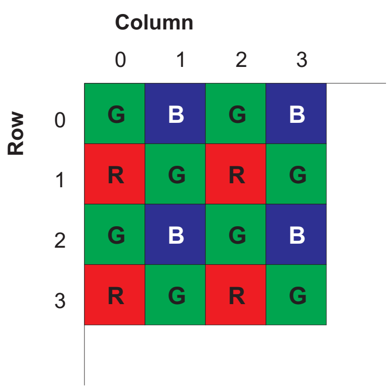

Figure 4.6: Bayer Pattern Arrangement in the Photonfocus 2048 color camera models

4.6 Frame Grabber relevant Configuration

The parameters and settings, which are essential to configure the frame grabber are shown in Table 4.6.

	D-160 / L-160	D-240
Pixel Clock	80 MHz	80 MHz
Number of Taps	2	3
Greyscale resolution	10 bit / 8 bit	8 bit
Line pause	2 [1] / 4 [2] / 8 [3] clock cycles	3 [4] / 4 [5] / 8 [6] clock cycles
CC1	EXSYNC	EXSYNC
CC2	not used	not used
CC3	not used	not used
CC4	not used	not used
Maximal average data rate	160 MB/s (8 bit) / 320 MB/s (10 bit)	190 MB/s

Table 4.6: Summary of parameters needed for frame grabber configuration. (Footnotes: [1] width <= 512, [2] 512 < width <= 1024, [3] width > 1024, [4] width <= 640, [5] 640 < width <= 1280, [6] width > 1280)

CameraLink® port and bit assignments are compliant with the CameraLink® standard (see [CL]). Table 4.7 shows the tap configurations for the D-160 and L-160 camera models. Table 4.8 shows the tap configurations for the D-240 cameras.

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 4.7: CameraLink® 2 Tap port and bit assignments for the D-160 and L-160 cameras

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

Table 4.8: CameraLink® 3 Tap port and bit assignments for the D-240 cameras

4.6.1 3 Tap Mode

The D-240 cameras comply with the 8bit monochrome 3-tap CameraLink® base standard. The first pixel in the image is located at tap 0, the second at tap 1 and the third is located at tap 2. At the time of writing, no framegrabber visualization GUI supports this mode. It is however possible and easy to write applications using this 3 tap mode when the 24-bit RGB mode is used instead. In this configuration the red channel is tap 0 (or pixel 0), the green channel is tap 1 (or pixel 1) and the blue channel is tap2 (or pixel 2).

If the 24-bit RGB mode is used, the framegrabber's image width must be set 3 times smaller than the camera's image width. The D-240 cameras send 3 pixel data per CameraLink® clock cycle in parallel. The framegrabber in 24-bit RGB mode however processes these 3 pixels as one RGB pixel.

In the RGB mode the memory management of a 24bit colour image has to be considered. Blue is usually stored at address 0, green at address 1 and red at address 2 and so on in this order. Since the blue channel in the camera link standard is located at tap 2 (pixel 2) and the red channel at tap 0 (pixel 0), pixel 0 & 2 would be stored in the wrong order in the memory. The D-240 cameras provide a "BGR" mode. This swaps pixels 0 & 2 at the camera link interface and the pixels then have the proper order in the memory. In this configuration an image can be grabbed in 24-bit RGB mode and the RGB buffer can be read out as an 8-bit monochrome buffer without the need of copying the pixel data.

The application note [AN031] (MV1-D1312(I)-240 cameras 3-tap grab procedure) explains the use of the 3-tap mode in more detail. There are examples for several frame grabbers in the `SDK\Example` sub-directory of the PFRemote installation directory.

Ask Photonfocus support (<support@photonfocus.com>) if you have a problem using the 3-tap mode.

5 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 cameras is explained in later chapters.

5.1 Reduction of Image Size

With the Photonfocus 2048 camera series 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).

5.1.1 Region of Interest (ROI)

Some applications do not need full image resolution. By reducing the image size to a certain region of interest (ROI), the frame rate can be 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).

The ROI width must be a multiple of 2 in the D-160 and L-160 cameras and a multiple of 6 in the D-240 cameras.

A list of common image dimension and its frame rates is shown in Table 5.1 and Table 5.2. There is a frame rate calculator in the support section of the Photonfocus web page www.photonfocus.com.

ROI Dimension [Standard]	D-160	D-240
2048 x 2048 [1]	37 fps	45 fps [2]
2048 x 1088	71 fps	85 fps [2]
1280 x 1024 (SXGA)	75 fps	180 fps [3]
1280 x 768 (WXGA)	100 fps	240 fps [3]
800 x 600 (SVGA)	255 fps	306 fps [4]
640 x 480 (VGA)	318 fps	755 fps [5]
512 x 1	23134 fps	27633 fps [6]
640 x 1	18903 fps	27633 fps [5]
480 x 480	629 fps	755 fps
640 x 640	239 fps	570 fps [5]
1024 x 1024	150 fps	180 fps [7]

Table 5.1: Frame rates of different ROI settings (minimal exposure time). (Footnotes: [1]4 MPix cameras only, [2]width=2046, [3]width=1278, [4]width=798, [5]width=636, [6]width=510, [7]width=1020)

Reduction in width also results in a frame rate increase. The increase is not linear but in steps (see Fig. 5.1 and Fig. 5.2).

ROI Dimension [Standard]	L-160
2048 x 1 [1)]	27300 fps
2048 x 2 [1)]	25400 fps
2048 x 3 [1)]	21900 fps
2048 x 4 [1)]	17300 fps
2048 x 1088	42 fps
1280 x 1024 (SXGA)	90 fps
1280 x 768 (WXGA)	120 fps
800 x 600 (SVGA)	306 fps
640 x 480 (VGA)	381 fps
512 x 1 [1)]	27300 fps
640 x 1 [1)]	27300 fps
480 x 480	381 fps
640 x 640	287 fps
1024 x 1024	90 fps

Table 5.2: Frame rates of different ROI settings for L-160 cameras (minimal exposure time). (Footnotes: [1)] line scan mode: EnLinescanHighSpeedMode must be set)

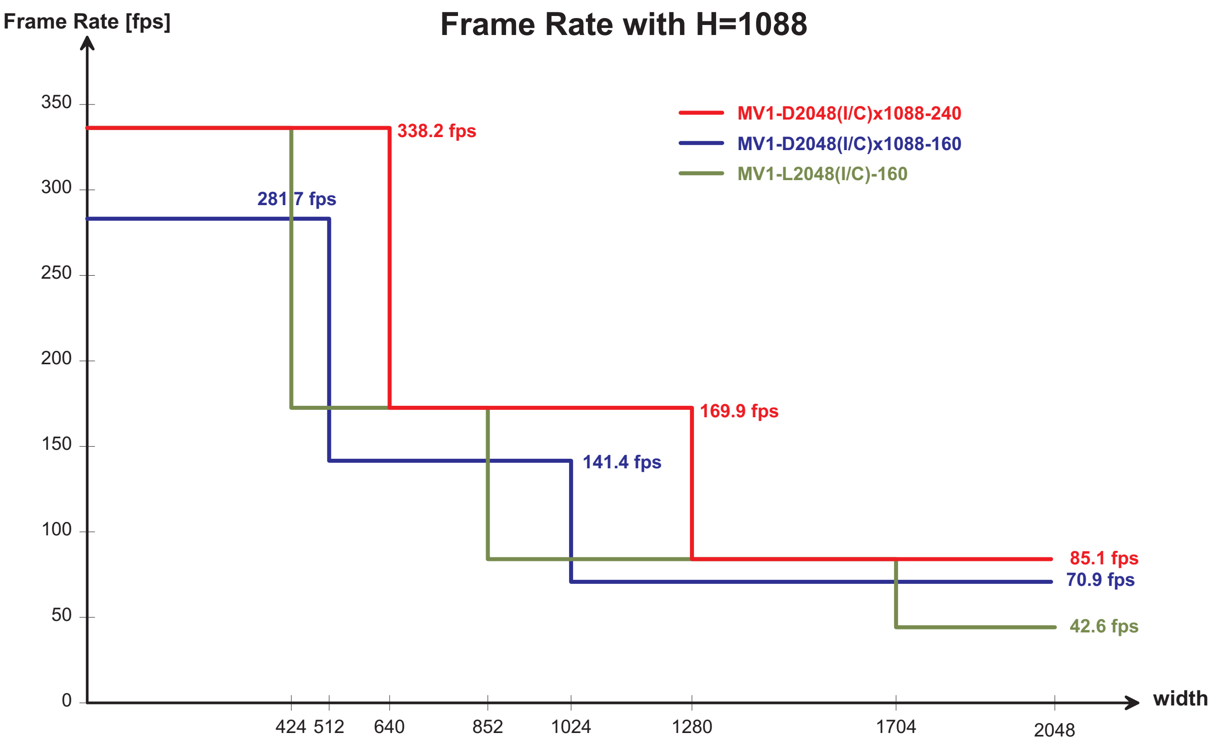

Figure 5.1: Frame rate in function of ROI width at H=1088

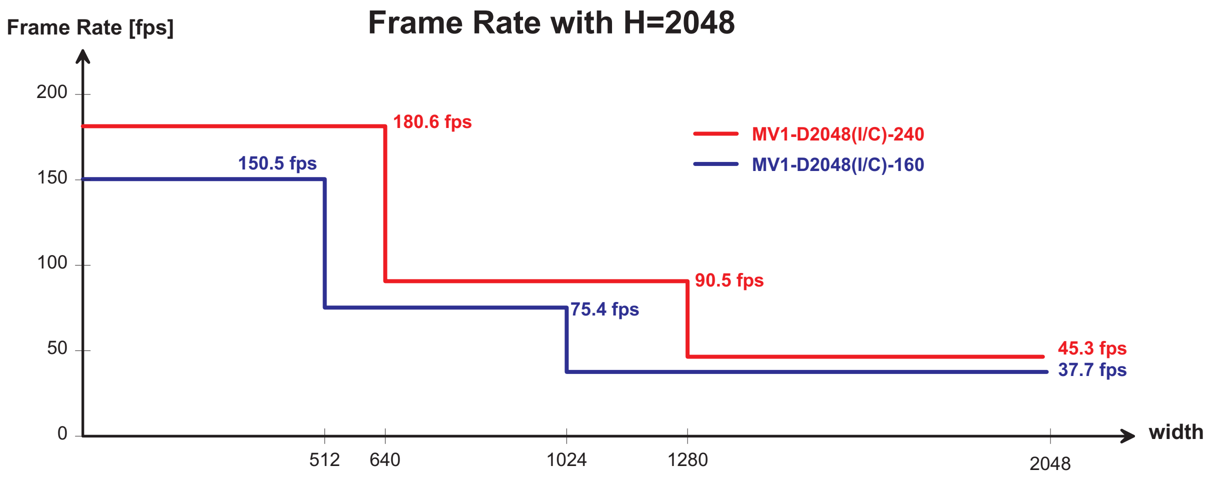

Figure 5.2: Frame rate in function of ROI width at H=2048

5.1.2 Line Scan Mode (L-cameras only)

Very high frame rates can be obtained in the Line Scan mode (see also Table 5.2). In this mode the L-cameras are a cost-effective replacement of line scan cameras. The number of rows and their position can be set by the normal ROI settings. More advanced settings as Decimation or MROI are supported in this mode. The resulting number of rows must not exceed 4 in the Line Scan mode.

Frame Combine

In the FrameCombine mode the camera combines n (n=NrOfFrames) into one frame. In some cases it consumes less CPU power to process these combined frames than to process every frame individually.

There exist possibilities to transmit the combined frame even if there is not enough data to fill it.

FrameCombineTimeout A timeout can be specified after which the combined frame will be transmitted, regardless if there was enough data to fill it. The timeout counter is reset after each frame and counts until a new trigger has been detected or until the timeout is reached.

☞ A FrameCombineTimeout value of 0 disables the FrameCombine timeout feature.

ForceTimeout The transmission of the combined frame is forced by writing to the ForceTimeout property.

When the FrameCombine is aborted, then the remaining data in the combined frame will be filled with filler data: the first two pixels of every filler row have the values 0xBB (decimal 187) and 0x44 (decimal 68). The remaining pixels of the filler rows have the value 0.

5.1.3 Multiple Regions of Interest

The Photonfocus 2048 camera series can handle up to 8 different regions of interest. This feature can be used to reduce the amount image data and increase the frame rate. An application example for using multiple regions of interest (MROI) is a laser triangulation system with several laser lines. The multiple ROIs are joined together and form a single image, which is transferred to the frame grabber.

An individual MROI region is defined by its starting value in y-direction and its height. The starting value in horizontal direction and the width is the same for all MROI regions and is defined by the ROI settings. The maximum frame rate in MROI mode depends on the number of rows and columns being read out. Overlapping ROIs are not allowed and no row must be read out more than once.

The individual ROI in a MROI must not overlap and no row should be included in more than one ROI.

In the colour models, every single ROI should start at an even row and should contain an even number rows to have a correct Bayer pattern in the output image.

Fig. 5.3 compares ROI and MROI: the setups (visualized on the image sensor area) are displayed in the upper half of the drawing. The lower half shows the dimensions of the resulting image. On the left-hand side an example of ROI is shown and on the right-hand side an example of MROI. It can be readily seen that the resulting image with MROI is smaller than the resulting image with ROI only and the former will result in an increase in image frame rate.
Fig. 5.4 shows another MROI drawing illustrating the effect of MROI on the image content.

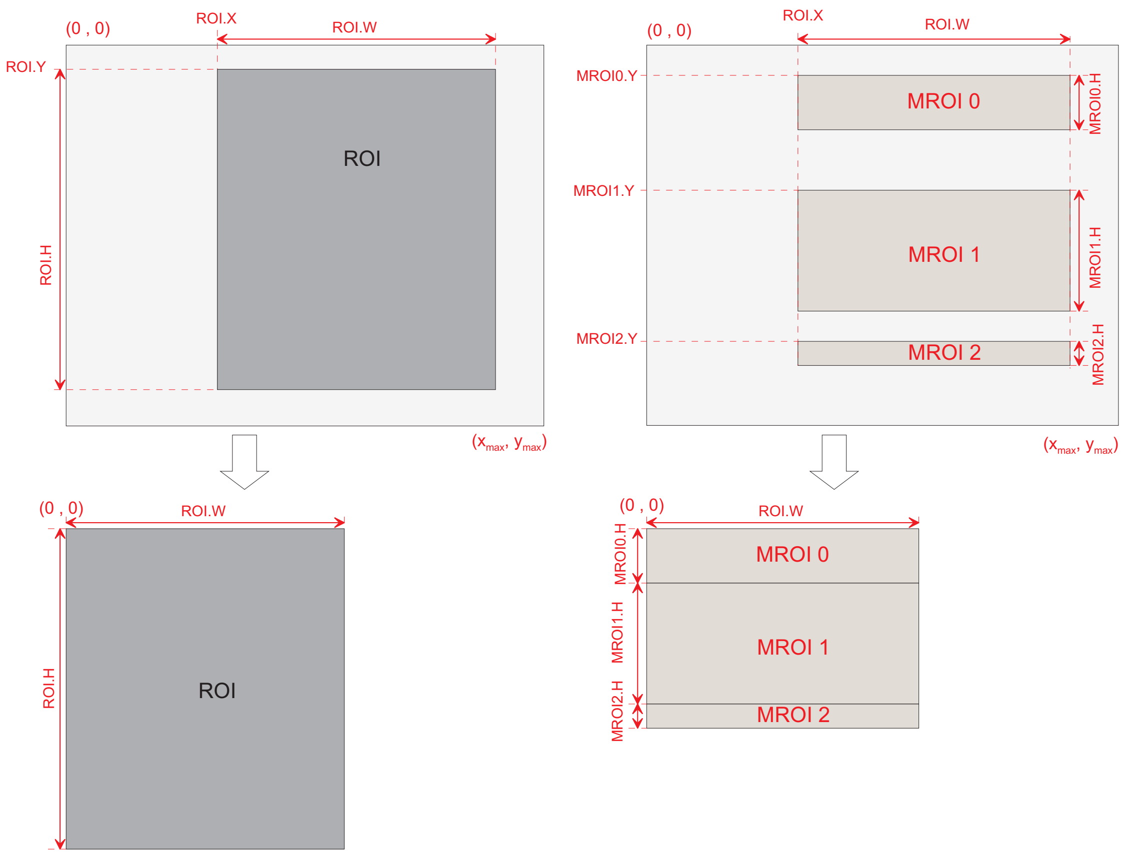

Figure 5.3: Multiple Regions of Interest

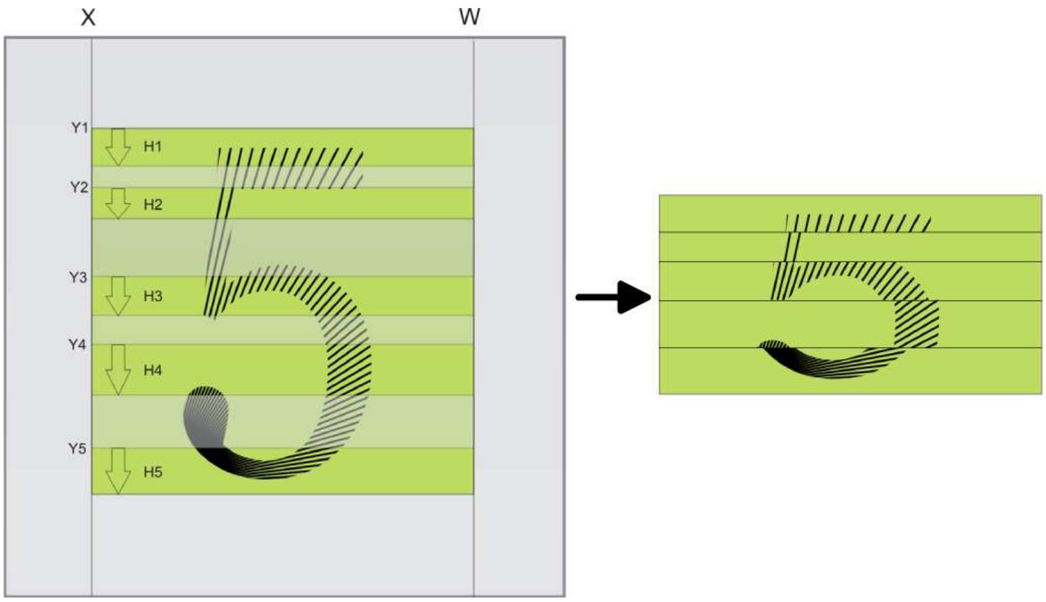

Figure 5.4: Multiple Regions of Interest with 5 ROIs

Fig. 5.5 shows an example from hyperspectral imaging where the presence of spectral lines at known regions need to be inspected. By using a MROI only a 636x54 region need to be readout and a frame rate of 5598 fps (D-240) can be achieved. Without using MROI the resulting frame rate would be 338 fps for a 636x1088 ROI (D-240).

