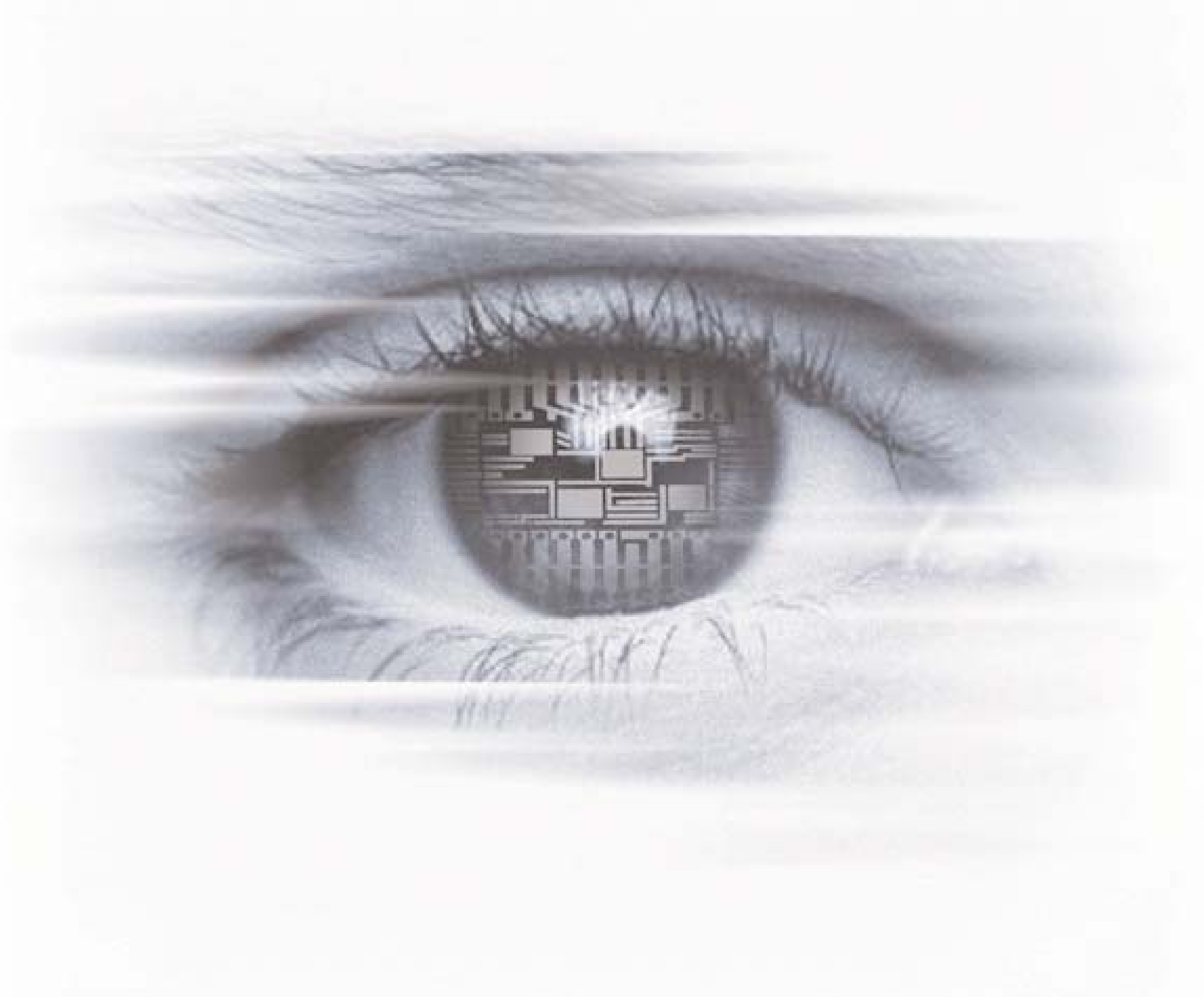
photon focus

User Manual

DS1-D1024 Series

CMOS Area Scan Cameras



MAN030 11/2008 V1.2

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1 Preface

1.1 About Photonfocus

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

1.2 Contact

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

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

Table 1.1: Photonfocus Contact

1.3 Sales Offices

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

1.4 Further information

For further information on the products, documentation and software updates please see our web site www.photonfocus.com or contact our distributors.

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

1.5 Legend

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

Important note

Alerts and additional information

Attention, critical warning

Notification, user guide

2

How to get started (CameraLink)

1. Install a suitable frame grabber in your PC.

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

2. Install the frame grabber software.

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

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

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

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

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

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

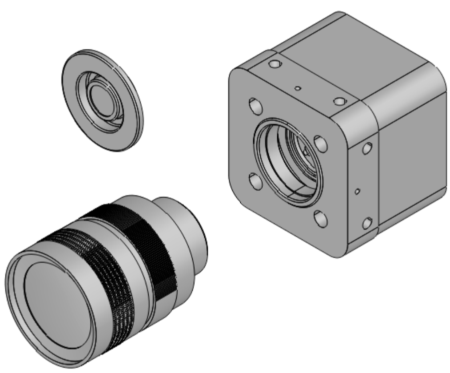

Figure 2.1: Camera with protective cap and lens.

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

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

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

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

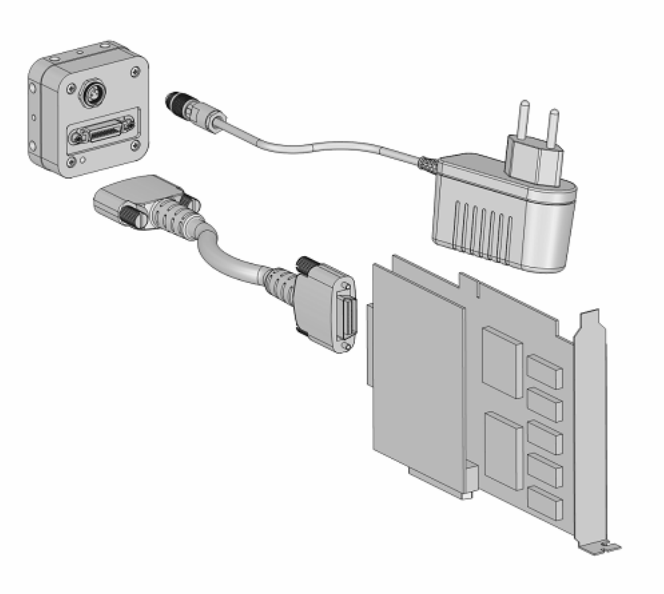

Figure 2.2: Camera with frame grabber, power supply and cable.

Do not connect or disconnect the CameraLink cable while camera power is on! For more information about CameraLink see Section 5.6.

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

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

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

The status LED on the rear of the camera will light red for a short moment, and then flash green. For more information see Section 6.1.9.

8. Download the camera software PFRemote to your computer.

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

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

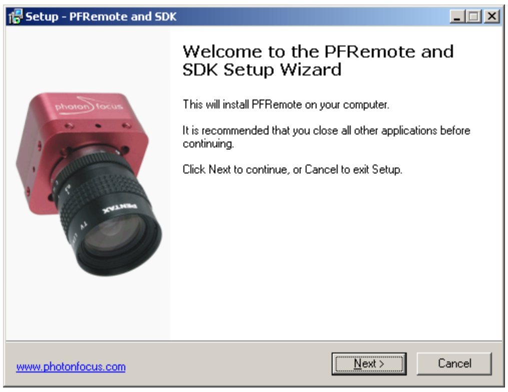

Figure 2.3: Screen shot PFremote setup wizard

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

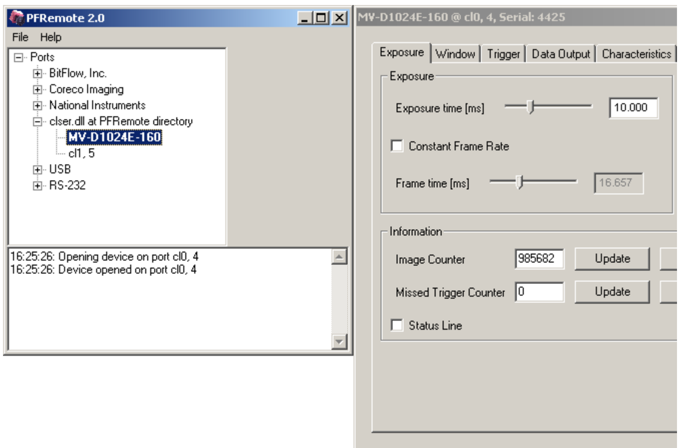

Figure 2.4: PFRemote start window

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

The status LED lights green when an image is being produced, and it is red when serial communication is active. For more information see Section 6.1.9.

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

3

How to get started (USB 2.0)

1. 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.
2. Check if your computer fulfils the hardware and software requirements.

   ☞ See Section 5.7 for more information.

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

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

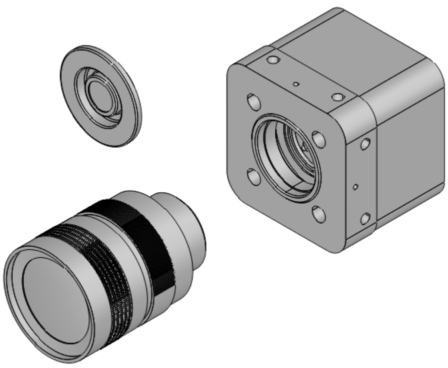

Figure 3.1: Camera with protective cap and lens.

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

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

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

4. Install the USB camera software. You can download the necessary software `PFInstaller.exe` from the Photonfocus website at www.photonfocus.com.

   During the installation, the camera must not be connected to the USB port.

5. Connect a suitable power supply to the provided 7-pole power plug and power on the camera. For the connector assembly see Fig. A.4. The pinout of the connector is shown in Appendix A.

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

6. Connect the camera to a USB 2.0 port at the PC with a suitable USB 2.0 Type B cable (see Fig. 3.2).

   Make sure that you use a high quality shielded USB 2.0 cable.

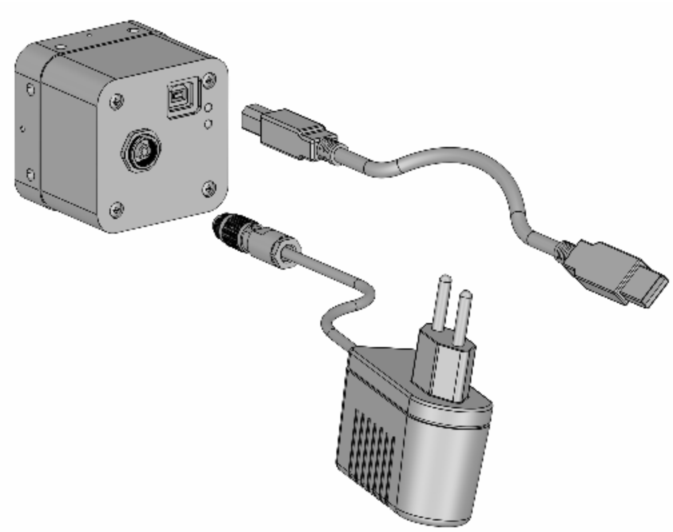

Figure 3.2: Camera with frame grabber, power supply and cable.

Only 1 USB camera can be connected per PC due to the point to point connection style of the Photonfocus USB 2.0 interface implementation.

7. Let Windows install the drivers. Windows should display the "New Hardware found" wizard automatically.

   If the wizard is not displayed, please continue as described in Section 7.3.1.

Let the hardware wizard install the drivers. It is not necessary to allow the search for current and updated software on the Internet. Proceed by choosing the option "Install the software automatically (Recommended)". Another Hardware Installation message will appear, which can be ignored ("Continue Anyway").

The procedure described here applies to Windows XP, Service pack 2.

8. Start the software "MicroDisplayUSB". In the **Camera Selection** window (see Fig. 3.3), choose the camera model and press OK.

Always start the software "MicroDisplayUSB" in the first step and proceed to start the camera software "PFRemote" in the second step. This step is mandatory for proper operation of the camera, because it downloads the USB firmware into the camera.

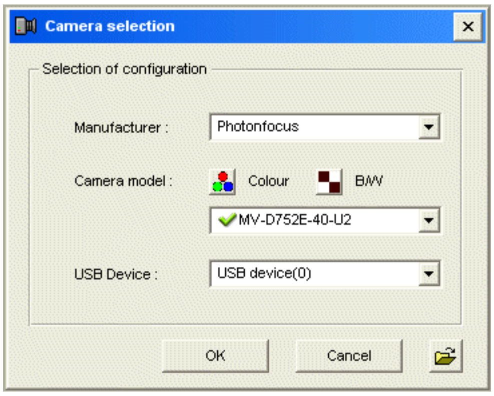

Figure 3.3: MicroDisplayUSB camera selection window

If the power supply or the USB cable of the camera have been disconnected, you have to restart MicroDisplayUSB in order to download the USB firmware again.

9. Start the camera software "PFRemote" and choose the communication port USB0.
10. Check the status LEDs on the rear of the camera

The status LED 2 (lower one) lights green when an image is being produced, and it lights red when serial communication is active. The LED 1 (upper one) lights green when USB is ready and blinks red depending on the transfer mode. For more information see Section 6.1.9.

11. You may display images using the microDisplay USB2.0 software.

The maximum frame rate depends on the USB chipset of the PC and on the camera parameters. Please see Section 5.4.1 and Section 5.7 for more information.

☞ You will find more information about microDisplay USB2.0 software in [MAN025].

