User Manual

Photonfocus MV1-D2080(IE)-G2 Gigabit Ethernet Series

CMOS Area Scan Camera

MAN059 09/2013 V1.1

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Preface

1.1 About Photonfocus

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

1.2 Contact

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

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

Table 1.1: Photonfocus Contact

1.3 Sales Offices

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

1.4 Further information

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1.5 Legend

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

Important note

Alerts and additional information

Attention, critical warning

Notification, user guide

2

How to get started (GigE G2)

2.1 Introduction

This guide shows you:

- How to install the required hardware (see Section 2.2)
- How to install the required software (see Section 2.3) and configure the Network Adapter Card (see Section 2.4 and Section 2.5)
- How to acquire your first images and how to modify camera settings (see Section 2.6)
- A Starter Guide [MAN051] can be downloaded from the Photonfocus support page. It describes how to access Photonfocus GigE cameras from various third-party tools.

2.2 Hardware Installation

The hardware installation that is required for this guide is described in this section.
The following hardware is required:

- PC with Microsoft Windows OS (XP, Vista, Windows 7)
- A Gigabit Ethernet network interface card (NIC) must be installed in the PC. The NIC should support jumbo frames of at least 9014 bytes. In this guide the Intel PRO/1000 GT desktop adapter is used. The descriptions in the following chapters assume that such a network interface card (NIC) is installed. The latest drivers for this NIC must be installed.
- Photonfocus GigE camera.
- Suitable power supply for the camera (see in the camera manual for specification) which can be ordered from your Photonfocus dealership.
- GigE cable of at least Cat 5E or 6.

☞ Photonfocus GigE cameras can also be used under Linux.

☞ Photonfocus GigE cameras work also with network adapters other than the Intel PRO/1000 GT. The GigE network adapter should support Jumbo frames.

⚠ Do not bend GigE cables too much. Excess stress on the cable results in transmission errors. In robots applications, the stress that is applied to the GigE cable is especially high due to the fast movement of the robot arm. For such applications, special drag chain capable cables are available.

The following list describes the connection of the camera to the PC (see in the camera manual for more information):

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

- Power supply connector
- Camera body cap

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

2. Connect the camera to the GigE interface of your PC with a GigE cable of at least Cat 5E or 6.

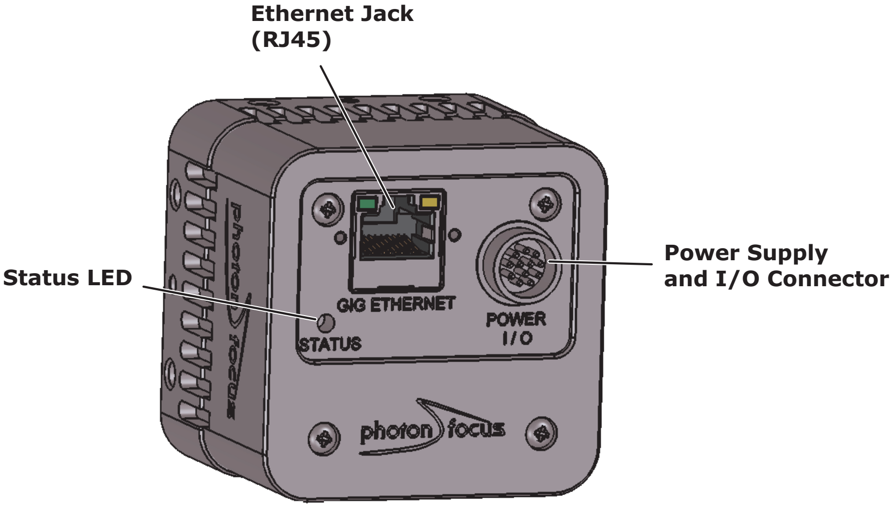


Figure 2.1: Rear view of a Photonfocus GigE camera with power supply and I/O connector, Ethernet jack (RJ45) and status LED

3. Connect a suitable power supply to the power plug. The pin out of the connector is shown in the camera manual.

   Check the correct supply voltage and polarity! Do not exceed the operating voltage range of the camera.

   A suitable power supply can be ordered from your Photonfocus dealership.

4. Connect the power supply to the camera (see Fig. 2.1).

2.3 Software Installation

This section describes the installation of the required software to accomplish the tasks described in this chapter.

1. Install the latest drivers for your GigE network interface card.
2. Download the latest eBUS SDK installation file from the Photonfocus server.

   You can find the latest version of the eBUS SDK on the support (Software Download) page at www.photonfocus.com.

3. Install the eBUS SDK software by double-clicking on the installation file. Please follow the instructions of the installation wizard. A window might be displayed warning that the software has not passed Windows Logo testing. You can safely ignore this warning and click on `Continue Anyway`. If at the end of the installation you are asked to restart the computer, please click on `Yes` to restart the computer before proceeding.
4. After the computer has been restarted, open the eBUS Driver Installation tool (`Start -> All Programs -> eBUS SDK -> Tools -> Driver Installation Tool`) (see Fig. 2.2). If there is more than one Ethernet network card installed then select the network card where your Photonfocus GigE camera is connected. In the Action drop-down list select `Install eBUS Universal Pro Driver` and start the installation by clicking on the `Install` button. Close the eBUS Driver Installation Tool after the installation has been completed. Please restart the computer if the program asks you to do so.

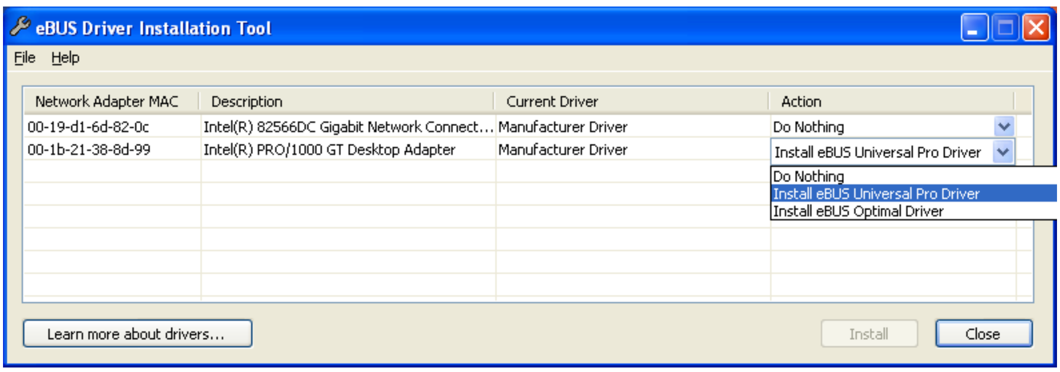


Figure 2.2: eBUS Driver Installation Tool

5. Download the latest PFInstaller from the Photonfocus server.
6. Install the PFInstaller by double-clicking on the file. In the `Select Components` (see Fig. 2.3) dialog check `PF_GEVPlayer and doc for GigE cameras`. For DR1 cameras select additionally `DR1 support and 3rd Party Tools`. For 3D cameras additionally select `PF3DSuite2 and SDK`.

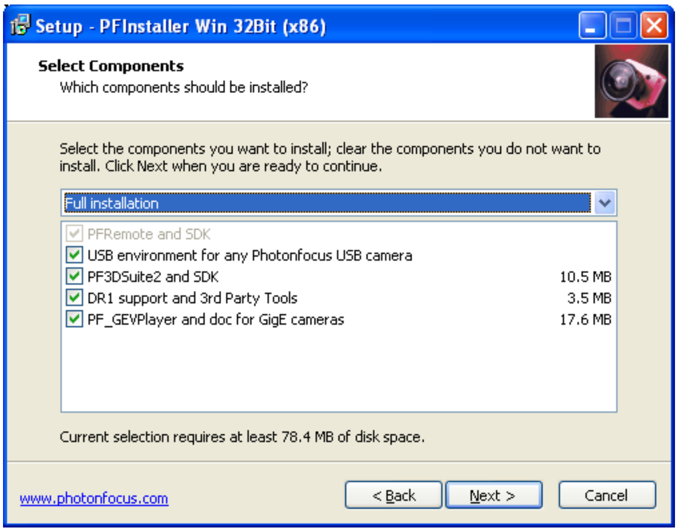


Figure 2.3: PFInstaller components choice

2.4 Network Adapter Configuration

This section describes recommended network adapter card (NIC) settings that enhance the performance for GigEVision. Additional tool-specific settings are described in the tool chapter.

1. Open the Network Connections window (`Control Panel -> Network and Internet Connections -> Network Connections`), right click on the name of the network adapter where the Photonfocus camera is connected and select `Properties` from the drop down menu that appears.

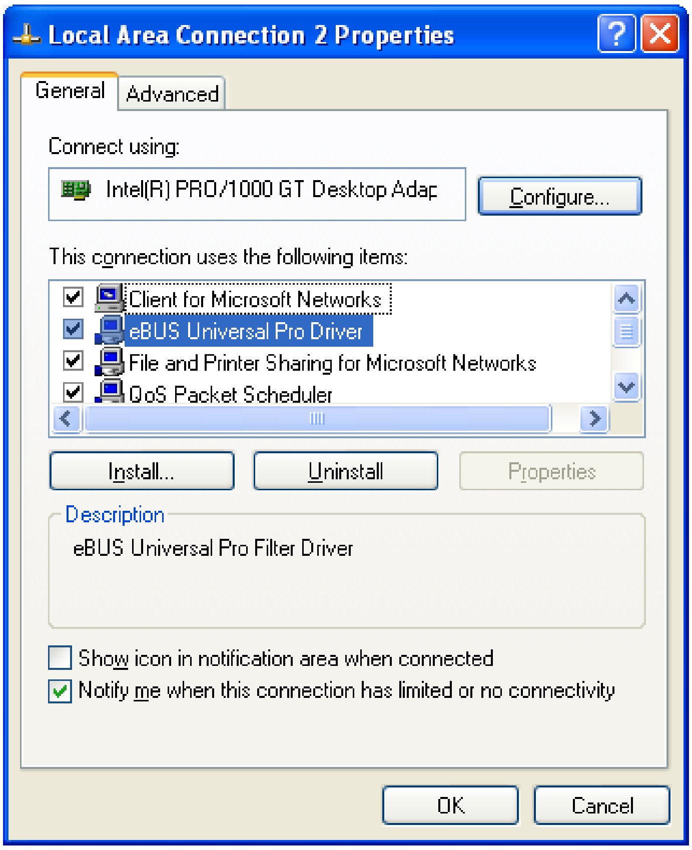


Figure 2.4: Local Area Connection Properties

2. By default, Photonfocus GigE Vision cameras are configured to obtain an IP address automatically. For this quick start guide it is recommended to configure the network adapter to obtain an IP address automatically. To do this, select `Internet Protocol (TCP/IP)` (see Fig. 2.4), click the `Properties` button and select `Obtain an IP address automatically` (see Fig. 2.5).

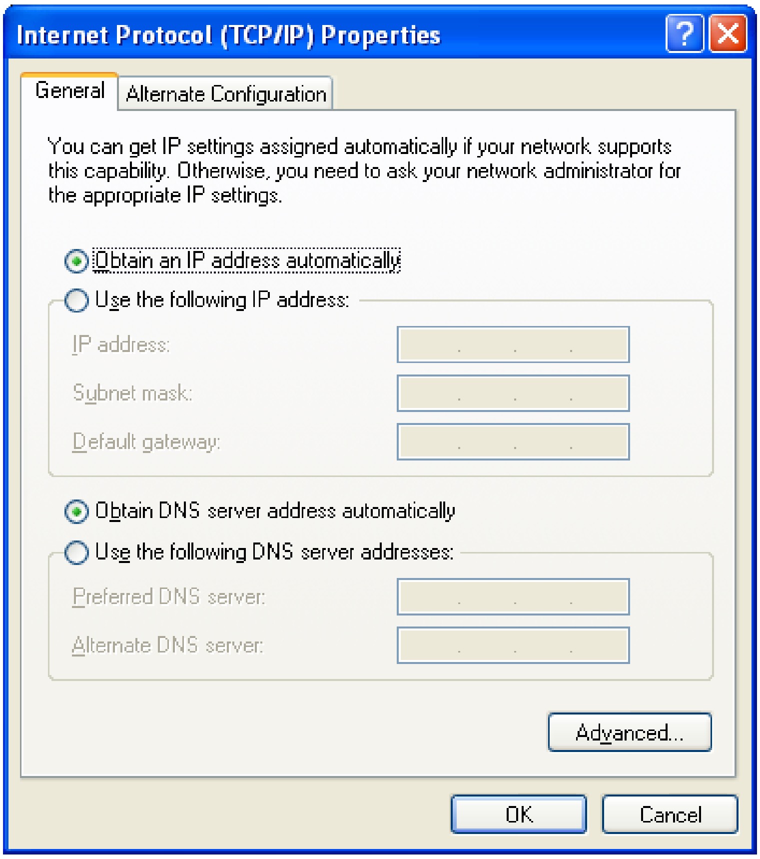


Figure 2.5: TCP/IP Properties

3. Open again the `Local Area Connection Properties` window (see Fig. 2.4) and click on the Configure button. In the window that appears click on the `Advanced` tab and click on `Jumbo Frames` in the Settings list (see Fig. 2.6). The highest number gives the best performance. Some tools however don't support the value 16128. For this guide it is recommended to select `9014 Bytes` in the Value list.

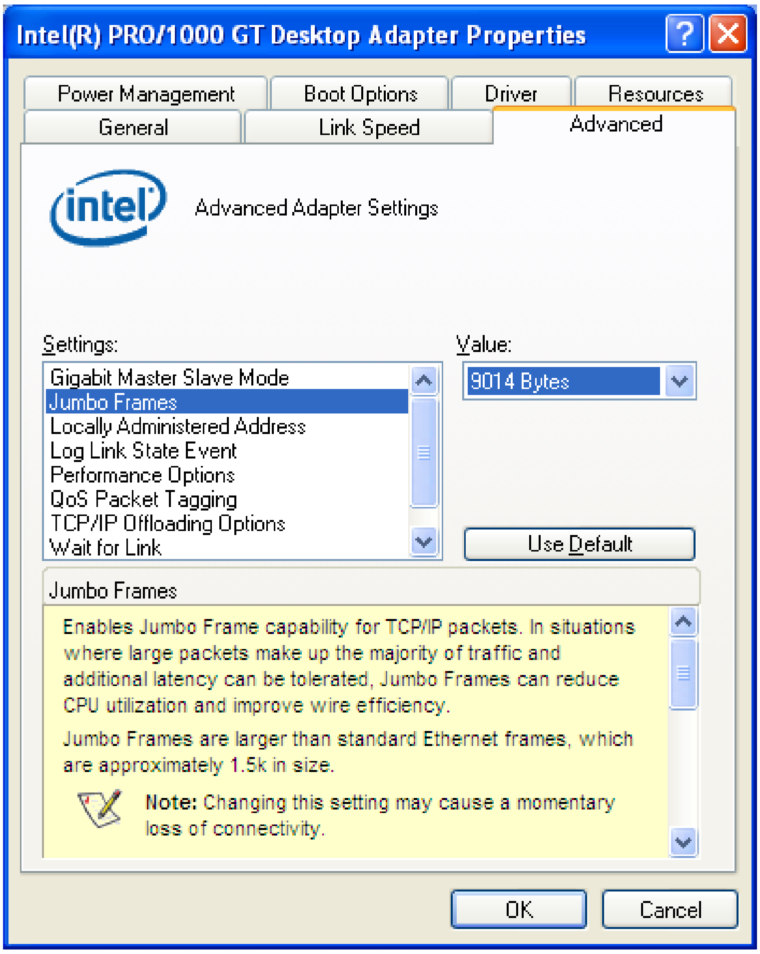


Figure 2.6: Advanced Network Adapter Properties

4. No firewall should be active on the network adapter where the Photonfocus GigE camera is connected. If the Windows Firewall is used then it can be switched off like this: Open the Windows Firewall configuration (`Start -> Control Panel -> Network and Internet Connections -> Windows Firewall`) and click on the Advanced tab. Uncheck the network where your camera is connected in the `Network Connection Settings` (see Fig. 2.7).

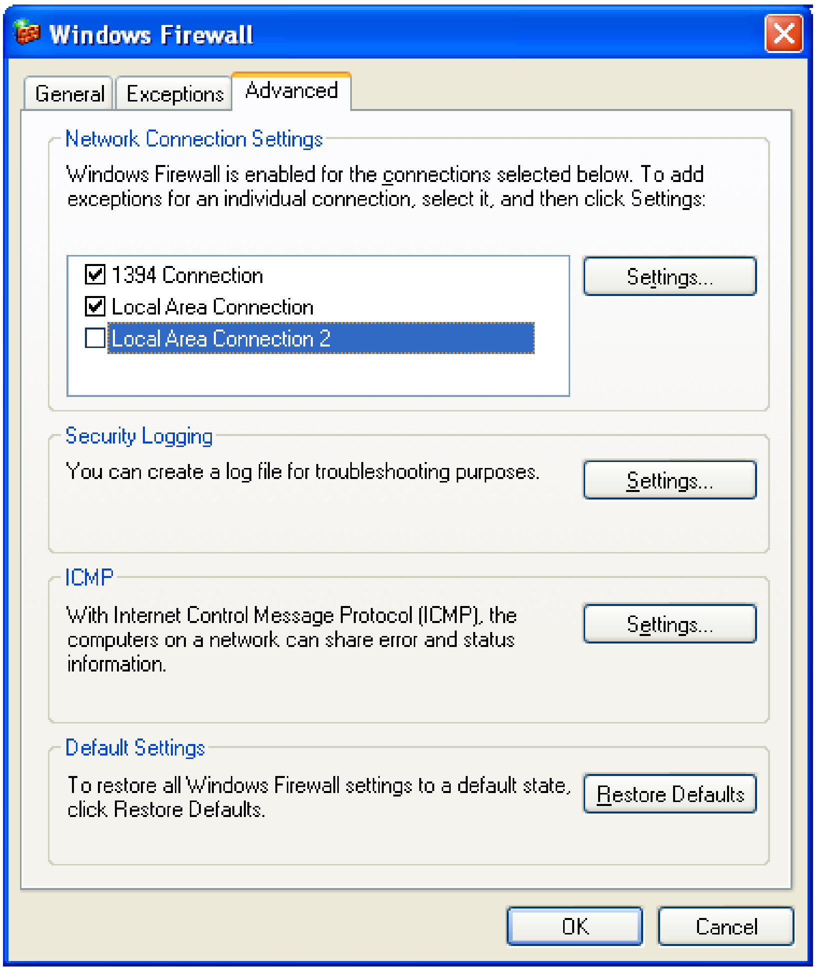


Figure 2.7: Windows Firewall Configuration

2.5 Network Adapter Configuration for Pleora eBUS SDK

Open the Network Connections window (`Control Panel -> Network and Internet Connections -> Network Connections`), right click on the name of the network adapter where the Photonfocus camera is connected and select `Properties` from the drop down menu that appears. A Properties window will open. Check the `eBUS Universal Pro Driver` (see Fig. 2.8) for maximal performance. Recommended settings for the Network Adapter Card are described in Section 2.4.

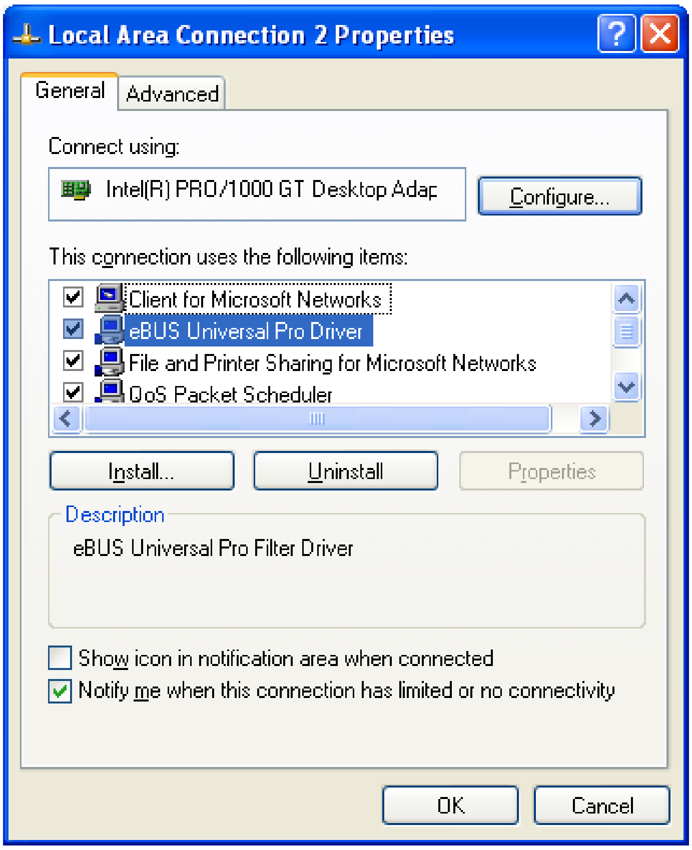


Figure 2.8: Local Area Connection Properties

2.6 Getting started

This section describes how to acquire images from the camera and how to modify camera settings.