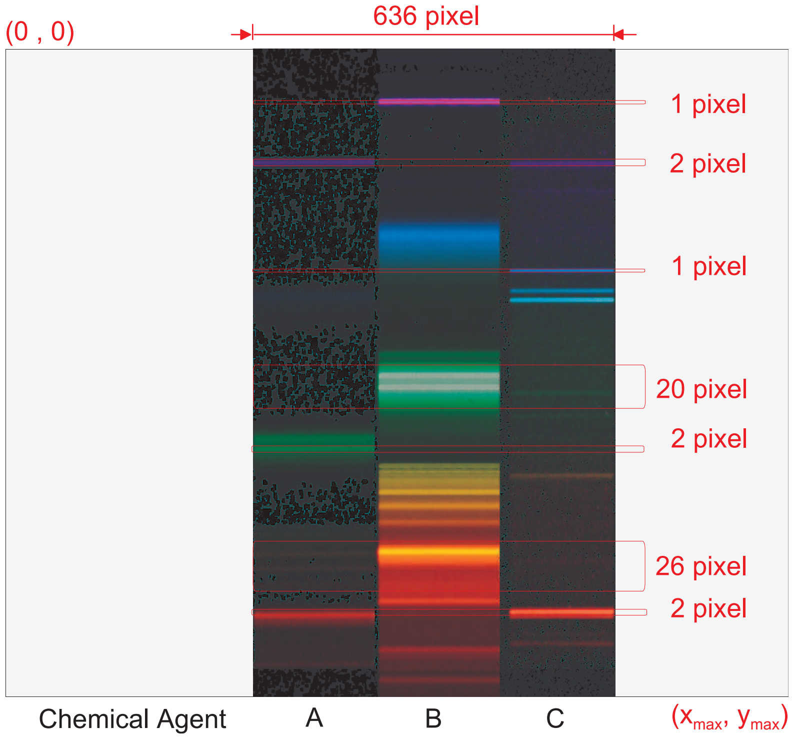

Figure 5.5: Multiple Regions of Interest in hyperspectral imaging

5.1.4 Decimation (monochrome cameras)

Decimation reduces the number of pixels in y-direction. Decimation in y-direction transfers every n^{th}row only and directly results in reduced read-out time and higher frame rate respectively.

Decimation can also be used together with ROI or MROI. In this case every ROI should have a height that is a multiple of the decimation setting. E.g. if decimation=3, then the height of every ROI should be a multiple of 3.

Fig. 5.6 shows decimation on the full image. The rows that will be read out are marked by red lines. Row 0 is read out and then every n^{th} row.

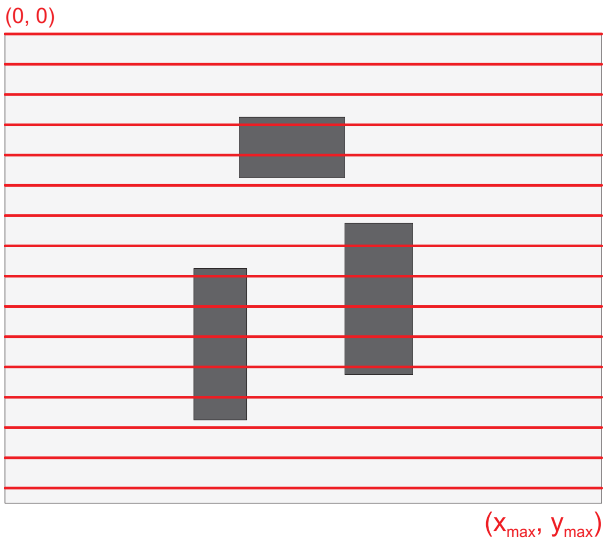

Figure 5.6: Decimation in full image

Fig. 5.7 shows decimation on a ROI. The row specified by the Window.Y setting is first read out and then every n^{th} row until the end of the ROI.
Fig. 5.8 shows decimation and MROI. For every MROI region m, the first row read out is the row specified by the MROI<m>.Y setting and then every n^{th} row until the end of MROI region m.

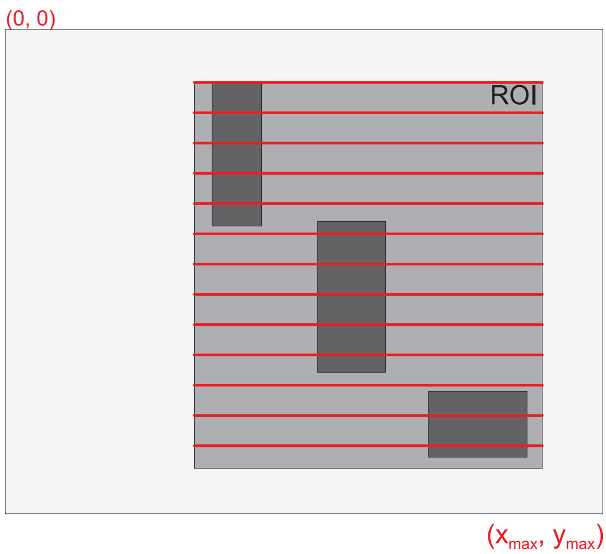

Figure 5.7: Decimation and ROI

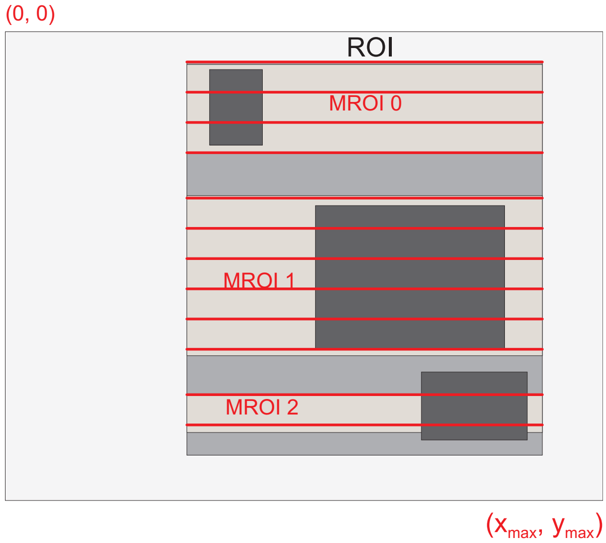

Figure 5.8: Decimation and MROI

The image in Fig. 5.9 on the right-hand side shows the result of decimation 3 of the image on the left-hand side.

Figure 5.9: Image example of decimation 3

An example of a high-speed measurement of the elongation of an injection needle is given in Fig. 5.10. In this application the height information is less important than the width information. Applying decimation 2 on the original image on the left-hand side doubles the resulting frame rate.

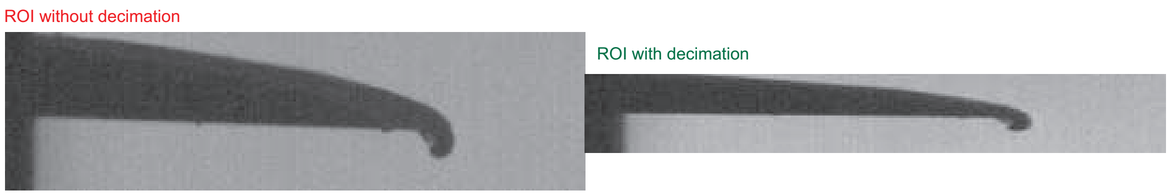

Figure 5.10: Example of decimation 2 on image of injection needle

5.1.5 Decimation (colour cameras)

Decimation reduces the number of pixels in y-direction by skipping rows. Decimation in colour cameras is slightly different from the monochrome cameras, because the order of the Bayer pattern must be maintained.

Beginning from the first row, always two rows are read out and then an even number of rows is skipped. The red rows in Fig. 5.11 are read out and the total number of rows is the sum of the red rows.

The number of skipped rows for decimation d are: $H_{\mathrm{skip}} = (d-1) * 2$

The resulting number or rows for Window.H=h: $h_{\mathrm{tot}} = 2 * \mathrm{floor}\,(h/d) + \min(h \mod (2*d), 2)$

The total number of rows can be read by the property `Window.HInterface`.

Decimation	H_{skip}
2	2
3	4
4	6
5	8

Table 5.3: Values of H_{skip} as a function of decimation

Window.H	h_{tot}, d=2	h_{tot}, d=3	Hh_{tot}, d=4
640	320	214	160
1024	512	342	256
1088	544	364	272
2048	1024	684	512

Table 5.4: Examples of total rows in colour decimation

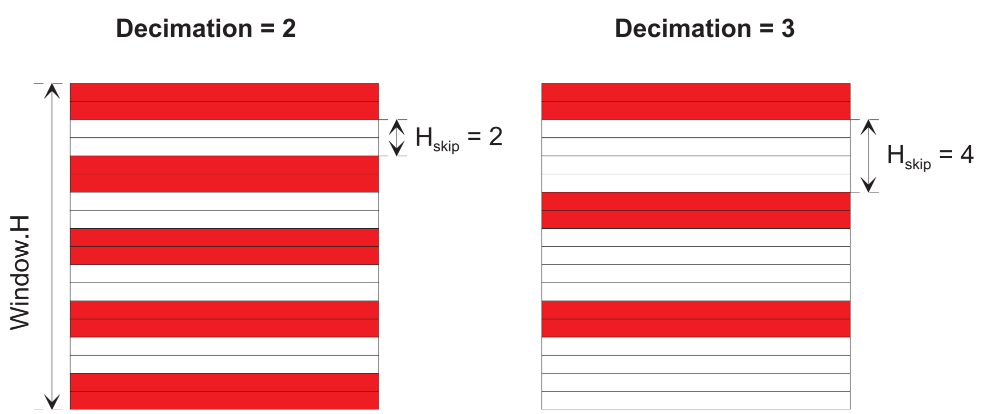

Figure 5.11: Example of decimation in colour cameras

5.1.6 Maximal Frame Rate

The maximal frame rate of the camera depends on the camera settings. The following factors influence the maximal frame rate (see also Table 5.1):

- The length of the exposure time: A shorter exposure time can lead to an increase in the maximal frame rate.
- ROI height: a smaller height ROI can lead to an increase in the maximal frame rate.
- ROI width: a smaller width ROI can lead to an increase in the maximal frame rate, but only in steps (see Fig. 5.1).
- In pulse width controlled exposure mode the maximal frame rate is lower than normal as the exposure start is only allowed after the read out of the previous frame.

The maximal frame rate of the camera can be determined by a frame rate calculator in the support section of the Photonfocus web page www.photonfocus.com. The maximal frame rate with the current camera settings can be read out by a camera register with pflib and it is also displayed in the PFRemote tool.

To have a rough idea about the maximal allowed frame rate for a given setting it is important to know the 3 possible frame timings that are described in the next sections.

☞ In free-running mode only the Simultaneous Read out Timings occur.

Camera	W <= W0	W0 < W <= 2*W0	W > 2*W0
D-160	3.225 μs	6.45 μs	12.9 μs
D-240	2.6875 μs	5.375 μs	10.75 μs

Table 5.5: Time to read out 1 row; D-160: W0=512, D-240: W0=640

Camera	W <= W0	W0 < W <= 2*W0	W > 2*W0
D-160	39.13 μs	45.58 μs	58.48 μs
D-240	32.60 μs	37.98 μs	48.73 μs

Table 5.6: Value of TReadoutDel; D-160: W0=512, D-240: W0=640

Camera	W <= 424	424 < W <= 852	852 < W <= 1704	W > 1704
Time for 1 row	3.225 μs	5.375 μs	10.75 μs	21.5 μs
TReadoutDel	32.60 μs	37.98 μs	48.73 μs	70.23 μs

Table 5.7: Values for L-160, area scan mode

Simultaneous Read out Timing 1

The exposure time is smaller than the read out time in this timing (see Fig. 5.12). Exposure is started during the sensor read out of the previous frame.

The maximal frame rate is in this case (values are given in Table 5.5, Table 5.6 and Table 5.7):

MaxFrameRate = 1 / (ReadoutTime + TExpDel + TReadoutDel)

To avoid a sensor artifact, the exposure must start at a fixed position from the start of the read out of one row. Therefore the exposure start must be delayed by a time TExpDel which can be as long as the read out of one row.

The ReadoutTime is the height of ROI multiplied by the read out time of one row (see Table 5.5).

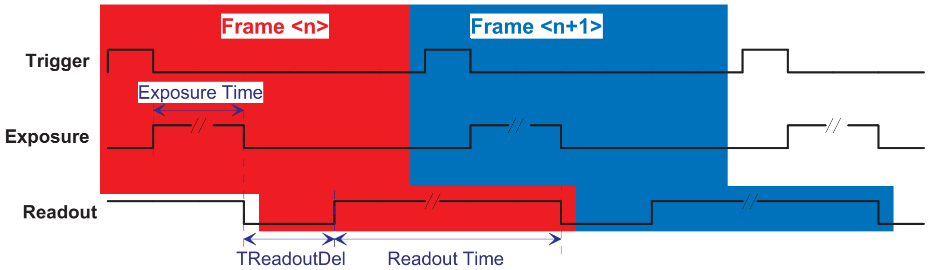

Figure 5.12: Simultaneous read out timing 1: exposure time smaller than read out time

Simultaneous Read out Timing 2

The exposure time is bigger than the read out time in this timing (see Fig. 5.13). Exposure is started during the sensor read out of the previous frame.

The maximal frame rate is in this case (values are given in Table 5.5):

MaxFrameRate = 1 / (ExposureTime + TExpDel1 + TReadoutDel)

TExpDel1 is 1.25 μs for the D-160 cameras and 1.042 μs for D-240 and L-160 cameras.

The ReadoutTime is the height of the ROI multiplied by the read out time of one row (see Table 5.5).

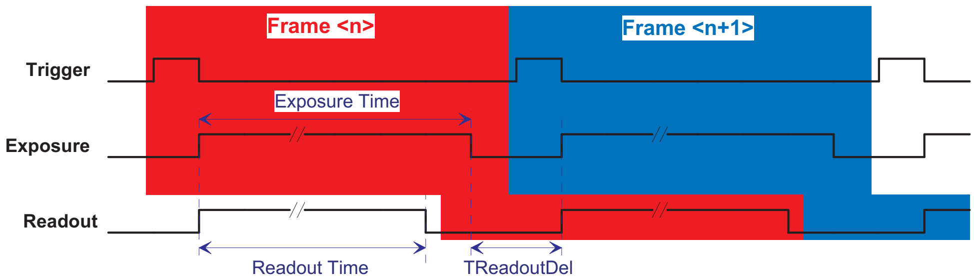

Figure 5.13: Simultaneous read out timing 2: exposure time bigger than read out time

Sequential Read out Timing

In this timing the exposure is started after the read out of the previous frame (see Fig. 5.14).

The maximal frame rate is in this case (values are given in Table 5.5):

MaxFrameRate = 1 / (ExposureTime + TReadoutDel + ReadoutTime)

The ReadoutTime is the height of the ROI multiplied by the read out time of one row (see Table 5.5).

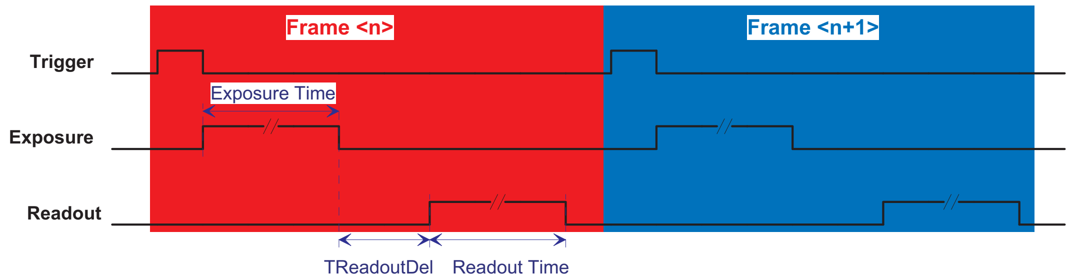

Figure 5.14: Sequential read out timing

5.2 Trigger and Strobe

5.2.1 Introduction

The start of the exposure of the camera's image sensor is controlled by the trigger. The trigger can either be generated internally by the camera (free running trigger mode) or by an external device (external trigger mode).

This section refers to the external trigger mode if not otherwise specified.

In external trigger mode, the trigger can be applied through the CameraLink ® interface (interface trigger) or directly by the power supply connector of the camera (I/O Trigger) (see Section 5.2.2). The trigger signal can be configured to be active high or active low. When the frequency of the incoming triggers is higher than the maximal frame rate of the current camera settings, then some trigger pulses will be missed. A missed trigger counter counts these events. This counter can be read out by the user.

The exposure time in external trigger mode can be defined by the setting of the exposure time register (camera controlled exposure mode) or by the width of the incoming trigger pulse (trigger controlled exposure mode) (see Section 5.2.3).

An external trigger pulse starts the exposure of one image. In Burst Trigger Mode however, a trigger pulse starts the exposure of a user defined number of images (see Section 5.2.5).

The start of the exposure is shortly after the active edge of the incoming trigger. An additional trigger delay can be applied that delays the start of the exposure by a user defined time (see Section 5.2.4). This often used to start the exposure after the trigger to a flash lighting source.

5.2.2 Trigger Source

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

Free running The trigger is generated internally by the camera. Exposure starts immediately after the camera is ready and the maximal possible frame rate is attained, if Constant Frame Rate mode is disabled. In Constant Frame Rate mode, exposure starts after a user-specified time (Frame Time) has elapsed from the previous exposure start and therefore the frame rate is set to a user defined value.

Interface Trigger In the interface trigger mode, the trigger signal is applied to the camera by the CameraLink® interface. Fig. 5.15 shows a diagram of the interface trigger setup. The trigger is generated by the frame grabber board and sent on the CC1 signal through the CameraLink® interface. Some frame grabbers allow the connection external trigger devices through an I/O card. A schematic diagram of this setup is shown in Fig. 5.16.

I/O Trigger In the I/O trigger mode, the trigger signal is applied directly to the camera by the power supply connector (via an optocoupler). A setup of this mode is shown in Fig. 5.17. The electrical interface of the I/O trigger input and the strobe output is described in Section 6.1.3.

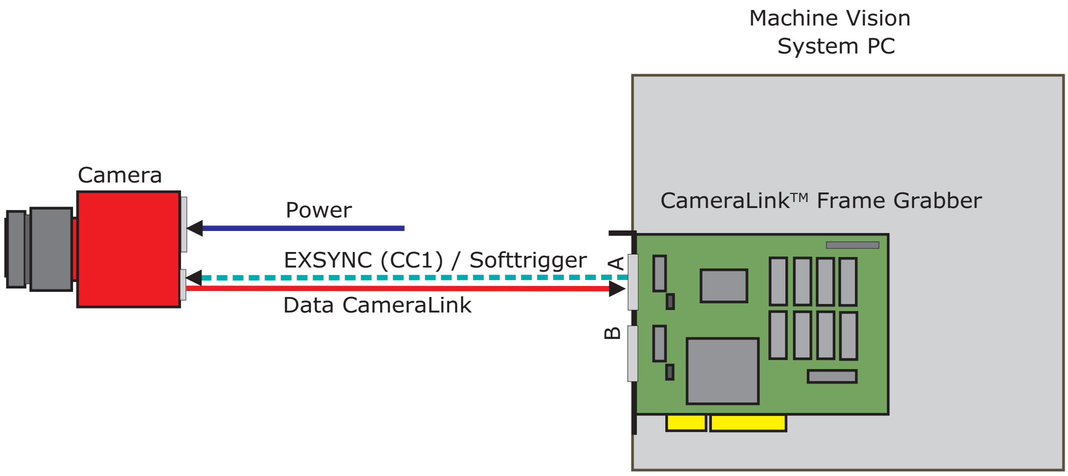

Figure 5.15: Interface trigger source

5.2.3 Exposure Time Control

Depending on the trigger mode, the exposure time can be determined either by the camera or by the trigger signal itself:

Camera-controlled Exposure time In this trigger mode the exposure time is defined by the camera. For an active high trigger signal, the camera starts the exposure with a positive trigger edge and stops it when the preprogrammed exposure time has elapsed. The exposure time is defined by the software.