4

Product Specification

4.1 Introduction

The DS1-D1024 CMOS camera series from Photonfocus is aimed at standard applications in industrial image processing. It provides a high dynamic at a resolution of 1024 x 1024 pixels. The cameras are built around a monochrome CMOS image sensor, designed and developed by Photonfocus. The principal advantages are:

- Low power consumption at high speeds.
- Very high resistance to blooming.
- High image contrast achieved by Photonfocus proprietary sensor technology.
- Ideal for high speed applications: global shutter in combination with freely selectable read out window (ROI).
- Grey scale resolution of up to 10 bit.
- Software provided for setting and storage of camera parameters.
- The cameras have a digital CameraLink or a USB2.0 interface.
- The compact size make the DS1-D1024 camera series the perfect solution for applications in which space is at a premium.
- The sensor in the DS1-D1024 CMOS camera series is uncovered, which makes it very suitable for optical measuring systems.

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

4.2 Feature Overview

Characteristics	**DS1-D1024 Series**
Interfaces	CameraLink base configuration (USB2.0 only for DS1-D1024-40)
Camera Control	PFRemote (Windows GUI) or programming library
Configuration Interface	CLSERIAL (9’600 baud)
Trigger Modes	Interface trigger / I/O Trigger
Features	Grey scale resolution 10 bit / 8 bit
	Region of Interest (ROI)
	Opto-coupled strobe output
	Test pattern (LFSR and grey level ramp)
	Shading correction (offset and gain)
	High blooming resistance

Table 4.1: Feature overview (see Chapter 5 for more information)

4.3 Technical Specification

Technical Parameters	DS1-D1024 Series
Technology	CMOS active pixel
Scanning system	progressive scan
Optical format / diagonal	1" / 15.42 mm
Resolution	1024 x 1024 pixels
Pixel size	10.6 μm x 10.6 μm
Active optical area	10.9 mm x 10.9 mm
Random noise	< 0.5 DN RMS @ 8 bit
Fixed pattern noise (FPN)	< 1 DN RMS @ 8 bit / offset correction on
Dark current	2 fA/pixel @ 30°C
Full well capacity	200 ke^{-}
Spectral range	400 nm ... 900 nm
Responsivity	120x10^{3} DN/(J/m^{2}) @ 610 nm / 8 bit
Optical fill factor	35%
Dynamic range	60 dB
Color format	monochrome
Characteristic curve	linear
Shutter mode	global shutter
Grey scale resolution	10 bit / 8 bit
Exposure Time	10 μs ... 0.41 s

Table 4.2: General specification of the DS1-D1024 camera series

	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
Exposure Time Increment	25 ns	50 ns	25 ns
Frame Rate (T_{int} = 10 μs)	37 fps	74 fps	149 fps
Pixel Clock Frequency	40 MHz	40 MHz	80 MHz
Pixel Clock Cycle	25 ns	50 ns	25 ns
Camera Taps	1	2	2
Readout mode	sequential exposure	sequential exposure	sequential exposure
	and readout	and readout or	and readout or
	-	simult. readout	simult. readout

Table 4.3: Model-specific parameters

	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
Operating temperature	0°C ... 60°C	0°C ... 60°C	0°C ... 60°C
Camera power supply	+12 V DC ($\pm$10%)	+12 V DC ($\pm$10%)	+12 V DC ($\pm$10%)
Trigger signal input range	+5 .. +15 V DC	+5 .. +15 V DC	+5 .. +15 V DC
Max. power consumption (CL)	1.6 W	3.0 W	3.2 W
Max. power consumption (USB2.0)	3.0 W	-	-
Lens mount	C- or CS-Mount	C- or CS-Mount	C- or CS-Mount
Dimensions (CameraLink)	55 x 55 x 32 mm^3	55 x 55 x 40 mm^3	55 x 55 x 40 mm^3
Dimensions (USB2.0)	55 x 55 x 42.1 mm^3	-	-
Mass (CameraLink)	200 g	210 g	210 g
Mass (USB2.0)	210 g	-	-
Conformity	CE / RoHS / WEEE	CE / RoHS / WEEE	CE / RoHS / WEEE

Table 4.4: Physical characteristics and operating ranges

Fig. 4.1 shows the spectral response of the photodiode of the camera. The quantum efficiency is displayed as a function of wavelength. For more information on photometric and radiometric measurements see the Photonfocus application notes AN006 and AN008.

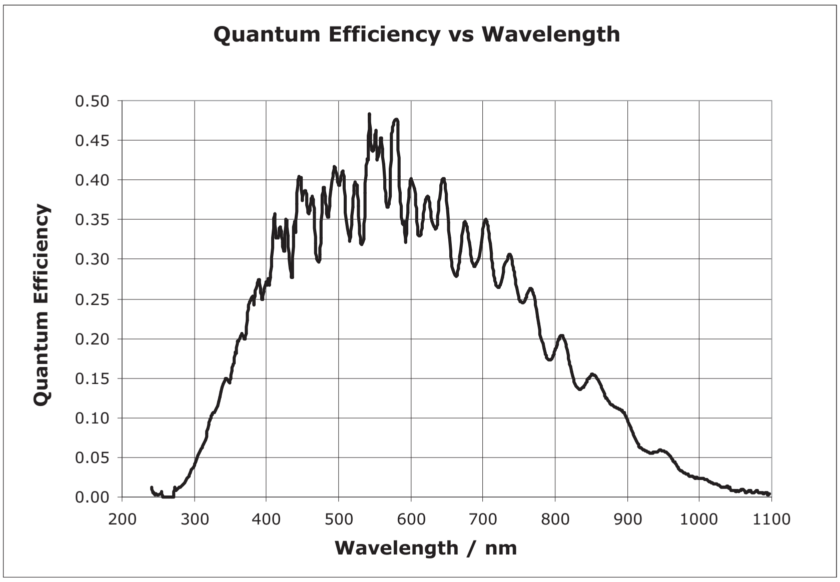

Figure 4.1: Spectral response of the A1024B CMOS sensor

4.4 Frame Grabber relevant Configuration

The parameters and settings, which are essential to configure the frame grabber are shown in the following table. The timing of the camera is given in Section 5.4.1.

	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
Pixel Clock per Tap	40 MHz	40 MHz	80 MHz
Number of Taps	1	2	2
Greyscale resolution	10 bit / 8 bit	10 bit / 8 bit	10 bit / 8 bit
CC1	EXSYNC	EXSYNC	EXSYNC
CC2	not used	not used	not used
CC3	not used	not used	not used
CC4	not used	not used	not used

Table 4.5: Summary of parameters needed for frame grabber configuration

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

Bit	Tap 0, 8 Bit	Tap 0, 10 Bit
0 (LSB)	A0	A0
1	A1	A1
2	A2	A2
3	A3	A3
4	A4	A4
5	A5	A5
6	A6	A6
7 (MSB for 8 Bit Mode)	A7	A7
8	-	B0
9 (MSB for 10 Bit Mode)	-	B1

Table 4.6: CameraLink port and bit assignments for the DS1-D1024-40 camera

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

Table 4.7: CameraLink port and bit assignments for the DS1-D1024-80 and for the DS1-D1024-160 cameras

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 DS1-D1024 cameras is explained in later chapters.

5.1 Image Acquisition

5.1.1 Free-running and Trigger Mode

The DS1-D1024 CameraLink series provides two different readout modes:

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

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

	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
Sequential readout	available	available	available
Simultaneous readout	-	available	available

Table 5.1: Readout mode of DS1-D1024 camera series

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

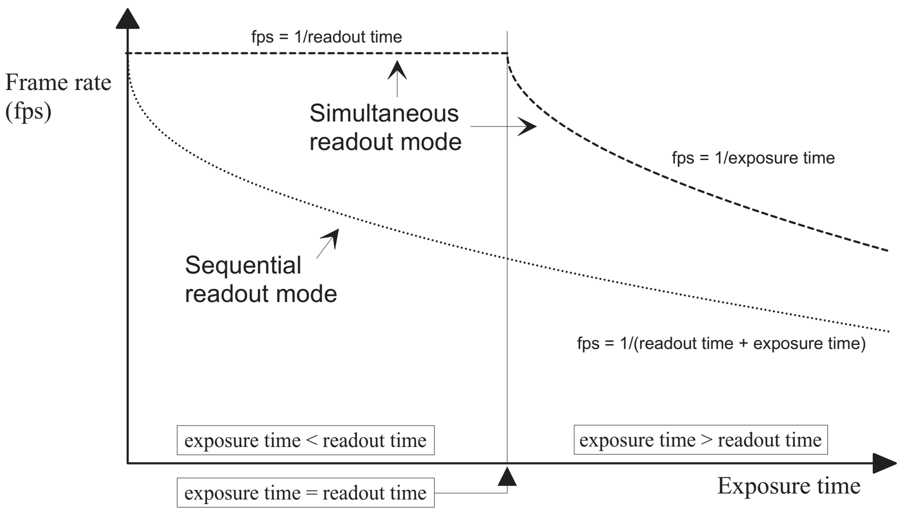

Figure 5.1: Frame rate in sequential readout mode and simultaneous readout mode

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

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

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

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

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

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

Sequential readout

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

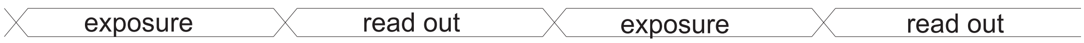

Figure 5.2: Timing in free-running sequential readout mode

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 5.5 and Section 6.4). In this mode, the camera is idle until it gets a signal to capture an image.

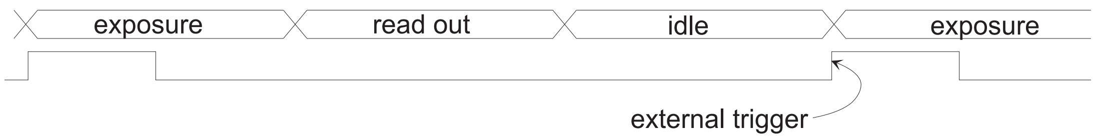

Figure 5.3: Timing in triggered sequential readout mode

Simultaneous readout (interleave exposure)

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

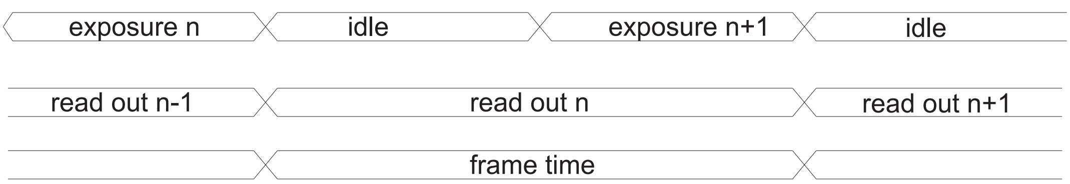

Figure 5.4: Timing in free-running simultaneous readout mode (readout time> exposure time)

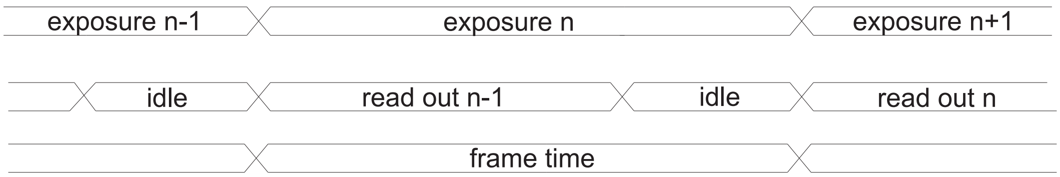

Figure 5.5: Timing in free-running simultaneous readout mode (readout time< exposure time)

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 5.5 and Section 6.4). In this mode, the camera is idle until it gets a signal to capture an image.

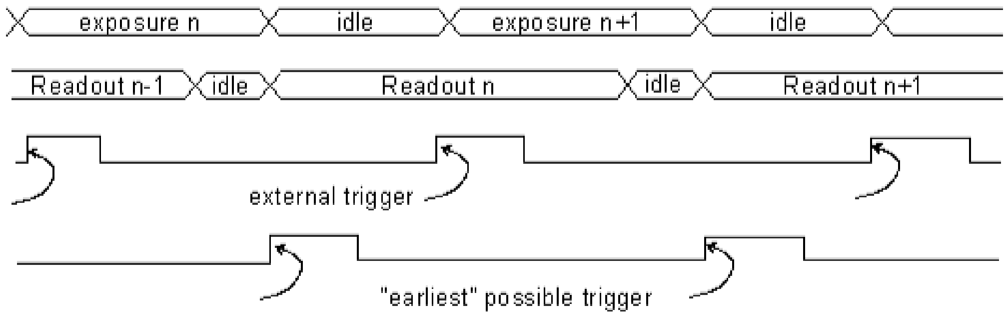

Figure 5.6: Timing in triggered simultaneous readout mode

5.1.2 Exposure Control

The exposure time defines the period during which the image sensor integrates the incoming light. Refer to Table 4.3 for the allowed exposure time range and see Section 6.4.1

5.1.3 Maximum Frame Rate

The maximum frame rate depends on the exposure time and the size of the image (see Region of Interest, for CameraLink see Section 5.4.1, and for USB 2.0 see Section 5.4.3).

5.2 Pixel Response

5.2.1 Linear Response

The DS1-D1024 camera series offers in first order a linear response between input light signal and output grey level.

Black Level Adjustment

The black level is the average image value at no light. It can be adjusted by the software by changing the black level offset. Thus, the overall image gets brighter or darker.

5.2.2 Test Images

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

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

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

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. 5.7).

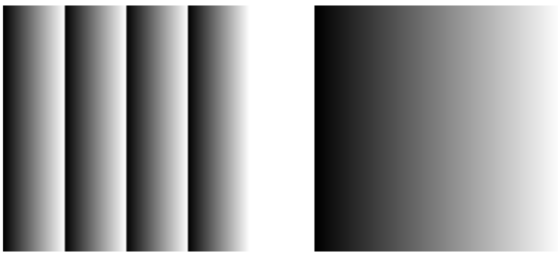

Figure 5.7: Ramp test images: 8 bit output (left), 10 bit output (right)

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.