1. Open the PF_GEVPlayer software (Start -> All Programs -> Photonfocus -> GigE_Tools -> PF_GEVPlayer) which is a GUI to set camera parameters and to see the grabbed images (see Fig. 2.9).

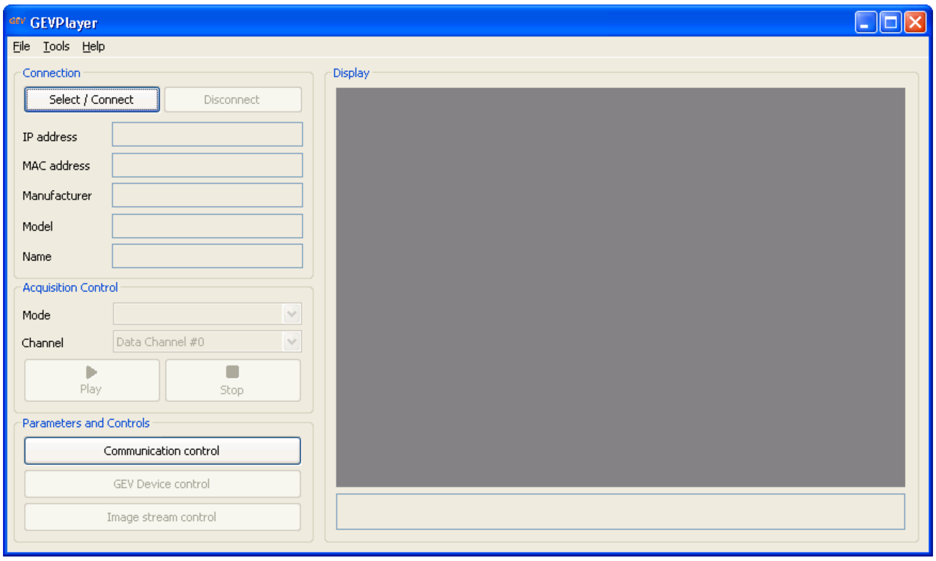


Figure 2.9: PF_GEVPlayer start screen

2. Click on the `Select / Connect` button in the PF_GEVPlayer . A window with all detected devices appears (see Fig. 2.10). If your camera is not listed then select the box `Show unreachable GigE Vision Devices`.

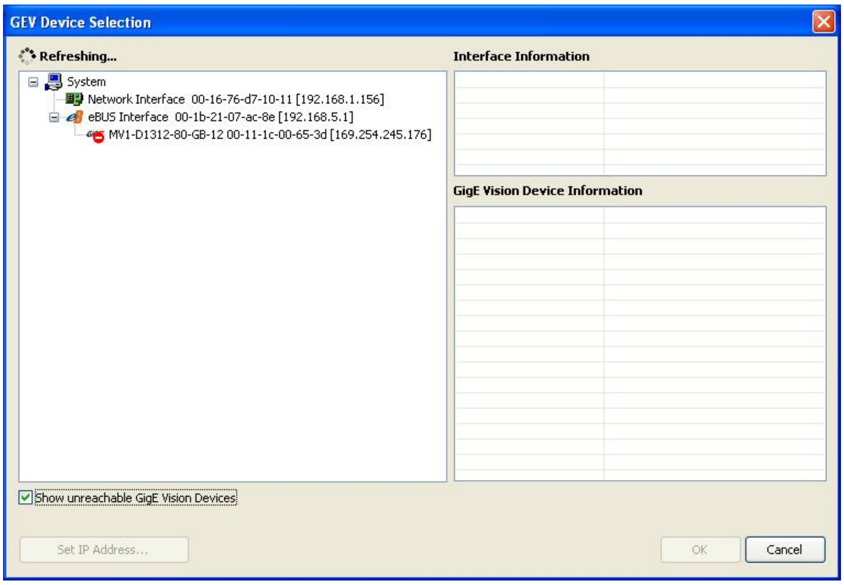


Figure 2.10: GEV Device Selection Procedure displaying the selected camera

3. Select camera model to configure and click on `Set IP Address...`.

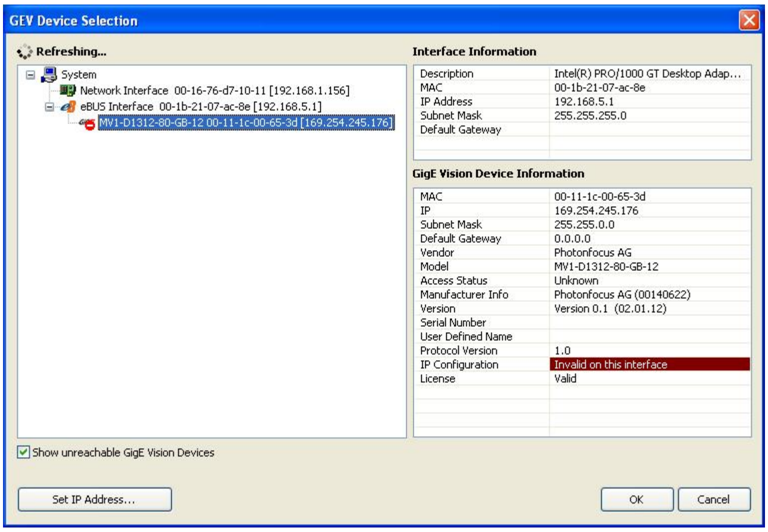


Figure 2.11: GEV Device Selection Procedure displaying GigE Vision Device Information

4. Select a valid IP address for selected camera (see Fig. 2.12). There should be no exclamation mark on the right side of the IP address. Click on `Ok` in the `Set IP Address` dialog. Select the camera in the `GEV Device Selection` dialog and click on `Ok`.

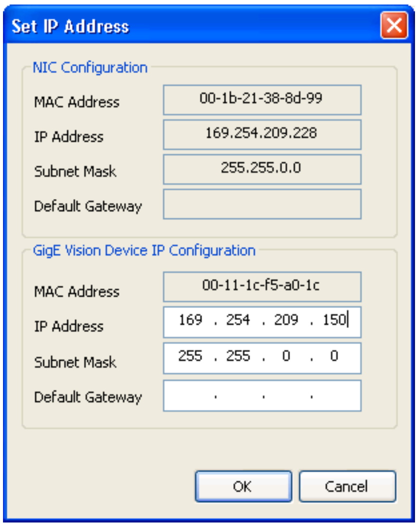


Figure 2.12: Setting IP address

5. Finish the configuration process and connect the camera to PF_GEVPlayer .

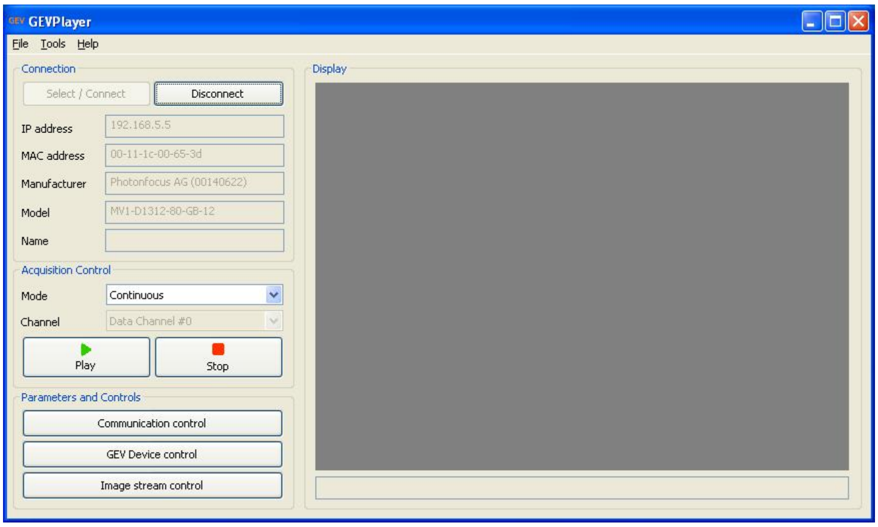


Figure 2.13: PF_GEVPlayer is readily configured

6. The camera is now connected to the PF_GEVPlayer . Click on the `Play` button to grab images.

   An additional check box `DR1` appears for DR1 cameras. The camera is in double rate mode if this check box is checked. The demodulation is done in the PF_GEVPlayer software. If the check box is not checked, then the camera outputs an unmodulated image and the frame rate will be lower than in double rate mode.

If no images can be grabbed, close the PF_GEVPlayer and adjust the Jumbo Frame parameter (see Section 2.3) to a lower value and try again.

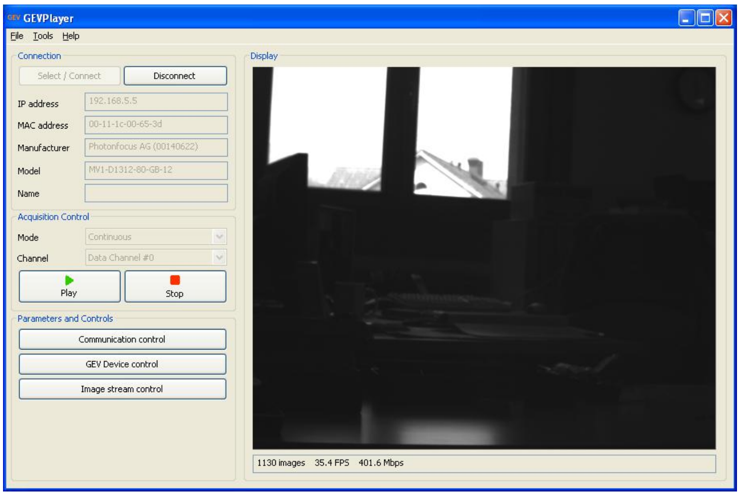


Figure 2.14: PF_GEVPlayer displaying live image stream

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

   The status LED light is green when an image is being acquired, and it is red when serial communication is active.

8. Camera parameters can be modified by clicking on `GEV Device control` (see Fig. 2.15). The visibility option Beginner shows most the basic parameters and hides the more advanced parameters. If you don't have previous experience with Photonfocus GigE cameras, it is recommended to use `Beginner` level.

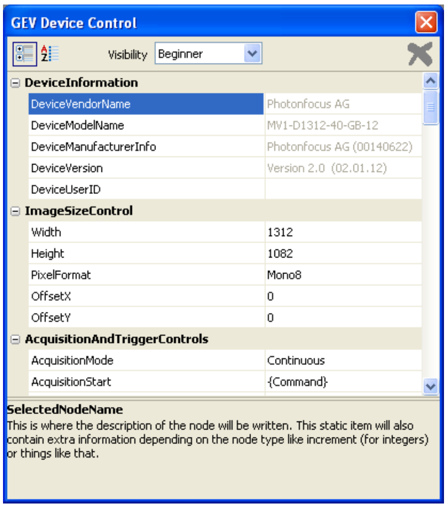


Figure 2.15: Control settings on the camera

9. To modify the exposure time scroll down to the `AcquisitionControl` control category (bold title) and modify the value of the `ExposureTime` property.

3

Product Specification

3.1 Introduction

The MV1-D2080(IE)-G2 GigE CMOS camera series is built around the monochrome A2080(IE) CMOS image sensor from Photonfocus, that provides a resolution of 2080 x 2080 pixels at a wide range of spectral sensitivity. It is aimed at demanding applications in industrial image processing and metrology that require a high Signal to Noise Ratio (SNR). The principal advantages are:

- Resolution of 2080 x 2080 pixels.
- Spectral range: standard 370 nm - 1000 nm, IE models: 370 - 1020 nm.
- High quantum efficiency (> 50%).
- High pixel fill factor (> 60%).
- Superior signal-to-noise ratio (SNR) and high full well capacity of 90 ke^-.
- Global shutter.
- Very high resistance to blooming.
- High dynamic range of up to 120 dB with patented LinLog® technology.
- Gigabit Ethernet interface, GigE Vision and GenICam compliant.
- Maximal frame rate at full resolution of 2080 x 2080 pixels: 25 fps.
- Greyscale resolution of up to 12 bit.
- On camera shading correction.
- 3x3 Convolver for image pre-processing included on camera.
- Up to 512 regions of interest (MROI).
- 2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT).
- Crosshairs overlay on the image.
- Image information and camera settings inside the image (status line).
- Software provided for setting and storage of camera parameters.
- The compact size of 60 x 60 x 51 mm^3 makes the MV1-D2080(IE)-G2 CMOS cameras the perfect solution for applications in which space is at a premium.
- Advanced I/O capabilities: 2 isolated trigger inputs, 2 differential isolated RS-422 inputs and 2 isolated outputs.
- Programmable Logic Controller (PLC) for powerful operations on input and output signals.
- Wide power input range from 12 V (-10 %) to 24 V (+10 %).

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

☞ The MV1-D2080IE-G2 camera with the A2080IE sensor will be available on request.

Figure 3.1: MV1-D2080(IE)-G2 CMOS camera

3.2 Feature Overview

Characteristics	MV1-D2080(IE) GigE Series
Interface	Gigabit Ethernet, GigE Vision and GenICam compliant
Camera Control	GigE Vision Suite (PF_GEVPlayer, SDK)
Trigger Modes	Software Trigger / External isolated trigger input / PLC Trigger
Features	Region of Interest (ROI)
	Up to 512 regions of interest (MROI)
	LinLog® for high dynamic range
	2 isolated trigger inputs, 2 differential isolated RS-422 inputs and 2 isolated outputs
	Shading Correction (Offset and Gain)
	3x3 Convolver included on camera
	High blooming resistance
	2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT)
	Greyscale resolution 12 bit / 10 bit / 8 bit
	Image information and camera settings inside the image (status line)
	Crosshairs overlay on the image
	Test pattern (LFSR and grey level ramp)

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

3.3 Available Camera Models

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

Name	Resolution	FPS	NIR [2]	Color
MV1-D2080-160-G2-12	2080 x 2080	25 fps [1]	no	no
MV1-D2080IE-160-G2-12	2080 x 2080	25 fps [1]	yes	no

Table 3.2: Available Photonfocus MV1-D2080(IE)-G2 GigE camera models (Footnotes: [1] frame rate at at full resolution, [2] NIR enhanced camera with A2080IE image sensor)

3.4 Technical Specification

Technical Parameters	MV1-D2080(IE) Series
Technology	CMOS active pixel (APS)
Scanning system	Progressive scan
Optical format / diagonal	1.3" (25.5 mm diagonal) @ maximum resolution
	2/3" (11.6 mm diagonal) @ 1024 x 1024 resolution with ROI
Resolution	2080 x 2080 pixels
Pixel size	8 μm x 8 μm
Active optical area	16.64 mm x 16.64 mm
Random noise	< 0.3 DN @ 8 bit [1)]
Fixed pattern noise (FPN)	3.4 DN @ 8 bit / correction OFF [1)]
Fixed pattern noise (FPN)	< 1DN @ 8 bit / correction ON [1)]
Dark current MV1-D2080	0.65 fA / pixel @ 27 °C
Dark current MV1-D2080IE	0.79 fA / pixel @ 27 °C
Full well capacity	~ 90 ke$^-$
Spectral range MV1-D2080	370 nm ... 1000 nm (see Fig. 3.2)
Spectral range MV1-D2080IE	370 nm ... 1020 nm (see Fig. 3.3) [2)]
Responsivity MV1-D2080	295 x10^3 DN/(J/m^2) @ 670 nm / 8 bit
Responsivity MV1-D2080IE	305 x10^3 DN/(J/m^2) @ 850 nm / 8 bit
Quantum Efficiency	> 50 %
Optical fill factor	> 60 %
Dynamic range	60 dB in linear mode, 120 dB with LinLog®
Colour format	Monochrome
Characteristic curve	Linear, LinLog®
Shutter mode	Global shutter
Greyscale resolution	12 bit / 10 bit / 8 bit
Exposure Time	10 μs ... 0.41 s / 25 ns steps
Maximal frame rate	25 fps [3)]

Table 3.3: General specification of the MV1-D2080(IE) camera series (Footnotes: [1)]Indicated values are typical values, [2)]If operated above 1000 nm, the image will be unsharp, [3)]at full resolution and minimal exposure time)

	MV1-D2080(IE)-160-G2
Operating temperature / moisture	0°C ... 50°C / 20 ... 80 %
Storage temperature / moisture	-25°C ... 60°C / 20 ... 95 %
Camera power supply	+12 V DC (- 10 %) ... +24 V DC (+ 10 %)
Trigger signal input range	+5 .. +30 V DC
Max. power consumption	< 6 W
Lens mount	M42x1; optional: F-Mount and C-Mount (1.3")
Dimensions	60 x 60 x 51 mm^3
Mass	280 g
Conformity	RoHS / WEE

Table 3.4: Physical characteristics and operating ranges of the MV1-D2080(IE) CMOS camera series

Fig. 3.2 shows the quantum efficiency and the responsivity of the A2080 CMOS sensor, displayed as a function of wavelength. For more information on photometric and radiometric measurements see the Photonfocus application notes AN006 and AN008 available in the support area of our website www.photonfocus.com.

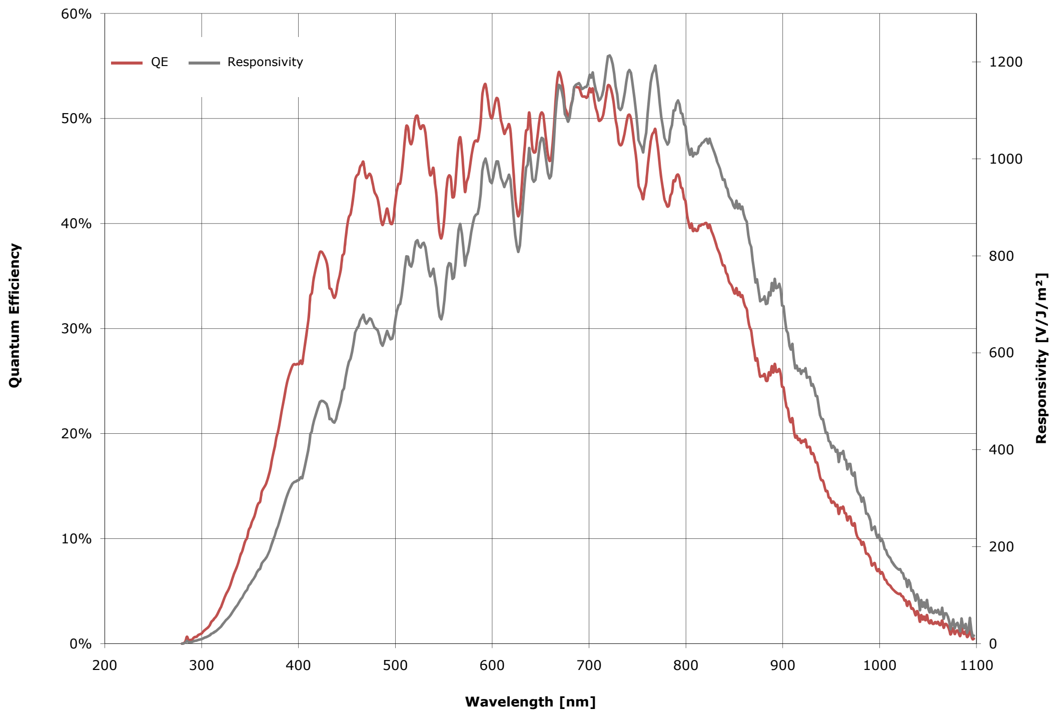


Figure 3.2: Spectral response of the A2080 CMOS image sensor (standard) in the MV1-2080 camera series

Fig. 3.3 shows the quantum efficiency and the responsivity of the A2080IE CMOS sensor, displayed as a function of wavelength. The enhancement in the NIR quantum efficiency could be used to realize applications in the 900 to 1064 nm region.