Trigger-controlled Exposure time In this trigger mode the exposure time is defined by the pulse width of the trigger pulse. For an active high trigger signal, the camera starts the exposure with the positive edge of the trigger signal and stops it with the negative edge.

External Trigger with Camera controlled Exposure Time

In the external trigger mode with camera controlled exposure time the rising edge of the trigger pulse starts the camera states machine, which controls the sensor and optional an

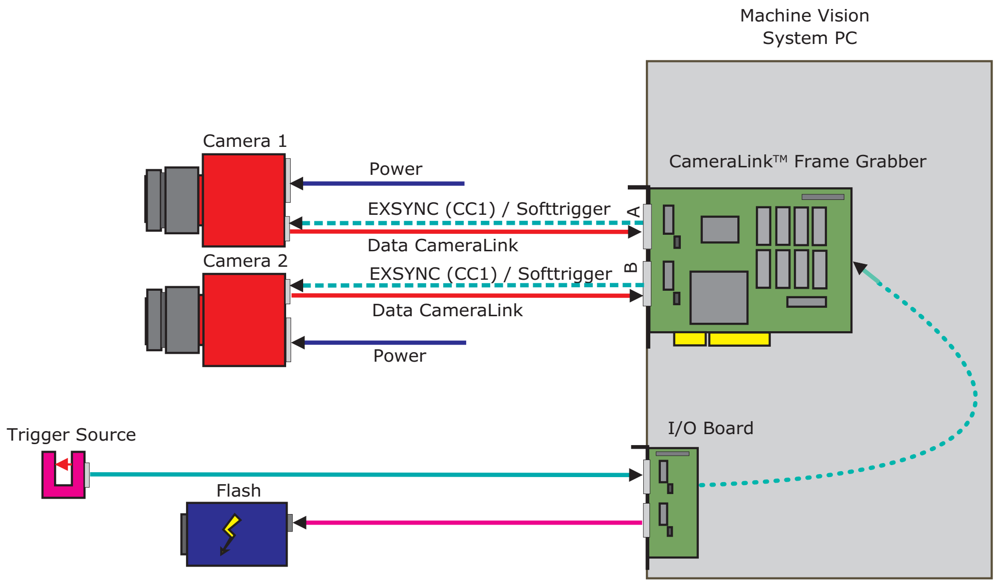

Figure 5.16: Interface trigger with 2 cameras and frame grabber I/O card

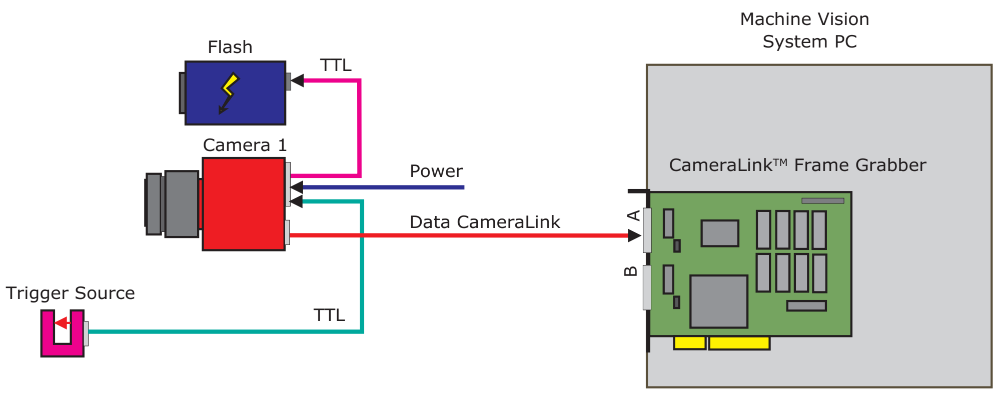

Figure 5.17: I/O trigger source

external strobe output. Fig. 5.18 shows the detailed timing diagram for the external trigger mode with camera controlled exposure time.
The rising edge of the trigger signal is detected in the camera control electronic which is implemented in an FPGA. Before the trigger signal reaches the FPGA it is isolated from the camera environment to allow robust integration of the camera into the vision system. In the signal isolator the trigger signal is delayed by time $t_{d-iso-input}$. This signal is clocked into the FPGA which leads to a jitter of t_{jitter}. The pulse can be delayed by the time $t_{trigger-delay}$ which can be configured by a user defined value via camera software. The trigger offset delay $t_{trigger-offset}$ results then from the synchronous design of the FPGA state machines and from to requirement to start an exposure at a fixed point from the start of the read out of a row. The exposure time $t_{exposure}$ is controlled with an internal exposure time controller.

The trigger pulse from the internal camera control starts also the strobe control state machines. The strobe can be delayed by $t_{strobe-delay}$ with an internal counter which can be controlled by the customer via software settings. The strobe offset delay $t_{strobe-delay}$ results then from the synchronous design of the FPGA state machines. A second counter determines the strobe duration $t_{strobe-duration}$(strobe-duration). For a robust system design the strobe output is also

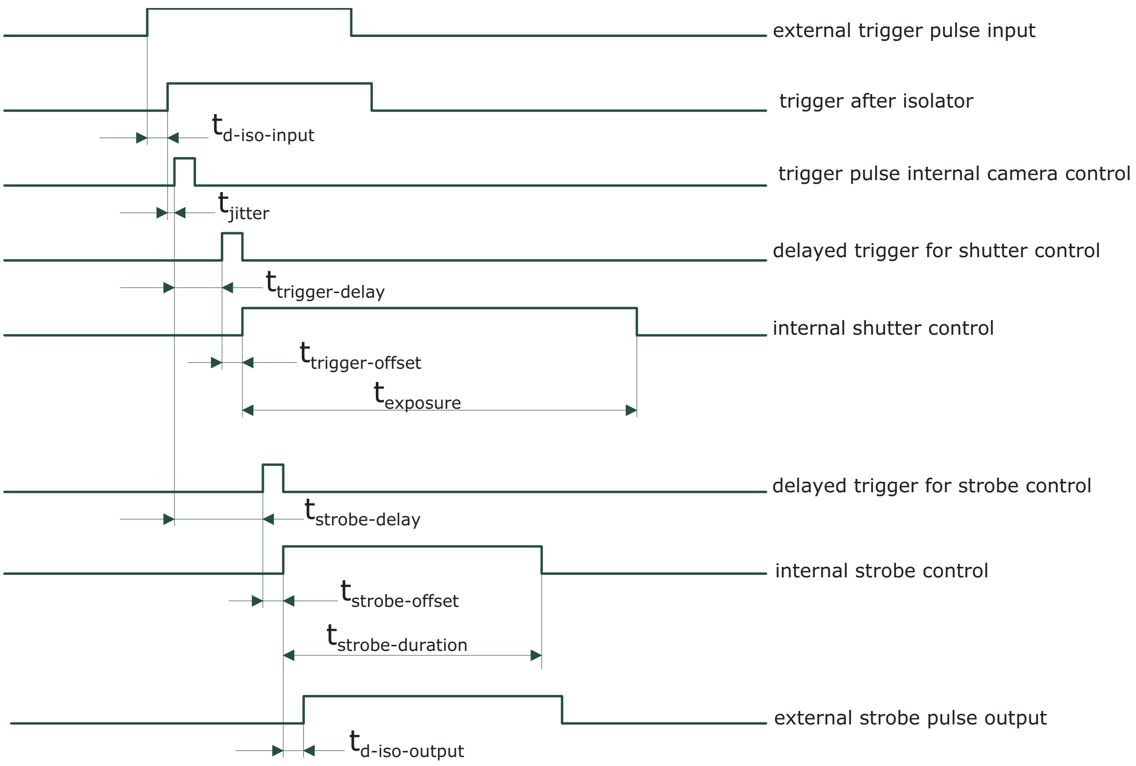

Figure 5.18: Timing diagram for the camera controlled exposure time

isolated from the camera electronic which leads to an additional delay of $t_{d-iso-output}$Table 5.8 and Table 5.9 gives an overview over the minimum and maximum values of the parameters.

External Trigger with Pulsewidth controlled Exposure Time

In the external trigger mode with Pulsewidth controlled exposure time the rising edge of the trigger pulse starts the camera states machine, which controls the sensor. The falling edge of the trigger pulse stops the image acquisition. Additionally the optional external strobe output is controlled by the rising edge of the trigger pulse. Timing diagram Fig. 5.19 shows the detailed timing for the external trigger mode with pulse width controlled exposure time.

The timing of the rising edge of the trigger pulse until to the start of exposure and strobe is equal to the timing of the camera controlled exposure time (see Section 5.2.3). In this mode however the end of the exposure is controlled by the falling edge of the trigger Pulsewidth:

The falling edge of the trigger pulse is delayed by the time $t_{d-iso-input}$ which results from the signal isolator. This signal is clocked into the FPGA which leads to a jitter of t_{jitter}. The pulse is then delayed by $t_{trigger-delay}$ by the user defined value which can be configured via camera software. After the trigger offset time $t_{trigger-offset}$ the exposure is stopped.

In the trigger pulse width controlled exposure mode the image sensor operates in sequential read out mode (see Section 5.1.6). The maximal frame rate is therefore lower than normal as the exposure start is only allowed after the read out of the previous frame.

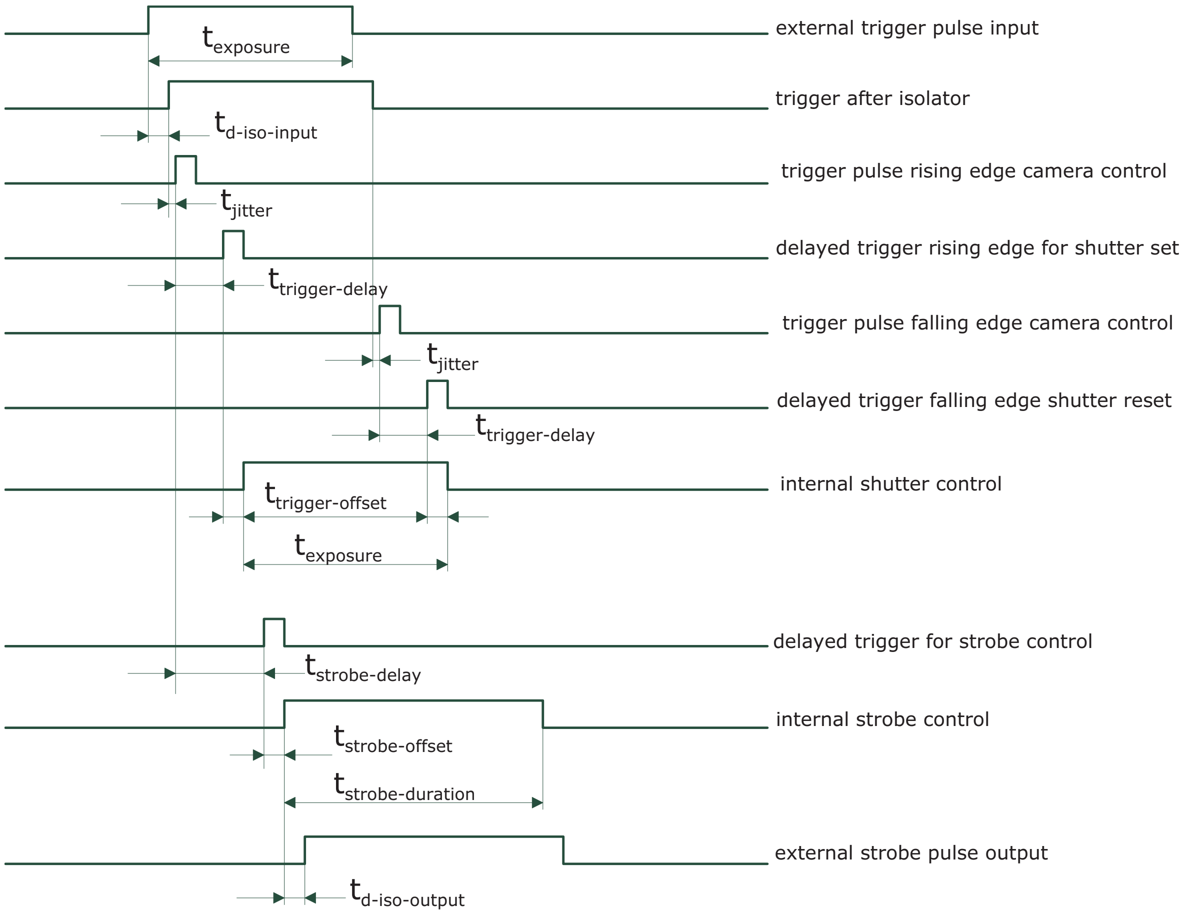

Figure 5.19: Timing diagram for the Pulsewidth controlled exposure time

5.2.4 Trigger Delay

The trigger delay is a programmable delay in milliseconds between the incoming trigger edge and the start of the exposure. This feature may be required to synchronize to external strobe with the exposure of the camera.

5.2.5 Burst Trigger

The camera includes a burst trigger engine. When enabled, it starts a predefined number of acquisitions after one single trigger pulse. The time between two acquisitions and the number of acquisitions can be configured by a user defined value via the camera software. The burst trigger feature works only in the mode "Camera controlled Exposure Time".

The burst trigger signal can be configured to be active high or active low. When the frequency of the incoming burst triggers is higher than the duration of the programmed burst sequence, then some trigger pulses will be missed. A missed burst trigger counter counts these events. This counter can be read out by the user.
The timing diagram of the burst trigger mode is shown in Fig. 5.20. The timing of the "external trigger pulse input" until to the "trigger pulse internal camera control" is equal to the timing in the section Fig. 5.19. This trigger pulse then starts after a user configurable burst trigger delay time $t_{burst-trigger-delay}$ the internal burst engine, which generates n internal

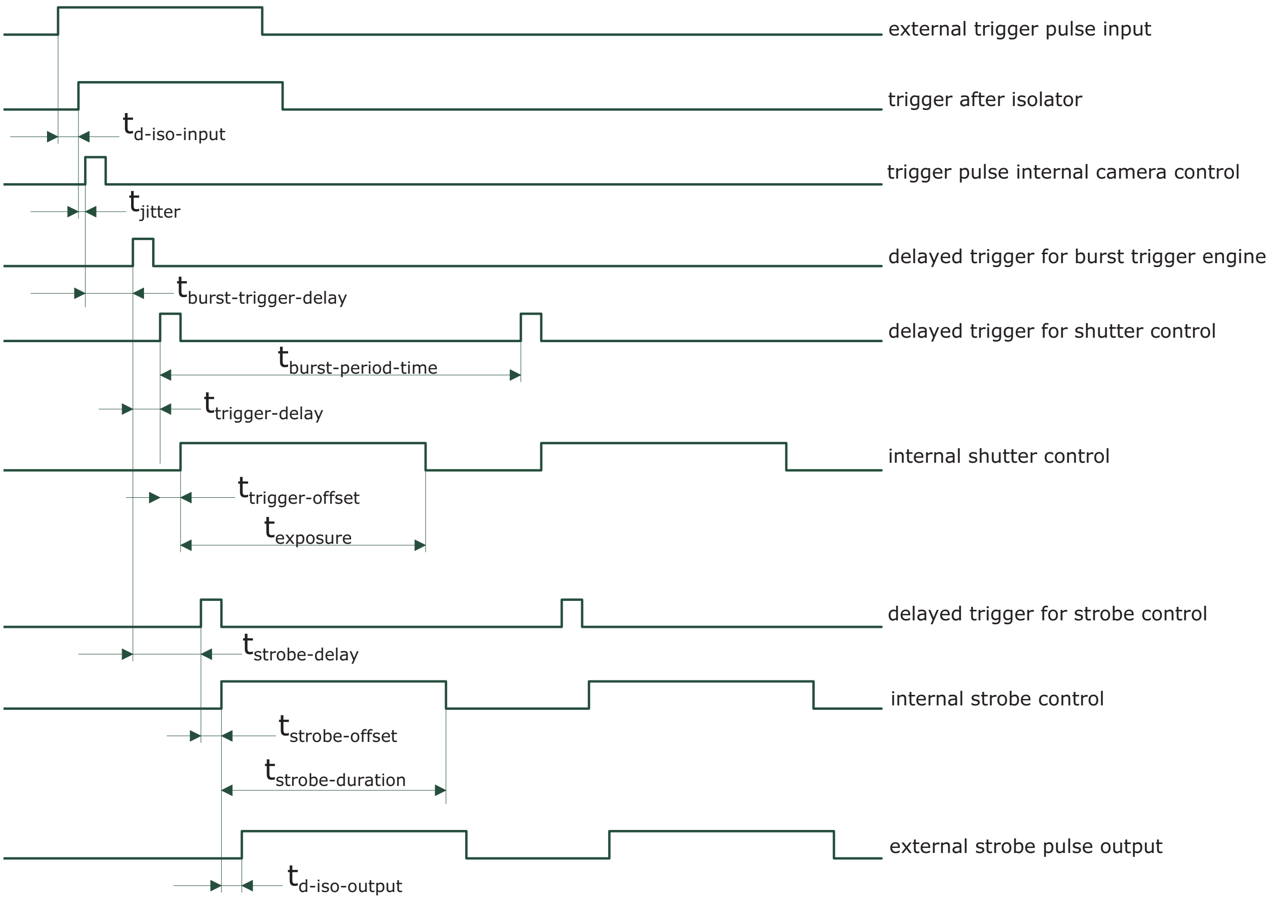

Figure 5.20: Timing diagram for the burst trigger mode

triggers for the shutter- and the strobe-control. A user configurable value defines the time $t_{burst-period-time}$ between two acquisitions.

5.2.6 Trigger timing values

Table 5.8 and Table 5.9 show the values of the trigger timing parameters.