Troubleshooting using the LFSR

To control the quality of your complete imaging system enable the LFSR mode and check the histogram at full resolution. If your frame grabber application does not provide a real-time histogram, store the image and use a graphic software tool to display the histogram.
In the LFSR (linear feedback shift register) mode the camera generates a constant pseudo-random test pattern containing all grey levels. If the data transmission is error free, the histogram of the received LFSR test pattern will be flat (Fig. 5.9). On the other hand, a non-flat histogram (Fig. 5.10) indicates problems, that may be caused either by the cable, by the connectors or by the frame grabber.

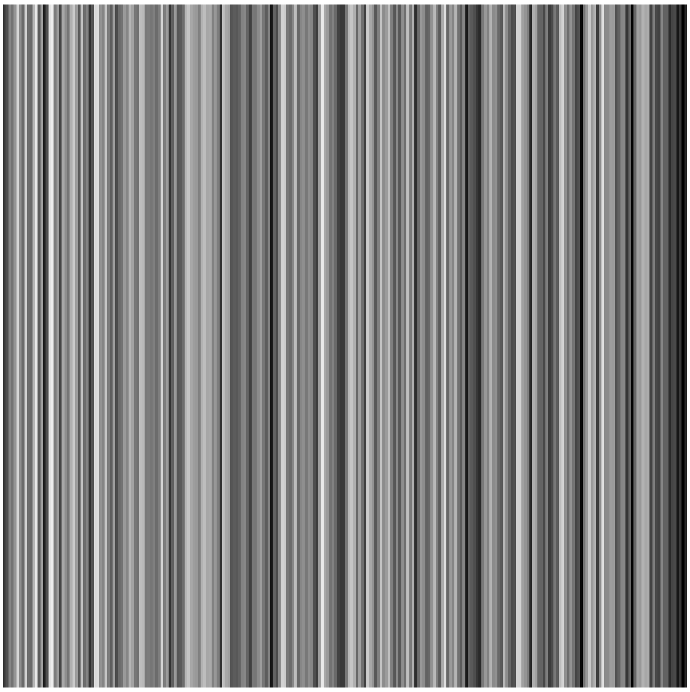

Figure 5.8: LFSR (linear feedback shift register) test image

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

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

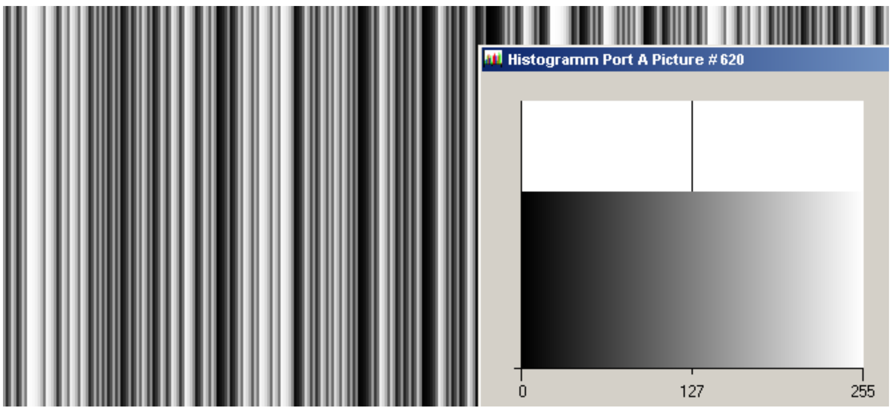

Figure 5.9: LFSR test pattern received at the frame grabber and typical histogram for error-free data transmission

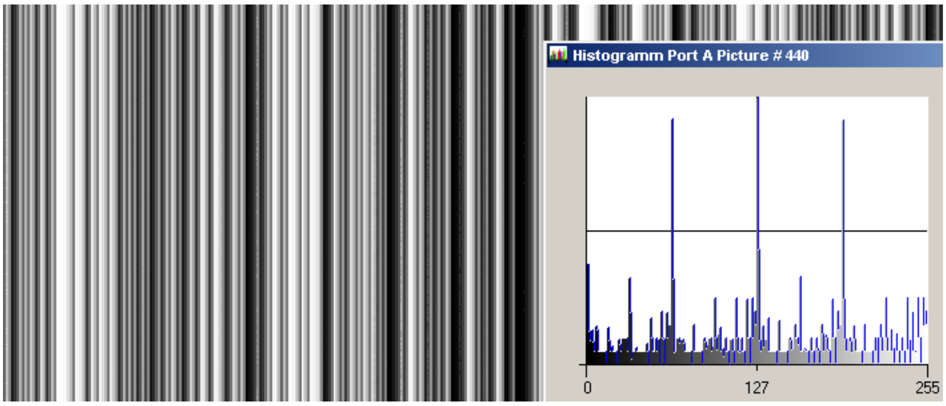

Figure 5.10: LFSR test pattern received at the frame grabber and histogram containing transmission errors

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.

5.3 Image Correction

5.3.1 Overview

The DS1-D1024 cameras possess image pre-processing features, that compensate for non-uniformities caused by the sensor, the lens or the illumination. This method of improving the image quality is generally known as 'Shading Correction' or 'Flat Field Correction' and consists of a combination of offset correction, gain correction and pixel interpolation.

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

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

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

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

5.3.2 Offset Correction (FPN, Hot Pixels)

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

Offset correction algorithm

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

1. Determine the average value of the black reference image.
2. Subtract the black reference image from the average value.
3. Mark pixels that have a grey level higher than 252 DN (@ 10 bit) as hot pixels.
4. Store the result in the camera as the offset correction matrix.
5. During image acquisition, subtract the correction matrix from the acquired image and interpolate the hot pixels (see Section 5.3.2).

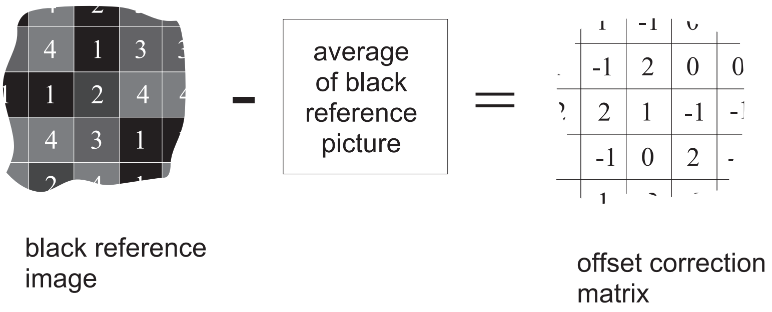

Figure 5.11: Schematic presentation of the offset correction algorithm

How to Obtain a Black Reference Image

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

- The black reference image must be obtained at no illumination, e.g. with lens aperture closed or closed lens opening.
- It may be necessary to adjust the black level offset of the camera. In the histogram of the black reference image, ideally there are no grey levels at value 0 DN after adjustment of the black level offset. All pixels that are saturated black (0 DN) will not be properly corrected (see Fig. 5.12). The peak in the histogram should be well below the hot pixel threshold of 252 DN @ 10 bit.
- Camera settings may influence the grey level. Therefore, for best results the camera settings of the black reference image must be identical with the camera settings of the image to be corrected.

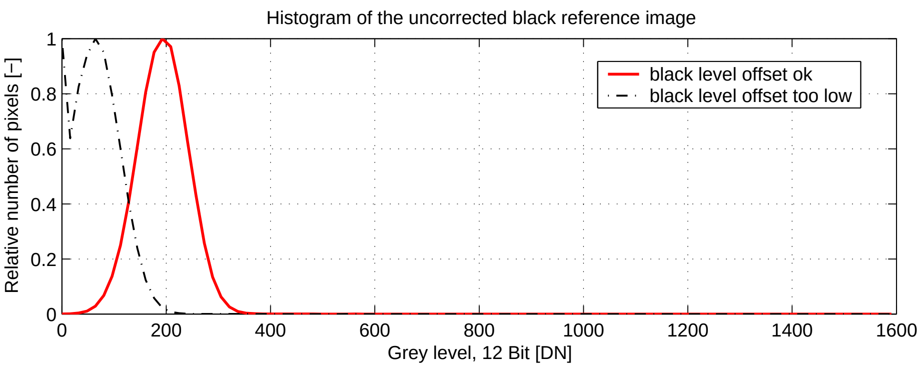

Figure 5.12: Histogram of a proper black reference image for offset correction

Hot pixel correction

Every pixel that exceeds a certain threshold in the black reference image is marked as a hot pixel. If the hot pixel correction is switched on, the camera replaces the value of a hot pixel by an average of its neighbour pixels (see Fig. 5.13).

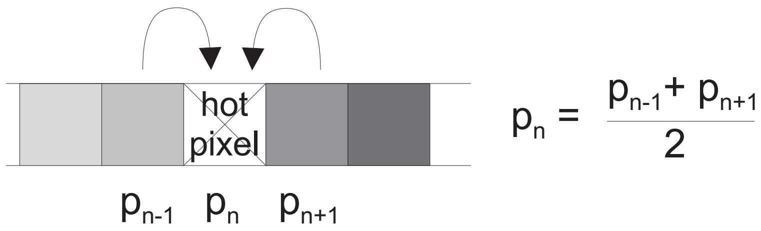

Figure 5.13: Hot pixel interpolation

5.3.3 Gain Correction

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

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

Gain correction algorithm

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

1. Determine the average value of the grey reference image.
2. Subtract the offset correction matrix from the grey reference image.
3. Divide the average value by the offset corrected grey reference image.
4. Pixels that have a grey level higher than a certain threshold are marked as hot pixels.
5. Store the result in the camera as the gain correction matrix.
6. During image acquisition, multiply the gain correction matrix from the offset-corrected acquired image and interpolate the hot pixels (see Section 5.3.2).

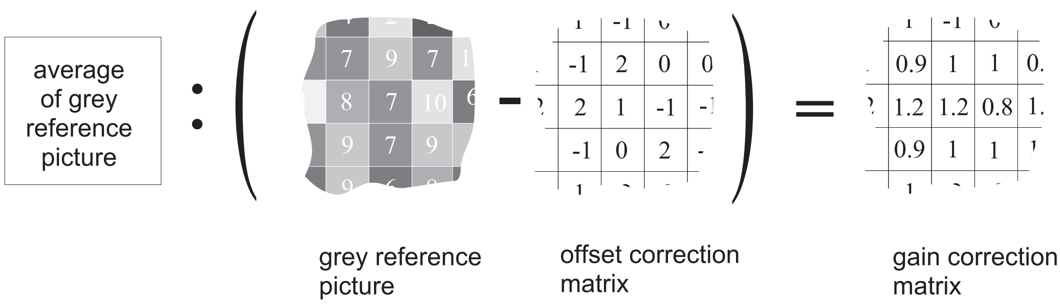

Figure 5.14: Schematic presentation of the gain correction algorithm

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

How to Obtain a Grey Reference Image

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

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

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

- When looking at the histogram of the grey reference image, ideally there are no grey levels at full scale (1023 DN @ 10 bit). All pixels that are saturated white will not be properly corrected (see Fig. 5.15).
- Camera settings may influence the grey level. Therefore, the camera settings of the grey reference image must be identical with the camera settings of the image to be corrected.

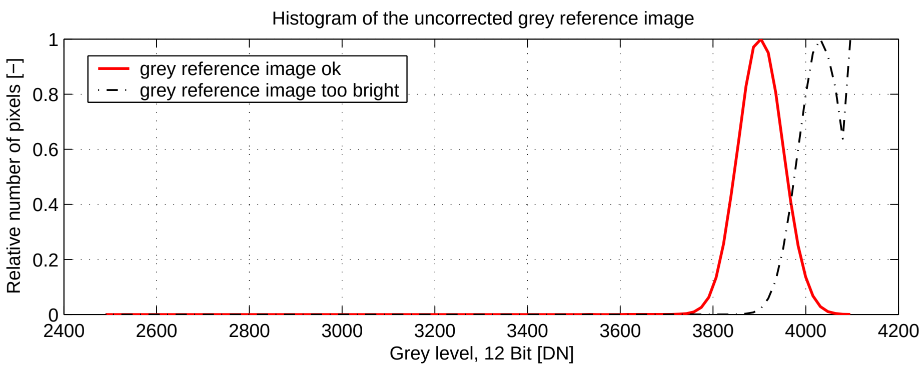

Figure 5.15: Proper grey reference image for gain correction

5.3.4 Corrected Image

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

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

In addition, the black reference image and grey reference image that are currently stored in the camera RAM can be output.
Table 5.2 shows the maximum values of the correction matrices, i.e. the error range that the offset and gain algorithm can correct.

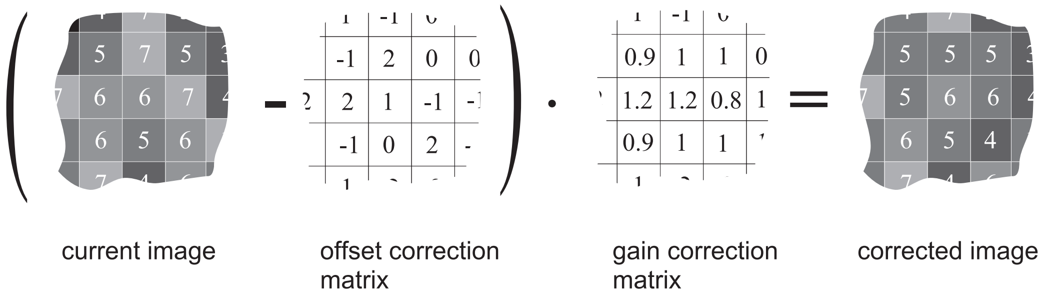

Figure 5.16: Schematic presentation of the corrected image using gain correction algorithm

	minimum	maximum
Offset correction	-127 DN @ 10 bit	+127 DN @ 10 bit
Gain correction	0.42	2.67

Table 5.2: Offset and gain correction ranges

5.4 Reduction of Image Size

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

5.4.1 Region of Interest (ROI)

Some applications do not need full image resolution (e.g. 1024x1024 pixels). By reducing the image size to a certain region of interest (ROI), the frame rate can be drastically increased. A region of interest can be almost any rectangular window and is specified by its position within the full frame and its width and height. Fig. 5.17 gives some possible configurations for a region of interest, and Table 5.6 shows some numerical examples of how the frame rate can be increased by reducing the ROI.