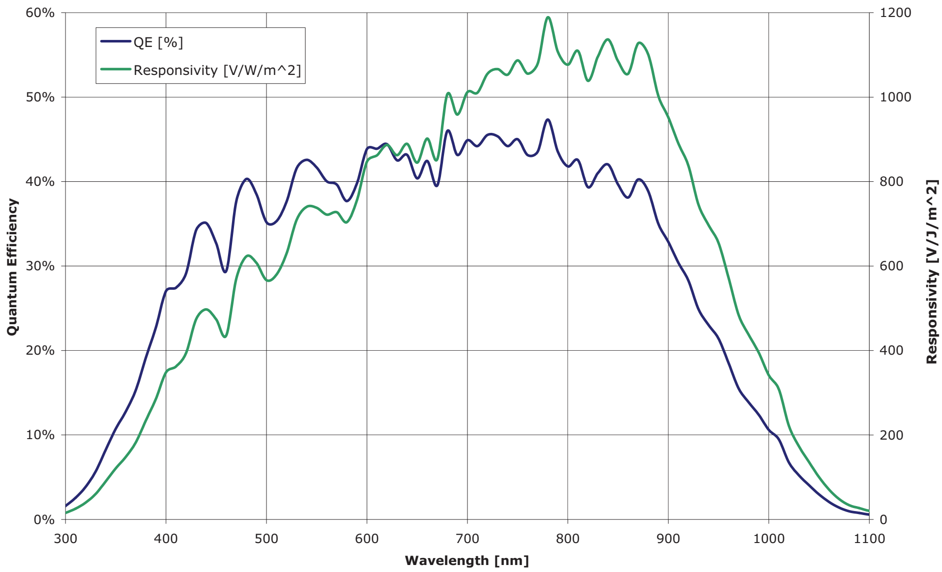


Figure 3.3: Spectral response of the A2080IE image sensor (NIR enhanced) in the MV1-D2080IE camera series

4

Functionality

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

4.1 Image Acquisition

4.1.1 Readout Modes

The MV1-D2080(IE) CMOS cameras provide two different readout modes:

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

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

Readout Mode	MV1-D2080(IE) Series
Sequential readout	available
Simultaneous readout	available

Table 4.1: Readout mode of MV1-D2080 Series camera

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

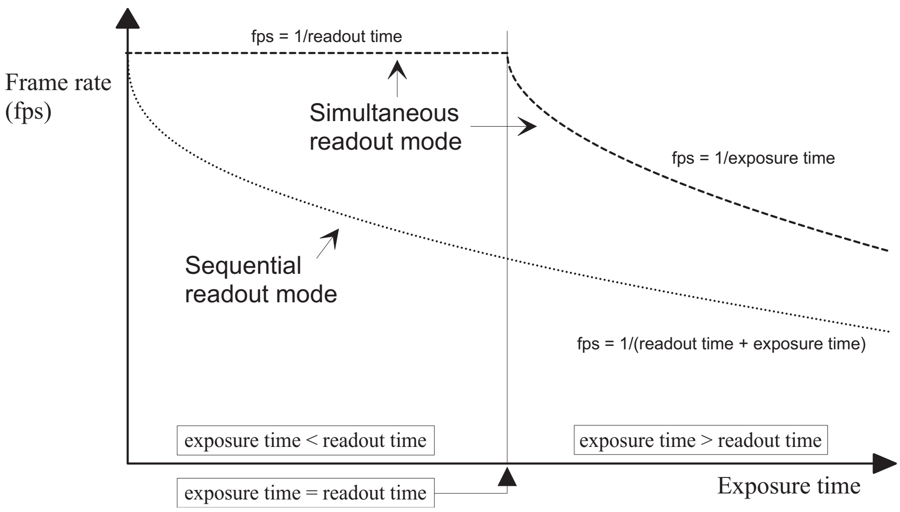


Figure 4.1: Frame rate in sequential readout mode and simultaneous readout mode

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

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

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

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

Sequential readout

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

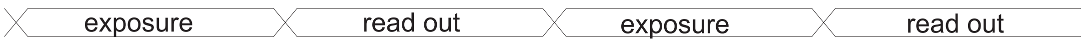


Figure 4.2: Timing in free-running sequential readout mode

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 4.4). In this mode, the camera is idle until it gets a signal to capture an image.

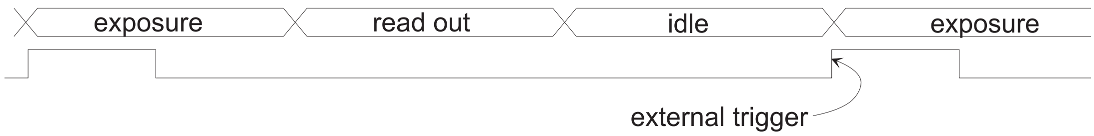


Figure 4.3: Timing in triggered sequential readout mode

Simultaneous readout (interleave exposure)

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

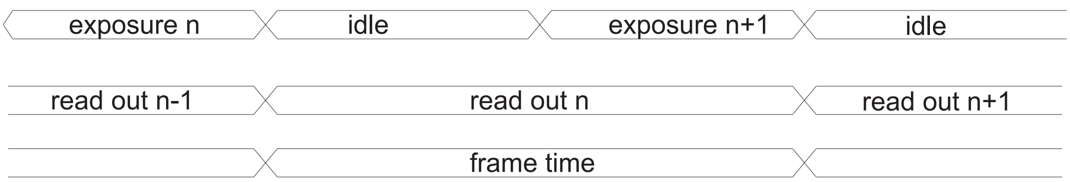


Figure 4.4: Timing in free-running simultaneous readout mode (readout time> exposure time)

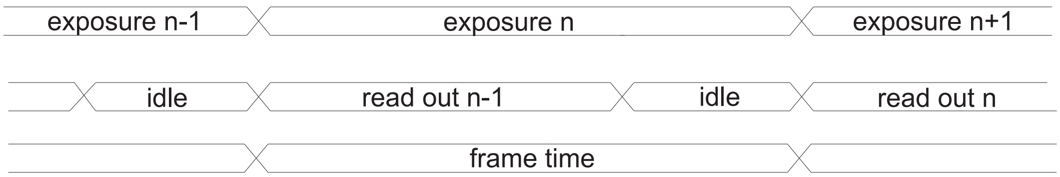


Figure 4.5: Timing in free-running simultaneous readout mode (readout time< exposure time)

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 4.4). In this mode, the camera is idle until it gets a signal to capture an image.

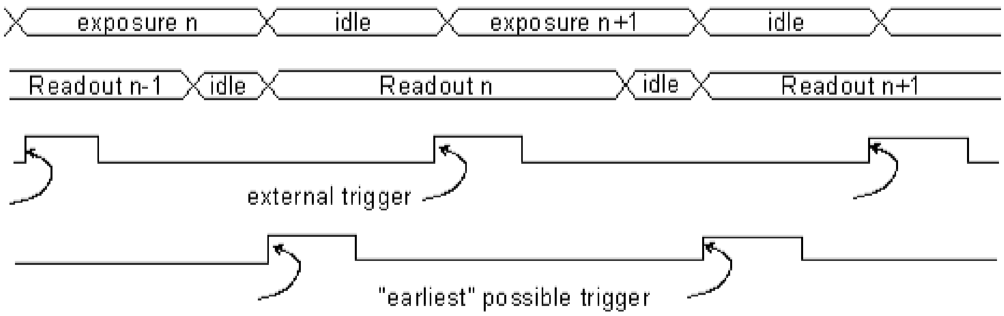


Figure 4.6: Timing in triggered simultaneous readout mode

4.1.2 Readout Timing

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.

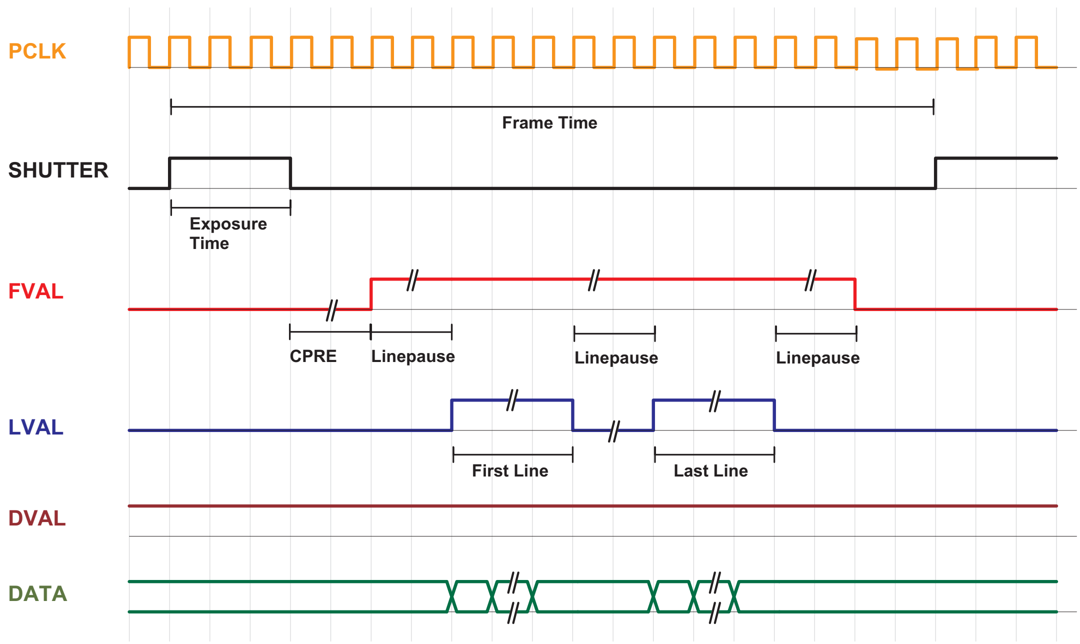


Figure 4.7: Timing diagram of sequential readout mode

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.

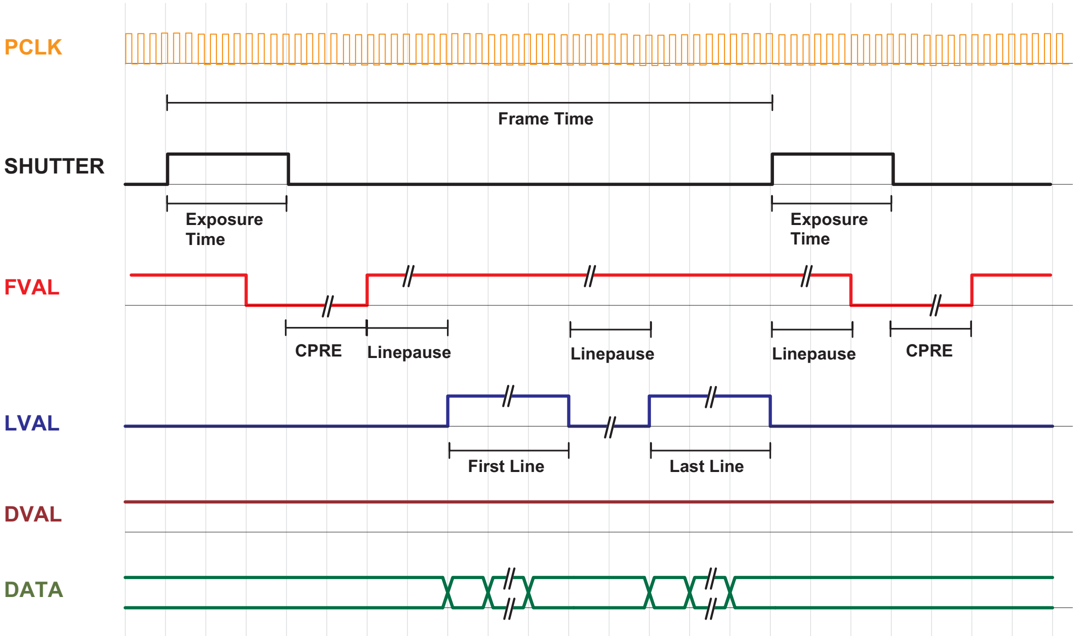


Figure 4.8: Timing diagram of simultaneous readout mode (readout time > exposure time)

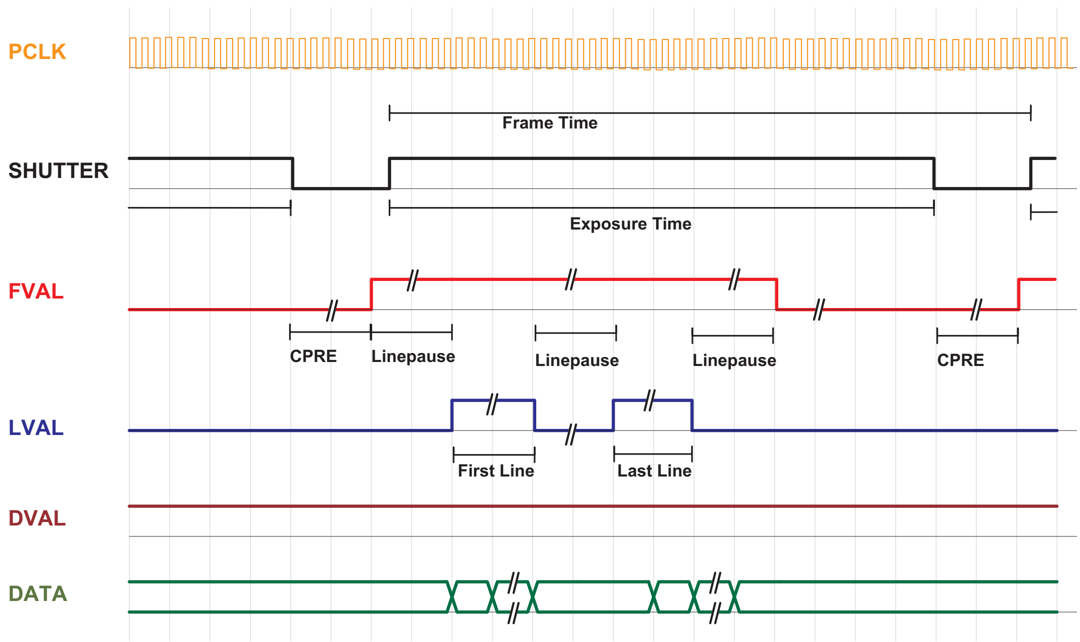


Figure 4.9: Timing diagram simultaneous readout mode (readout time < exposure time)

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

These terms will be used also in the timing diagrams of Section 4.4.

4.1.3 Exposure Control

The exposure time defines the period during which the image sensor integrates the incoming light. Refer to Section 3.4 for the allowed exposure time range.

4.1.4 Maximum Frame Rate

The maximum frame rate depends on the exposure time and the size of the image (see Section 4.3.)

4.2 Pixel Response

4.2.1 Linear Response

The camera offers a linear response between input light signal and output grey level. This can be modified by the use of LinLog®as described in the following sections. In addition, a linear digital gain may be applied, as follows. Please see Table 3.3 for more model-dependent information.

Black Level Adjustment

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

4.2.2 LinLog®

Overview

The LinLog® technology from Photonfocus allows a logarithmic compression of high light intensities inside the pixel. In contrast to the classical non-integrating logarithmic pixel, the LinLog® pixel is an integrating pixel with global shutter and the possibility to control the transition between linear and logarithmic mode.
In situations involving high intrascene contrast, a compression of the upper grey level region can be achieved with the LinLog® technology. At low intensities each pixel shows a linear response. At high intensities the response changes to logarithmic compression (see Fig. 4.10). The transition region between linear and logarithmic response can be smoothly adjusted by software and is continuously differentiable and monotonic.

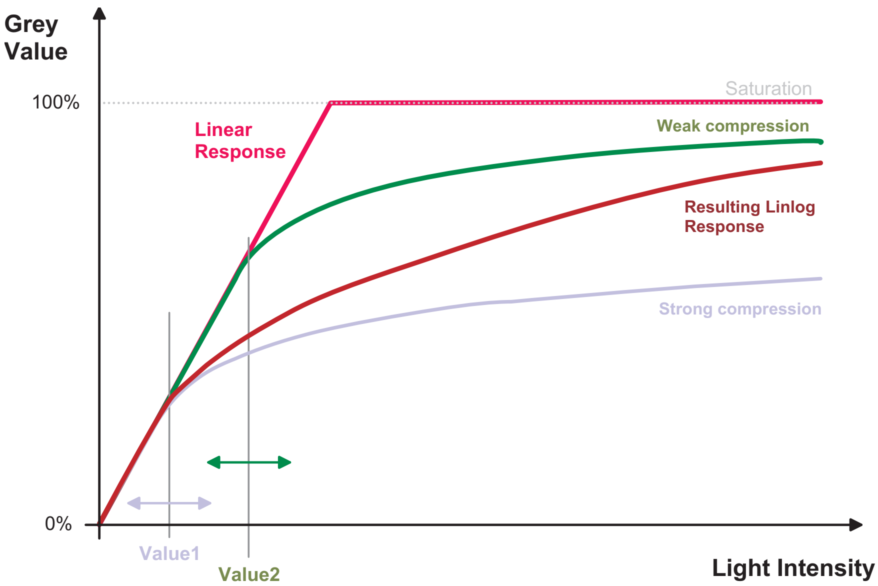


Figure 4.10: Resulting LinLog2 response curve

LinLog® is controlled by up to 4 parameters (`Time1`, `Time2`, `Value1` and `Value2`). `Value1` and `Value2` correspond to the LinLog® voltage that is applied to the sensor. The higher the parameters `Value1` and `Value2` respectively, the stronger the compression for the high light intensities. `Time1`

and Time2 are normalised to the exposure time. They can be set to a maximum value of 1000, which corresponds to the exposure time.
Examples in the following sections illustrate the LinLog® feature.

LinLog1

In the simplest way the pixels are operated with a constant LinLog® voltage which defines the knee point of the transition.This procedure has the drawback that the linear response curve changes directly to a logarithmic curve leading to a poor grey resolution in the logarithmic region (see Fig. 4.12).

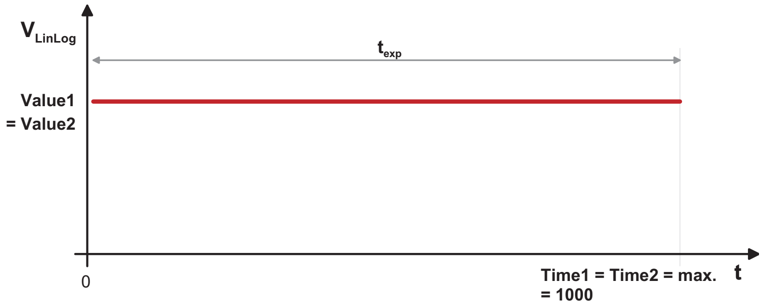


Figure 4.11: Constant LinLog voltage in the Linlog1 mode

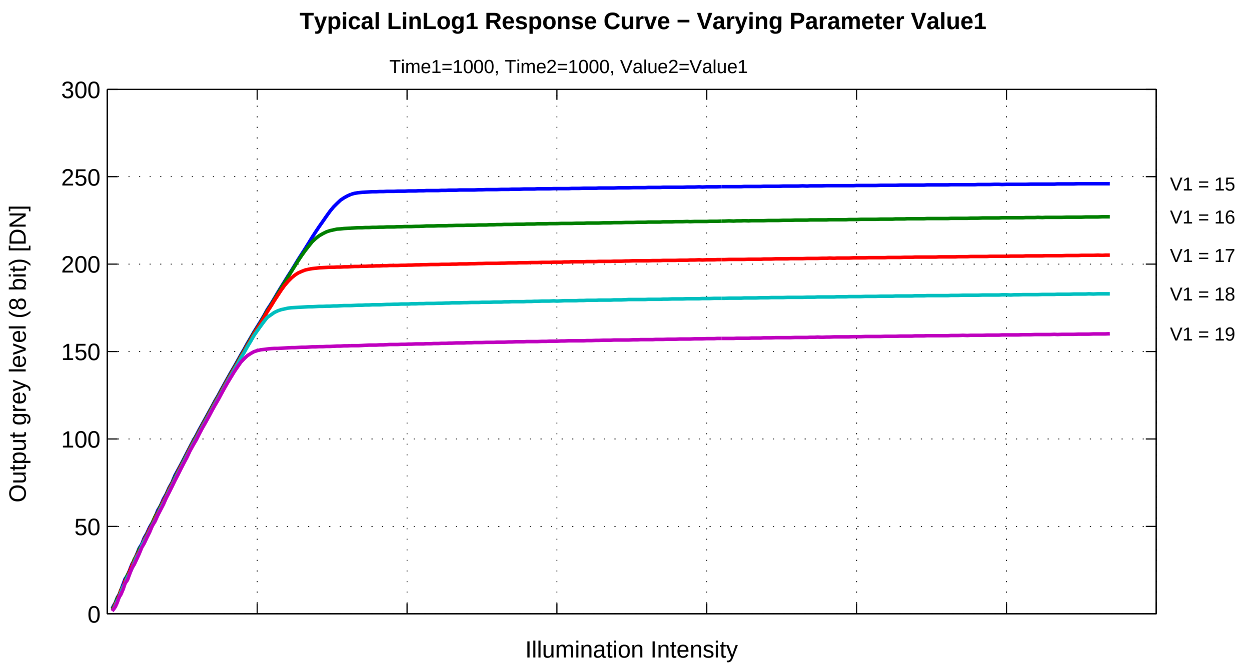


Figure 4.12: Response curve for different LinLog settings in LinLog1 mode

LinLog2

To get more grey resolution in the LinLog® mode, the LinLog2 procedure was developed. In LinLog2 mode a switching between two different logarithmic compressions occurs during the exposure time (see Fig. 4.13). The exposure starts with strong compression with a high LinLog®voltage (`Value1`). At `Time1` the LinLog®voltage is switched to a lower voltage resulting in a weaker compression. This procedure gives a LinLog®response curve with more grey resolution. Fig. 4.14 and Fig. 4.15 show how the response curve is controlled by the three parameters `Value1`, `Value2` and the LinLog®time `Time1`.