	D-160	**D-160**
Timing Parameter	**Minimum**	**Maximum**
$t_{d-iso-input}$	45 ns	60 ns
t_{jitter}	0	25 ns
$t_{trigger-delay}$	0	0.42 s
$t_{burst-trigger-delay}$	0	0.42 s
$t_{burst-period-time}$	depends on camera settings	0.42 s
$t_{trigger-offset}$ (non burst mode)	100 ns	duration of 1 row
$t_{trigger-offset}$ (burst mode)	125 ns	125 ns
$t_{exposure}$	15 μs [1)] / 28 μs	0.42 s
$t_{strobe-delay}$	0	0.42 s
$t_{strobe-offset}$ (non burst mode)	100 ns	100 ns
$t_{strobe-offset}$ (burst mode)	125 ns	125 ns
$t_{strobe-duration}$	200 ns	0.42 s
$t_{d-iso-output}$	45 ns	60 ns
$t_{trigger-pulsewidth}$	200 ns	n/a
Number of bursts n	1	30000

Table 5.8: Summary of timing parameters relevant in the external trigger mode using the D-160 cameras (Footnotes: [1)] 2 MPix cameras)

	D-240 / L-160	D-240 / L-160
Timing Parameter	**Minimum**	**Maximum**
$t_{d-iso-input}$	45 ns	60 ns
t_{jitter}	0	20.8 ns
$t_{trigger-delay}$	0	0.35 s
$t_{burst-trigger-delay}$	0	0.35 s
$t_{burst-period-time}$	depends on camera settings	0.35 s
$t_{trigger-offset}$ (non burst mode)	83.2 ns	duration of 1 row
$t_{trigger-offset}$ (burst mode)	104 ns	104 ns
$t_{exposure}$	13 μs [1)] / 26 μs	0.35 s
$t_{strobe-delay}$	0	0.35 s
$t_{strobe-offset}$ (non burst mode)	83.2 ns	83.2 ns
$t_{strobe-offset}$ (burst mode)	104 ns	104 ns
$t_{strobe-duration}$	200 ns	0.35 s
$t_{d-iso-output}$	45 ns	60 ns
$t_{trigger-pulsewidth}$	200 ns	n/a
Number of bursts n	1	30000

Table 5.9: Summary of timing parameters relevant in the external trigger mode using the D-240 and L-160 cameras (Footnotes: [1)] 2 MPix cameras)

5.2.7 Software Trigger

The software trigger enables to emulate an external trigger pulse by the camera software through the serial data interface. It works with both burst mode enabled and disabled. As soon as it is performed via the camera software, it will start the image acquisition(s), depending on the usage of the burst mode and the burst configuration. The trigger mode must be set to `Interface Trigger` or `I/O Trigger`.

5.2.8 Missed Trigger Counters

Missed Trigger Counter If an external trigger (interface trigger or I/O trigger) is applied while the camera is not ready to accept a new trigger, a counter (Missed Trigger Counter) is incremented and the trigger is rejected. The value of the Missed Trigger Counter can be read out from a camera register (`Counter.MissedTrigger`) or from the status line (see Section 5.8). When the Missed Trigger Counter reaches its maximal value it will not wrap around. The user can reset the Missed Trigger Counter.

Missed Burst Trigger Counter The missed burst trigger counter counts trigger pulses that were ignored by the camera in the burst trigger mode because they occurred while the camera was not ready to accept a new trigger. To avoid this, the Burst Period Time must be incremented so that the minimal frame time for the current settings is not violated. The value of the Missed Burst Trigger Counter can be read out from a camera register (Counter.MissedBurstTrigger) or from the status line (see Section 5.8). When the Missed Trigger Counter reaches its maximal value it will not wrap around. The user can reset the Missed Burst Trigger Counter.

5.2.9 Counter Reset by an External Signal

The image counter and the real time counter (timestamp) (see Section 5.8.1) can be reset by an external signal. Both counters can be embedded into the image by the status line (see Section 5.8) or their register can be read out. These counters may be used to check that no images are lost or to ease the synchronisation of multiple cameras.

The external signal to reset the above mentionend counters is selected by the property `ResetCounter.Source`. Available choices are `CC1` to `CC4`, `IO_Trigger` and `ExposureStart`. `ExposureStart` resets the counters at the start of an exposure.

The property `ResetCounter.Mode` determines how often the selected source should reset the counters. The setting `Once` works together with the property `ResetCounter.OnNextTrigger`.

If `Counter_ResetCounterMode=Once`, then the counters are reset on the next active edge of the selected reset source (property `ResetCounter.Source`) after the device is armed with `ResetCounter.OnNextTrigger`=True. The register `ResetCounter.OnNextTrigger` is reset after the resetting trigger is received.

The setting `Counter_ResetCounterMode=Continuous` resets the counters on every occurrence of an active edge of the reset source without the requirement to arm the device first. This setting is suited if the reset source signal is different than the camera trigger.

The active edge of the reset input can be set by the property `ResetCounter.SourceInvert`. If set to `True`, then the rising edge is the active edge, else the falling edge.

Counter reset by an external signal is important if you would like to synchronize multiple cameras. One signal is applied to all cameras which resets the counters simultaneously. The timestamps of all cameras are then theoretically synchronous with each other. In practice every camera runs on its own clock source which has a precision of +/- 30 ppm and therefore the values of the timestamp (real time counter) of the cameras may diverge with time. If this is an issue, then the counters could be reset periodically by the external signal.

The counter reset by an external signal feature is not available on all camera revisions, see Appendix B for a list of available features.

5.2.10 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 6.1.3 and Fig. 5.16 and Fig. 5.17 for more information.

5.3 High Dynamic Range (multiple slope) Mode

The High Dynamic Range (HDR) mode is a special integration mode that increases the dynamic range of the pixels, and thus avoids the saturation of the pixels in many cases. The HDR mode is also called multiple slope mode or piecewise linear mode.

The HDR (multi slope) mode clips illuminated pixels which reach a programmable voltage, while leaving the darker pixels untouched (see Fig. 5.21). The clipping level can be adjusted once (2 slopes) or twice (3 slopes) within the exposure time.

Parameters:

Multislope_Mode There are 3 predefined HDR parameter sets: `LowCompression`, `NormalCompression` and `HighCompression`. If `Multislope_Mode` is set to `UserDefined` then the individual parameters can be set to user defined values.

Multislope_NrSlopes Number of slopes. `Multislope_NrSlopes`=2: 2 slopes with only kneepoint B. `Multislope_NrSlopes`=3: 3 slopes with kneepoints A and B.

Multislope_Value1 Corresponds to Vlow1: the higher the value, the higher the compression.

Multislope_Time1 Time corresponding to kneepoint B. The value is the fraction (per mill) of the total exposure time.

Multislope_Value2 Corresponds to Vlow2: the higher the value, the higher the compression. This value is ignored if `Multislope_NrSlopes` =2.

Multislope_Time2 Time corresponding to kneepoint A. The value is the fraction (per mill) of the total exposure time. This value is ignored if `Multislope_NrSlopes` =2.

The red line in Fig. 5.21 shows a pixel with high illumination. Without the HDR (3 slopes) mode, the pixel would have reached its saturated value. With HDR mode, the pixel reaches value P1 which is below the saturation value. The resulting pixel response in this case is shown in Fig. 5.22. The blue line (P2) shows a pixel with low illumination. Its value never reaches Vlow2 or Vlow1 at the kneepoints and the resulting response is linear.

☞ The parameters `Multislope_Value1` and `Multislope_Value2` are only applied after a camera trigger. Note that in free-running mode the camera trigger is applied internally by the camera itself.

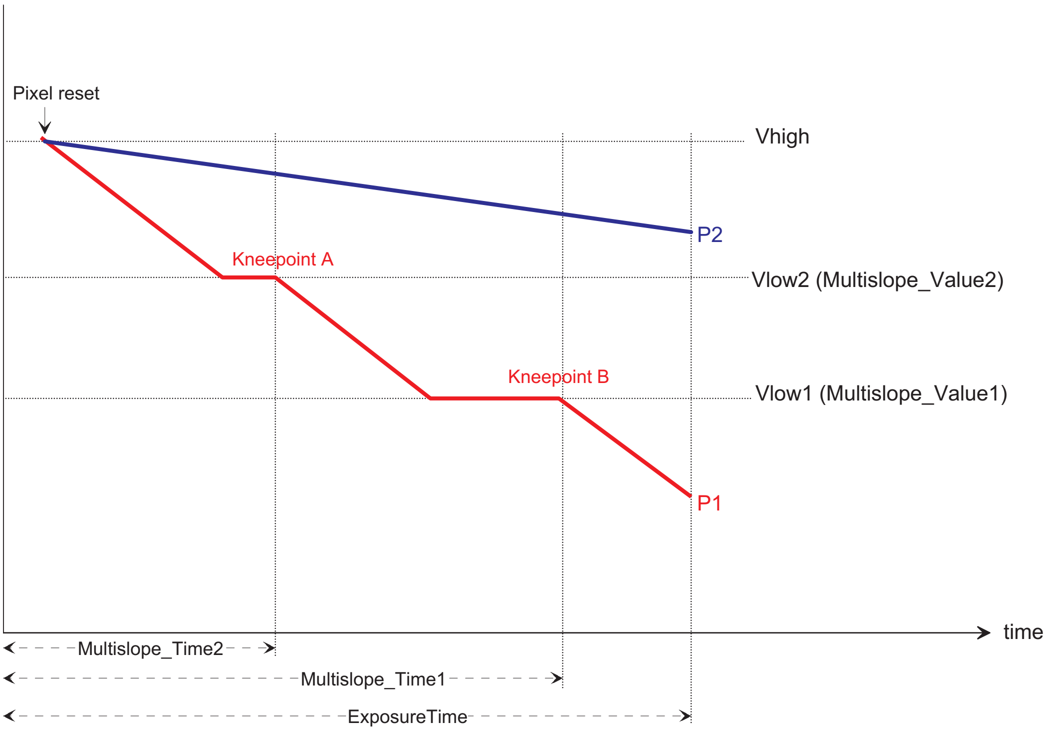

Figure 5.21: Multi Slope (HDR mode)

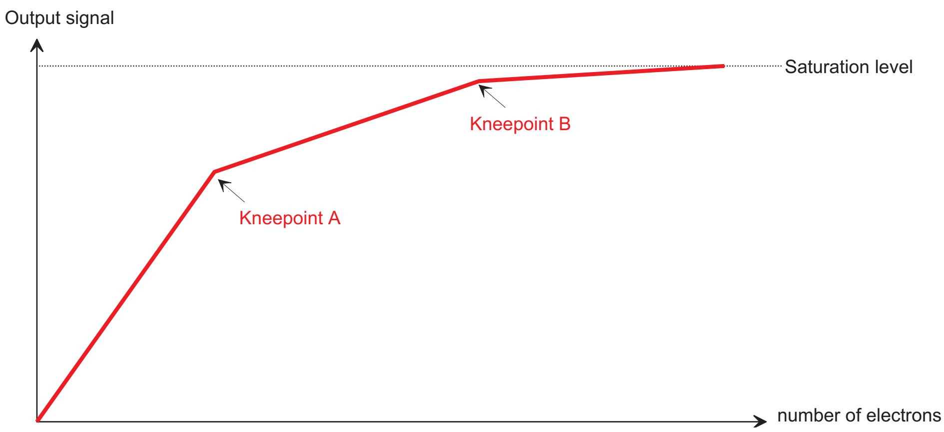

Figure 5.22: Piecewise linear response

5.4 Data Path Overview

The data path is the path of the image from the output of the image sensor to the output of the camera. The sequence of blocks is shown in figure Fig. 5.23.

The status line is not available on all camera revisions, see Appendix B for a list of available features.

Output data resolution is fixed to 8 bit in DR1 and D-240 camera models.

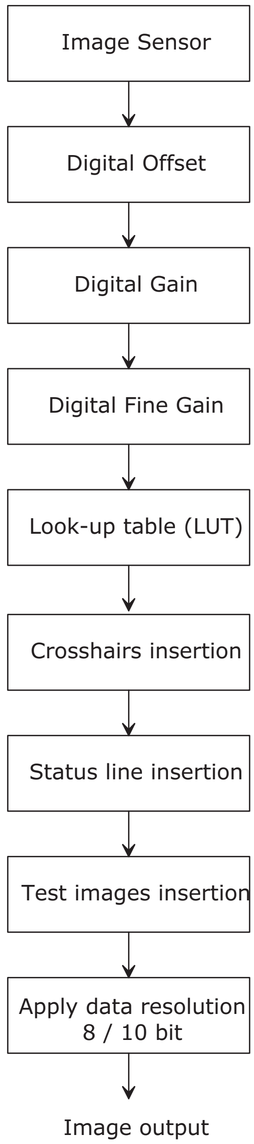

Figure 5.23: camera data path

5.5 Gain and Offset

There are three different gain settings on the camera:

Analog Gain Analog gain on the image sensor (only available in some models, see Appendix B). Available values: x1, x1.2, x1.4, x1.6. Note that `Digital Offset` is applied after the `Analog Gain`.

Gain (Digital Fine Gain) Digital fine gain accepts fractional values from 0.01 up to 15.99. It is implemented as a multiplication operation. Colour camera models only: There is additionally a gain for every RGB colour channel. The RGB channel gain is used to calibrate the white balance in an image, which has to be set according to the current lighting condition.

Digital Gain Digital Gain is a coarse gain with the settings x1, x2, x4 and x8. It is implemented as a binary shift of the image data where '0' is shifted to the LSB's of the gray values. E.g. for gain x2, the output value is shifted by 1 and bit 0 is set to '0'.

The resulting gain is the product of the three gain values, which means that the image data is multiplied in the camera by this factor.

☞ Digital Fine Gain and Digital Gain may result in missing codes in the output image data.

A user-defined value can be subtracted from the gray value in the digital offset block. If digital gain is applied and if the brightness of the image is too big then the interesting part of the output image might be saturated. By subtracting an offset from the input of the gain block it is possible to avoid the saturation.

5.6 Grey Level Transformation (LUT)

Grey level transformation is remapping of the grey level values of an input image to new values. The look-up table (LUT) is used to convert the greyscale value of each pixel in an image into another grey value. It is typically used to implement a transfer curve for contrast expansion. The camera performs a 12-to-8-bit mapping, so that 4096 input grey levels can be mapped to 256 output grey levels. The use of the three available modes is explained in the next sections. Two LUT and a Region-LUT feature are available in the Photonfocus 2048 camera series (see Section 5.6.4).

☞ The LUT is implemented as a 12-to-8 bit LUT to be compatible with other Photonfocus cameras. Bits 0 & 1 of the 12 bit LUT input data are set to random values.

☞ The output grey level resolution of the look-up table (independent of gain, gamma or user-definded mode) is always 8 bit.

☞ There are 2 predefined functions, which generate a look-up table and transfer it to the camera. For other transfer functions the user can define his own LUT file.

Some commonly used transfer curves are shown in Fig. 5.24. Line a denotes a negative or inverse transformation, line b enhances the image contrast between grey values x0 and x1.

Line c shows brightness thresholding and the result is an image with only black and white grey levels. and line d applies a gamma correction (see also Section 5.6.2).

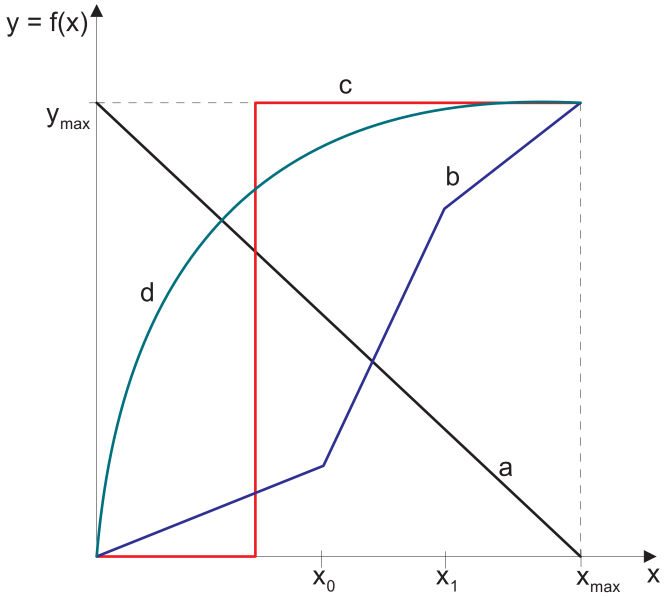

Figure 5.24: Commonly used LUT transfer curves

5.6.1 Gain

The 'Gain' mode performs a digital, linear amplification with clamping (see Fig. 5.25). It is configurable in the range from 1.0 to 4.0 (e.g. 1.234).

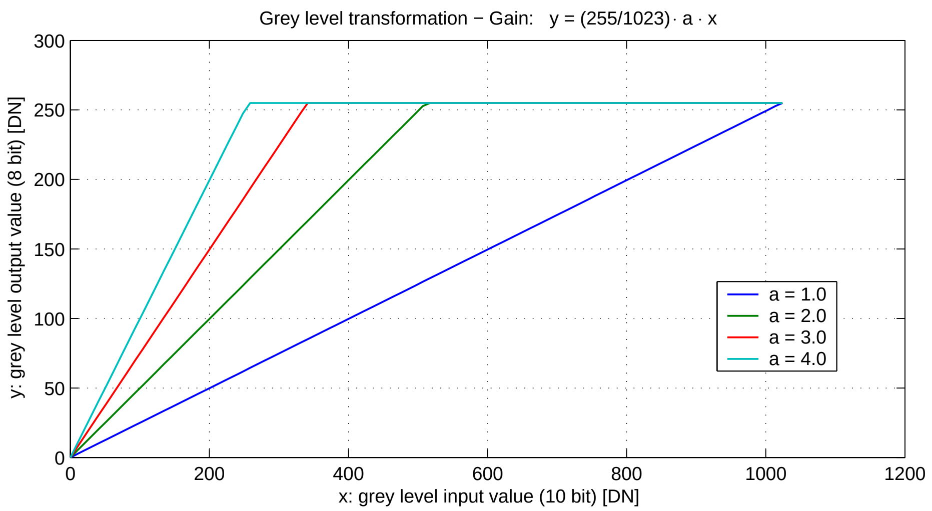

Figure 5.25: Applying a linear gain with clamping to an image

5.6.2 Gamma

The 'Gamma' mode performs an exponential amplification, configurable in the range from 0.4 to 4.0. Gamma > 1.0 results in an attenuation of the image (see Fig. 5.26), gamma < 1.0 results in an amplification (see Fig. 5.27). Gamma correction is often used for tone mapping and better display of results on monitor screens.