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

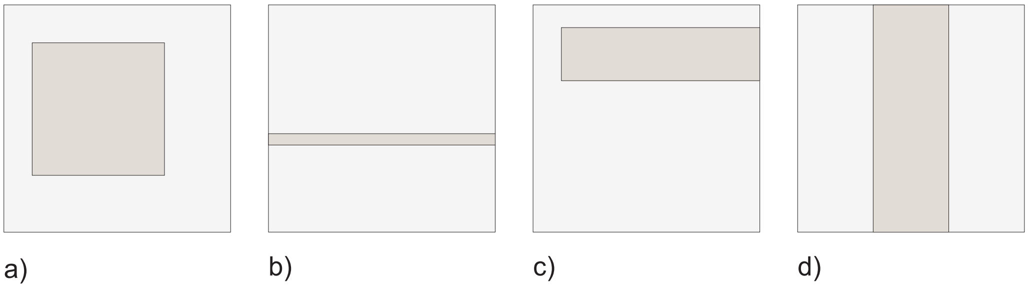

Figure 5.17: ROI configuration examples

ROI Dimension	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
1024 x 1024	37 fps	74 fps	149 fps
512 x 512	149 fps	293 fps	586 fps
256 x 256	585 fps	1127 fps	2230 fps
128 x 128	2230 fps	4081 fps	7843 fps
128 x 16	15 000 fps	23041 fps	37453 fps

Table 5.3: Frame rates of different ROI settings (exposure time 10 μs; correction off, CFR off, skimming off and sequential readout mode).

Exposure time	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
10 μs	37 fps	74 / 74 fps	149 / 148 fps
100 μs	37 fps	74 / 74 fps	147 / 146 fps
500 μs	37 fps	72 / 72 fps	139 / 139 fps
1 ms	36 fps	69 / 72 fps	130 / 139 fps
2 ms	35 fps	65 / 72 fps	115 / 140 fps
5 ms	31 fps	54 / 72 fps	85 / 140 fps
10 ms	27 fps	42 / 72 fps	60 / 99 fps
12 ms	26 fps	39 / 72 fps	53 / 82 fps

Table 5.4: Frame rate of different exposure times, [sequential readout mode / simultaneous readout mode], resolution 1024x1024 pixel.

☞ The DS1-D1024-40 does not support the simultaneous readout mode.

5.4.2 Calculation of the maximum frame rate (CameraLink)

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

Calculation of the frame time (sequential mode)

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

Calculation of the frame time (simultaneous mode)

$$t_{frame} \geq \max(t_{exp} + 76\ \mu s,\ t_{ro} + 476\ \mu s)$$

$\mathbf{t_{frame}}$ frame time
$\mathbf{t_{exp}}$ exposure time
$\mathbf{t_{ro}}$ readout time

ROI Dimension	DS1-D1024-40-CL	DS1-D1024-80	DS1-D1024-160
1024 x 1024	t_{ro} = 26.4 ms	t_{ro} = 13.3 ms	t_{ro} = 6.7 ms
1024 x 512	t_{ro} = 13.2 ms	t_{ro} = 6.7 ms	t_{ro} = 3.3 ms
1024 x 256	t_{ro} = 6.6 ms	t_{ro} = 3.3 ms	t_{ro} = 1.7 ms
512 x 512	t_{ro} = 6.6 ms	t_{ro} = 3.3 ms	t_{ro} = 1.7 ms

Table 5.5: Read out time for the DS1-D1024 CameraLink Series

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

5.4.3 Calculation of the maximum frame rate (USB 2.0)

The frame rate of the DS1-D1024-40-U2 camera mainly depends on the exposure time, readout time, host USB chipset and data resolution. If the camera is not operated on a host with Intel supported chipset or is not used in 8 bit mode the read out time must be multiplied by 2 or 4 respectively. The frame rate is the inverse of the frame time.
fps $= \frac{1}{t_{frame}}$

Calculation of the frame time

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

$\mathbf{t_{frame}}$	frame time
$\mathbf{t_{exp}}$	exposure time
$\mathbf{t_{ro}}$	readout time
MODE	1 if Intel supported chipset (fast mode) AND data resolution = 8 bit
	2 if no Intel supported chipset (slow mode) XOR data resolution $\neq$ 8 bit
	4 if no Intel supported chipset (slow mode) AND data resolution $\neq$ 8 bit

ROI Dimension	MODE = 1	MODE = 2	MODE = 4
1024 x 1024	t_{ro} = 26.4 ms	t_{ro} = 52.8 ms	t_{ro} = 105.6 ms
1024 x 512	t_{ro} = 13.2 ms	t_{ro} = 26.4 ms	t_{ro} = 52.8 ms
1024 x 256	t_{ro} = 6.6 ms	t_{ro} = 13.2 ms	t_{ro} = 26.4 ms
512 x 512	t_{ro} = 6.6 ms	t_{ro} = 13.2 ms	t_{ro} = 26.4 ms

Table 5.6: Read out time for the DS1-D1024-40-U2, depending on chipset and data resolution

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

5.5 External Trigger

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

5.5.1 Trigger Source

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

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

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

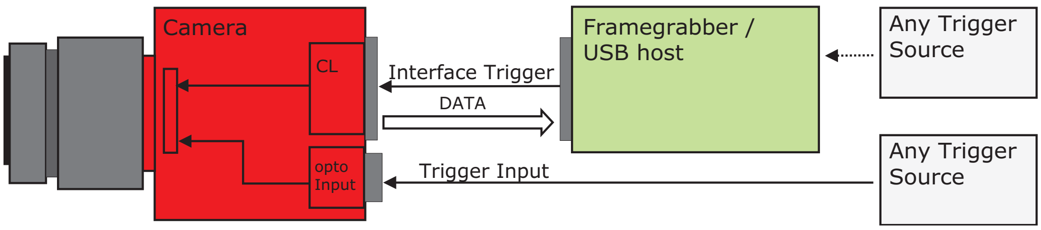

Figure 5.18: Trigger Inputs

5.6 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. 5.19 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. .

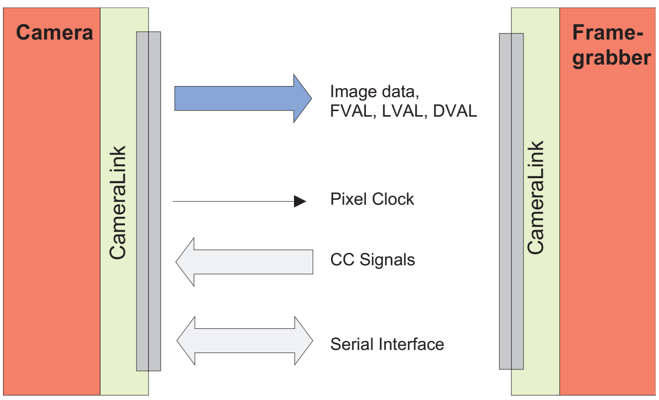

Figure 5.19: CameraLink serial interface for camera communication

5.7 Configuration Interface (USB 2.0)

USB stands for "Universal Serial Bus" and is a bus system developed in 1995 by a consortium of leading companies in the computer industry, in cooperation with Intel. The USB 1.1 specification defined the port speed to be 12 MByte/s, the USB 2.0 specification a remarkable 48 MByte/s. However, not every PC with an USB 2.0 interface can be used in the fast 48 MByte/s mode. Depending on the available USB chipset on the PC, only a data rate of 24 MByte/s can be achieved.

☞ The maximum speed of the USB 2.0 interface (24 MByte/s or 48 MByte/s) is determined by the USB driver automatically and cannot be configured.

The implementation of the USB 2.0 interface in Photonfocus CMOS cameras is designed as a point to point connection between the camera and the PC. The USB 2.0 interface uses the upper most available band width of 48 MByte/s and thus enables very high frame rates even at megapixel resolution. On the other hand this interface does not allow multi camera vision systems. Multi camera vision systems of other USB 2.0 interface implementations have to face the drawback of considerably lower data rate per each camera.

5.7.1 Software requirements

To reach the full performance of 48 MByte/s, Windows XP with Service Pack 2 is required. For Windows 2000 and Windows XP Service Pack 1, the camera will run with 24 MByte/s only.

☞ The camera can only be operated with the software MicroDisplayUSB to grab images, together with PFRemote to control the camera. Alternatively, the Grab Module USB SDK and the PFLib SDK can be used. Other software is not supported.

The camera firmware, which is essential for the operation of the camera, is automatically transmitted to the camera via USB during the start-up of the MicroDisplayUSB software. Therefore, the camera must always be connected to the USB bus during start up, otherwise the camera will not be functional.

5.7.2 Hardware requirements

To reach the full performance of 48 Mbyte/s (isochronous mode), a PC Mainboard with Intel chipsets is required and the Southbridge must support ICH4, ICH5 or higher. The camera must be connected to a USB port that is provided by the Southbridge of the PC and not by an additional USB 2.0 host adapter. More information about the Southbridge is available in the motherboard manual of your PC. A list of Intel chipsets is available at www.intel.com/products/chipsets/index.htm.

☞ Intel provides a chipset identification utility (the tool `chiputil.exe`) to determine the chipset being used on a PC. It can be downloaded from:
ftp://aiedownload.intel.com/df-support/7355/eng/chiputil.exe
Alternative link: http://downloadfinder.intel.com/scripts-df/support_intel.asp (search for 'chiputil').

The camera is optimised for high data transfer, and other USB devices may stop functioning or perform poorly.

Additional USB 2.0 host adapters may only transfer up to 24 Mbyte/s because they are not directly connected to the Southbridge and therefore do not support the isochronous mode.

The data transfer mode of the camera (48 MByte/s or 24 MByte/s) is indicated by the upper LED on the back of the camera (see Section 6.1.9) or in the Info tab of PFRemote.

Only 1 USB camera can be connected per PC due to the point to point connection style of the USB 2.0 implementation

6

Hardware Interface

6.1 Connectors

6.1.1 CameraLink Connector for CameraLink Camera Models

The CameraLink cameras are interfaced to external components via

- a CameraLink connector, which is defined by the CameraLink standard as a 26 pin, 0.05" 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.

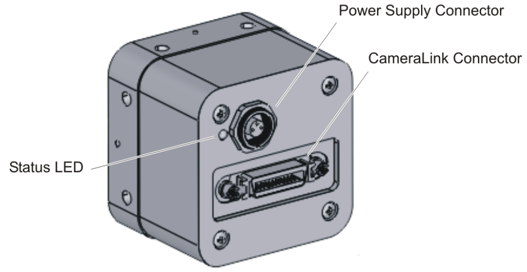

Figure 6.1: Rear view of the CameraLink camera

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

6.1.2 Power Supply for CameraLink Camera Models

The camera requires a single voltage input (see Table 4.4). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear power supplies provide optimum performance.

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

A suitable power supply is available from Photonfocus.

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

6.1.3 CameraLink Connector for PoCL Camera Models

With the definition of the PoCL interface the target was to maintain the backward compatibility with the standard CameraLink interface. The only changes in the PoCL interface standard (a substandard of the CameraLink standard) are the redefinitions for the inner shield wires (see Table 6.1).

Pin	CameraLink Standard	PoCL Standard
1	Inner Shield	Power (nominal + 12 V DC)
13	Inner Shield	Power Return - Inner Shield
14	Inner Shield	Power Return - Inner Shield
26	Inner Shield	Power (nominal + 12 V DC)

Table 6.1: Redefiniton of the inner shield wires for the PoCL standard

The PoCL camera models are interfaced to external components via

- a miniature CameraLink (MiniCL) connector, which is defined by the CameraLink standard as a 26 pin, 0.031" Shrunk Delta-Ribbon (SDR) connector to transmit configuration, image data, trigger signals and power. The approved MiniCL connectors are the SDR Shrunk Delta Ribbon connector available from 3M Company and the HDR series connector available from Honda Connectors.
- a subminiature connector for the trigger input and for the strobe output, 7-pin Binder series 712. The connector pinout is compatible with the CameraLink camera models.

The connectors are located on the back of the camera. Fig. 6.2 shows the plugs and the status LED which indicates camera operation.

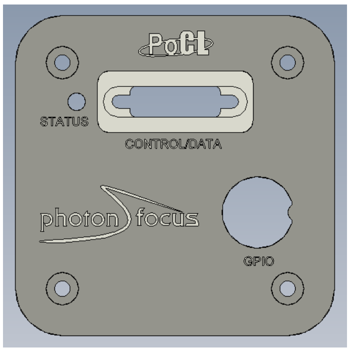

Figure 6.2: Rear view of the PoCL camera models

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

6.1.4 Power Supply for PoCL Camera Models

PoCL camera models do not need extra power supply. The power for the camera is provided via the data cable.
In order to maintain backward compatibility to CameraLink camera models, PoCL cable uses the same connector and cable structure. It uses drain wires, of which two are converted to

insulated-wire for power feeding (+12V DC). The remaining two drain wires are used as is for power return and shield.

Supply voltage must be +12V DC (± 1V DC) and is supplied by the PoCL frame grabber hardware. The supply current must have a 400 mA capability.