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

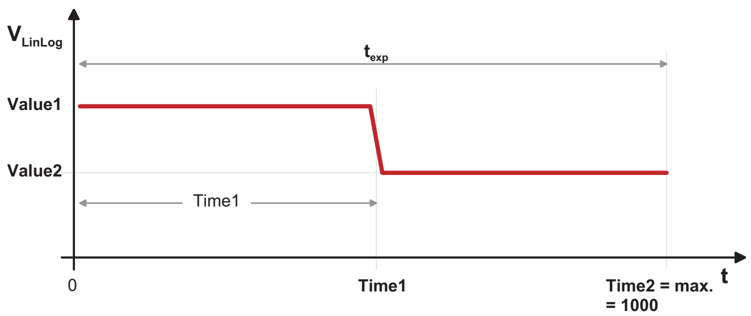


Figure 4.13: Voltage switching in the Linlog2 mode

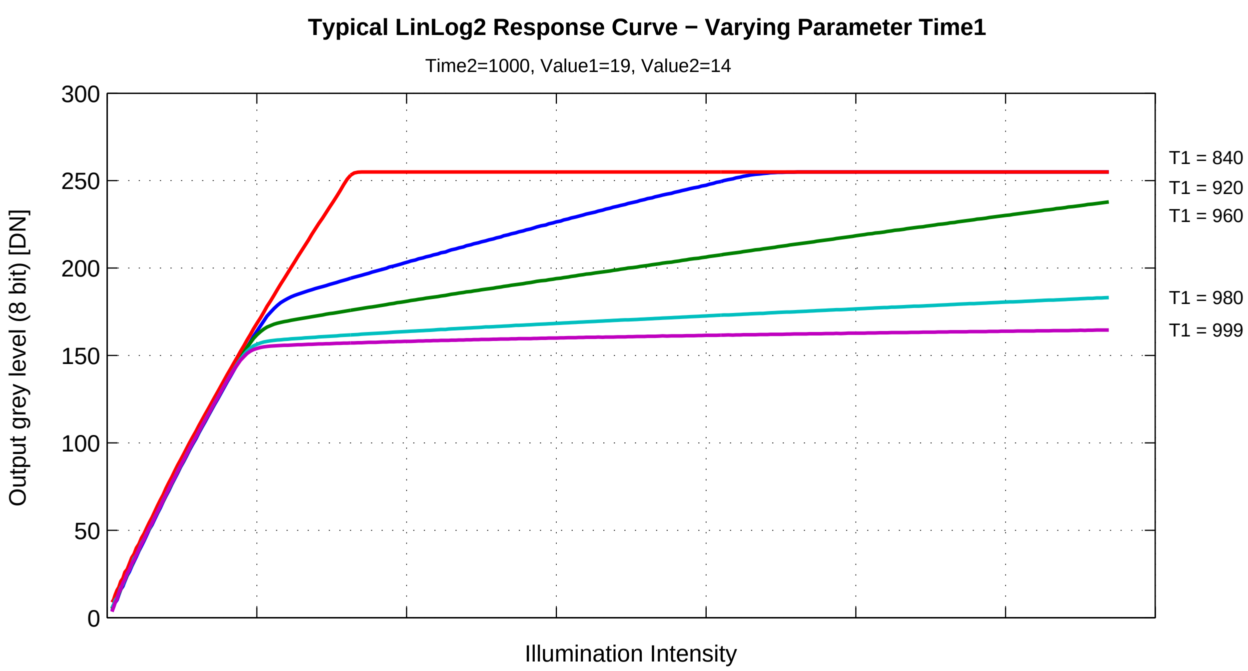


Figure 4.14: Response curve for different LinLog settings in LinLog2 mode

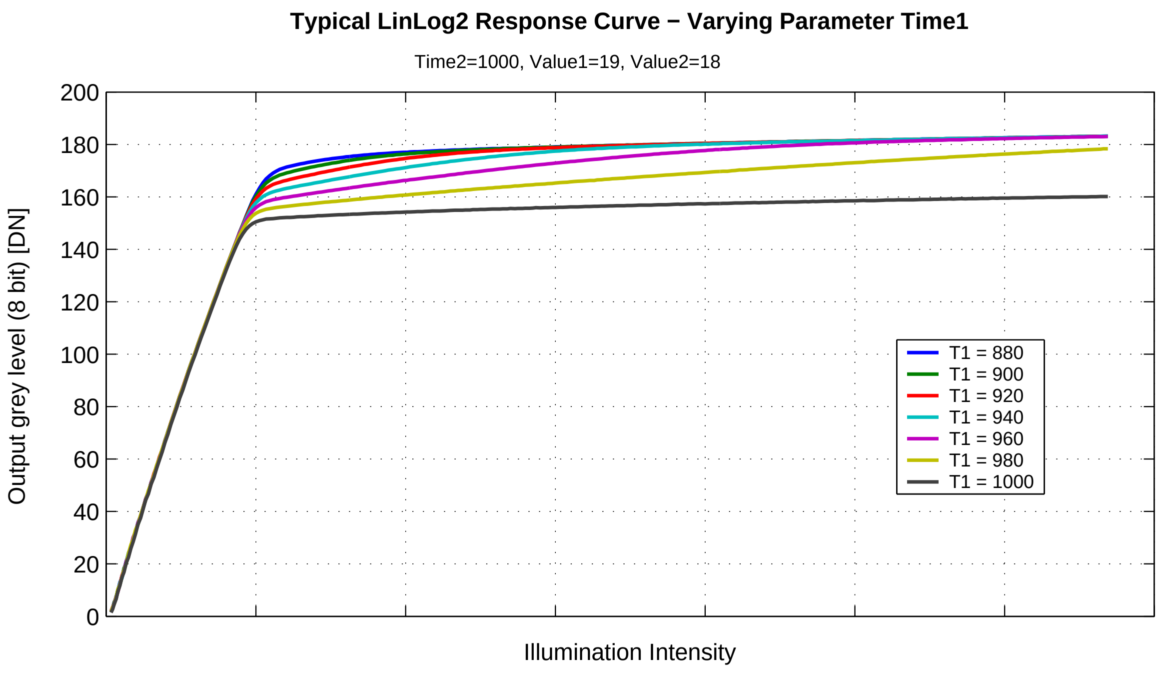


Figure 4.15: Response curve for different LinLog settings in LinLog2 mode

LinLog3

To enable more flexibility the LinLog3 mode with 4 parameters was introduced. Fig. 4.16 shows the timing diagram for the LinLog3 mode and the control parameters.

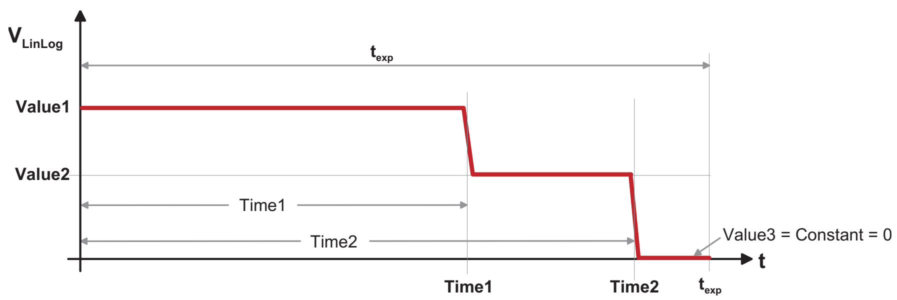


Figure 4.16: Voltage switching in the LinLog3 mode

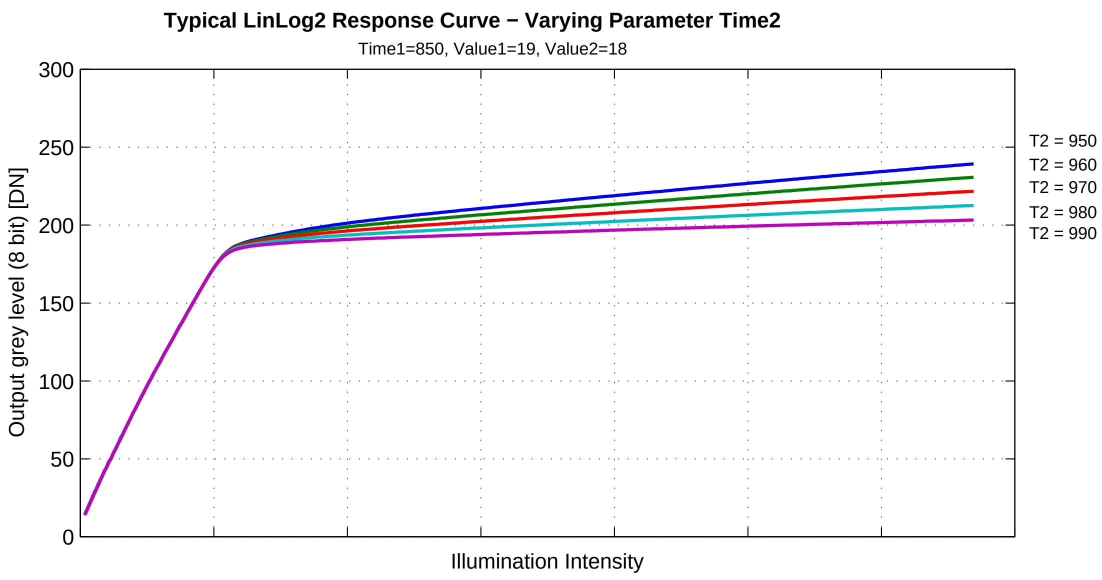


Figure 4.17: Response curve for different LinLog settings in LinLog3 mode

4.3 Reduction of Image Size

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

4.3.1 Region of Interest (ROI)

Some applications do not need full image resolution (e.g. 2080 x 2080 pixels). By reducing the image size to a certain region of interest (ROI), the frame rate can be drastically increased. A region of interest can be almost any rectangular window and is specified by its position within the full frame and its width (W) and height (H). Table 4.3 presents numerical examples of how the frame rate can be increased by reducing the ROI.

☞ Reductions in y-direction result in a higher frame rate. Reduction in x-direction may result in a higher frame rate as the required data bandwidth is lowered.

☞ The ROI width must be a multiple of 2.

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

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

4.3.2 Interface restriction on maximum frame rate

The camera can be operated with settings that exceed the maximal available band width of approx. 108 MB/s on the GigE interface. This will result in lost (dropped) images. The maximal data rate for the GigE interface is:

$$maxFpsIf = \frac{8 \cdot 108 \cdot 10^6}{w \cdot h \cdot bpp}$$

where w=width, h=height and bpp=bits per pixel (see also).
Example: `w`=2080, `h`=2080, `bpp`=8 (8 bit mode): `maxFpsIf` = 24.96 fps. The camera indicates a maximal frame rate of 34.8 fps. If 12 bits (Mono12Packed) is used instead then `maxFpsIf` is reduced to 16.6 fps.
How can the maximal frame rate be decreased to comply with the formula shown before?

- In free-running mode (`TriggerMode`=Off): if `AcquisitionFrameRateMax` is higher than `maxFpsIf`, then set `AcquisitionFrameRateEnable` to `True` and set `AcquisitionFrameRate` to `maxFpsIf`. If `maxFpsIf` is lower than `AcquisitionFrameRateMax`, then `AcquisitionFrameRateEnable` can be set to False to get the maximal frame rate.
- In external triggered mode (`TriggerMode`=On) the applied trigger frequency must not exceed `maxFpsIf` to avoid dropped images.

ROI Dimension [Standard]	MV1-D2080(IE)-160-G2
2080 x 2080 (full resolution)	25 fps
1920 x 1080 (Full HD)	52 fps
1280 x 1024 (SXGA)	70 fps
1280 x 768 (WXGA)	93 fps
800 x 600 (SVGA)	79 fps
640 x 480 (VGA)	119 fps
2080 x 1024	50 fps
2080 x 512	101 fps
2080 x 256	202 fps
2080 x 128	405 fps
2080 x 64	811 fps
2080 x 32	1539 fps
2080 x 16	2317 fps

Table 4.3: Frame rates of different ROI settings that can be achieved in continuous readout (minimal exposure time; correction on, 8 bit data resolution).

4.3.3 Multiple Regions of Interest

The MV1-D2080(IE) camera series can handle up to 512 different regions of interest. This feature can be used to reduce the image data and increase the frame rate. An application example for using multiple regions of interest (MROI) is a laser triangulation system with several laser lines. The multiple ROIs are joined together and form a single image, which is transferred to the frame grabber.
An individual MROI region is defined by its starting value in y-direction and its height. The starting value in horizontal direction and the width is the same for all MROI regions and is defined by the ROI settings. The maximum frame rate in MROI mode depends on the number of rows and columns being read out. Overlapping ROIs are allowed. See Section 4.3.2 for information on the calculation of the maximum frame rate.
Fig. 4.18 compares ROI and MROI: the setups (visualized on the image sensor area) are displayed in the upper half of the drawing. The lower half shows the dimensions of the resulting image. On the left-hand side an example of ROI is shown and on the right-hand side an example of MROI. It can be readily seen that resulting image with MROI is smaller than the resulting image with ROI only and the former will result in an increase in image frame rate.
Fig. 4.19 shows another MROI drawing illustrating the effect of MROI on the image content.
Fig. 4.20 shows an example from hyperspectral imaging where the presence of spectral lines at known regions need to be inspected. By using MROI only a 656x54 region need to be readout and a frame rate of 1050 fps can be achieved. Without using MROI the resulting frame rate would be 40 fps for a 656x1800 ROI.

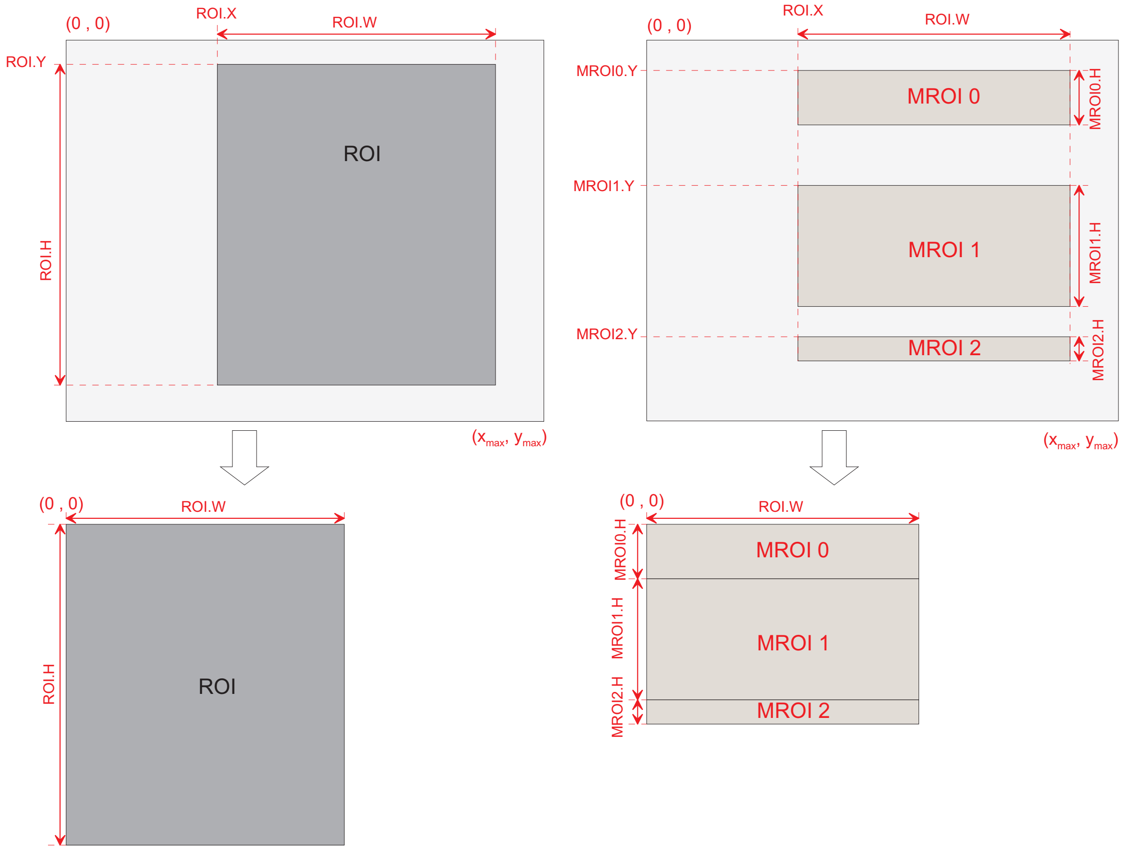


Figure 4.18: Multiple Regions of Interest

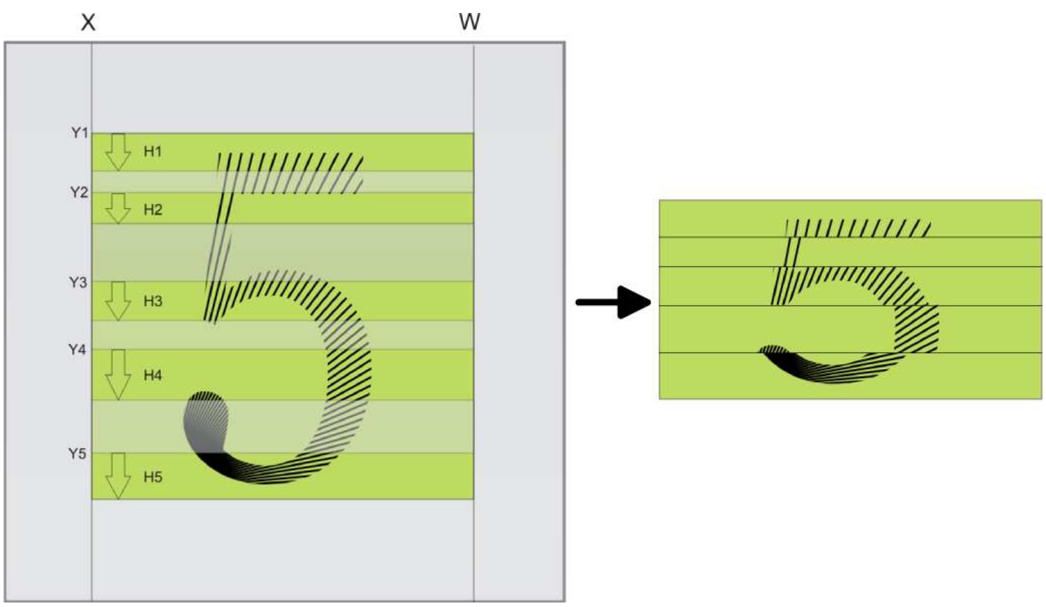


Figure 4.19: Multiple Regions of Interest with 5 ROIs

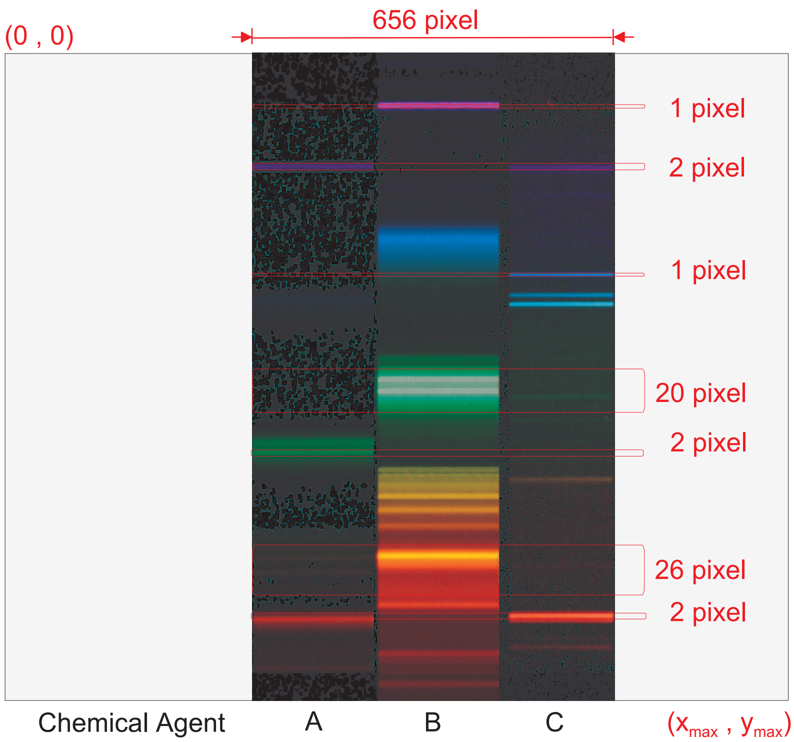


Figure 4.20: Multiple Regions of Interest in hyperspectral imaging

4.3.4 Decimation

Decimation reduces the number of pixels in y-direction. Decimation can also be used together with ROI or MROI. Decimation in y-direction transfers every n^{th}row only and directly results in reduced read-out time and higher frame rate respectively.
Fig. 4.21 shows decimation on the full image. The rows that will be read out are marked by red lines. Row 0 is read out and then every n^{th} row.