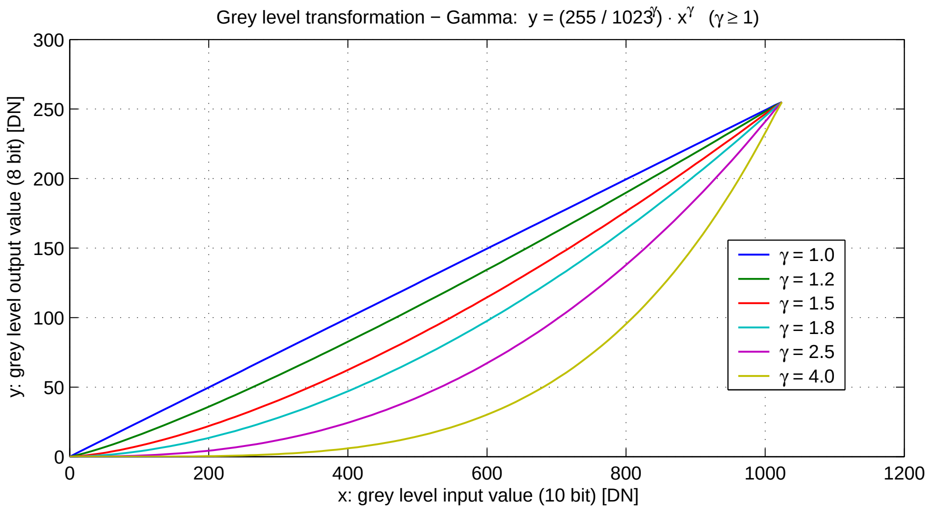

Figure 5.26: Applying gamma correction to an image (gamma > 1)

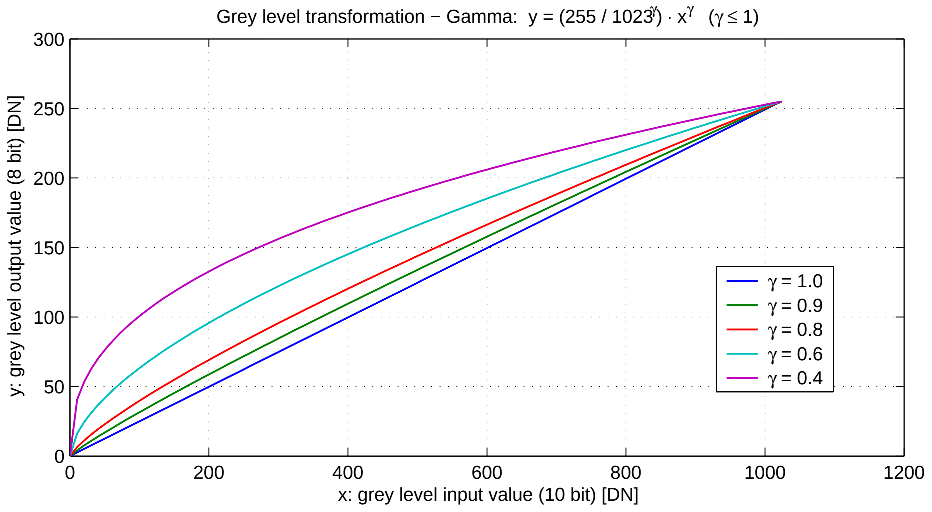

Figure 5.27: Applying gamma correction to an image (gamma < 1)

5.6.3 User-defined Look-up Table

In the 'User' mode, the mapping of input to output grey levels can be configured arbitrarily by the user. There is an example file in the PFRemote folder. LUT files can easily be generated with a standard spreadsheet tool. The file has to be stored as tab delimited text file.

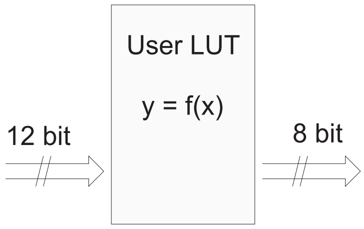

Figure 5.28: Data path through LUT

5.6.4 Region LUT and LUT Enable

Two LUTs and a Region-LUT feature are available in the Photonfocus 2048 camera series. Both LUTs can be enabled independently (see Table 5.10). LUT 0 superseeds LUT1.

Enable LUT 0	Enable LUT 1	Enable Region LUT	Description
-	-	-	LUT are disabled.
X	don't care	-	LUT 0 is active on whole image.
-	X	-	LUT 1 is active on whole image.
X	-	X	LUT 0 active in Region 0.
X	X	X	LUT 0 active in Region 0 and LUT 1 active
			in Region 1. LUT 0 supersedes LUT1.

Table 5.10: LUT Enable and Region LUT

When Region-LUT feature is enabled, then the LUTs are only active in a user defined region. Examples are shown in Fig. 5.29 and Fig. 5.30.

Fig. 5.29 shows an example of overlapping Region-LUTs. LUT 0, LUT 1 and Region LUT are enabled. LUT 0 is active in region 0 ((x00, x01), (y00, y01)) and it supersedes LUT 1 in the overlapping region. LUT 1 is active in region 1 ((x10, x11), (y10, y11)).
Fig. 5.30 shows an example of keyhole inspection in a laser welding application. LUT 0 and LUT 1 are used to enhance the contrast by applying optimized transfer curves to the individual regions. LUT 0 is used for keyhole inspection. LUT 1 is optimized for seam finding.

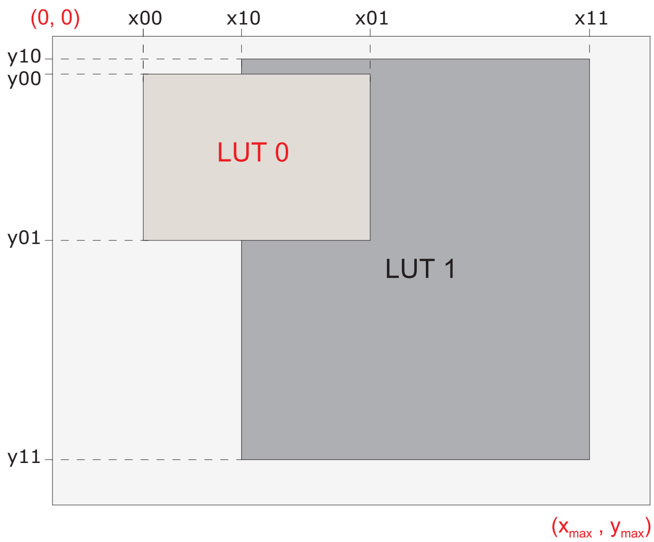

Figure 5.29: Overlapping Region-LUT example

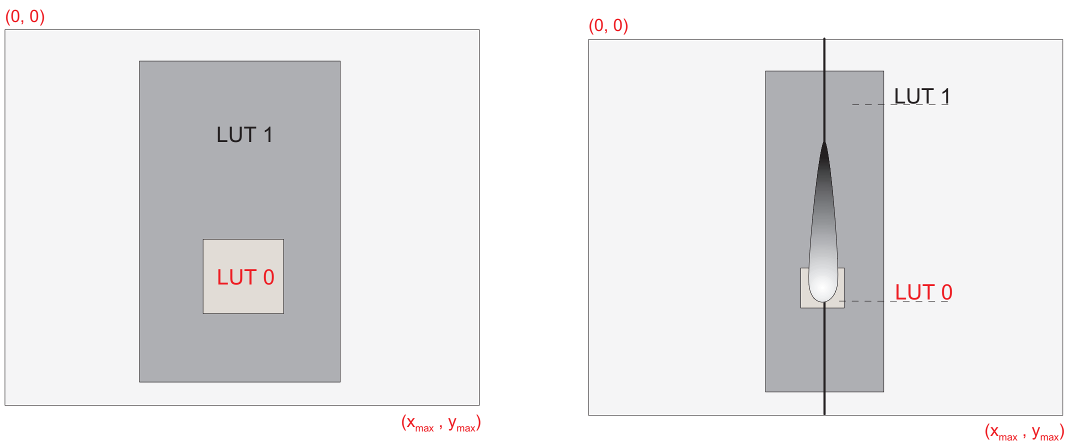

Figure 5.30: Region-LUT in keyhole inspection

Fig. 5.31 shows the application of the Region-LUT to a camera image. The original image without image processing is shown on the left-hand side. The result of the application of the Region-LUT is shown on the right-hand side. One Region-LUT was applied on a small region on the lower part of the image where the brightness has been increased.

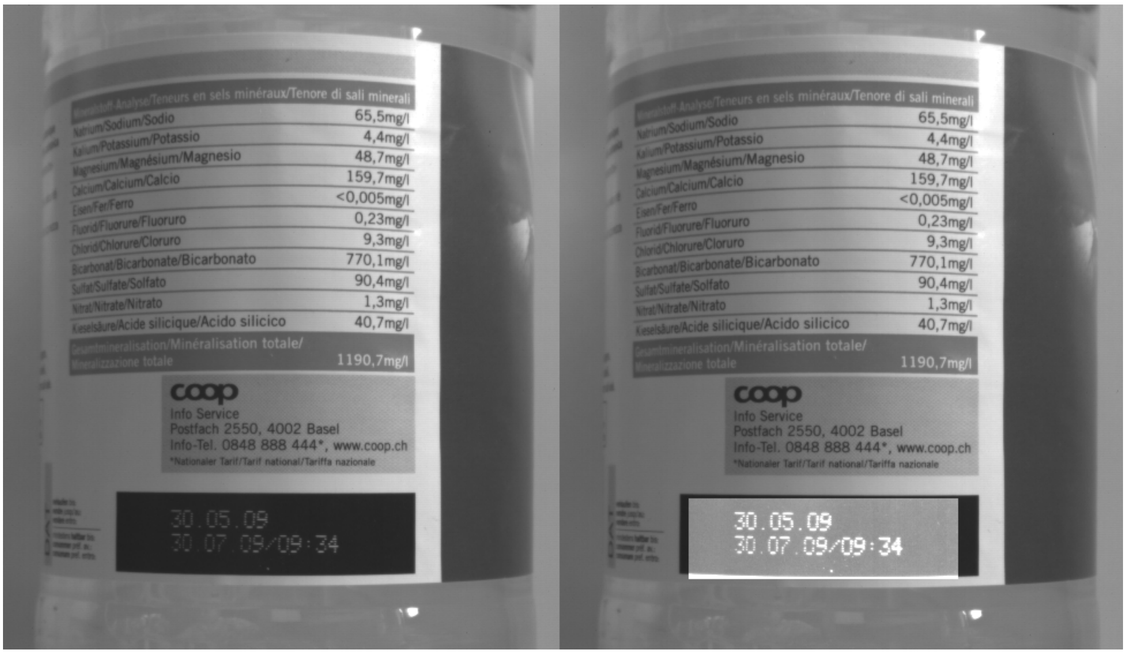

Figure 5.31: Region-LUT example with camera image; left: original image; right: gain 4 region in the are of the date print of the bottle

5.7 Crosshairs

5.7.1 Functionality

The crosshairs inserts a vertical and horizontal line into the image. The width of these lines is one pixel. The grey level is defined by a 12 bit value (0 means black, 4095 means white). This allows to set any grey level to get the maximum contrast depending on the acquired image. The x/y position and the grey level can be set via the camera software. Figure Fig. 5.32 shows two examples of the activated crosshairs with different grey values. One with white lines and the other with black lines.

☞ The 12-bit format of the grey level was chosen to be compatible with other Photonfocus cameras.

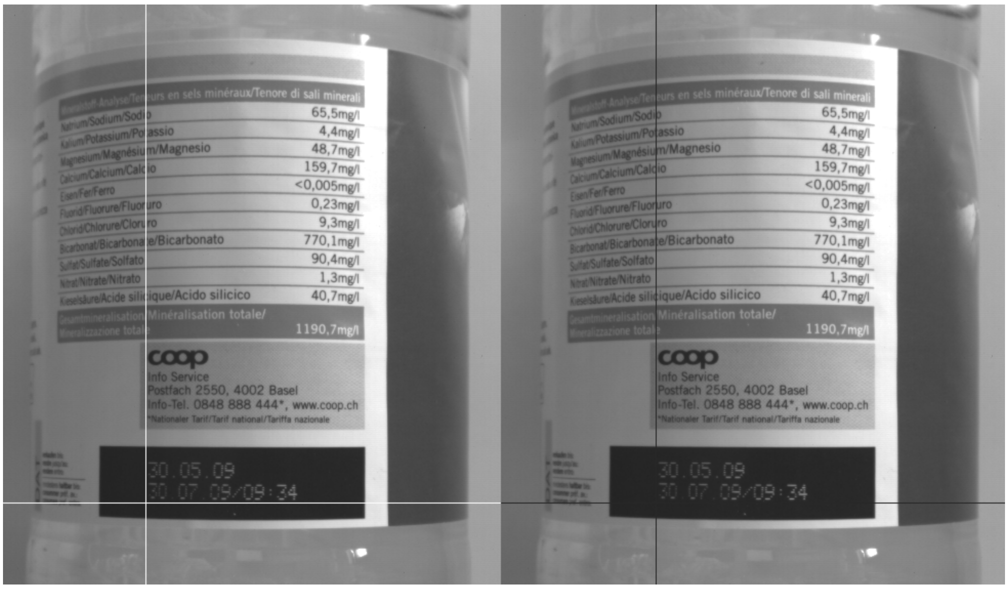

Figure 5.32: Crosshairs Example with different grey values

The Crosshairsl feature is not available on all camera revisions, see Appendix B for a list of available features.

☞ DR1 models: The crosshairs might be slightly distorted in the DR1-encoded image.

The x- and y-positon is absolute to the sensor pixel matrix. It is independent on the ROI, MROI or decimation configurations. Figure Fig. 5.33 shows two situations of the crosshairs configuration. The same MROI settings is used in both situations. The crosshairs however is set differently. The crosshairs is not seen in the image on the right, because the x- and y-position is set outside the MROI region.

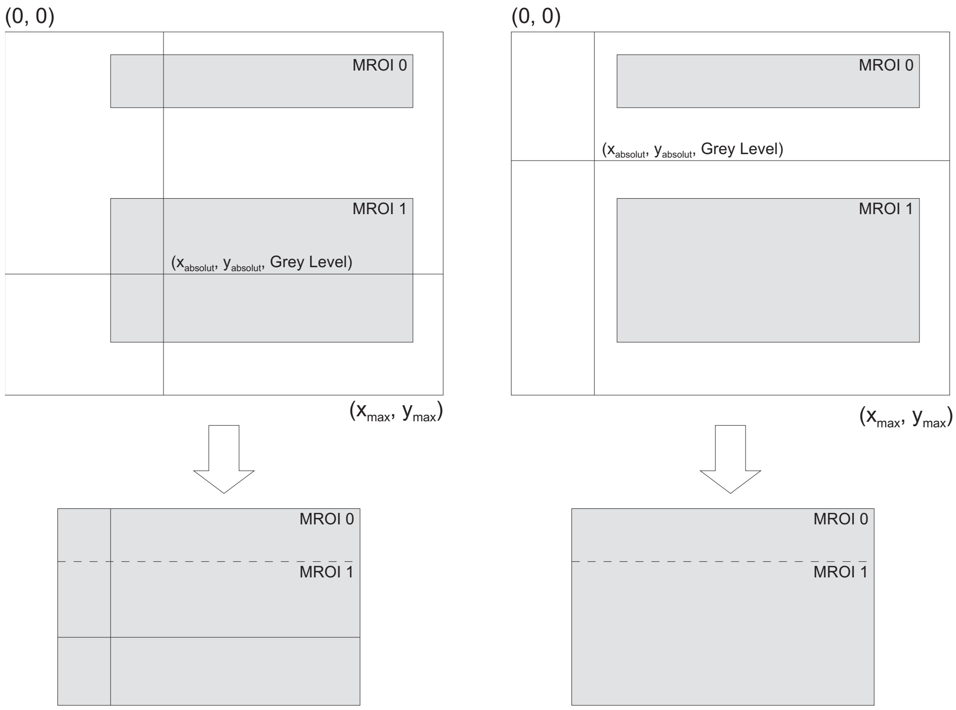

Figure 5.33: Crosshairs absolute position

5.8 Image Information and Status Line

There are camera properties available that give information about the acquired images, such as an image counter, average image value and the number of missed trigger signals. These properties can be queried by software. Alternatively, a status line within the image data can be switched on that contains all the available image information.

5.8.1 Counters and Average Value

Image counter The image counter provides a sequential number of every image that is output. After camera startup, the counter counts up from 0 (counter width 24 bit). The counter can be reset by the camera control software.

Real Time counter The time counter starts at 0 after camera start, and counts real-time in units of 1 micro-second. The time counter can be reset by the software in the SDK (Counter width 32 bit).

Missed trigger counter The missed trigger counter counts trigger pulses that were ignored by the camera because they occurred within the exposure or read-out time of an image. In free-running mode it counts all incoming external triggers (counter width 8 bit / no wrap around) (see also Section 5.2.8).

Missed burst trigger counter When the camera is in burst trigger mode (see Section 5.2.5), a missed burst trigger counter will be incremented, when a subsequent external trigger (`TriggerMode=On`) is applied while a burst sequence is running (see also Section 5.2.8).

Average image value The average image value gives the average of an image in 12 bit format (0 .. 4095 DN), regardless of the currently used grey level resolution. Note that the 12-bit format was chosen to be compatible with other Photonfocus cameras.

5.8.2 Status Line

If enabled, the status line replaces the last row of the image with camera status information. Every parameter is coded into fields of 4 pixels (LSB first) and uses the lower 8 bits of the pixel value, so that the total size of a parameter field is 32 bit (see Fig. 5.34). The assignment of the parameters to the fields is listed in Table 5.11.

☞ The status line is available in all camera modes.

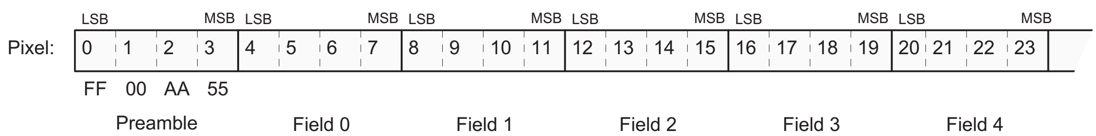

Figure 5.34: Status line parameters replace the last row of the image

Start pixel index	Parameter width [bit]	Parameter Description
0	32	Preamble: 0x55AA00FF
4	24	Image Counter (see Section 5.8.1)
8	32	Real Time Counter (see Section 5.8.1)
12	8	Missed Trigger Counter (see Section 5.8.1)
16	12	Image Average Value("raw" data without taking in account gain settings) (see Section 5.8.1)
20	24	Integration Time in units of clock cycles (see Table 4.3)
24	16	Reserved (Burst Trigger Number)
28	8	Missed Burst Trigger Counter
32	11	Horizontal start position of ROI (Window.X)
36	11	Horizontal end position of ROI (= Window.X + Window.W - 1)
40	11	Vertical start position of ROI (Window.Y). In MROI-mode this parameter is the start position of the first ROI.
44	11	Number of rows -1
48	2	Trigger Source
52	2	Digital Gain
56	2	Digital Offset
60	16	Camera Type Code (see Table 5.12)
64	32	Camera Serial Number
68	32	Reserved
72	32	Custom value: value of register StatusLineCustomValue that can be set by the user
76	16	FineGain. This is fixed a point value in the format: 4 digits integer value, 12 digits fractional value.
80	24	Reserved
84	32	Reserved
88	32	Reserved
92	4	Trigger Level: signal level of the trigger input signal (only available in some models, see Appendix B). Bit 0: ExSync (CC1): Bit 1: I/O Trigger; Bit 2: CC3; Bit 3: CC4. This entry is only available in some models, see Appendix B.

Table 5.11: Assignment of status line fields

5.8.3 Camera Type Codes

Camera Model	Camera Type Code
MV1-D2048x1088-160-CL-10	402
MV1-D2048x1088I-160-CL-10	413
MV1-D2048x1088C-160-CL-10	412
MV1-D2048x1088-240-CL-8	403
MV1-D2048x1088I-240-CL-8	TBD
MV1-D2048-160-CL-10	452
MV1-D2048I-160-CL-10	453
MV1-D2048C-160-CL-10	454
MV1-D2048-240-CL-8	458
MV1-D2048I-240-CL-8	TBD
MV1-L2048-160-CL-10	420
MV1-L2048I-160-CL-10	TBD
MV1-L2048C-160-CL-10	422

Table 5.12: Type codes of Photonfocus 2048 camera series

5.9 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 gives a flat histogram only if the image width is a multiple of 1024 (in 10 bit mode) or 256 (in 8 bit mode).