6.1.5 USB 2.0 Connector

The USB 2.0 camera models are interfaced to external components via

- a USB 2.0 (B-Type) connector (see Fig. 6.3).
- a subminiature 7-pin Binder connector (Binder series 712) for the power supply, trigger and strobe signal.

Figure 6.3: USB type-B Connector

The connectors are located on the back of the camera. Fig. 6.4 shows the plugs and the status LEDs which indicate camera operation.

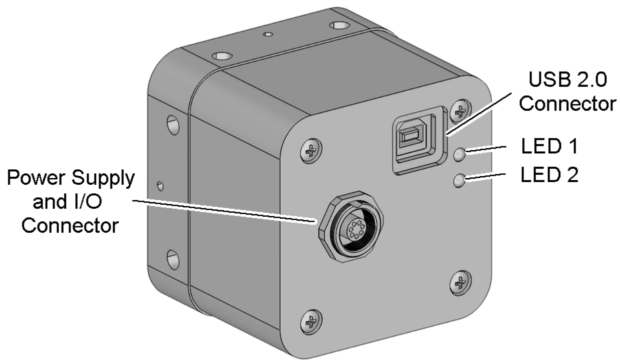

Figure 6.4: Rear view of the USB 2.0 cameras

6.1.6 Power Supply for USB2.0 Camera Models

The camera requires a single voltage input (see Table 4.4). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear power supplies provide optimum performance.

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

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

6.1.7 Trigger and Strobe Signals

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

The input voltage to the TRIGGER pin must not exceed +15V DC, to avoid damage to the internal 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 6.2) to STROBE_VDD (5 .. 15 V DC) as shown in Fig. 6.5. This resistor should be located directly at the signal receiver.

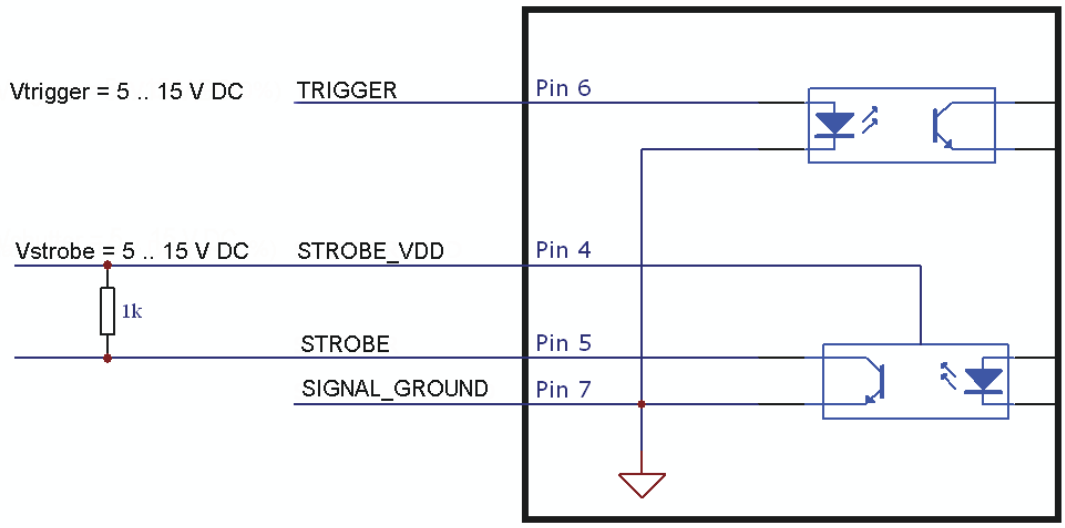

Figure 6.5: Circuit for the trigger input and strobe output signals

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 opto coupler.

☞ The recommended sink current of the TRIGGER pin is 5 mA.

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

Table 6.2: Pull-up resistor for strobe output and different voltage levels

6.1.8 Status Indicator (CameraLink cameras)

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

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

Table 6.3: Meaning of the LED of the CameraLink cameras

6.1.9 Status Indicator (USB 2.0 Camera)

Two dual-color LEDs on the back of the USB 2.0 camera give information about the current camera status and the USB 2.0 interface status.

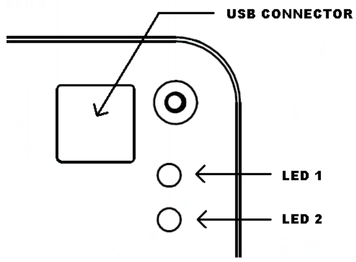

Figure 6.6: Position of the status indicator LEDs of the USB 2.0 cameras

6.2 CameraLink Data Interface

The CameraLink standard contains signals for transferring the image data, control information and the serial communication. In PoCL camera models the power supply is provided by the same data interface.

LED 1 Green	Green when a physical USB connection is established.
LED 1 Red	After the USB firmware was uploaded to the camera by MicroDisplayUSB, the camera is ready for data transfer. The blinking frequency of the red LED indicates the current transfer mode. In the slow mode (24 MByte/s), the blinking interval is 1 Hz, in the fast mode (48 Mbyte/s) it is 4 Hz.
LED 2 Green	Green when an image is output. At slow frame rates, the LED blinks with the FVAL signal. At high frame rates the LED changes to an apparently continuous green light, with intensity proportional to the ratio of readout time over frame time.
LED 2 Red	Red indicates active serial communication with the camera.

Table 6.4: Description of the status indicator LEDs of the USB 2.0 cameras

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 6.5 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 6.5: 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 5.6 for more information.

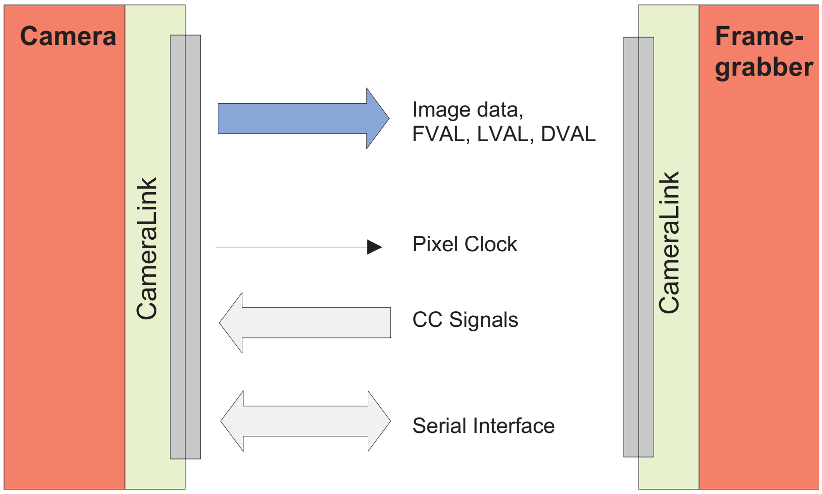

Figure 6.7: 1-tap CameraLink system

The frame grabber needs to be configured with the proper tap and resolution settings, otherwise the image will be distorted or not displayed with the correct aspect ratio. Refer to Section 4.4 for a summarised table of frame grabber relevant specifications. Fig. 6.7 shows symbolically a 1-tap system. For more information about taps refer to [AN021] on the Photonfocus website (www.photonfocus.com).

6.3 Read-out Timing

6.3.1 Free running Mode

Sequential readout timing

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

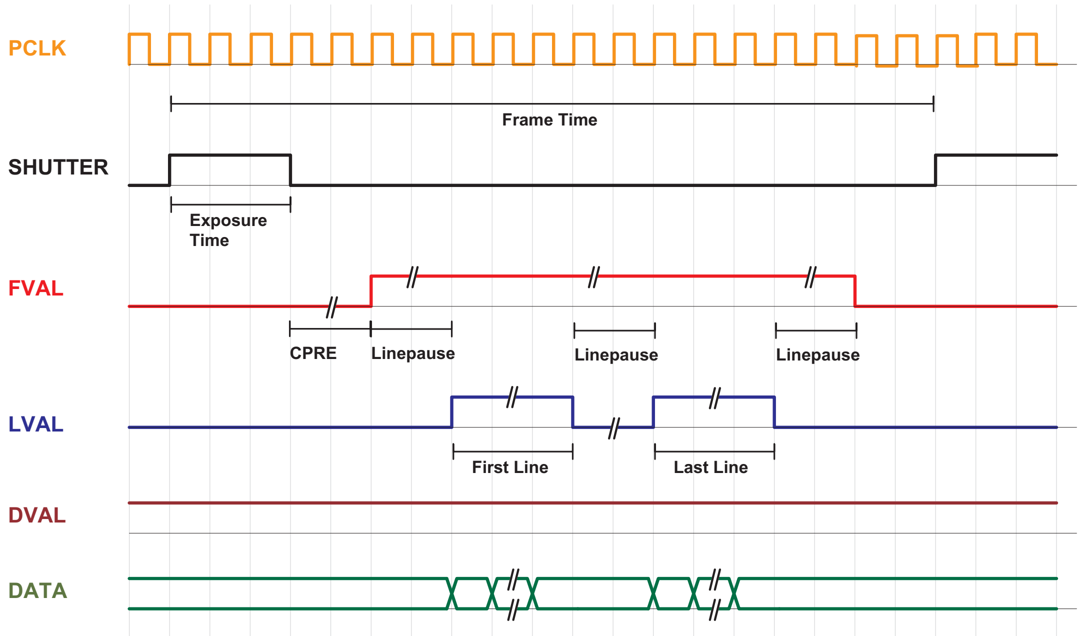

Figure 6.8: Timing diagram sequential readout mode

Simultaneous readout timing

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

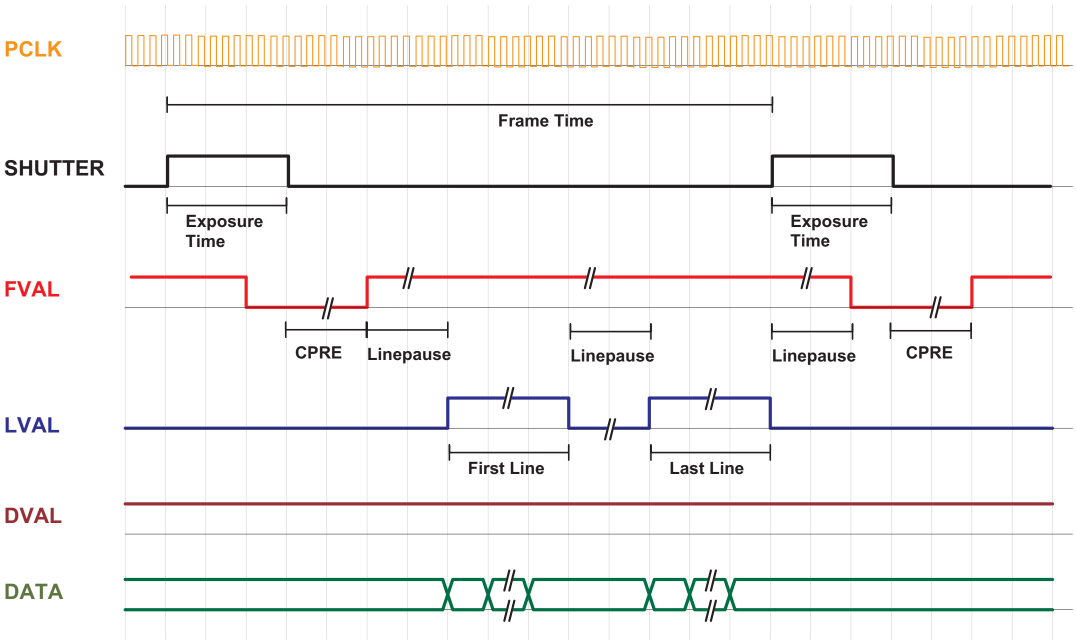

Figure 6.9: Timing diagram simultaneous readout mode (readout time > exposure time)

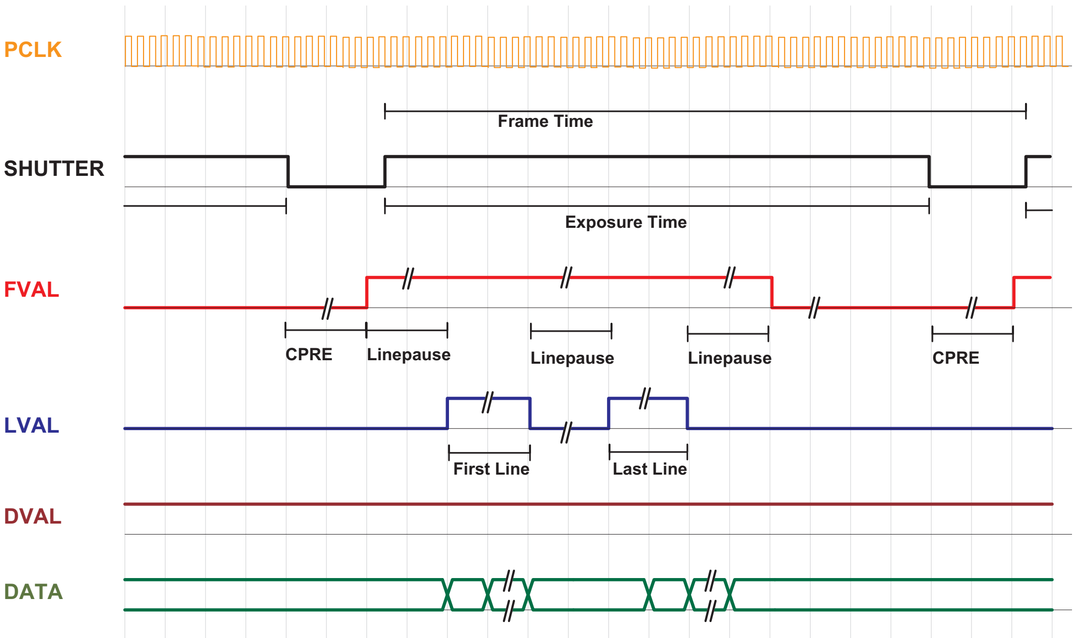

Figure 6.10: Timing diagram simultaneous readout mode (readout time < exposure time)

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

Table 6.6: Explanation of control and data signals used in the timing diagram

These terms will be used also in the timing diagrams of Section 6.4.