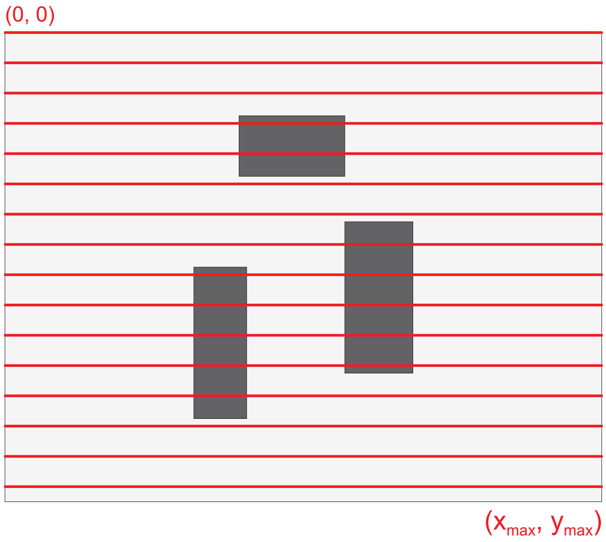


Figure 4.21: Decimation in full image

Fig. 4.22 shows decimation on a ROI. The row specified by the Window.Y setting is first read out and then every n^{th} row until the end of the ROI.

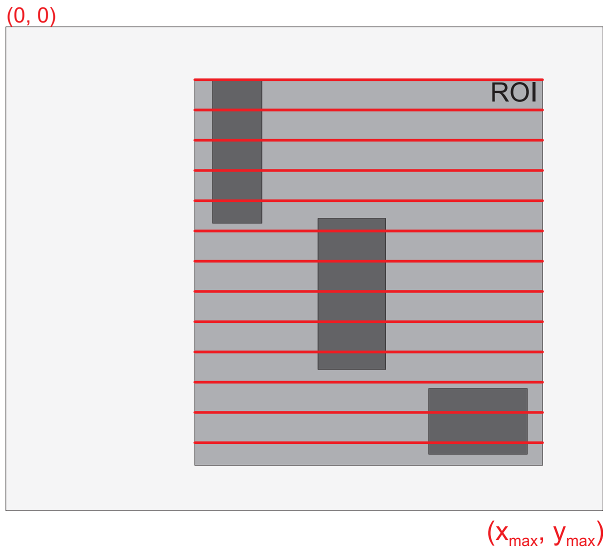


Figure 4.22: Decimation and ROI

Fig. 4.23 shows decimation and MROI. For every MROI region m, the first row read out is the row specified by the MROI<m>.Y setting and then every n^{th} row until the end of MROI region m.

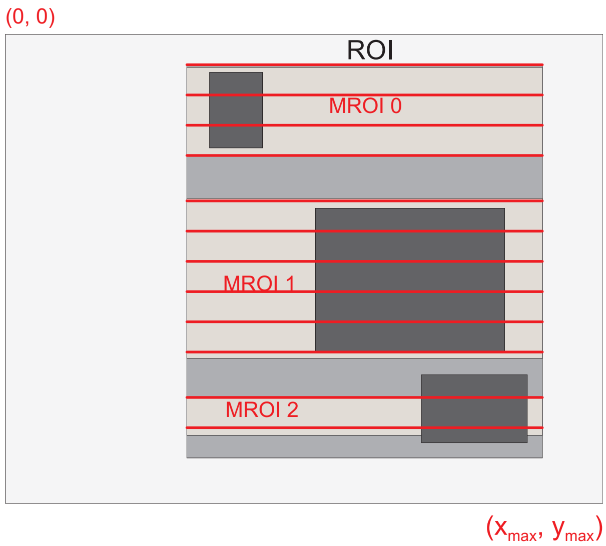


Figure 4.23: Decimation and MROI

The image in Fig. 4.24 on the right-hand side shows the result of decimation 3 of the image on the left-hand side.

Figure 4.24: Image example of decimation 3

An example of a high-speed measurement of the elongation of an injection needle is given in Fig. 4.25. In this application the height information is less important than the width information. Applying decimation 2 on the original image on the left-hand side doubles the resulting frame.

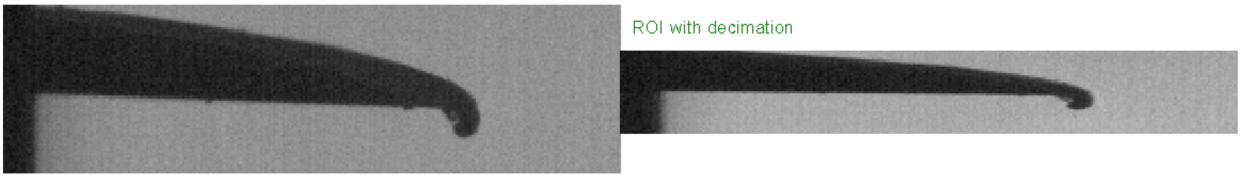


Figure 4.25: Example of decimation 2 on image of injection needle

4.4 Trigger and Strobe

4.4.1 Introduction

The start of the exposure of the camera's image sensor is controlled by the trigger. The trigger can either be generated internally by the camera (free running trigger mode) or by an external device (external trigger mode).
This section refers to the external trigger mode if not otherwise specified.
In external trigger mode, the trigger can be applied through the CameraLink ® interface (interface trigger) or directly by the power supply connector of the camera (I/O Trigger) (see Section 4.4.2). The trigger signal can be configured to be active high or active low. When the frequency of the incoming triggers is higher than the maximal frame rate of the current camera settings, then some trigger pulses will be missed. A missed trigger counter counts these events. This counter can be read out by the user.
The exposure time in external trigger mode can be defined by the setting of the exposure time register (camera controlled exposure mode) or by the width of the incoming trigger pulse (trigger controlled exposure mode) (see Section 4.4.4).
An external trigger pulse starts the exposure of one image. In Burst Trigger Mode however, a trigger pulse starts the exposure of a user defined number of images (see Section 4.4.6).
The start of the exposure is shortly after the active edge of the incoming trigger. An additional trigger delay can be applied that delays the start of the exposure by a user defined time (see Section 4.4.5). This often used to start the exposure after the trigger to a flash lighting source.

4.4.2 Trigger Source

The trigger signal can be configured to be active high or active low by the `TriggerActivation` (category `AcquisitionControl`) property. One of the following trigger sources can be used:

Free running The trigger is generated internally by the camera. Exposure starts immediately after the camera is ready and the maximal possible frame rate is attained, if `AcquisitionFrameRateEnable` is disabled. Settings for free running trigger mode: `TriggerMode` = Off. In Constant Frame Rate mode (`AcquisitionFrameRateEnable` = True), exposure starts after a user-specified time has elapsed from the previous exposure start so that the resulting frame rate is equal to the value of `AcquisitionFrameRate`.

Software Trigger The trigger signal is applied through a software command (`TriggerSoftware` in category `AcquisitionControl`). Settings for Software Trigger mode: `TriggerMode` = On and `TriggerSource` = Software.

Line1 Trigger The trigger signal is applied directly to the camera by the power supply connector through pin ISO_IN1 (see also Section A.1). A setup of this mode is shown in Fig. 4.26 and Fig. 4.27. The electrical interface of the trigger input and the strobe output is described in Section 5.2.3. Settings for Line1 Trigger mode: `TriggerMode` = On and `TriggerSource` = Line1.

PLC_Q4 Trigger The trigger signal is applied by the Q4 output of the PLC (see also Section 5.2.4). Settings for PLC_Q4 Trigger mode: `TriggerMode` = On and `TriggerSource` = PLC_Q4.

☞ Some trigger signals are inverted. A schematic drawing is shown in Fig. 6.4.

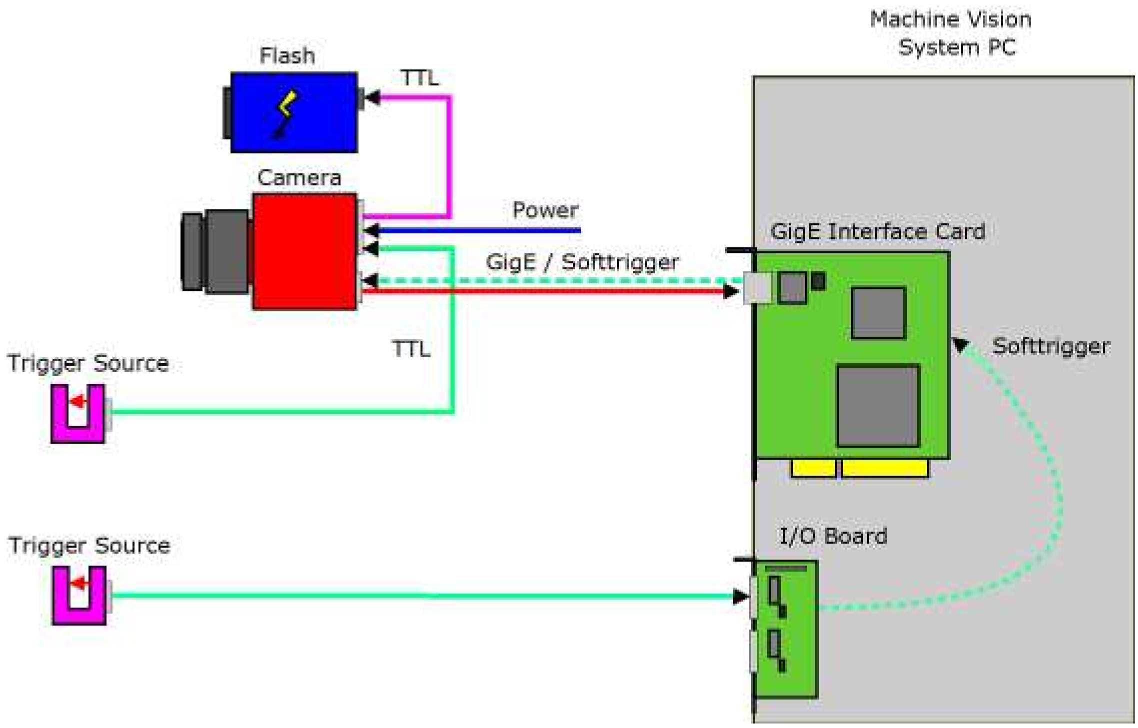


Figure 4.26: Trigger source

4.4.3 Trigger and AcquisitionMode

The relationship between AcquisitionMode and TriggerMode is shown in Table 4.4. When `TriggerMode`=Off, then the frame rate depends on the `AcquisitionFrameRateEnable` property (see also under Free running in Section 4.4.2).

☞ The `ContinuousRecording` and `ContinousReadout` modes can be used if more than one camera is connected to the same network and need to shoot images simultaneously. If all cameras are set to Continuous mode, then all will send the packets at same time resulting in network congestion. A better way would be to set the cameras in `ContinuousRecording` mode and save the images in the memory of the IPEngine. The images can then be claimed with `ContinousReadout` from one camera at a time avoid network collisions and congestion.

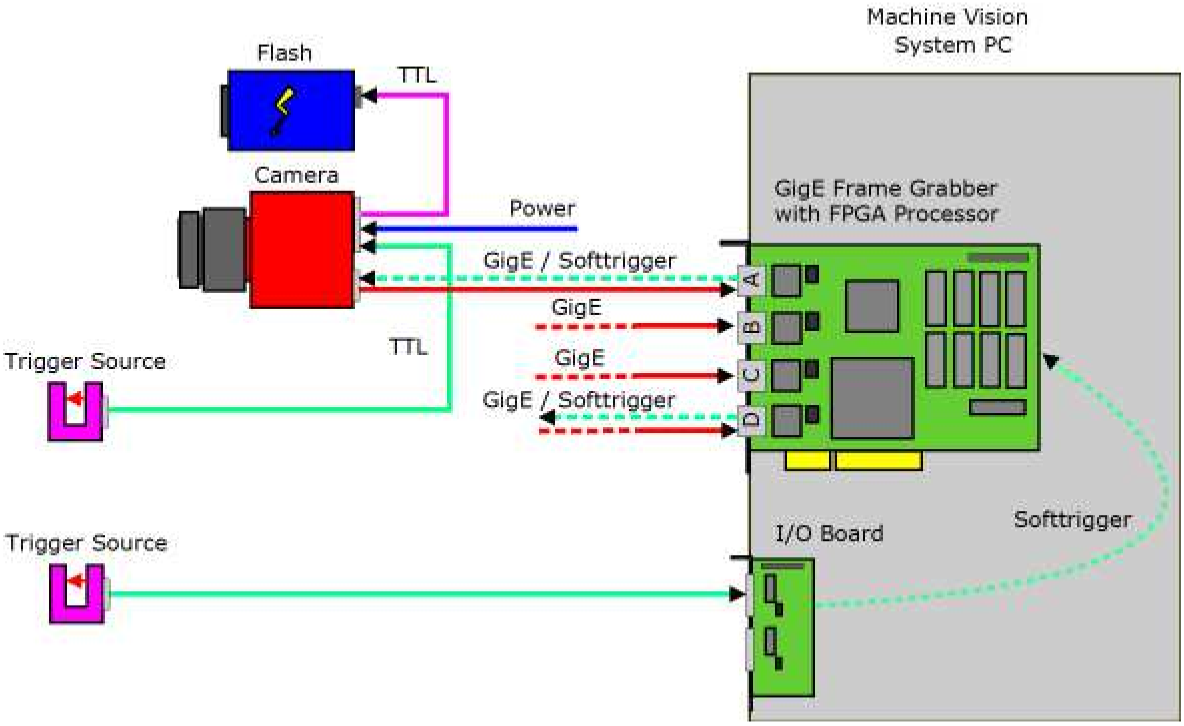


Figure 4.27: Trigger Inputs - Multiple GigE solution

AcquisitionMode	TriggerMode	After the command AcquisitionStart is executed:
Continuous	Off	Camera is in free-running mode. Acquisition can be stopped by executing AcquisitionStop command.
Continuous	On	Camera is ready to accept triggers according to the TriggerSource property. Acquisition and trigger acceptance can be stopped by executing AcquisitionStop command.
SingleFrame	Off	Camera acquires one frame and acquisition stops.
SingleFrame	On	Camera is ready to accept one trigger according to the TriggerSource property. Acquisition and trigger acceptance is stopped after one trigger has been accepted.
MultiFrame	Off	Camera acquires n=AcquisitionFrameCount frames and acquisition stops.
MultiFrame	On	Camera is ready to accept n=AcquisitionFrameCount triggers according to the TriggerSource property. Acquisition and trigger acceptance is stopped after n triggers have been accepted.
SingleFrameRecording	Off	Camera saves one image on the on-board memory of the IP engine.
SingleFrameRecording	On	Camera is ready to accept one trigger according to the TriggerSource property. Trigger acceptance is stopped after one trigger has been accepted and image is saved on the on-board memory of the IP engine.
SingleFrameReadout	don’t care	One image is acquired from the IP engine’s on-board memory. The image must have been saved in the SingleFrameRecording mode.
ContinuousRecording	Off	Camera saves images on the on-board memory of the IP engine until the memory is full.
ContinuousRecording	On	Camera is ready to accept triggers according to the TriggerSource property. Images are saved on the on-board memory of the IP engine until the memory is full. The available memory is 24 MB.
ContinousReadout	don’t care	All Images that have been previously saved by the ContinuousRecording mode are acquired from the IP engine’s on-board memory.

Table 4.4: AcquisitionMode and Trigger

4.4.4 Exposure Time Control

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

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

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

Trigger-controlled exposure time is not available in simultaneous readout mode.

External Trigger with Camera controlled Exposure Time

In the external trigger mode with camera controlled exposure time the rising edge of the trigger pulse starts the camera states machine, which controls the sensor and optional an external strobe output. Fig. 4.28 shows the detailed timing diagram for the external trigger mode with camera controlled exposure time.

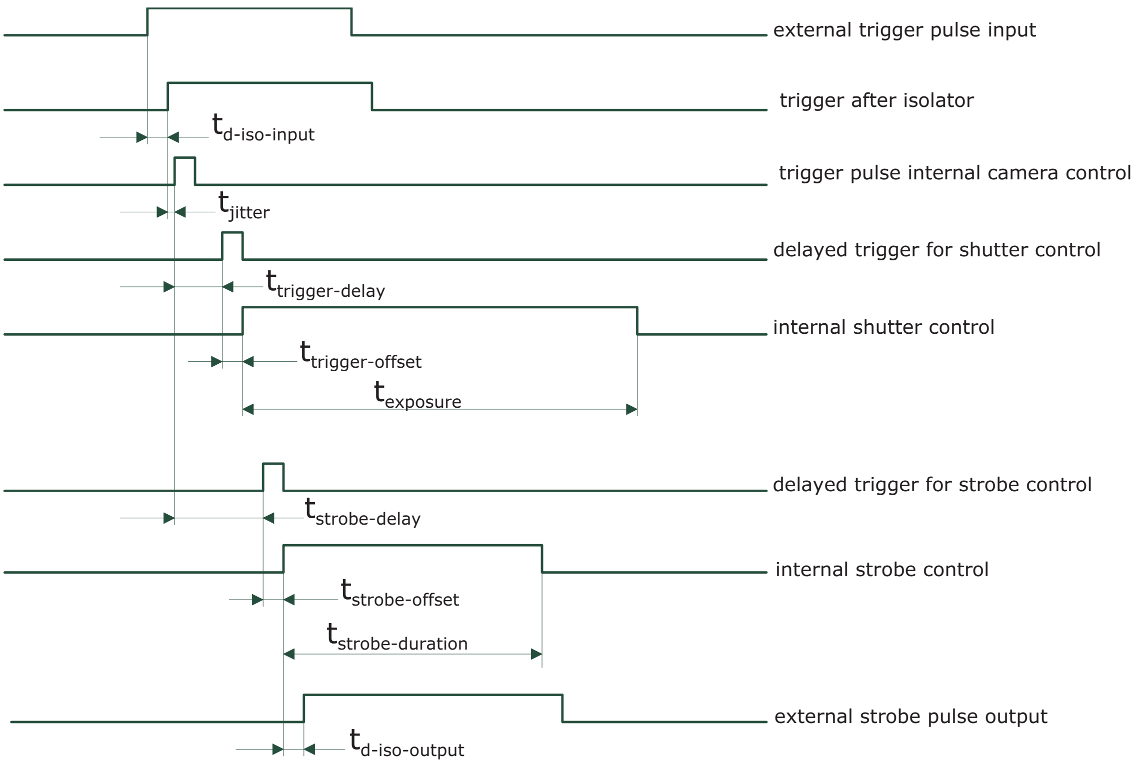


Figure 4.28: Timing diagram for the camera controlled exposure time

The rising edge of the trigger signal is detected in the camera control electronic which is implemented in an FPGA. Before the trigger signal reaches the FPGA it is isolated from the

camera environment to allow robust integration of the camera into the vision system. In the signal isolator the trigger signal is delayed by time $t_{d-iso-input}$. This signal is clocked into the FPGA which leads to a jitter of t_{jitter}. The pulse can be delayed by the time $t_{trigger-delay}$ which can be configured by a user defined value via camera software. The trigger offset delay $t_{trigger-offset}$ results then from the synchronous design of the FPGA state machines. The exposure time $t_{exposure}$ is controlled with an internal exposure time controller.
The trigger pulse from the internal camera control starts also the strobe control state machines. The strobe can be delayed by $t_{strobe-delay}$ with an internal counter which can be controlled by the customer via software settings. The strobe offset delay $t_{strobe-delay}$ results then from the synchronous design of the FPGA state machines. A second counter determines the strobe duration $t_{strobe-duration}$(strobe-duration). For a robust system design the strobe output is also isolated from the camera electronic which leads to an additional delay of $t_{d-iso-output}$. Section 4.4.6 gives an overview over the minimum and maximum values of the parameters.

External Trigger with Pulsewidth controlled Exposure Time

In the external trigger mode with Pulsewidth controlled exposure time the rising edge of the trigger pulse starts the camera states machine, which controls the sensor. The falling edge of the trigger pulse stops the image acquisition. Additionally the optional external strobe output is controlled by the rising edge of the trigger pulse. Timing diagram Fig. 4.29 shows the detailed timing for the external trigger mode with pulse width controlled exposure time.