5.9.1 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. 5.35).

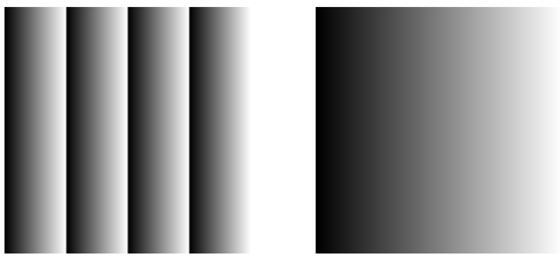

Figure 5.35: Ramp test images: 8 bit output (left), 10 bit output (right)

5.9.2 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.

5.9.3 Troubleshooting using the LFSR

To control the quality of your complete imaging system enable the LFSR mode, set the camera window to a width that is a multiple of 1024 and check the histogram. 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. 5.37). On the other hand, a

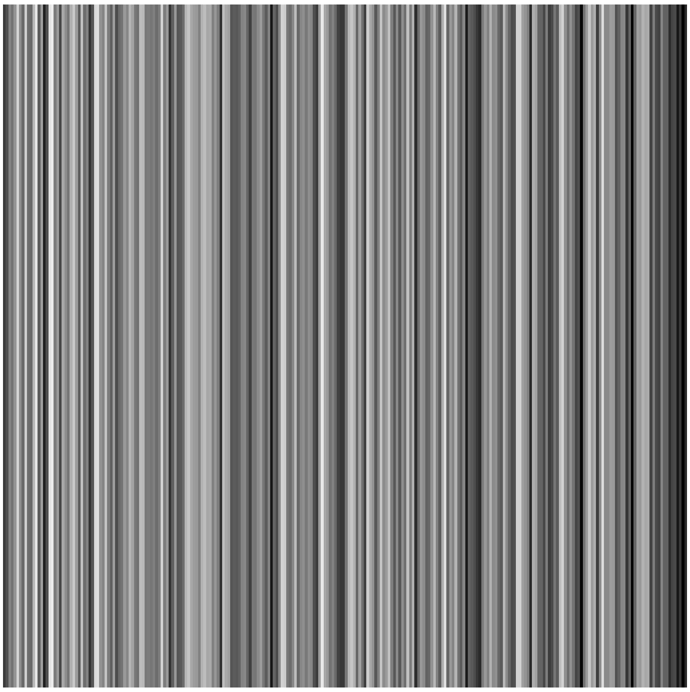

Figure 5.36: LFSR (linear feedback shift register) test image

non-flat histogram (Fig. 5.38) 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. The maximal cable length depends on the frequency of the pixel clock. At a pixel clock of 80 MHz, a length of 8 m can be achieved with a good cable. 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 5.37: LFSR test pattern received at the frame grabber and typical histogram for error-free data transmission

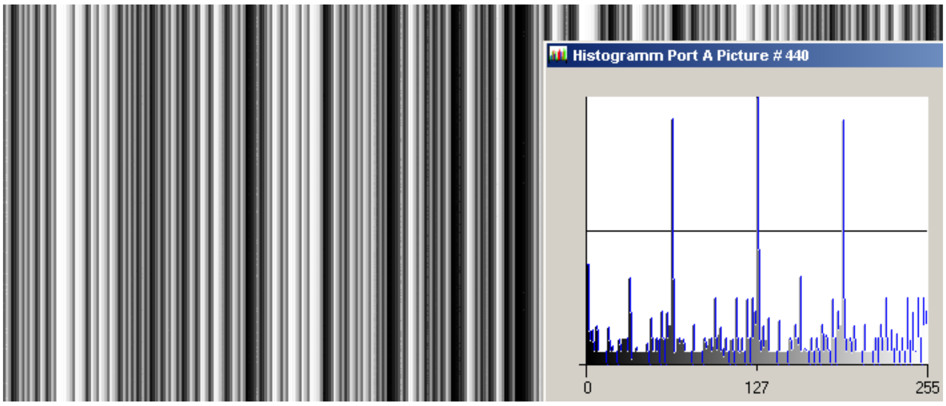

Figure 5.38: LFSR test pattern received at the frame grabber and histogram containing transmission errors

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.

5.10 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. 5.39 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.

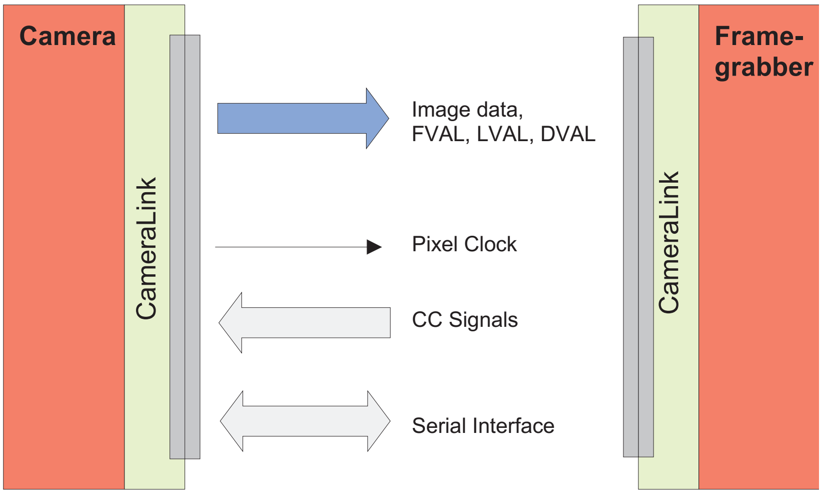

Figure 5.39: CameraLink serial interface for camera communication

6

Hardware Interface

6.1 Connectors

6.1.1 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. 6.1 shows the plugs and the status LED which indicates camera operation.

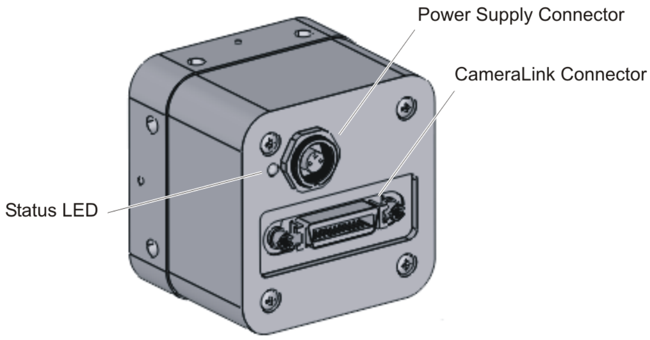

Figure 6.1: Rear view of the CameraLink camera

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

6.1.2 Power Supply

The camera requires a single voltage input (see Table 4.5). 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 Appendix A.

6.1.3 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 6.1) to `STROBE_VDD` (5 .. 15 V DC) as shown in Fig. 6.2. This resistor should be located directly at the signal receiver.

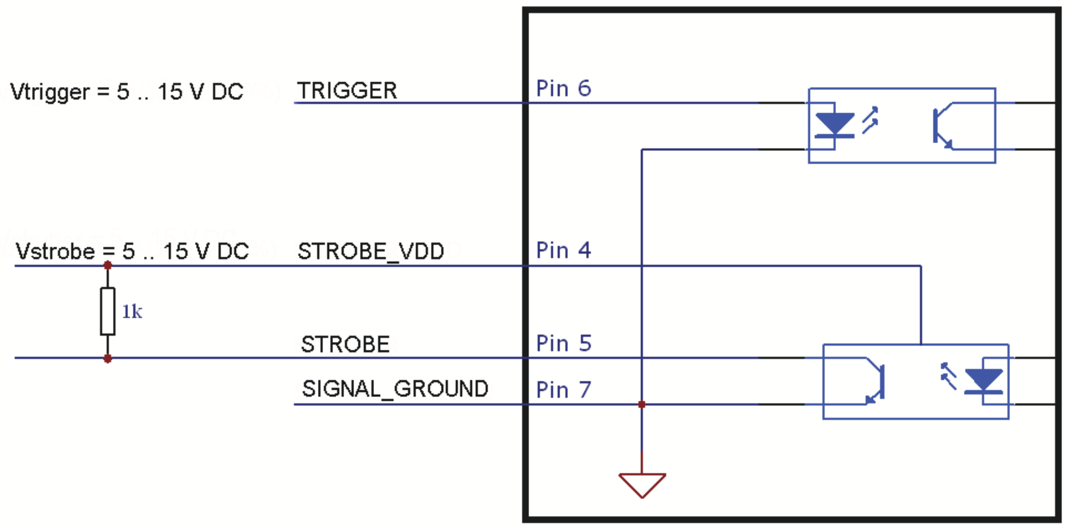

Figure 6.2: Circuit for the trigger input signals

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

6.1.4 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. A pulsating heartbeat indicates, that the camera is powered up and is in idle mode without sending images.
LED Red	Red indicates an active serial communication with the camera.

Table 6.2: Meaning of the LED of the CameraLink® cameras

6.1.5 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 6.3 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 6.3: 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 5.10 for more information.

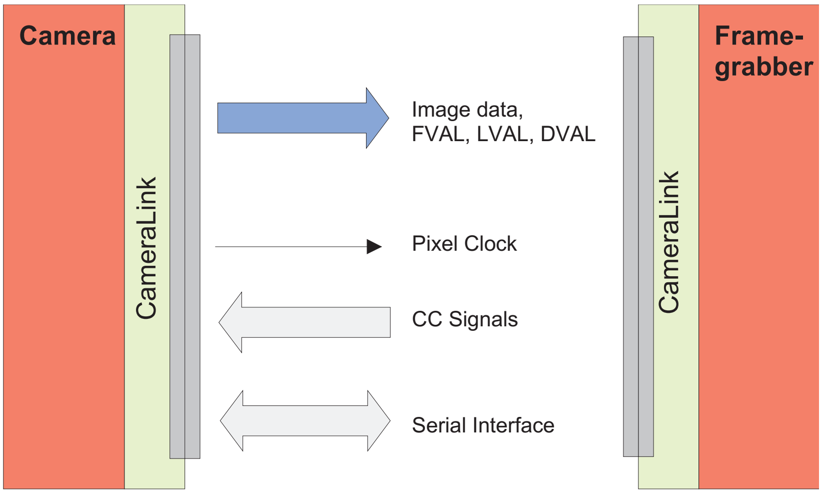

Figure 6.3: CameraLink interface system

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 4.3 and to Section 4.6 for a summary of frame grabber relevant specifications. Fig. 6.3 shows symbolically a CameraLink® system. For more information about taps refer to the relevant application note [AN021] on the Photonfocus website.

7

The PFRemote Control Tool

7.1 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]).

7.2 PFRemote and PFLib

As shown in Fig. 7.1, 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.

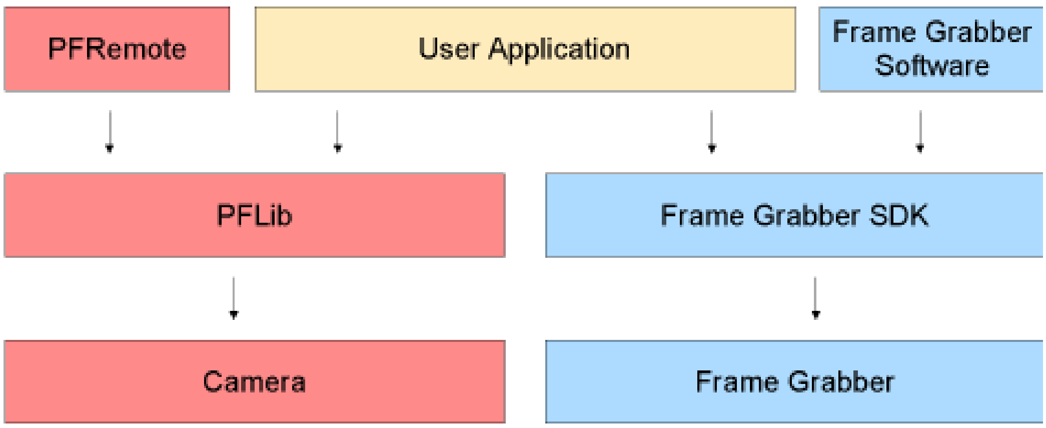

Figure 7.1: PFRemote and PFLib in context with the CameraLink frame grabber software

7.3 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.

7.4 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
- `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].

7.5 Graphical User Interface (GUI)

PFRemote consists of a main window (Fig. 7.2) 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.

7.5.1 Port Browser

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

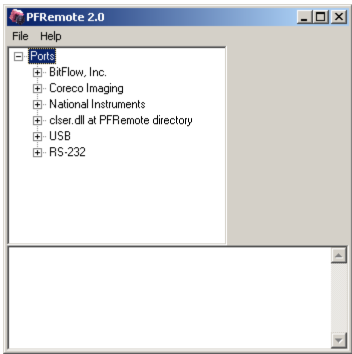

Figure 7.2: PFRemote main window with PortBrowser and log messages

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)

7.5.2 Ports, Device Initialization

After starting **PFRemote**, the main window as shown in Fig. 7.2 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?

7.5.3 Main Buttons

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

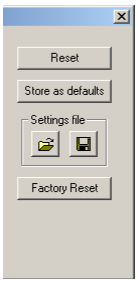

Figure 7.3: Main buttons

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.

7.6 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.

8

Graphical User Interface (GUI)

8.1 MV1-D2048(x1088)-160, MV1-L2048-160

GUI description GUI description description description
This section describes the parameters of the following camera:

- MV1-D2048(x1088)-160-CL, CameraLink interface
- MV1-D2048(x1088)-240-CL, CameraLink interface
- MV1-L2048-160-CL, CameraLink interface
- MV1-D2048(x1088)I-160-CL, CameraLink interface
- MV1-D2048(x1088)I-240-CL, CameraLink interface
- MV1-D2048(x1088)C-160-CL, CameraLink interface
- MV1-D2048(x1088)C-240-CL, CameraLink interface

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

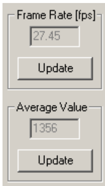

Figure 8.1: Frame rate and average value indication

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.

8.1.1 Exposure

This tab contains exposure settings.

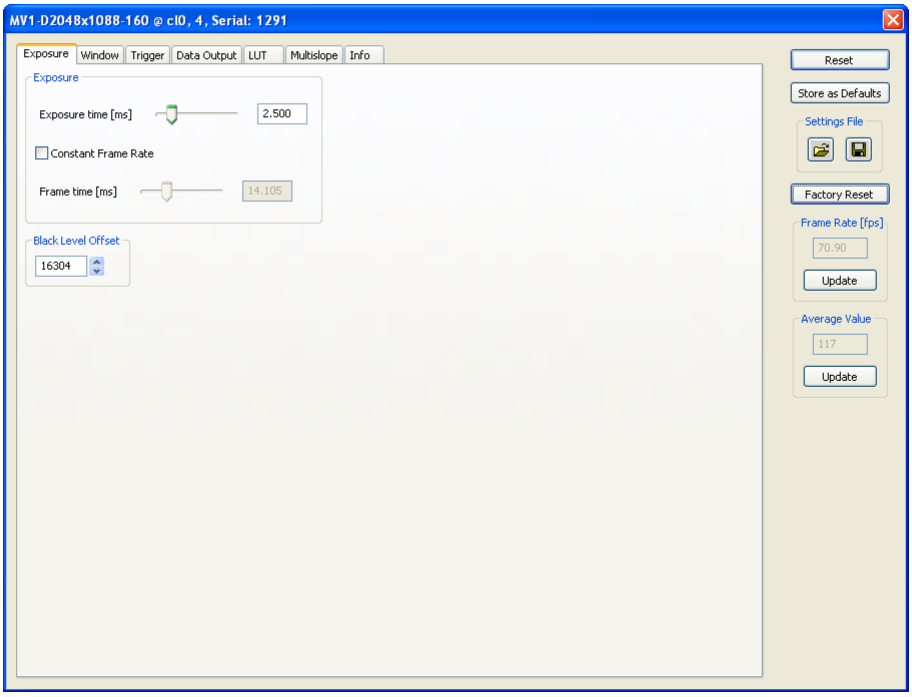

Figure 8.2: Exposure panel

Exposure

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

Constant Frame Rate: When the Constant Frame Rate (CFR) is switched on, the frame rate (number of frames per second) can be varied from almost 0 up to the maximum frame rate. Thus, fewer images can be acquired than would otherwise be possible. When Constant Frame Rate is switched off, the camera delivers images as fast as possible, depending on the exposure time and the read-out time.

Frame time [ms]: Configure the frame time in milliseconds. Only available if Constant Frame Rate is enabled. The minimum frame time depends on the exposure time and readout 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.

8.1.2 Window

This tab contains the settings for the region of interest.

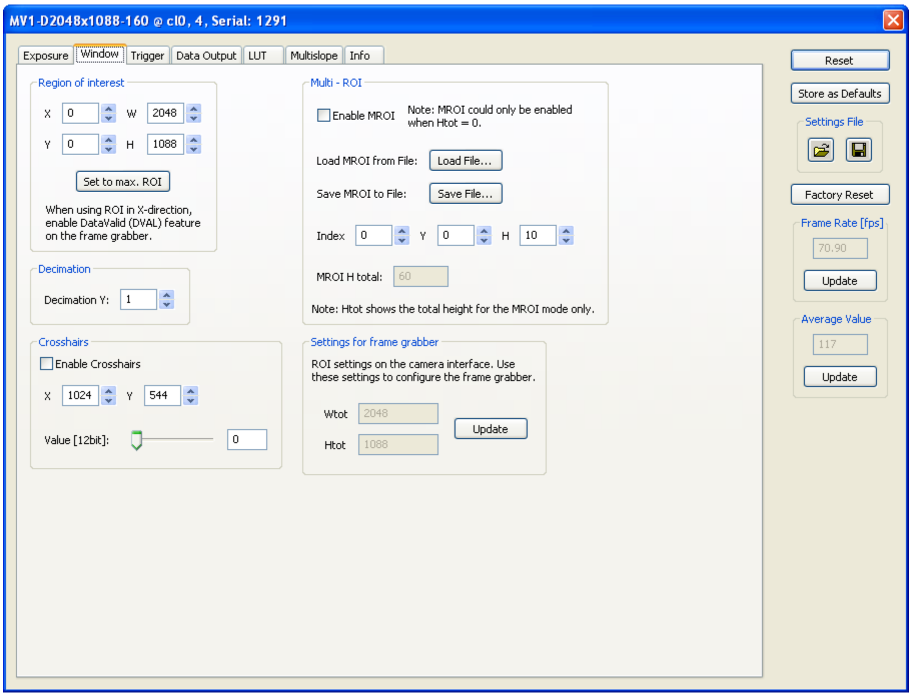

Figure 8.3: Window panel

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 2 pixel).

H: Window height.