6.4 Trigger

6.4.1 Trigger Modes

The following sections show the timing diagram for the trigger modes. The signal ExSync denotes the trigger signal that is provided either by the interface trigger or the I/O trigger (see Section 5.5). The other signals are explained in Table 6.6. For an active high trigger signal, the image acquisition begins with the rising edge of the trigger signal. The image is read out after the pre-configured exposure time. After the readout, the sensor returns to the reset state and the camera waits for a new trigger pulse (see Fig. 6.11).
The data is output on the rising edge of the pixel clock, the handshaking signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER in Fig. 6.11 indicates the active integration phase of the sensor and is shown for clarity only.

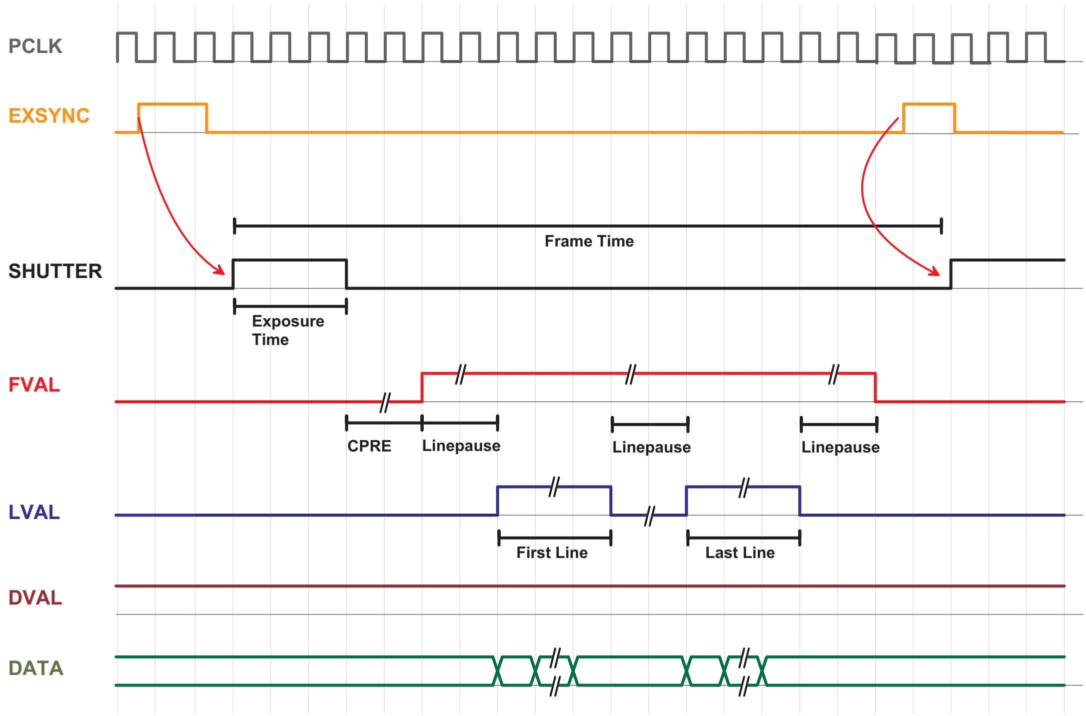

Figure 6.11: Trigger timing diagram for camera controlled exposure

6.4.2 Trigger Delay

The total delay between the trigger edge and the camera exposure consists of the delay in the frame grabber and the camera (Fig. 6.12). Usually, the delay in the frame grabber is relatively large to avoid accidental triggers caused by voltage spikes (see Fig. 6.13).

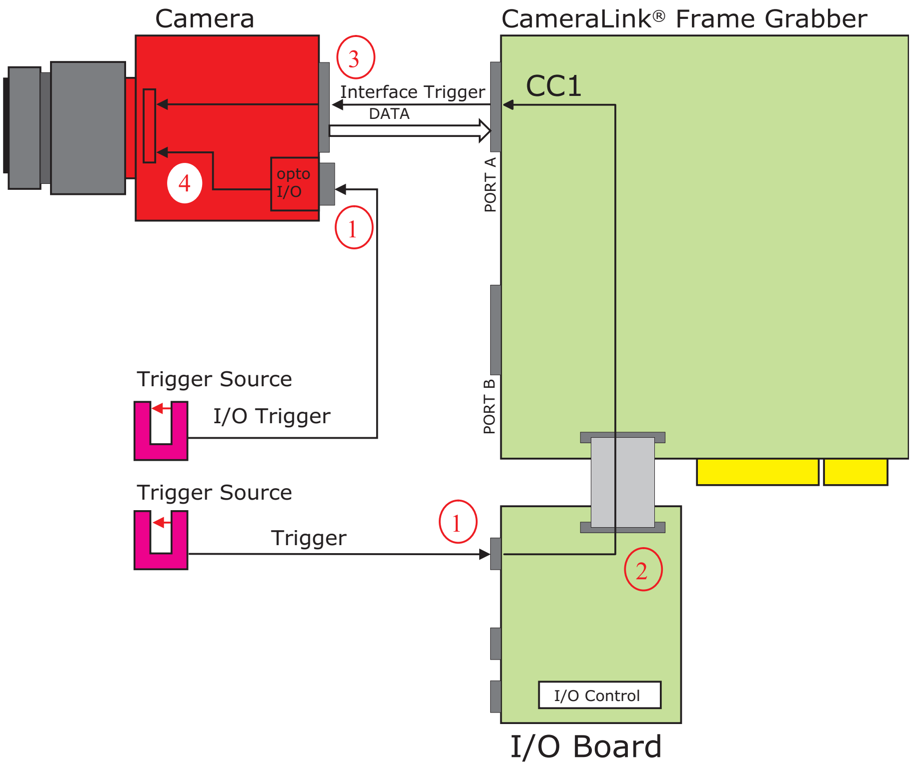

Figure 6.12: Trigger Delay visualisation from the trigger source to the camera

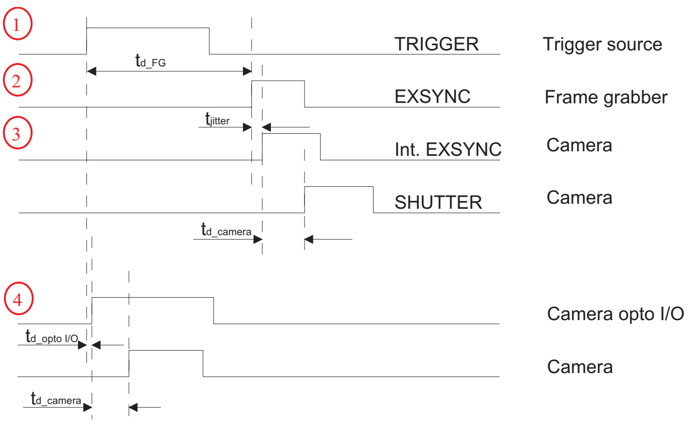

Figure 6.13: Timing Diagram for Trigger Delay

For the delay in the frame grabber, please ask your frame grabber manufacturer. The camera delay consists of a constant trigger delay and a variable delay (jitter), due to the sampling of the trigger signal by the clocked camera electronic. The trigger delay and the jitter are specified in table 6.8 and shown in Fig. 6.12. The description of the parameters is summarized in table 6.7.

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

Table 6.7: Trigger Delay Parameters

Trigger delay type	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
t_{jitter}	25 ns	50 ns	25 ns
$t_{d-camera}$	150 ns	300 ns	150 ns

Table 6.8: Trigger Delay for the DS1-D1024 cameras

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]).

7.1.1 CameraLink Model

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.

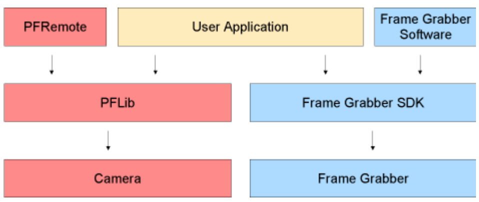

Figure 7.1: PFRemote and PFLib in context with the CameraLink frame grabber software

7.1.2 USB 2.0 Model

For the USB camera model, there is no external frame grabber necessary, as the camera connects directly to the USB 2.0 port. Instead, the frame grabber functionality was transferred into the camera.
As shown in Fig. 7.2, the camera parameters can be controlled by PFRemote and PFLib respectively. To grab an image use the MicroDisplayUSB software or the USB SDK.

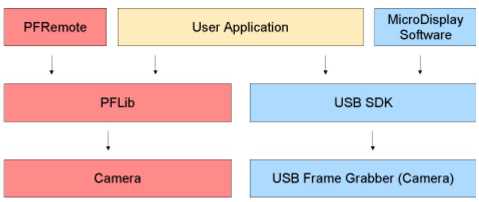

Figure 7.2: PFRemote and PFLib in context with the USB 2.0 frame grabber software

The USB isochronous interface mode (fast mode 48 MBytes/sec) works only with Windows XP and ServicePack 2 and an Intel Chipset!

7.2 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.

7.3 Installation Notes

For CameraLink Cameras: Before installing the required software with the PFInstaller, make sure that your frame grabber software is installed correctly.

For USB Cameras: Before installing the required software to control a Photonfocus camera with USB 2.0 interface, make sure that no USB camera is connected to the computer.

- During PFinstaller installation, choose "Install PFRemote with USB environment".
- After the installation, power on the camera and connect it to the USB interface.
- Windows should display the "New Hardware found" wizard automatically. If this wizard is not displayed, please continue as described in the following section.
- Let the hardware wizard install the drivers. It is not necessary to allow the search for current and updated software on the Internet. Proceed by choosing the option "Install the software automatically (Recommended)". Another hardware installation message will appear, which can be ignored ("Continue Anyway").

The procedure described above applies to Windows XP and Service pack 2.

7.3.1 Manual Driver Installation (only USB 2.0 Model)

If Windows did not automatically install the driver for your USB camera, please proceed as follows:

- Open the Device Manager in the Windows Control Panel.
- There will be an unknown device called "Silicon Software GmbH microUSB2".
- Right click on the unknown device and choose "Update driver".
- The hardware update wizard will appear. It is not necessary to allow the search for current and updated software on the Internet. Click on "No, not this time" and "Next".
- Then choose "Install the software automatically (Recommended)" and proceed with "Next".
- When you get asked about the driver location, specify `\Photonfocus\microDisplayUSB\driver`.

  ☞ This procedure applies to Windows XP and Service pack 2.

7.3.2 DLL Dependencies

Several DLLs are necessary in order to be able to communicate with the cameras:

- `PFCAM.DLL`: The main DLL file that handles camera detection, switching to specific camera DLL and provides the interface for the SDK.
- `'CAMERANAME'.DLL`: Specific camera DLL, e.g. mv_d1024e_40.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].

7.4 Graphical User Interface (GUI)

PFRemote consists of a main window (Fig. 7.3) 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.

7.4.1 Port Browser

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

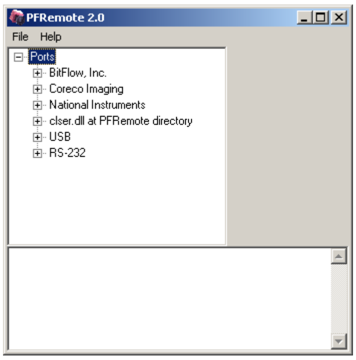

Figure 7.3: PFRemote main window with PortBrowser and log messages

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)

7.4.2 Ports, Device initialization

After starting **PFRemote**, the main window as shown in Fig. 7.3 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 doesn't 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?

7.4.3 Main Buttons

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

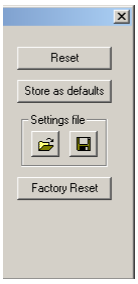

Figure 7.4: Main buttons

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.

7.5 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 DS1-D1024-40

This section describes the parameters of the following cameras:

- DS1-D1024-40-CL, CameraLink interface
- DS1-D1024-40-PC, Power over CameraLink interface
- DS1-D1024-40-U2, USB 2.0 interface

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

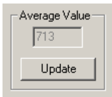

Figure 8.1: DS1-D1024-40 average value

Average Value: Grey scale average of the actual image. This value is in 10 bit (0...1023).

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

8.1.1 Exposure, Window

This tab contains exposure time and ROI settings.

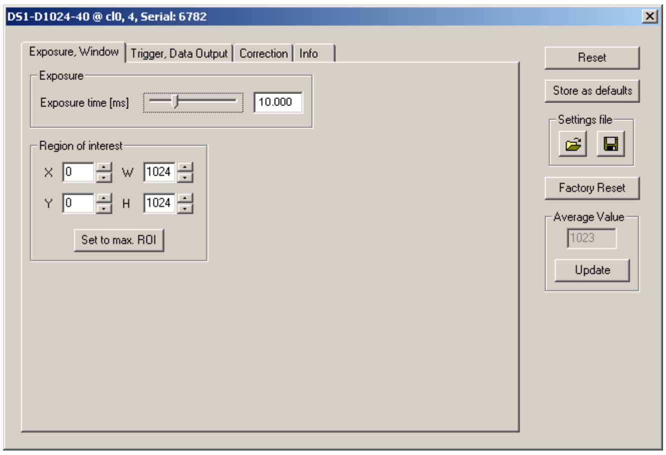

Figure 8.2: DS1-D1024-40 exposure and window panel

Exposure

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

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.

H: Window height.

Set to max ROI: Set Window to maximal ROI (X=0; Y=0; W=1024; H=1024).

For the DS1-D1024-40-U2 camera: W x Htot > 1024.