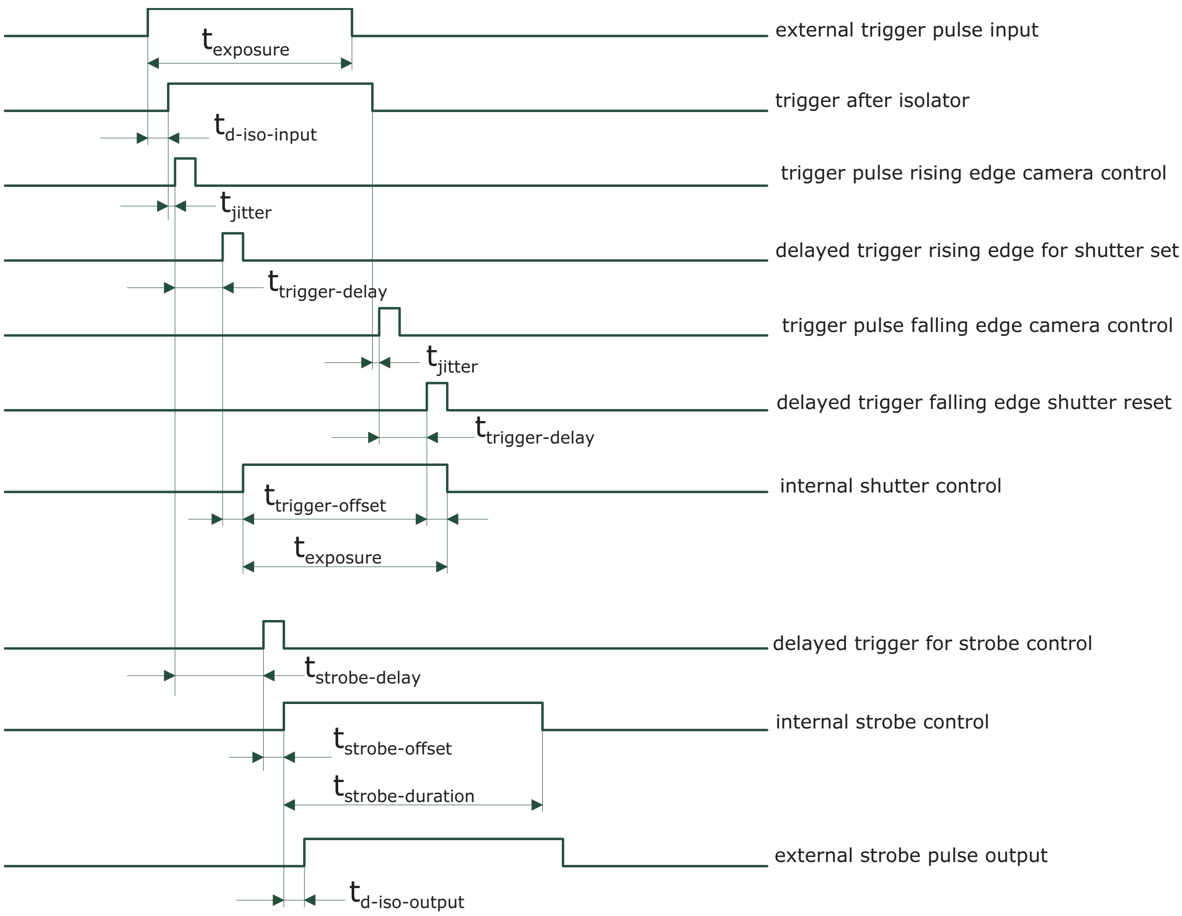


Figure 4.29: Timing diagram for the Pulsewidth controlled exposure time

The timing of the rising edge of the trigger pulse until to the start of exposure and strobe is equal to the timing of the camera controlled exposure time (see Section 4.4.4). In this mode however the end of the exposure is controlled by the falling edge of the trigger Pulsewidth: The falling edge of the trigger pulse is delayed by the time $t_{d-iso-input}$ which is results from the signal isolator. This signal is clocked into the FPGA which leads to a jitter of t_{jitter}. The pulse is then delayed by $t_{trigger-delay}$ by the user defined value which can be configured via camera software. After the trigger offset time $t_{trigger-offset}$ the exposure is stopped.

4.4.5 Trigger Delay

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

4.4.6 Burst Trigger

The camera includes a burst trigger engine. When enabled, it starts a predefined number of acquisitions after one single trigger pulse. The time between two acquisitions and the number of acquisitions can be configured by a user defined value via the camera software. The burst trigger feature works only in the mode "Camera controlled Exposure Time".
The burst trigger signal can be configured to be active high or active low. When the frequency of the incoming burst triggers is higher than the duration of the programmed burst sequence, then some trigger pulses will be missed. A missed burst trigger counter counts these events. This counter can be read out by the user.
The burst trigger mode is only available when `TriggerMode`=On. Trigger source is determined by the `TriggerSource` property.
The timing diagram of the burst trigger mode is shown in Fig. 4.30.

4.4.7 Strobe Outputs

There are two isolated outputs on the power supply connector that can be used to trigger external devices, such as a strobe device or another camera (see also Section 5.2.3 and Section 6.10):

ISO_OUT0 / Strobe: The strobe output can be used both in free-running and in trigger mode. It is triggered by the internal trigger. The pulse width can be adjusted with `Strobe_PulseWidth` and There is a programmable delay `Strobe_Delay` available to adjust the strobe pulse to your application.

ISO_OUT1: This output is connected to the PLC Q1 output (see also Section 6.10).

☞ The ISO outputs need a separate power supply. Please see Section 5.2.3, Fig. 4.26 and Fig. 4.27 for more information.

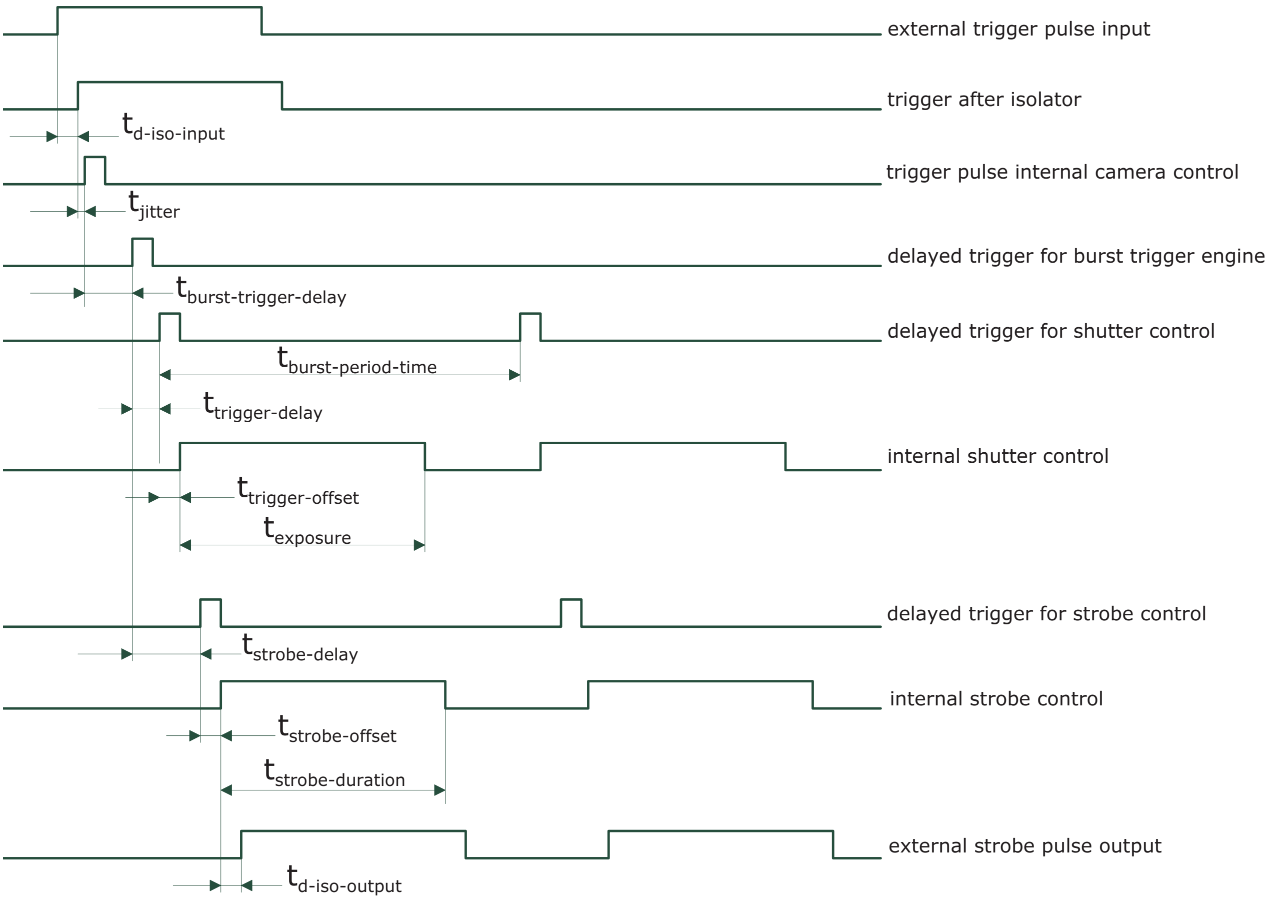


Figure 4.30: Timing diagram for the burst trigger mode

	MV1-D2080(IE)-160-G2	MV1-D2080(IE)-160-G2
Timing Parameter	**Minimum**	**Maximum**
$t_{d-iso-input}$	1 μs	1.5 μs
$t_{d-RS422-input}$	65 ns	185 ns
t_{jitter}	0	25 ns
$t_{trigger-delay}$	0	0.42 s
$t_{burst-trigger-delay}$	0	0.42 s
$t_{burst-period-time}$	depends on camera settings	0.42 s
$t_{trigger-offset}$ (non burst mode)	100 ns	duration of 1 row
$t_{trigger-offset}$ (burst mode)	125 ns	125 ns
$t_{exposure}$	10 μs	0.42 s
$t_{strobe-delay}$	600 ns	0.42 s
$t_{strobe-offset}$ (non burst mode)	100 ns	100 ns
$t_{strobe-offset}$ (burst mode)	125 ns	125 ns
$t_{strobe-duration}$	200 ns	0.42 s
$t_{d-iso-output}$	150 ns	350 ns
$t_{trigger-pulsewidth}$	200 ns	n/a
Number of bursts n	1	30000

Table 4.5: Summary of timing parameters relevant in the external trigger mode using camera MV1-D2080(IE)-160-G2

4.5 Data Path Overview

The data path is the path of the image from the output of the image sensor to the output of the camera. The sequence of blocks is shown in figure Fig. 4.31.

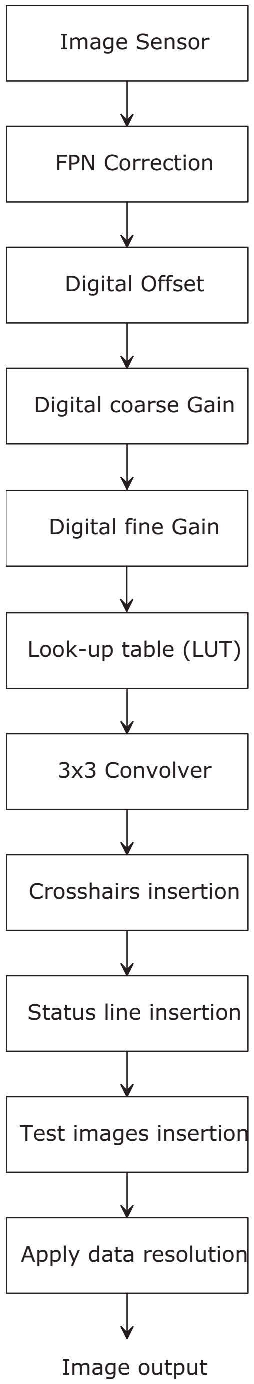


Figure 4.31: camera data path

4.6 Image Correction

4.6.1 Overview

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

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

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

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

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

4.6.2 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 1008 DN (@ 12 bit) as hot pixels.
4. Store the result in the camera as the offset correction matrix.
5. During image acquisition, subtract the correction matrix from the acquired image and interpolate the hot pixels (see Section 4.6.2).

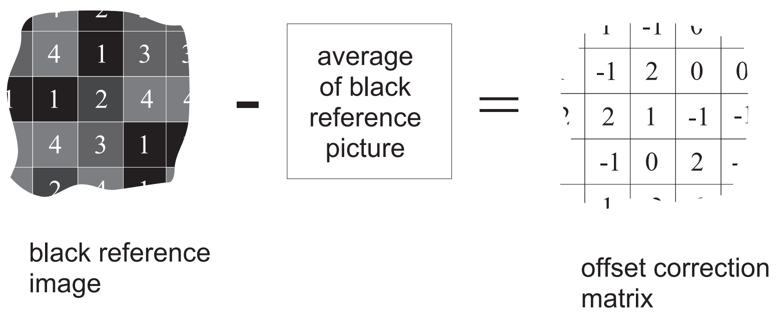


Figure 4.32: Schematic presentation of the offset correction algorithm

How to Obtain a Black Reference Image

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

The detailed procedure to set the black reference image is described in Section 6.5.

- The black reference image must be obtained at no illumination, e.g. with lens aperture closed or closed lens opening.
- It may be necessary to adjust the black level offset of the camera. In the histogram of the black reference image, ideally there are no grey levels at value 0 DN after adjustment of the black level offset. All pixels that are saturated black (0 DN) will not be properly corrected (see Fig. 4.33). The peak in the histogram should be well below the hot pixel threshold of 1008 DN @ 12 bit.
- Camera settings may influence the grey level. Therefore, for best results the camera settings of the black reference image must be identical with the camera settings of the image to be corrected.

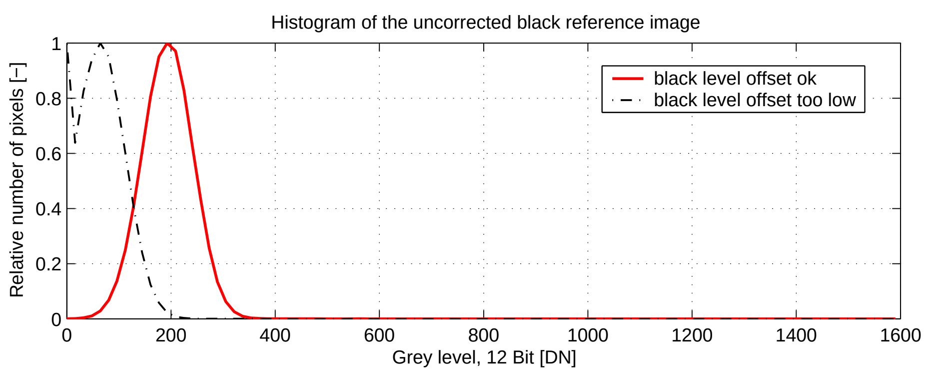


Figure 4.33: Histogram of a proper black reference image for offset correction

Hot pixel correction

Every pixel that exceeds a certain threshold in the black reference image is marked as a hot pixel. If the hot pixel correction is switched on, the camera replaces the value of a hot pixel by an average of its neighbour pixels (see Fig. 4.34).

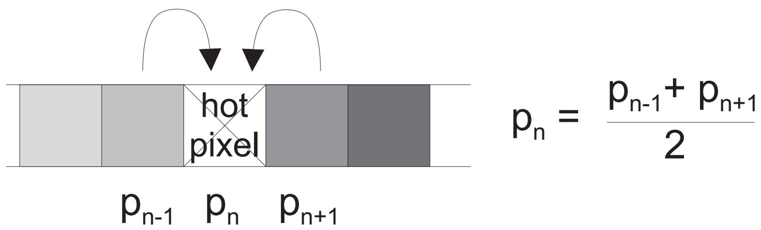


Figure 4.34: Hot pixel interpolation

4.6.3 Gain Correction

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

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

Gain correction algorithm

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

1. Determine the average value of the grey reference image.
2. Subtract the offset correction matrix from the grey reference image.
3. Divide the average value by the offset corrected grey reference image.
4. Pixels that have a grey level higher than a certain threshold are marked as hot pixels.
5. Store the result in the camera as the gain correction matrix.
6. During image acquisition, multiply the gain correction matrix from the offset-corrected acquired image and interpolate the hot pixels (see Section 4.6.2).

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

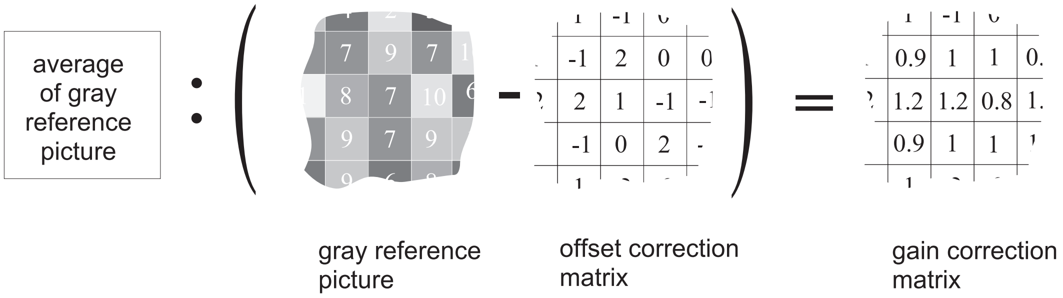


Figure 4.35: Schematic presentation of the gain correction algorithm

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 detailed procedure to set the grey reference image is described in Section 6.5.

- 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 (4095 DN @ 12 bit). All pixels that are saturated white will not be properly corrected (see Fig. 4.36).
- 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.

4.6.4 Corrected Image

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

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

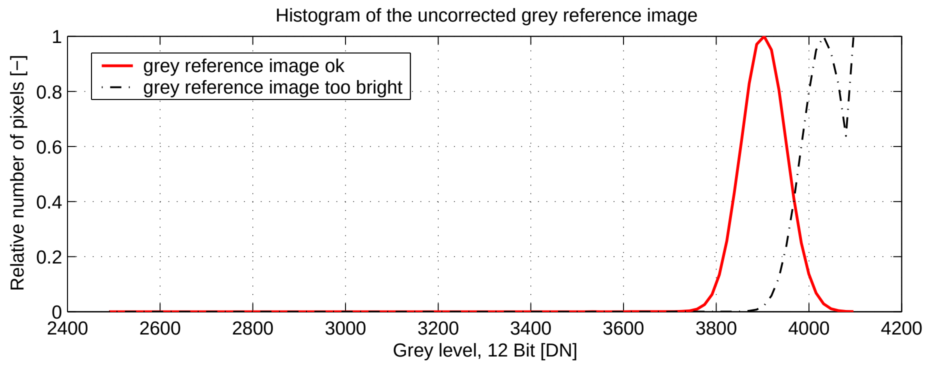


Figure 4.36: Proper grey reference image for gain correction

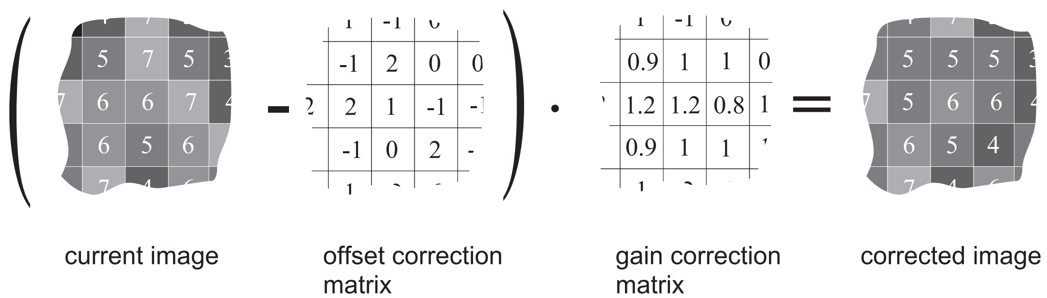


Figure 4.37: Schematic presentation of the corrected image using gain correction algorithm

In addition, the black reference image and grey reference image that are currently stored in the camera RAM can be output.
Table 4.6 shows the minimum and maximum values of the correction matrices, i.e. the range that the offset and gain algorithm can correct.

	Minimum	**Maximum**
Offset correction	-1023 DN @ 12 bit	+1023 DN @ 12 bit
Gain correction	0.42	2.67

Table 4.6: Offset and gain correction ranges

4.7 Digital Gain and Offset

There are two different gain settings on the camera:

Gain (Digital Fine Gain) Digital fine gain accepts fractional values from 0.01 up to 15.99. It is implemented as a multiplication operation.