Set to max ROI: Set Window to maximal ROI (X=0; Y=0; W=2048; H=1088).

Window width is only available in steps of 2 pixel.

When using ROI in x-direction, enable DataValid (DVAL) feature on the frame grabber.

Decimation

`Decimation` reduces the number of pixels in y-direction. Decimation can also be used together with a ROI or MROI. Decimation in y-direction transfers every n-th row only and directly results in reduced read-out time and higher frame rate respectively.

Decimation Y: Decimation value for y-direction. Example: Value = 3 reads every third row only.

Crosshairs

Crosshairs is a cross inside the image. The crosshairs value is overlapped the original image data. The position of the crosshairs can be configured. The unit of the grey value is always 12 bit.

Enable Crosshairs: Enable crosshairs.

X: Vertical line position of crosshairs.

Y: Horizontal line position of crosshairs

Value [12bit]: Crosshairs grey value in 12bit.

Multi - ROI

This camera can handle up to 8 different regions of interest. The multiple ROIs are joined together and form a single image, which is transferred to the frame grabber. An ROI is defined by its starting value in y-direction and its height. The width and the horizontal offset are specified by X and W settings. The maximum frame rate in MROI mode depends on the number of rows and columns being read out. Overlapping ROIs are NOT allowed. No row should be included in more than one ROI.

Enable MROI: Enable MROI. If MROI is enabled, the ROI and MROI settings cannot be changed.

Load File...: Load a user defined MROI-file into the camera. A sample MROI configuration file (`mv1_d2048x1088_160_mroi.txt`) with description of the data format is available in the directory `MROI-files` located in the PFRemote installation directory.

Save File...: Save the current MROI settings to a *.txt file.

Index: Select one of the 8 MROI.

Y: Y - coordinate of the current MROI (selected by Index).

H: Height of the current MROI (selected by Index).

H tot: Shows the sum of all MROIs as the total image height.

Settings for frame grabber

Shows the ROI settings on the camera interface. Use these settings to configure the frame grabber.

Wtot: Number of pixels in a line (Width of the image).

Htot: Number of lines out of the camera (Height of the image).

Update: Update values of Wtot and Htot.

8.1.3 Trigger

This tab contains trigger and strobe settings.

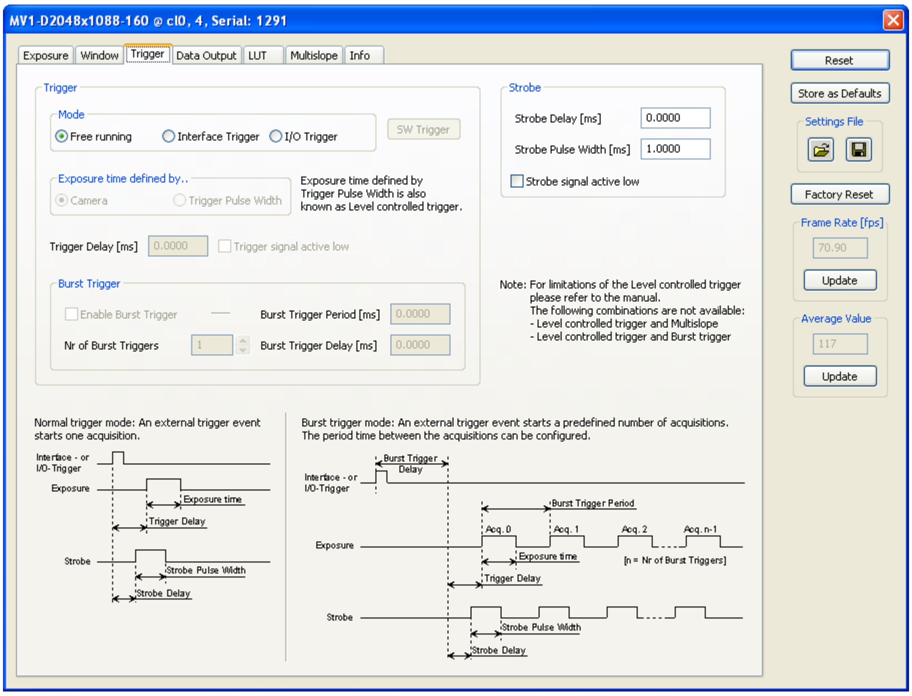

Figure 8.4: Trigger panel

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.

Exposure time defined by:

Camera: The exposure time is defined by the property `ExposureTime`.

Trigger Pulse Width: The exposure time is defined by the pulse width of the trigger signal (level-controlled exposure).

This property disables Multislope, Burst trigger.

Exposure time defined by "Trigger Pulse Width" is also known as Level controlled trigger.

Further trigger settings:

Trigger Delay [ms]: Programmable delay in milliseconds between the incoming trigger edge and the start of the exposure.

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

Burst Trigger

An external trigger event start a predefined number of acquisition. The period time between the acquisitions can be configured.

Enable Burst Trigger: Delay in milliseconds from the input trigger edge to the rising edge of the strobe output signal.

Number of Burst Triggers: Set the number of burst

Burst Trigger Period [ms]: Set the time between the burst in milliseconds.

Burst Trigger Delay [ms]: Set the delay of the burst trigger in milliseconds.

Strobe

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

Strobe Delay [ms]: Delay in milliseconds from the input trigger edge to the rising edge of the strobe output signal.

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

Strobe signal active low: Define the strobe output to be active high (default) or active low.

8.1.4 Data Output

This tab contains image data settings.

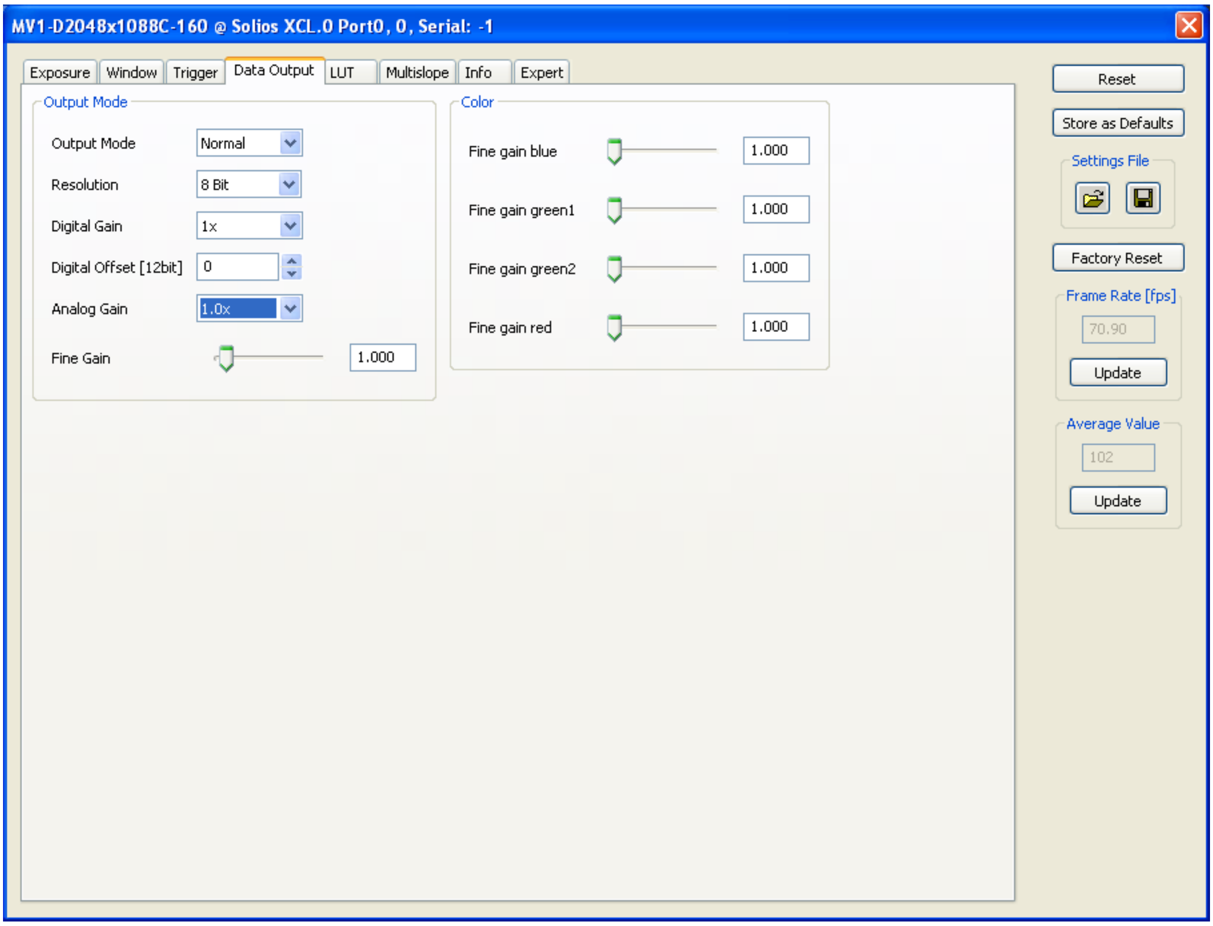

Figure 8.5: MV1-D2048(x1088)(I/C)-160 and MV1-L2048(I/C) data output panel

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.

Digital Gain:

1x: No digital gain, normal mode.

2x: Digital gain 2.

4x: Digital gain 4.

8x: Digital gain 8.

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

1.0x: No analog gain (gain 1.0x).

1.2x: Analog gain 1.2x.

1.4x: Analog gain 1.4x.

1.6x: Analog gain 1.6x.

Fine Gain: The fine gain can be used to adjust the brightness of the whole image in small steps.

Color (Color models only)

There is additionally a gain for every color channel. The color fine gain is used to calibrate the white balance in an image, which has to be set according to the current lighting condition.

Fine gain blue: Gain applied to the blue channel

Fine gain green1: Gain applied to the green channel on the same row as the blue channel

Fine gain green2: Gain applied to the green channel on the same row as the red channel

Fine gain red: Gain applied to the red channel

8.1.5 Data Output (MV1-D2048x1088(I)-240 only)

This tab contains image data settings.

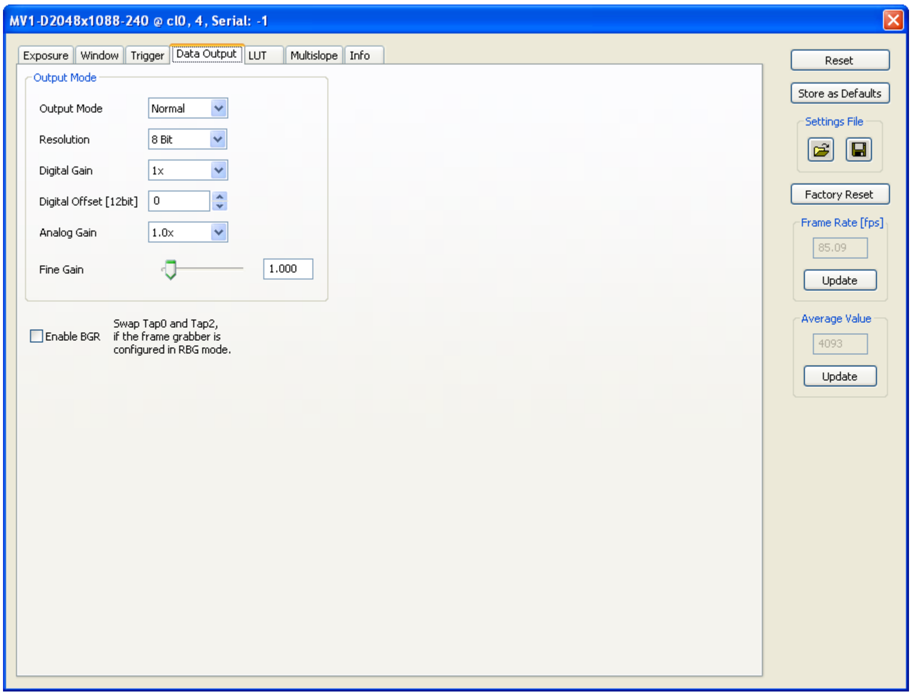

Figure 8.6: MV1-D2048x1088-240 data output panel

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.

Digital Gain:

1x: No digital gain, normal mode.

2x: Digital gain 2.

4x: Digital gain 4.

8x: Digital gain 8.

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

1.0x: No analog gain (gain 1.0x).

1.2x: Analog gain 1.2x.

1.4x: Analog gain 1.4x.

1.6x: Analog gain 1.6x.

Fine Gain: The fine gain can be used to adjust the brightness of the whole image in small steps.

Enable BGR

Enable BGR: Swap Tap0 and Tap2, if the frame grabber is configured in RBG mode.

8.1.6 LUT (Look-Up-Table)

This tab contains LUT settings.

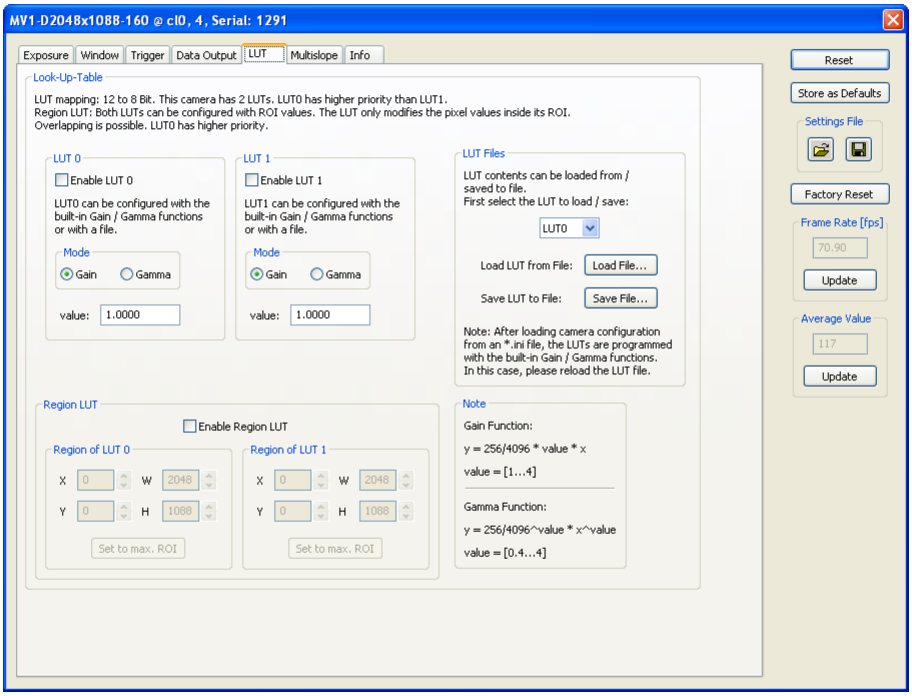

Figure 8.7: LUT panel

Grey level transformation is remapping of the grey level values of an input image to new values which transform the image in some way. The look-up-table (LUT) is used to convert the greyscale value of each pixel in an image into another grey value. It is typically used to implement a transfer curve for contrast expansion.

This camera performs a 12-to-8-bit mapping, so that 4096 input grey levels can be mapped to 256 output grey levels (0 to 4096 and 0 to 255).

This camera support 2 LUT, both are identical. The default LUTs is a gain function with value = 1. LUT0 has higher priority as LUT1.

Both LUT can be configured with the built-in Gain / Gamma functions or with a LUT-file

LUTX

Enable LUT X Enable the LUTX

Gain: Linear function. Y = 256 / 4096 * value * X; Valid range for `value` [1...4].

Gamma: Gamma function. Y = 256 / 4096^value * X ^ value; Valid range for `value` [0.4...4].

value: Enter a value. The LUT will be calculated and downloaded to the camera.

Region LUT

Both LUT can be configured with ROI vlaues. The LUT is only working inside the the ROI values. Overlapping is possible. LUT0 has higher priority.

Enable Region LUT: Enable the region LUT functionality.

Region of LUT:

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

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

W: Region LUT window width (in steps of 2 pixel).

H: Region LUT window height.

Set to max ROI: Set Region LUT window to maximal ROI (X=0; Y=0; W=2080; H=2080).

LUT Files

To load or save a LUT file

LUT Index: Select the LUT, you want to load or save a file.

File functions:

Load File...: Load a user defined LUT - file into the camera (*.txt tab delimited). There is an example file (mv1_d2048x1088_160_lut.txt) in the directory LUT-files located in the PFRemote installation directory.

Save File...: Save LUT from camera into a file.

8.1.7 Multislope

This tab contains Multislope settings.

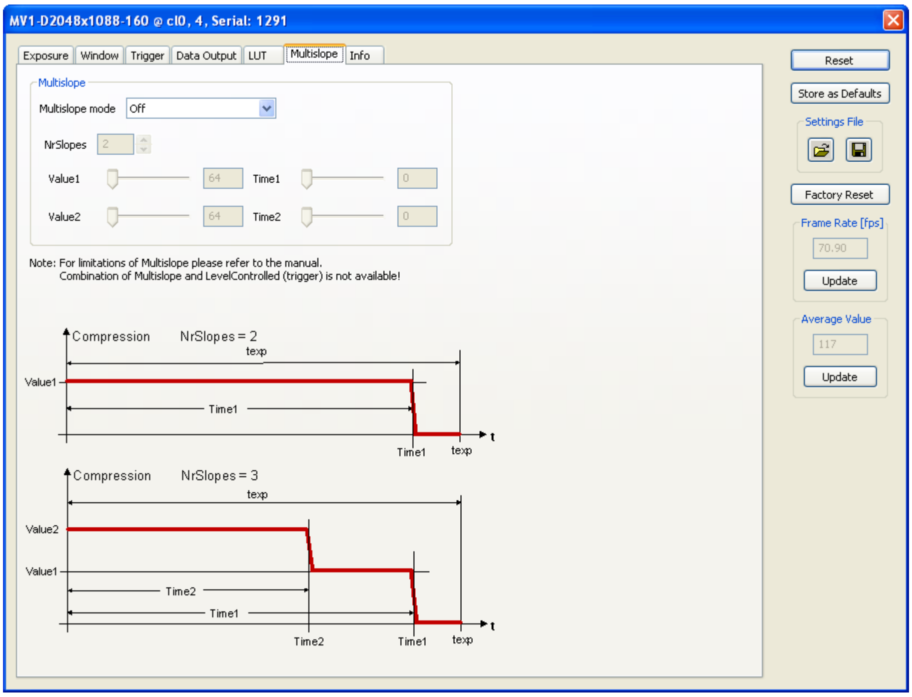

Figure 8.8: Multislope panel

Multislope

Tis camera has the possibility to achieve a high optical dynamic range by using a piecewise linear response. This feature will clip illuminated pixels, while leaving the darker pixels untouched.The clipping level can be adjusted 2 times within one exposure time to achieve a maximum of 3 slopes in the response curve. There are 3 predefined Multislope settings available. Alternatively, custom settings can be defined in the `User defined` Mode.

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

8.1.8 LineScan (MV1-L2048 only)

This tab contains the settings for the Line Scan mode available in the MV1-L2048 cameras.