8.1.2 Trigger

This tab contains trigger and data output settings.

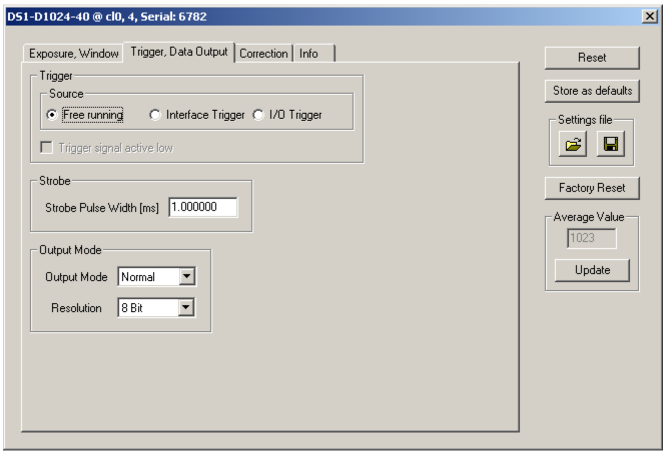

Figure 8.3: DS1-D1024-40 trigger and data output panel

Trigger

Trigger Source options are:

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 via the power supply connector.

Further trigger settings:

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

Strobe

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

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

Output Mode

Output Mode options are:

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 options are:

8 Bit: Grey level resolution of 8 bit.

10 Bit: Grey level resolution of 10 bit.

8.1.3 Correction

This tab contains correction settings.

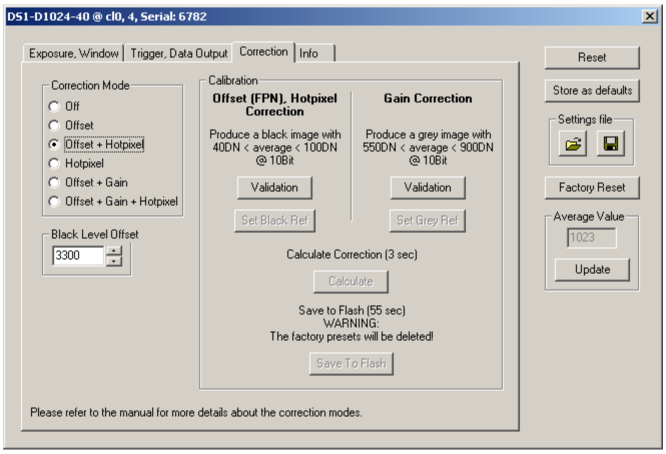

Figure 8.4: DS1-D1024-40 correction panel

Correction Mode

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

Off: No correction.

Offset: Activate offset correction.

Offset + Hotpixel: Activate offset and hot pixel correction.

Hotpixel: Activate hot pixel correction.

Offset + Gain: Activate offset and gain correction.

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

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.

Calibration

Offset (FPN), Hotpixel Correction: The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimize the static noise. Close the lens of the camera. Click on the Validation button. If the Set Black Ref - button is still inactive, the average of the image is out of range. Change the Property `Voltage.BlackLevelOffset` until the average value of the image is between 40 and 100 DN. Click again on the Validation button and then on the Set Black Ref Button.

If only offset and hot pixel correction are needed it is not necessary to calibrate a grey image.

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

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

Produce a grey image with an average value between 550 and 900 DN. Click on the Validation button to check the average value. If the average value is in range, the Set Grey Ref button is active.

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

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

This will overwrite the factory presets.

8.1.4 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.

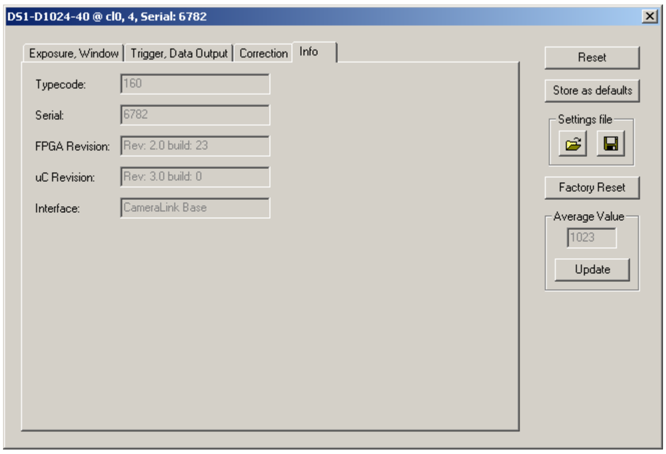

Figure 8.5: DS1-D1024-40 info panel

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.

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

8.2 DS1-D1024-80 and DS1-D1024-160

This section describes the parameters of the following cameras:

- DS1-D1024-80-CL, CameraLink interface
- DS1-D1024-80-PC, Power over CameraLink interface
- DS1-D1024-160-CL, CameraLink interface
- DS1-D1024-160-PC, Power over CameraLink interface

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

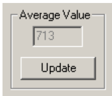

Figure 8.6: DS1-D1024-160 average value

Average Value: Grey scale average of the actual image. This value is in 10 bit (0...1023).

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

8.2.1 Exposure, Window

This tab contains exposure time and ROI settings.

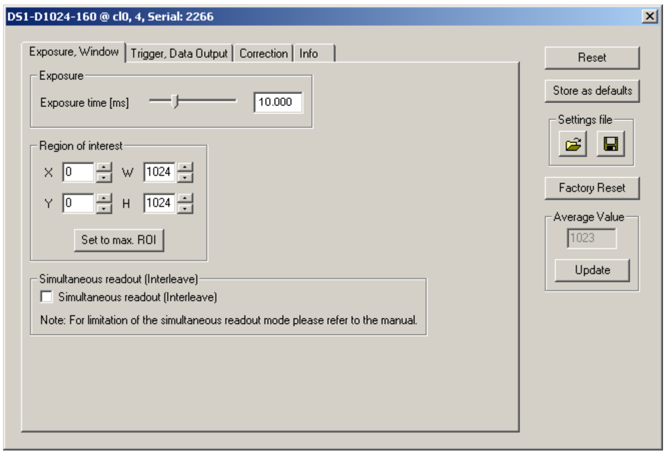

Figure 8.7: DS1-D1024-160 exposure and window panel

Exposure

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

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 4 pixel).

H: Window height.

Set to max ROI: Set Window to maximal ROI (X=0; Y=0; W=1024; H=1024).

☞ Window width is only available in steps of 4 pixel.

Simultaneous readout (Interleave)

The simultaneous readout mode allows higher frame rate.

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

8.2.2 Trigger

This tab contains trigger and data output settings.

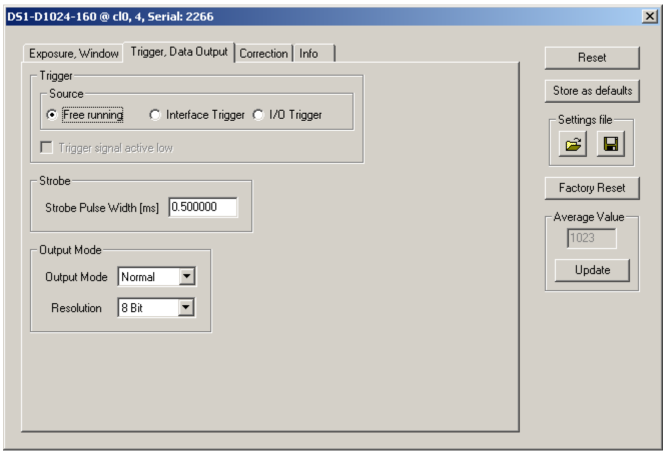

Figure 8.8: DS1-D1024-160 trigger and data output panel

Trigger

Trigger Source options are:

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

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

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

Further trigger settings:

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

Strobe

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

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

Output Mode

Output Mode options are:

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 options are:

8 Bit: Grey level resolution of 8 bit.

10 Bit: Grey level resolution of 10 bit.

8.2.3 Correction

This tab contains correction settings.

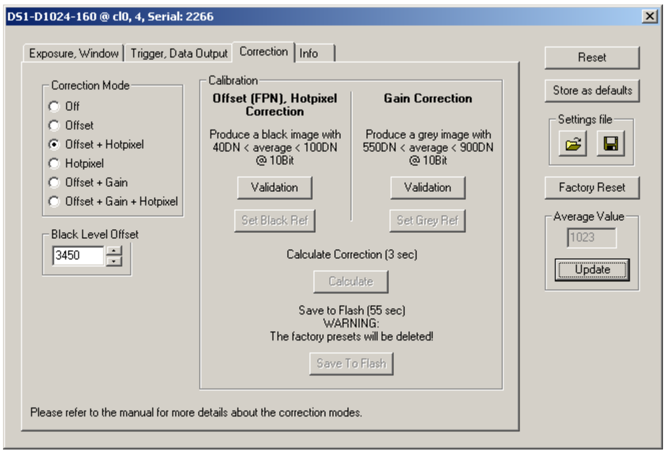

Figure 8.9: DS1-D1024-160 correction panel

Correction Mode

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

Off: No correction.

Offset: Activate offset correction.

Offset + Hotpixel: Activate offset and hot pixel correction.

Hotpixel: Activate hot pixel correction.

Offset + Gain: Activate offset and gain correction.

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

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.

Calibration

Offset (FPN), Hotpixel Correction: The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimize the static noise. Close the lens of the camera. Click on the Validation button. If the Set Black Ref - button is still inactive, the average of the image is out of range. Change the Property `Voltage.BlackLevelOffset` until the average value of the image is between 40 and 100 DN. Click again on the Validation button and then on the Set Black Ref Button.

If only offset and hot pixel correction are needed it is not necessary to calibrate a grey image.

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

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

Produce a grey image with an average value between 550 and 900 DN. Click on the Validation button to check the average value. If the average value is in range, the Set Grey Ref button is active.

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

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

This will overwrite the factory presets.

8.2.4 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.

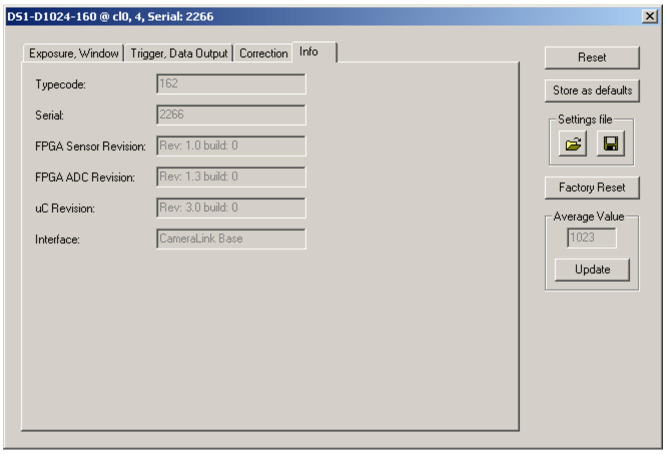

Figure 8.10: DS1-D1024-160 info panel

Typecode: Type code of the connected camera.

Serial: Serial number of the connected camera.

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

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

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

Interface: Description of the camera interface.

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

9

Mechanical and Optical 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 Cameras with CameraLink Interface

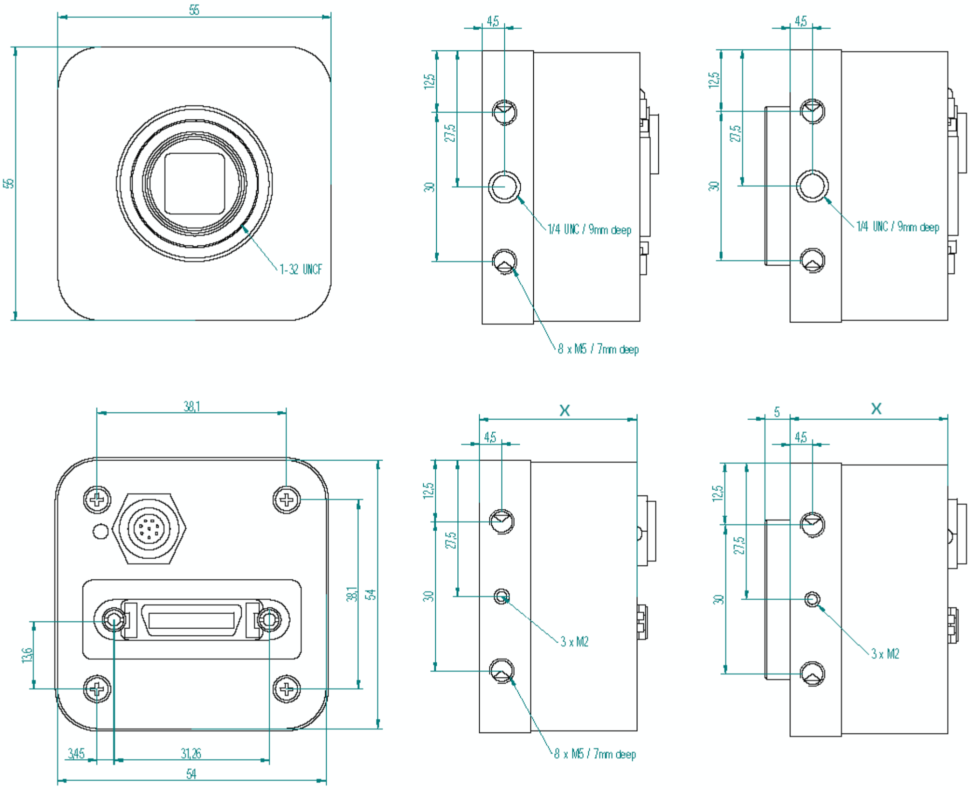

Figure 9.1: Mechanical dimensions of the CameraLink model, displayed without and with C-Mount adapter

Fig. 9.1 shows the mechanical drawing of the camera housing for the CameraLink cameras. The housing depths of the CameraLink cameras are summarized in Table 9.1 (all values in [mm]).