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

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

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

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

4.8 Grey Level Transformation (LUT)

Grey level transformation is remapping of the grey level values of an input image to new values. The look-up table (LUT) is used to convert the greyscale value of each pixel in an image into another grey value. It is typically used to implement a transfer curve for contrast expansion. The camera performs a 12-to-8-bit mapping, so that 4096 input grey levels can be mapped to 256 output grey levels. The use of the three available modes is explained in the next sections. Two LUT and a Region-LUT feature are available in the MV1-D2080 camera series (see Section 4.8.4).

☞ For MV1-D2080-240 camera series, bits 0 & 1 of the LUT input are fixed to 0.

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

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

Some commonly used transfer curves are shown in Fig. 4.38. Line a denotes a negative or inverse transformation, line b enhances the image contrast between grey values x0 and x1. Line c shows brightness thresholding and the result is an image with only black and white grey levels. and line d applies a gamma correction (see also Section 4.8.2).

4.8.1 Gain

The 'Gain' mode performs a digital, linear amplification with clamping (see Fig. 4.39). It is configurable in the range from 1.0 to 4.0 (e.g. 1.234).

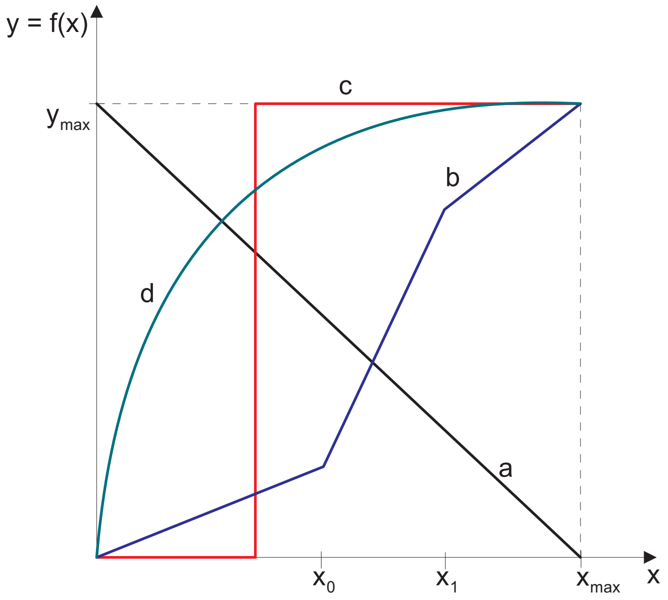


Figure 4.38: Commonly used LUT transfer curves

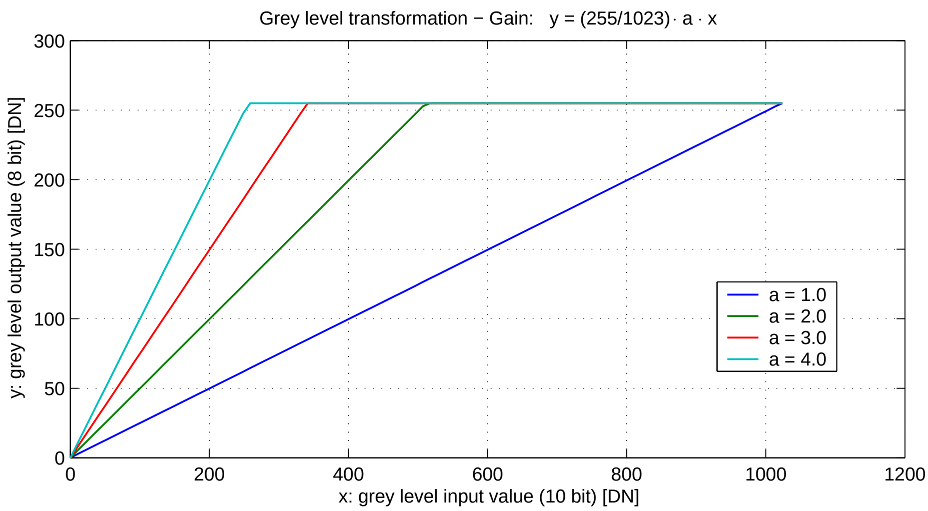


Figure 4.39: Applying a linear gain with clamping to an image

4.8.2 Gamma

The 'Gamma' mode performs an exponential amplification, configurable in the range from 0.4 to 4.0. Gamma > 1.0 results in an attenuation of the image (see Fig. 4.40), gamma < 1.0 results in an amplification (see Fig. 4.41). Gamma correction is often used for tone mapping and better display of results on monitor screens.

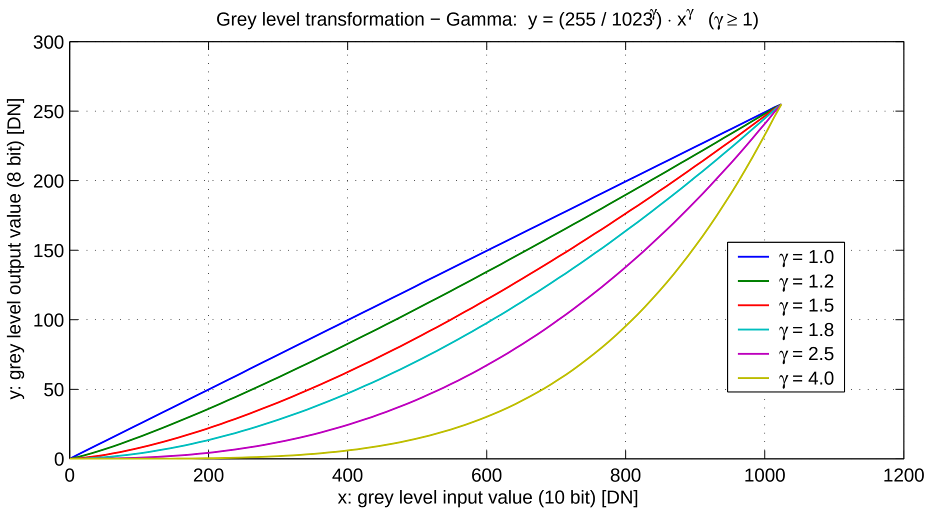


Figure 4.40: Applying gamma correction to an image (gamma > 1)

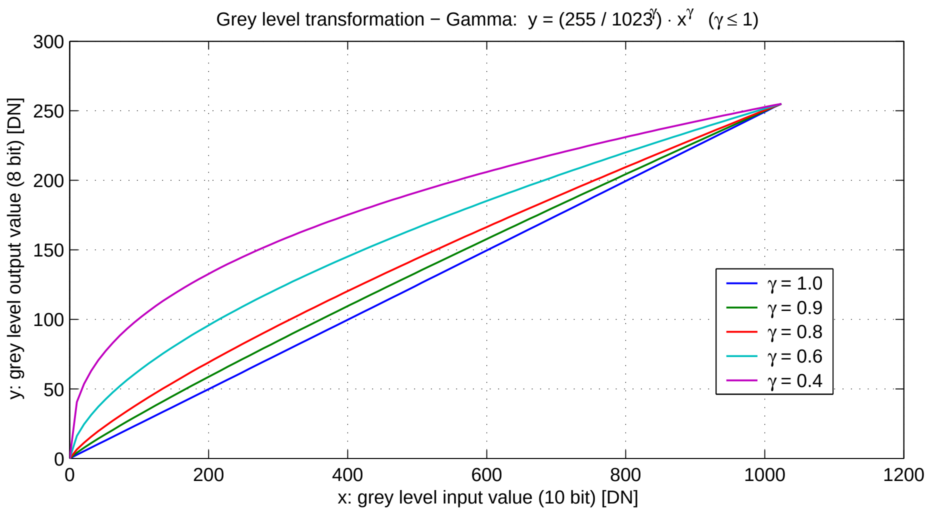


Figure 4.41: Applying gamma correction to an image (gamma < 1)

4.8.3 User-defined Look-up Table

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

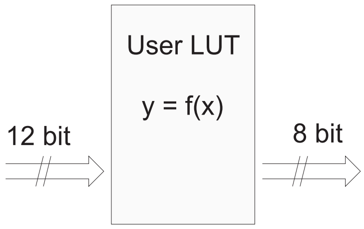


Figure 4.42: Data path through LUT

4.8.4 Region LUT and LUT Enable

Two LUTs and a Region-LUT feature are available in the MV1-D2080(IE) camera series. Both LUTs can be enabled independently (see Table 4.7). LUT 0 superseds LUT1.
When Region-LUT feature is enabled, then the LUTs are only active in a user defined region. Examples are shown in Fig. 4.43 and Fig. 4.44.
Fig. 4.43 shows an example of overlapping Region-LUTs. LUT 0, LUT 1 and Region LUT are enabled. LUT 0 is active in region 0 ((x00, x01), (y00, y01)) and it supersedes LUT 1 in the overlapping region. LUT 1 is active in region 1 ((x10, x11), (y10, y11)).
Fig. 4.44 shows an example of keyhole inspection in a laser welding application. LUT 0 and LUT 1 are used to enhance the contrast by applying optimized transfer curves to the individual regions. LUT 0 is used for keyhole inspection. LUT 1 is optimized for seam finding.
Fig. 4.45 shows the application of the Region-LUT to a camera image. The original image without image processing is shown on the left-hand side. The result of the application of the Region-LUT is shown on the right-hand side. One Region-LUT was applied on a small region on the lower part of the image where the brightness has been increased.

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

Table 4.7: LUT Enable and Region LUT

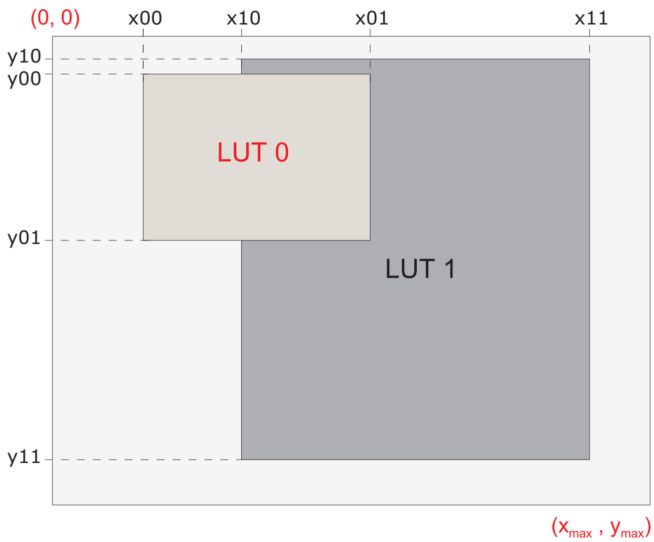


Figure 4.43: Overlapping Region-LUT example

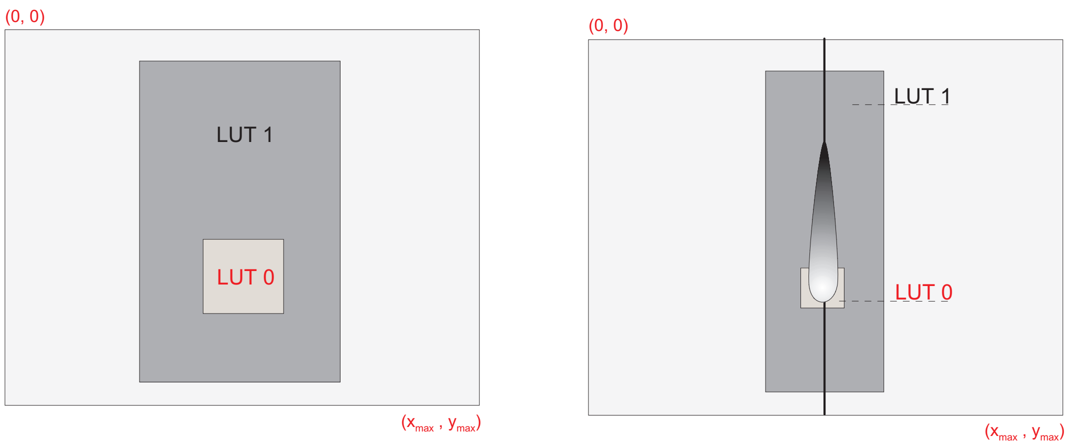


Figure 4.44: Region-LUT in keyhole inspection

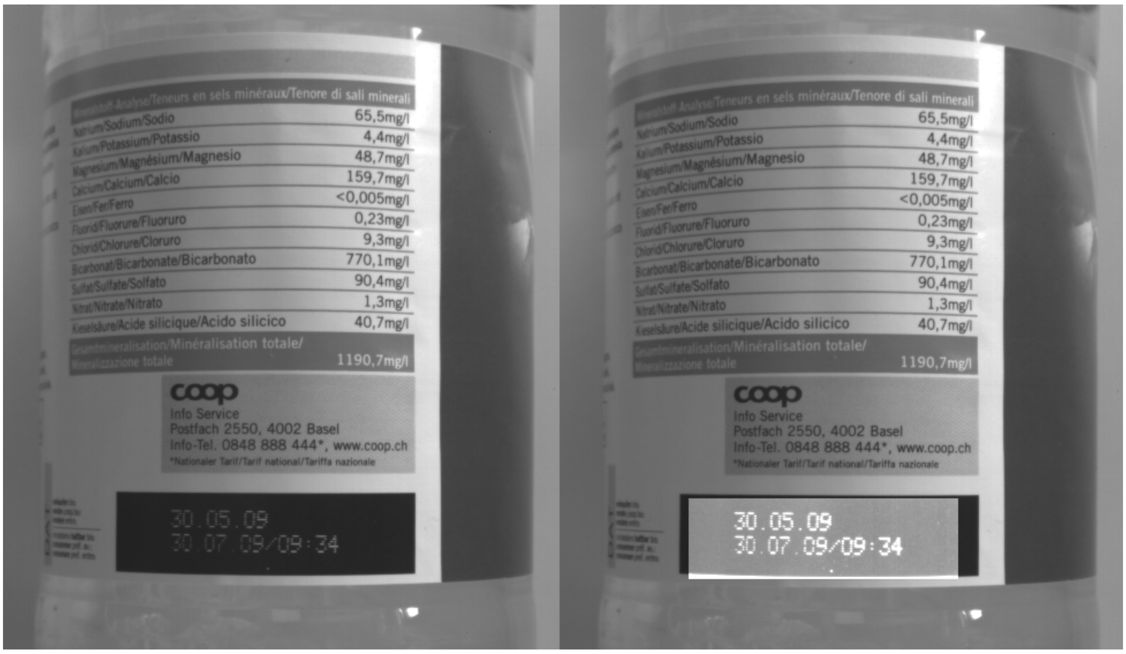


Figure 4.45: Region-LUT example with camera image; left: original image; right: gain 4 region in the are of the date print of the bottle

4.9 Convolver

4.9.1 Functionality

The "Convolver" is a discrete 2D-convolution filter with a 3x3 convolution kernel. The kernel coefficients can be user-defined.
The M x N discrete 2D-convolution p_{out}(x,y) of pixel p_{in}(x,y) with convolution kernel h, scale s and offset o is defined in Fig. 4.46.

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

Figure 4.46: Convolution formula

4.9.2 Settings

The following settings for the parameters are available:

Offset Offset value o (see Fig. 4.46). Range: -4096 ... 4095

Scale Scaling divisor s (see Fig. 4.46). Range: 1 ... 4095

Coefficients Coefficients of convolution kernel h (see Fig. 4.46). Range: -4096 ... 4095. Assignment to coefficient properties is shown in Fig. 4.47.

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

Figure 4.47: Convolution coefficients assignment

4.9.3 Examples

Fig. 4.48 shows the result of the application of various standard convolver settings to the original image. shows the corresponding settings for every filter.
A filter called `Unsharp Mask` is often used to enhance near infrared images. Fig. 4.50 shows examples with the corresponding settings.

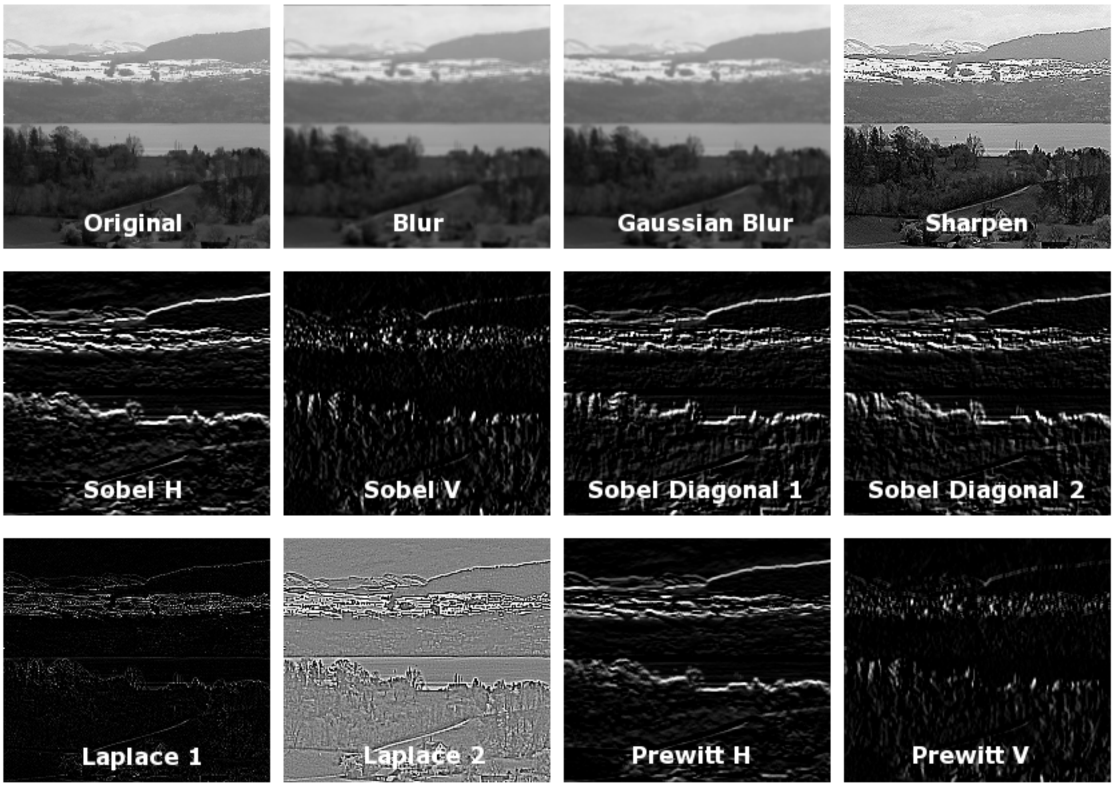
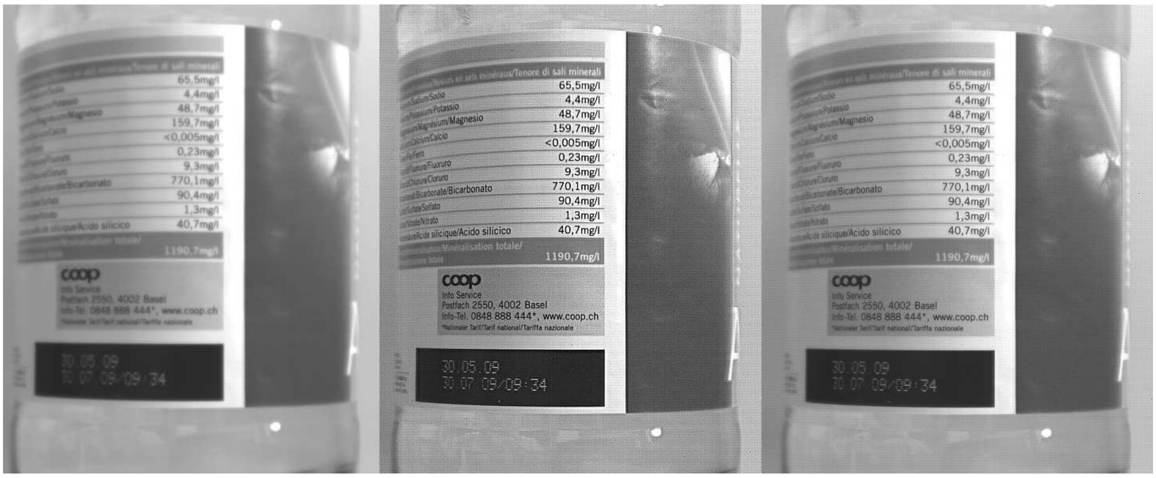


Figure 4.48: 3x3 Convolution filter examples 1

Original Offset = 0 Scale = 1 $\begin{bmatrix}0&0&0\\0&1&0\\0&0&0\end{bmatrix}$	**Blur** Offset = 0 Scale = 9 $\begin{bmatrix}1&1&1\\1&1&1\\1&1&1\end{bmatrix}$	**Gaussian Blur** Offset = 0 Scale = 16 $\begin{bmatrix}1&2&1\\2&4&2\\1&2&1\end{bmatrix}$	**Sharpen** Offset = 0 Scale = 1 $\begin{bmatrix}0&-1&0\\-1&5&-1\\0&-1&0\end{bmatrix}$
Sobel H Offset = 0 Scale = 1 $\begin{bmatrix}1&2&1\\0&0&0\\-1&-2&-1\end{bmatrix}$	**Sobel V** Offset = 0 Scale = 1 $\begin{bmatrix}1&0&-1\\2&0&-2\\1&0&-1\end{bmatrix}$	**Sobel Diagonal 1** Offset = 0 Scale = 1 $\begin{bmatrix}2&1&0\\1&0&-1\\0&-1&-2\end{bmatrix}$	**Sobel Diagonal 2** Offset = 0 Scale = 1 $\begin{bmatrix}0&1&2\\-1&0&1\\-2&-1&0\end{bmatrix}$
Laplace 1 Offset = 0 Scale = 1 $\begin{bmatrix}0&-1&0\\-1&4&-1\\0&-1&0\end{bmatrix}$	**Laplace 2** Offset = 128 Scale = 1 $\begin{bmatrix}-1&-1&-1\\-1&8&-1\\-1&-1&-1\end{bmatrix}$	**Prewitt H** Offset = 0 Scale = 1 $\begin{bmatrix}1&1&1\\0&0&0\\-1&-1&-1\end{bmatrix}$	**Prewitt V** Offset = 0 Scale = 1 $\begin{bmatrix}1&0&-1\\1&0&-1\\1&0&-1\end{bmatrix}$

Figure 4.49: 3x3 Convolution filter examples 1 settings



Original image

Unsharp mask
Offset = 0
Scale = 1

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Unsharp mask with Gaussian
Offset = 0
Scale = 6

$$\begin{bmatrix} -1 & -4 & -1 \\ -4 & 26 & -4 \\ -1 & -4 & -1 \end{bmatrix}$$

Figure 4.50: Unsharp Mask Examples

4.10 Crosshairs

4.10.1 Functionality

The crosshairs inserts a vertical and horizontal line into the image. The width of these lines is one pixel. The grey level is defined by a 12 bit value (0 means black, 4095 means white). This allows to set any grey level to get the maximum contrast depending on the acquired image. The x/y position and the grey level can be set via the camera software. Figure Fig. 4.51 shows two examples of the activated crosshairs with different grey values. One with white lines and the other with black lines.