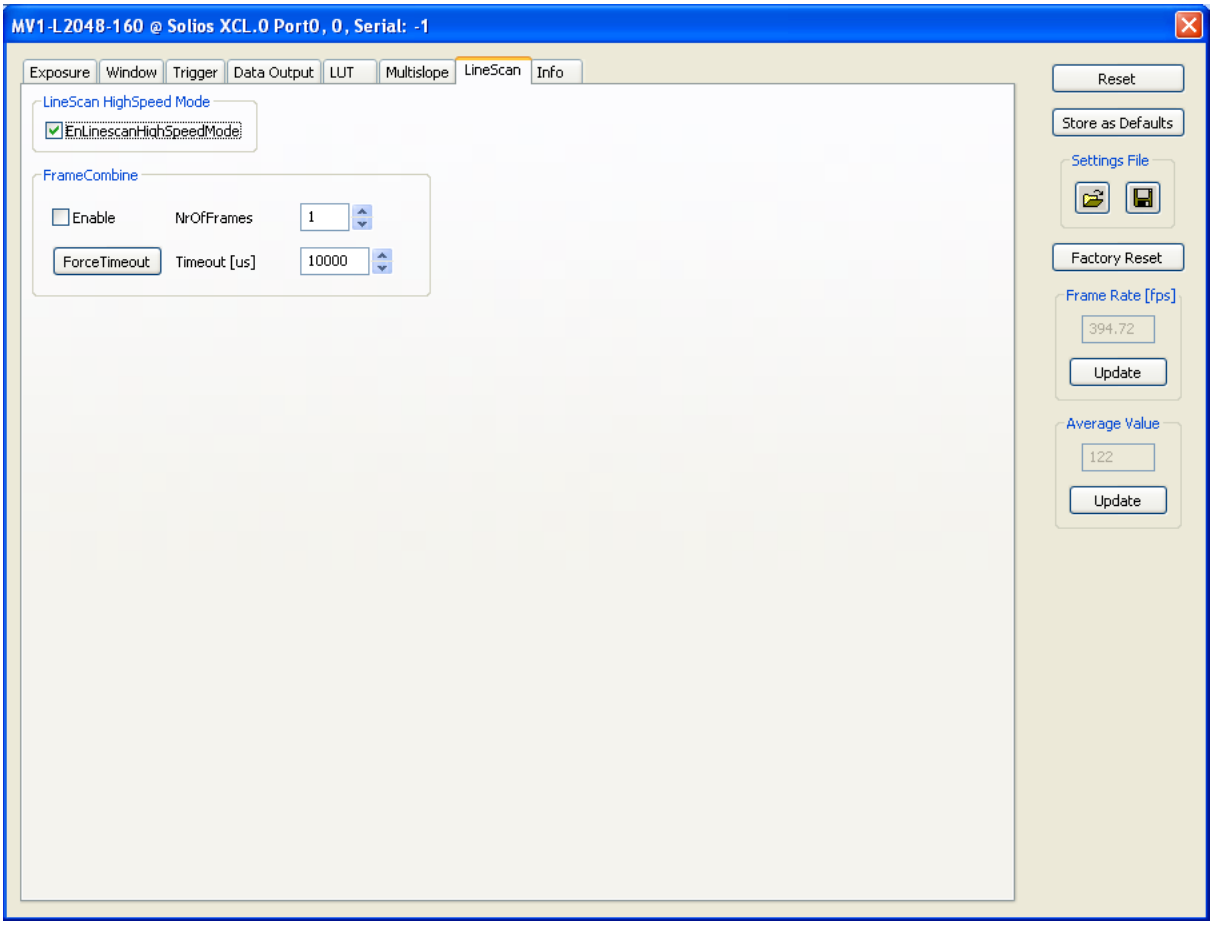

Figure 8.9: LineScan panel

LineScan HighSpeed Mode

Very high frame rates can be obtained in the Line Scan mode.

EnLinescanHighSpeedMode Enables the LineScan mode where high frame rates can be obtained. Up to 4 rows can be read out in this mode. The number of rows and their position can be set in the `Region Of Interest` setting in the `Window` panel as usual. More advanced settings such as Decimation or MROI are supported in this mode. The resulting number of rows must not exceed 4 in the Line Scan mode.

FrameCombine

The FrameCombine mode can only be used when `EnLinescanHighSpeedMode` is checked. When the FrameCombine mode has been enabled, the camera combines n (n=NrOfFrames) into one frame. In some cases it consumes less CPU power to process these combined frames than to process every frame individually.

If the time from one frame to the next frame exceeds a timeout value, the combined frame is generated and the missing individual frames are replaced by dummy frames. Note, that the frame grabber timeout should be bigger than the FrameCombine timeout to avoid a timeout on the frame grabber.

The resulting height setting `Htot` for the frame grabber is visible in the `Window` panel (see Section 8.1.2).

Enable Enable the FrameCombine mode. Note that the FrameCombine mode is only available if `EnLinescanHighSpeedMode` is checked.

NrOfFrames Number of individual frames that are combined into one combined frame.

ForceTimeout A combined frame is generated when the button is clicked. Missing individual frames are replaced by dummy frames.

Timeout FrameCombine timeout value [us]

8.1.9 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.

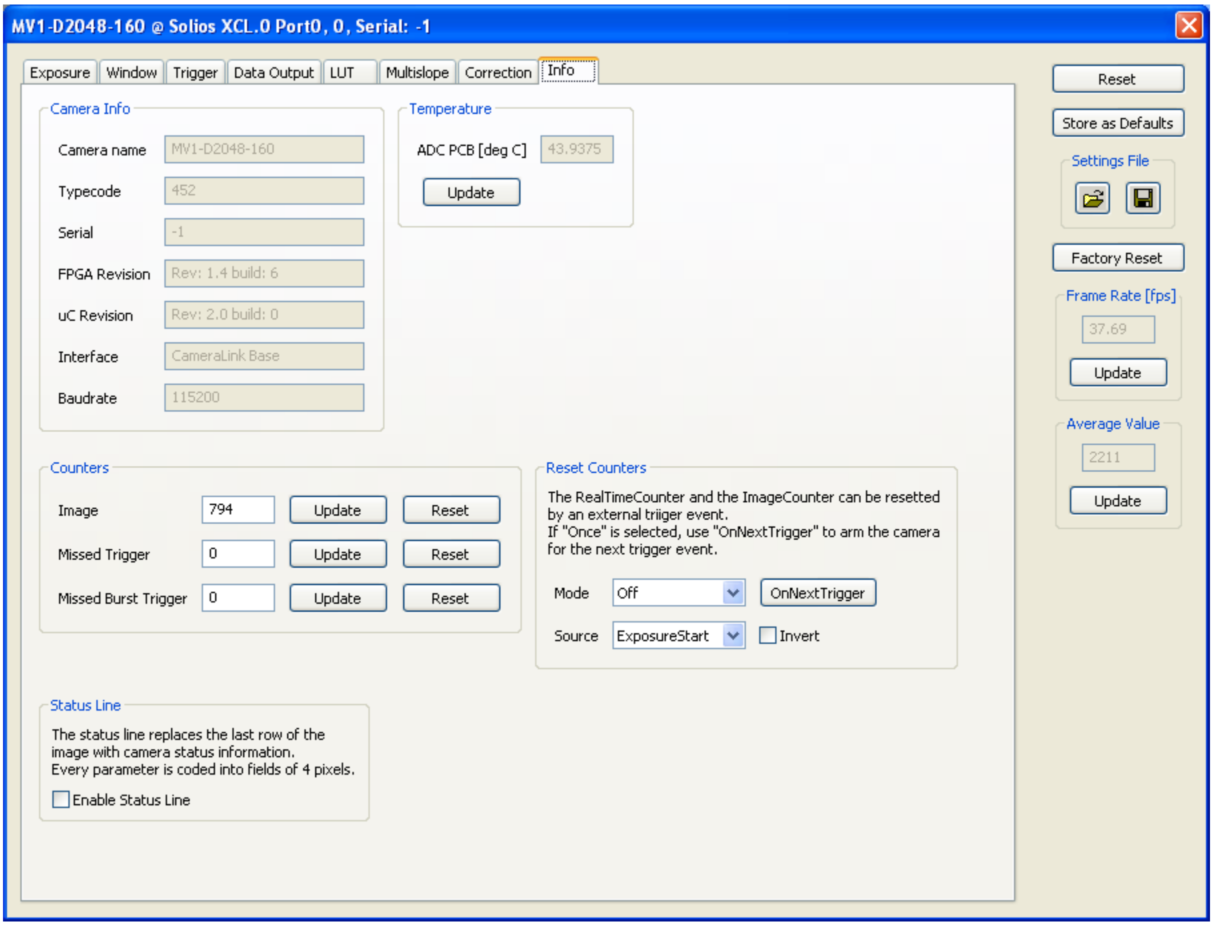

Figure 8.10: Info panel

Camera Info

Camera name: Name of the connected camera.

Typecode: Type code of the connected camera.

Serial: Serial number of the connected camera.

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

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

Interface: Description of the camera interface.

Baudrate: The actual baud rate between camera and frame grabber.

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

Counters

The camera has the following counters.

Image: The image counter is a 24 bit real-time counter and is incremented by 1 for every new image.

Missed Trigger: This is a counter for trigger pulses that were blocked because the trigger pulse was received during image exposure or readout. In free-running mode it counts all pulses received from interface trigger or from I/O trigger interface.

Missed Burst Trigger: This is a counter for burst trigger pulses that were blocked because the burst trigger pulse was received during the last burst is not yet finished.

To update the value of the information properties, click on the Update-Button; to reset the properties, click on the Reset-Button.

Reset Counters

This feature allows to reset the image counter and the real-time counter (timestamp) to be reset by an external signal.

☞ The Reset Counters feature is not available in all camera revisions

Mode: Reset Counters mode. It determines how often the selected source should reset the counters. The setting `Once` works together with the `ResetCounter.OnNextTrigger` (button `OnNextTrigger`)..

OnNextTrigger: This property applies only to `ResetCounter.Mode` = `Once`. In this mode the counters are reset on the next active edge of the selected reset source (property `ResetCounter.Source`) after the device is armed with a click on the button `OnNextTrigger`.

Source: Reset counter source.

Invert The rising edge of the selected reset source is teh active trigger edge. The falling edge is the active edge If `Invert` is selected.

Status Line

Enable Status Line: The status line replaces the last line of an image with image information, please refer the manual for additional information.

Temperature

ADC PCB [deg C]: The temperature of the Processor PCB.

Update: Press this button to update all temperature values.

9

Mechanical Considerations

9.1 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.

9.1.1 MV1 cameras with CameraLink® Interface

Fig. 9.1 shows the mechanical drawing of the camera housing for the Photonfocus 2048 CMOS cameras with CameraLink® interface (all values in mm).

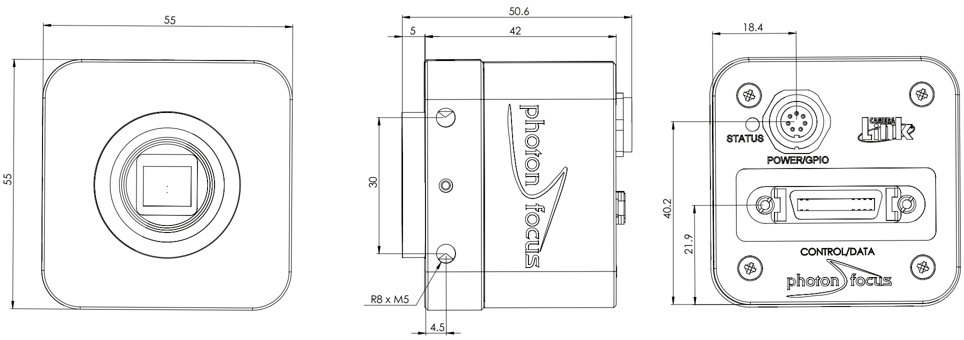

Figure 9.1: Mechanical dimensions of the MV1-D2048(x1088)(I/C) and MV1-L2048(I/C) CameraLink models

10 Warranty

The manufacturer alone reserves the right to recognize warranty claims.

10.1 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.

10.2 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.

11 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

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

AN031 Application Note "MV1-D1312(I)-240 cameras 3-tap grab procedure", Photonfocus, February 2010

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.

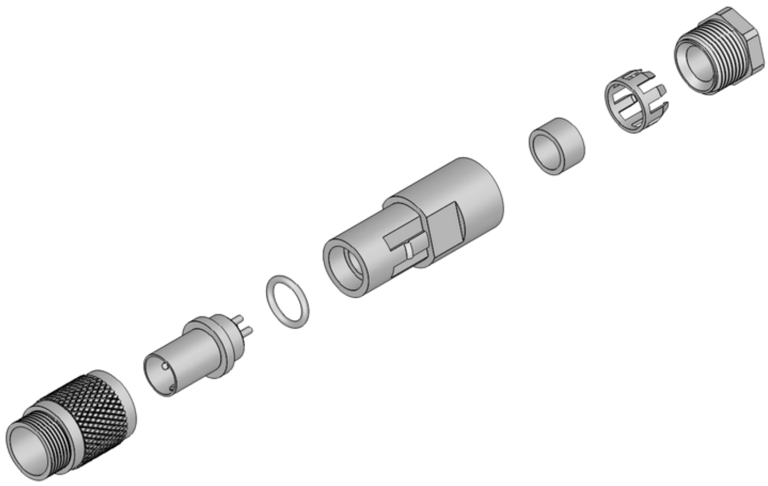

Figure A.1: Power connector assembly

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)

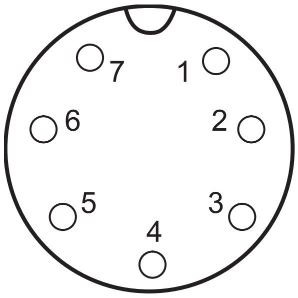

Figure A.2: Power supply plug, 7-pole (rear view of plug, solder side)

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).

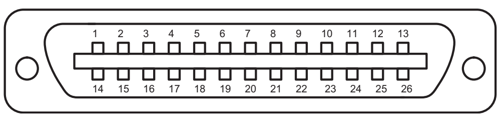

Figure A.3: CameraLink cable 3M MDR-26 plug (both ends)

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

Camera Revisions

B.1 General Remarks

This chapter lists differences between the revisions of the camera models.

List of terms used in this chapter:

Status Line V1.0 Status line fields up to start pixel 76 (FineGain). Values are sampled at the time when the status line is inserted.

Status Line V1.1 All fields of Status Line V1.0 plus additional field `Trigger Level`. Values are sampled at the start of exposure.

Counter Reset External Reset of image counter and real time counter by an external signal.

B.2 2MP Area Scan Cameras

Table B.1 shows revision information for the following models:

D160 MV1-D2048X1088-160-CL-10

I160 MV1-D2048X1088I-160-CL-10

C160 MV1-D2048X1088C-160-CL-10

D240 MV1-D2048X1088-240-CL-8

I160 MV1-D2048X1088I-240-CL-8

	D160 / I160 V1.0	C160 V1.0	D240 / I240 V1.0
ROI	yes	yes	yes
Line Scan Mode	no	no	no
Frame Combine	no	no	no
MROI	yes	yes	yes
Decimation	yes	yes	yes
Standard Trigger	yes	yes	yes
Counter Reset External	no	no	no
Multiple Slope	yes	yes	yes
Column FPN Correction	no	no	no
Digital Gain / Offset	yes	yes	yes
Analog Gain	yes	yes	yes
LUT	yes	yes	yes
Crosshairs	yes	yes	yes
Status Line V1.0	yes	yes	yes
Status Line V1.1	no	no	no
Test Images	yes	yes	yes
Data Resolution 8 Bit	yes	yes	yes
Data Resolution 10 Bit	yes	yes	no

Table B.1: Revisions Camera Link 2 MP Area Scan Cameras

B.3 4MP Area Scan Cameras Speedgrade 160

Table B.2 shows revision information for the following models:

D160 MV1-D2048-160-CL-10

I160 MV1-D2048I-160-CL-10

C160 MV1-D2048C-160-CL-10

	D160 / I160 /C160 V1.0	D160 / I160 /C160 V2.0
ROI	yes	yes
Line Scan Mode	no	no
Frame Combine	no	no
MROI	yes	yes
Decimation	yes	yes
Standard Trigger	yes	yes
Counter Reset External	no	yes
Multiple Slope	yes	yes
Column FPN Correction	no	yes
Digital Gain / Offset	yes	yes
Analog Gain	yes	yes
LUT	yes	yes
Crosshairs	yes	yes
Status Line V1.0	yes	no
Status Line V1.1	no	yes
Test Images	yes	yes
Data Resolution 8 Bit	yes	yes
Data Resolution 10 Bit	yes	yes

Table B.2: Revisions Camera Link 4 MP Area Scan Cameras

B.4 4MP Area Scan Cameras Speedgrade 240

Table B.3 shows revision information for the following models:

D240 MV1-D2048-240-CL-8

I240 MV1-D2048I-240-CL-8

	D240 / I240 V1.0	D240 / I240 V2.0
ROI	yes	yes
Line Scan Mode	no	no
Frame Combine	no	no
MROI	yes	yes
Decimation	yes	yes
Standard Trigger	yes	yes
Counter Reset External	no	yes
Multiple Slope	yes	yes
Column FPN Correction	no	yes
Digital Gain / Offset	yes	yes
Analog Gain	yes	yes
LUT	yes	yes
Crosshairs	yes	yes
Status Line V1.0	yes	no
Status Line V1.1	no	yes
Test Images	yes	yes
Data Resolution 8 Bit	yes	yes
Data Resolution 10 Bit	no	no

Table B.3: Revisions Camera Link 4 MP Area Scan Cameras Speedgrade 240

B.5 Line Scan Cameras

Table B.4 shows revision information for the following models:

L160 MV1-L2048-160-CL-10

L160I MV1-L2048I-160-CL-10

L160C MV1-L2048C-160-CL-10

	L160 / L160I /L160C V1.0	L160 / L160I / L160C V1.1
ROI	yes	yes
Line Scan Mode	yes	yes
Frame Combine	yes	yes
MROI	yes	yes
Decimation	yes	yes
Standard Trigger	yes	yes
Counter Reset External	no	yes
Multiple Slope	yes	yes
Column FPN Correction	no	yes
Digital Gain / Offset	yes	yes
Analog Gain	yes	yes
LUT	yes	yes
Crosshairs	yes	yes
Status Line V1.0	yes	no
Status Line V1.1	no	yes
Test Images	yes	yes
Data Resolution 8 Bit	yes	yes
Data Resolution 10 Bit	yes	yes

Table B.4: Revisions Camera Link Line Scan Cameras

C

Revision History

Revision	Date	Changes
1.0	April 2012	First version
1.1	May 2012	Colour models added
1.2	March 2013	Secion "Maximal Frame Rate": corrected value of TReadoutDel of camera MV1-D2048(x1088)(I/C)-240, W > 2*W0. MV1-L2048(I/C) camera series added. Minimal exposure time corrected.Chapter `Introduction` added and abbreviated camera names used in the manual.
1.3	November 2013	Minimal exposure time for 4 MPix models corrected. Added description of Counter Reset by external signal. Added Trigger Level field in status line. Added appendix with listing of camera revisions