	DS1-D1024-40-CL	DS1-D1024-80-CL	DS1-D1024-160-CL
X (housing depth)	32 mm	40 mm	40 mm

Table 9.1: Model-specific parameters

9.1.2 Cameras with PoCL Interface

The general mechanical data of the cameras are listed in Section 4, Table 4.4. Fig. 9.2 shows the mechanical drawing of the PoCL camera models. Table 9.2 summarizes model-specific parameters.

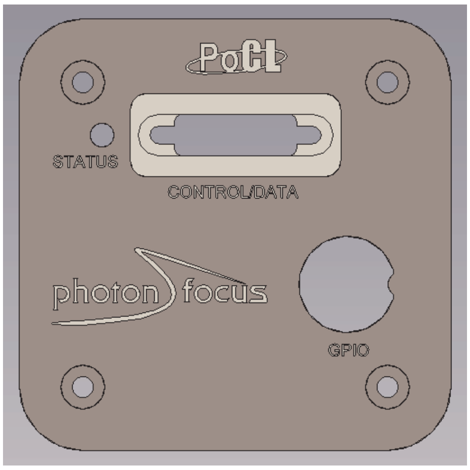

Figure 9.2: Drawing of the PoCL camera model rear view

All values are in [mm].

	DS1-D1024-40	DS1-D1024-80	DS1-D1024-160
X (housing depth)	32 mm	40 mm	40 mm

Table 9.2: Model-specific parameters

9.1.3 Cameras with USB 2.0 Interface

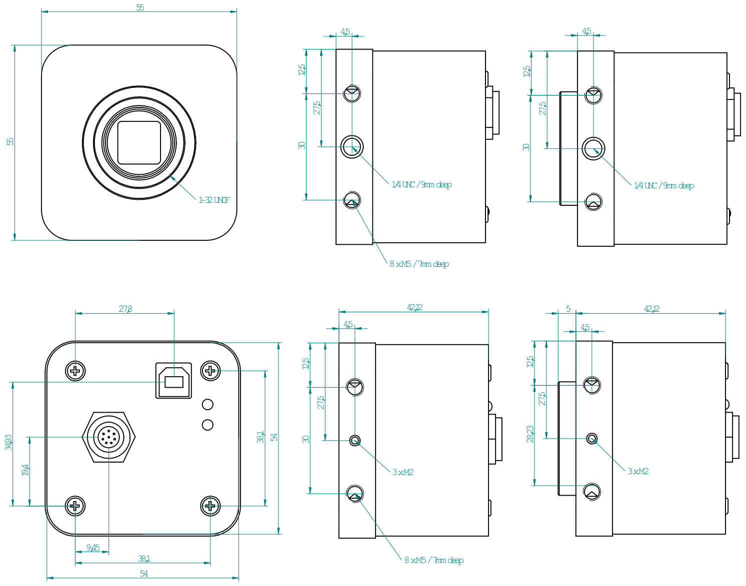

Figure 9.3: Mechanical dimensions of the USB 2.0 model, displayed without and with C-Mount adapter

Fig. 9.3 shows the mechanical drawing of the camera body for the USB 2.0 camera. The housing depth of the USB 2.0 camera is indicated in Table 9.3 (in [mm]).

	DS1-D1024-40-U2
housing depth	42.1 mm

Table 9.3: Model-specific parameters

9.2 Optical Interface

9.2.1 Cleaning the Sensor

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

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

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

3. If further cleaning is required, use a suitable lens wiper or Q-Tip moistened with an appropriate cleaning fluid to wipe the sensor surface as described below. Examples of suitable lens cleaning materials are given in Table 9.4. Cleaning materials must be ESD-safe, lint-free and free from particles that may scratch the sensor surface.

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

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

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

Table 9.4: Recommended materials for sensor cleaning

For cleaning the sensor, Photonfocus recommends the products available from the suppliers as listed in Table 9.4.

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

9.3 Compliance

CE Compliance Statement

We,

Photonfocus AG,
CH-8853 Lachen, Switzerland

declare under our sole responsibility that the following products

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

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

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

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

MV-D1024E-3D01-160

MV2-D1280-640-CL-8

SM2-D1024-80 / VisionCam PS

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

DS1-D1312-160-CL, MV1-D1312-160-CL

Digipeater CLB26

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

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

Photonfocus AG, October 2008

Figure 9.4: CE Compliance Statement

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

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

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

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

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

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

AN021 Application Note "CameraLink", Photonfocus, July 2004

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

A

Pinouts

A.1 Power Supply Connector for CameraLink Camera Models

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.

A suitable power supply is available from Photonfocus.

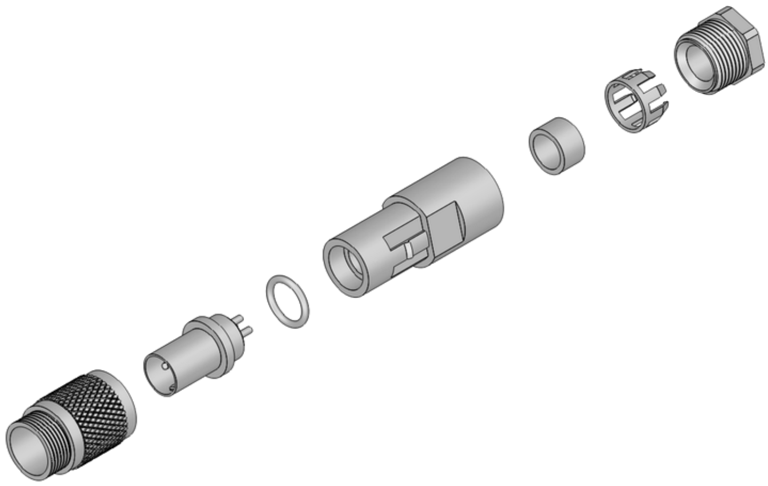

Figure A.1: Power connector assembly

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)

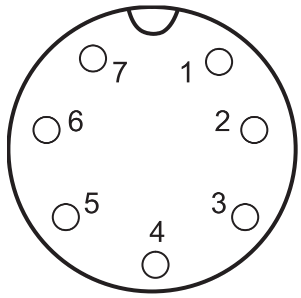

Figure A.2: Power supply plug, 7-pole (rear view of plug, solder side)

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	O	RESERVED	Do not connect
5	O	RESERVED	Do not connect
6	I	TRIGGER	External trigger (opto-isolated), +5 .. +15V DC
7	PWR	GROUND	Signal ground (for opto-isolated trigger signal)

Table A.2: Power supply plug pin assignment

A.2 CameraLink Connector for CameraLink Camera Models

The pinout for the CameraLink 26 pin, 0.05" 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).

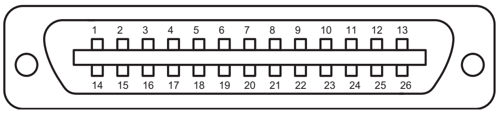

Figure A.3: CameraLink cable 3M MDR-26 plug (both ends)

PIN	IO	Name	Description
1	PW	INNER SHIELD	Inner 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	INNER SHIELD	Inner Shield
14	PW	INNER SHIELD	Inner 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	INNER SHIELD	Inner Shield
S	PW	SHIELD	Shield

Table A.3: Pinout CameraLink connector

A.3 I/O Connector for PoCL Camera Models

The I/O connector plug for PoCL camera models is available from Binder connectors at www.binder-connector.de. The pinout of the I/O plug for the PoCL camera models is compatible with the power supply plug for the CameraLink camera models (see Table A.2).

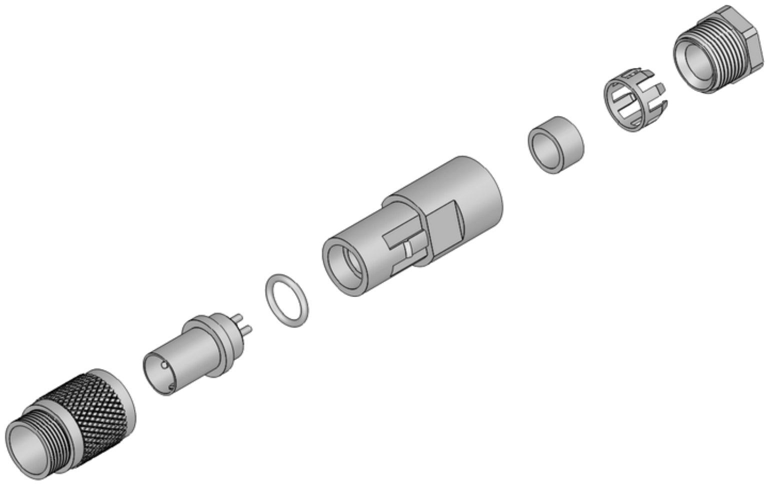

Figure A.4: I/O connector assembly

A.4 I/O Connector

Table A.4 summarizes the order codes for the 7-pole Binder connector. Table A.5 gives the pin assignment for the I/O connector.

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

Table A.4: I/O connectors (Binder subminiature series 712)

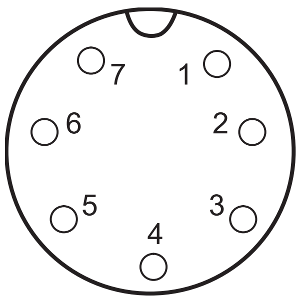

Figure A.5: I/O plug, 7-pole (rear view of plug, solder side)

Pin	I/O Type	Name	Description
1	-	NC	not connected
2	-	NC	not connected
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.5: I/O plug pin assignment

A.5 CameraLink Connector for PoCL Camera Models

The pinout for the MiniCL 26 pin, 0.031" Shrunk Delta Ribbon (SDR) connector is according to the CameraLink standard ([CL]) and is listed here for reference only (see Table A.6). The drawing of the PoCL cable plug is shown in Fig. A.6. PoCL cables can be purchased from Photonfocus directly (www.photonfocus.com).

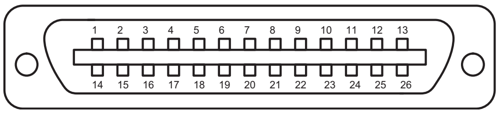

Figure A.6: PoCL cable 26 plug (both ends)

PIN	IO	Name	Description
1	PW	POWER LINE	+ 12 V DC
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	INNER SHIELD	Inner Shield
14	PW	INNER SHIELD	Inner 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	POWER LINE	+ 12 V DC
S	PW	SHIELD	Shield

Table A.6: Pinout PoCL connector

A.6 USB 2.0 Connector

The USB 2.0 interface and connector were developed by a group of companies (Intel, Agere Systems, NEC, Hewlett-Packard, Philips, etc.) which are now organized in the USB Implementers Forum (www.usb.org).
The USB connector is used to transmit configuration signals and image data. The pinout complies with the standard USB pinout and is listed here for the sake of completeness (see Fig. A.7 and Table A.7).

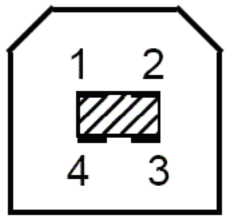

Figure A.7: USB type B connector (front view)

PIN	IO	Name	Description
1	PWR	VBUS	+5V power supply*
2	I/O	DATA -	Negative Data
3	I/O	DATA +	Positive Data
4	PWR	GND	Ground

Table A.7: Pinout USB 2.0 connector (not connected to camera electronic)*

B

Troubleshooting

B.1 Common pitfalls with microDisplay USB and PFRemote

Message "mEnable not found" appears after microDisplay USB was started

- The camera is not powered on or is not connected to the USB interface.
- The USB driver is not installed correctly. Try reinstalling PFInstaller.
- When the camera is connected to the USB bus and powered on, check if there is a "Multifunction adapter" with the entry "Silicon Software GmbH microUSB2" in the Windows device manager.
- Reinstall the driver manually. It is located in `\Photonfocus\microDisplayUSB\driver`.

PFRemote cannot communicate

- microDisplay USB must always be started before PFRemote, because it downloads the USB firmware to the camera.

No image is output

- Check if the camera is outputting images (check if the lower LED is green, see Section 6.1.9). Maybe the camera is in external trigger mode and does not receive a trigger signal.
- The camera USB interface or power supply has been disconnected since the last start of microDisplay USB. Restart microDisplay USB.
- Due to the minimum data frame size that can be transferred by USB, the minimum ROI must be at least 1024 bytes. Choose an ROI of Width x Height > 1024 pixels.
- If there is already an earlier USB driver installed on your PC and you have problems installing the new PFInstaller, please contact the Photonfocus support at support@photonfocus.com.

Message "Camera clock on port A is inactive"

- A wrong hardware applet was downloaded to the camera when starting microDisplay USB. Always choose the correct camera model at the start of microDisplay USB.
- The camera USB interface or power supply has been disconnected since the last start of microDisplay USB. Restart microDisplay USB.

B.2 Camera reactivation

Camera shows no images

- Check on the power. Is the camera properly connected to the power supply?
- Check on the camera settings. Are any settings conflicting or contradictory?
- Check on the trigger connections.

When all methods fail

- Reset the camera to the stored settings (Press reset button in the main window of PFRemote).

No images are output

- After reset of the camera a factory reset may become necessary (Execute Factory Reset in the main window of PFRemote).
- This will overwrite the stored camera settings and reactivate the factory settings of your camera.

C

Revision History

Revision	Date	Changes
1.0	July 2007	First release
1.1	September 2007	Added DS1-D1024-80-CL-10 and DS1-D1024-160-CL-10.
1.2	November 2008	Included freely selectable ROI, extended trigger signals
		and strobe output. Update of CE conformity statement.
		Added description of PoCL interface.
		Included new QE data of A1024B CMOS image sensor.