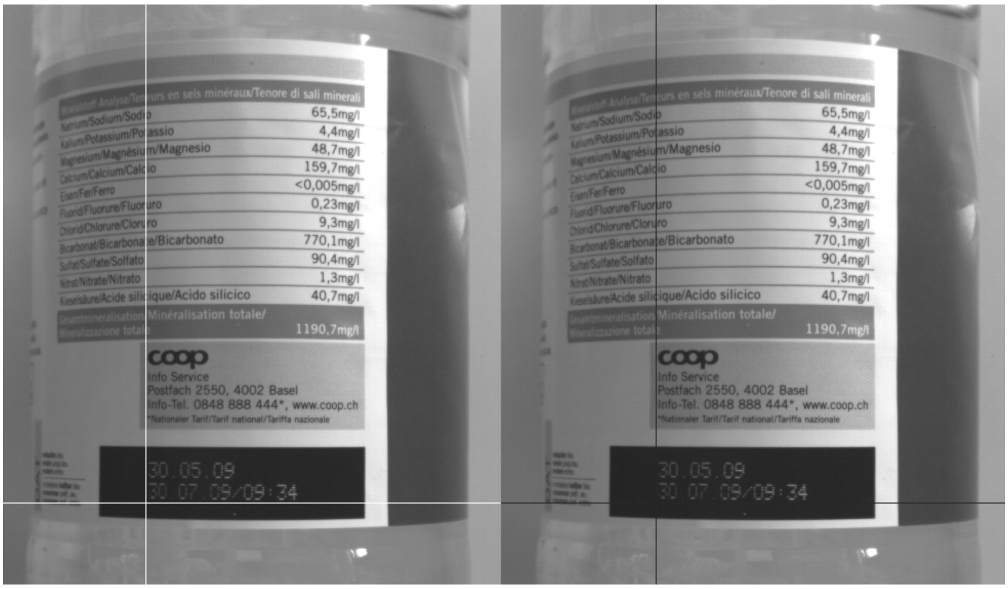


Figure 4.51: Crosshairs Example with different grey values

The x- and y-positon is absolute to the sensor pixel matrix. It is independent on the ROI, MROI or decimation configurations. Figure Fig. 4.52 shows two situations of the crosshairs configuration. The same MROI settings is used in both situations. The crosshairs however is set differently. The crosshairs is not seen in the image on the right, because the x- and y-position is set outside the MROI region.

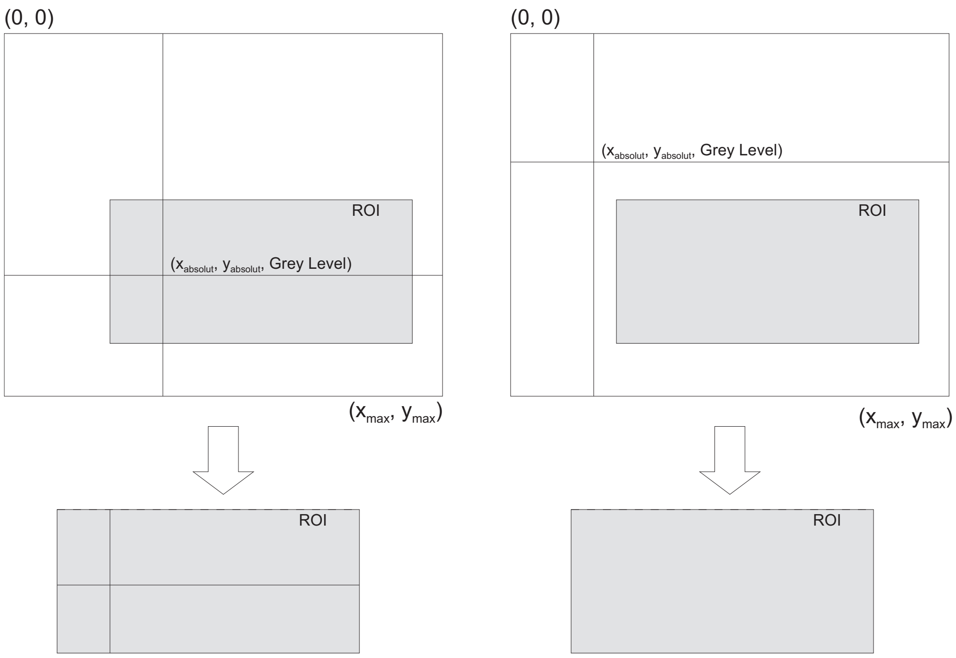


Figure 4.52: Crosshairs absolute position

4.11 Image Information and Status Line

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

4.11.1 Counters and Average Value

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

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

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

Missed burst trigger counter The missed burst trigger counter counts trigger pulses that were ignored by the camera in the burst trigger mode because they occurred while the camera still was processing the current burst trigger sequence.

Average image value The average image value gives the average of an image in 12 bit format (0 .. 4095 DN), regardless of the currently used grey level resolution.

4.11.2 Status Line

If enabled, the status line replaces the last row of the image with camera status information. Every parameter is coded into fields of 4 pixels (LSB first) and uses the lower 8 bits of the pixel value, so that the total size of a parameter field is 32 bit (see Fig. 4.53). The assignment of the parameters to the fields is listed in Table 4.8.

The status line is available in all camera modes.

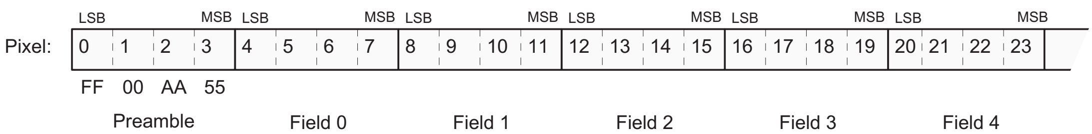


Figure 4.53: Status line parameters replace the last row of the image

Start pixel index	Parameter width [bit]	Parameter Description
0	32	Preamble: 0x55AA00FF
4	24	Image Counter (see Section 4.11.1)
8	32	Real Time Counter (see Section 4.11.1)
12	8	Missed Trigger Counter (see Section 4.11.1)
16	12	Image Average Value("raw" data without taking
		gain settings in account) (see Section 4.11.1)
20	24	Integration Time in units of clock cycles (see Table 3.3)
24	16	Burst Trigger Number (not yet supported, fixed to 0)
28	8	Missed Burst Trigger Counter
32	11	Horizontal start position of ROI (Window.X)
36	11	Horizontal end position of ROI
		(= Window.X + Window.W - 1)
40	11	Vertical start position of ROI (Window.Y)
		In MROI-mode this parameter is 0
44	11	Vertical end position of ROI (Window.Y + Window.H - 1)
		In MROI-mode this parameter is the total height - 1
48	2	Trigger Source
52	2	Digital Gain
56	2	Digital Offset
60	16	Camera Type Code (see Table 4.9)
64	32	Camera Serial Number

Table 4.8: Assignment of status line fields

Camera Model	Camera Type Code
MV1-D2080-160-G2-12	303
MV1-D2080IE-160-G2-12	TBD

Table 4.9: Type codes of MV1-D2080-G2 camera series

4.12 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 acquisition software. 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 or errors in the access of the image buffers by the acquisition software.

The analysis of the test images with a histogram tool gives gives a flat histogram only if the image width is a multiple of 1024 (in 10 bit or 12 bit mode) or 256 (in 8 bit mode). The height should be a multiple of 1024 In 12 bit mode.

4.12.1 Ramp

Depending on the configured grey level resolution, the ramp test image outputs a constant pattern with increasing grey level from the left to the right side (see Fig. 4.54).

Figure 4.54: Ramp test images: 8 bit (left), 10 bit (middle), 12 bit (right)

4.12.2 LFSR

The LFSR (linear feedback shift register) test image outputs a constant pattern with a pseudo-random grey level sequence containing every possible grey level that is repeated for every row. The LFSR test pattern was chosen because it leads to a very high data toggling rate, which stresses the interface electronic and the cable connection.

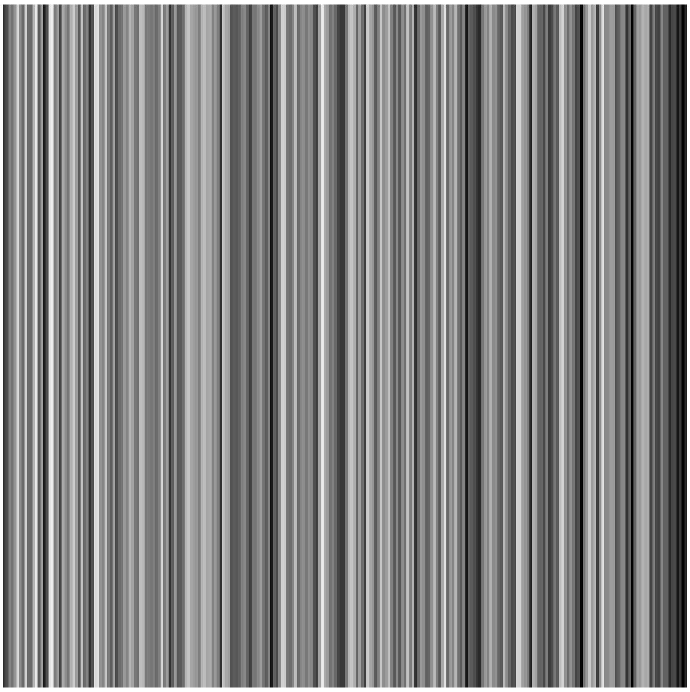


Figure 4.55: LFSR (linear feedback shift register) test image

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.

4.12.3 Troubleshooting using the LFSR

To control the quality of your complete imaging system enable the LFSR mode, set the camera window to 1024 x 1024 pixels (x=0 and y=0) and check the histogram. If your image acquisition application does not provide a real-time histogram, store the image and use a graphic software tool (e.g. ImageJ) 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 correctly received, the histogram of the image will be flat (Fig. 4.56). On the other hand, a non-flat histogram (Fig. 4.57) indicates problems, that may be caused either by a defective camera, by problems in the acquisition software or in the transmission path.
In robots applications, the stress that is applied to the camera 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.

Figure 4.56: LFSR test pattern received and typical histogram for error-free data transmission

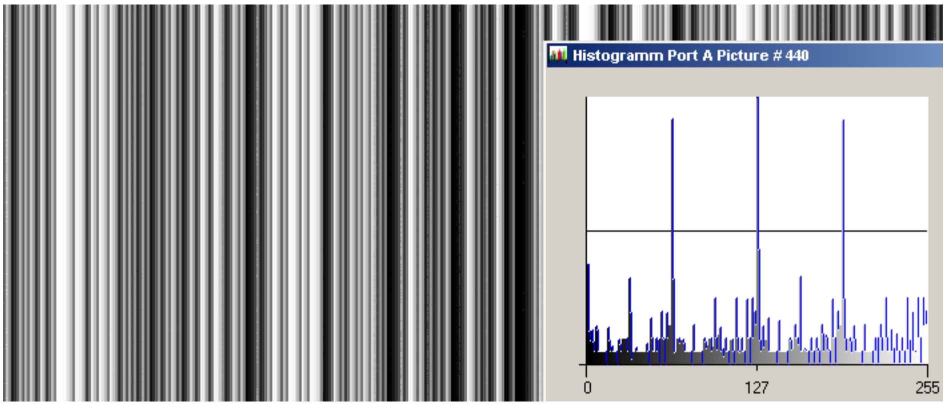


Figure 4.57: LFSR test pattern received and histogram containing transmission errors

5 Hardware Interface

5.1 GigE Connector

The GigE cameras are interfaced to external components via

- an Ethernet jack (RJ45) to transmit configuration, image data and trigger.
- a 12 pin subminiature connector for the power supply, Hirose HR10A-10P-12S (female) .

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

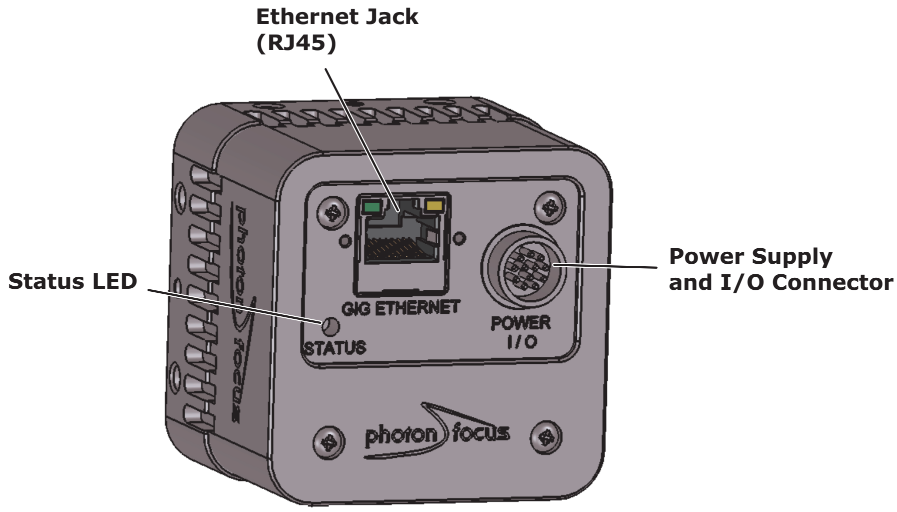


Figure 5.1: Rear view of the GigE camera

5.2 Power Supply Connector

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

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

☞ A suitable power supply can be ordered from your Photonfocus dealership.

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

5.2.1 Status Indicator (GigE cameras)

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

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

Table 5.1: Meaning of the LED of the GigE CMOS cameras

5.2.2 Power and Ground Connection for GigE G2 Cameras

The interface electronics is isolated from the camera electronics and the power supply including the line filters and camera case. Fig. 5.2 shows a schematic of the power and ground connections.

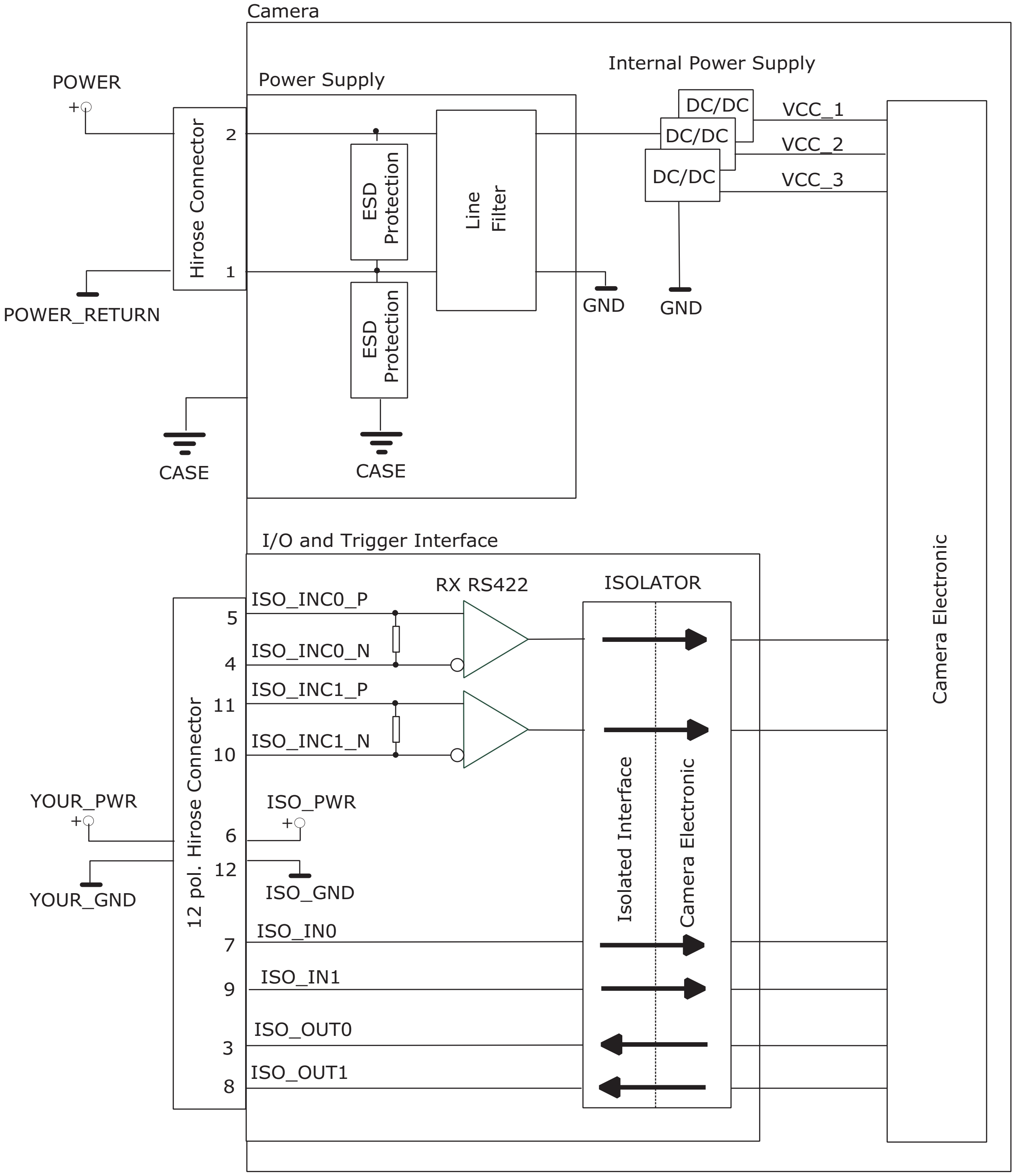


Figure 5.2: Schematic of power and ground connections

5.2.3 Trigger and Strobe Signals for GigE G2 Cameras

Overview

The 12-pol. Hirose power connector contains two external trigger inputs, two strobe outputs and two differential RS-422 inputs. All inputs and outputs are connected to the Programmable Logic Controller (PLC) (see also Section 5.2.4) that offers powerful operations.

☞ The pinout of the power connector is described in Section A.1.

☞ ISO_INC0 and ISO_INC1 RS-422 inputs have -10 V to +13 V extended common mode range.

☞ ISO_OUT0 and ISO_OUT1 have different output circuits (see also Section 5.2.3).

☞ A suitable trigger breakout cable for the Hirose 12 pol. connector can be ordered from your Photonfocus dealership.

☞ Simulation with LTSpice is possible, a simulation model can be downloaded from our web site www.photonfocus.com on the software download page (in Support section). It is filed under "Third Party Tools".

Fig. 5.3 shows the schematic of the inputs and outputs. All inputs and outputs are isolated. ISO_VCC is an isolated, internally generated voltage.

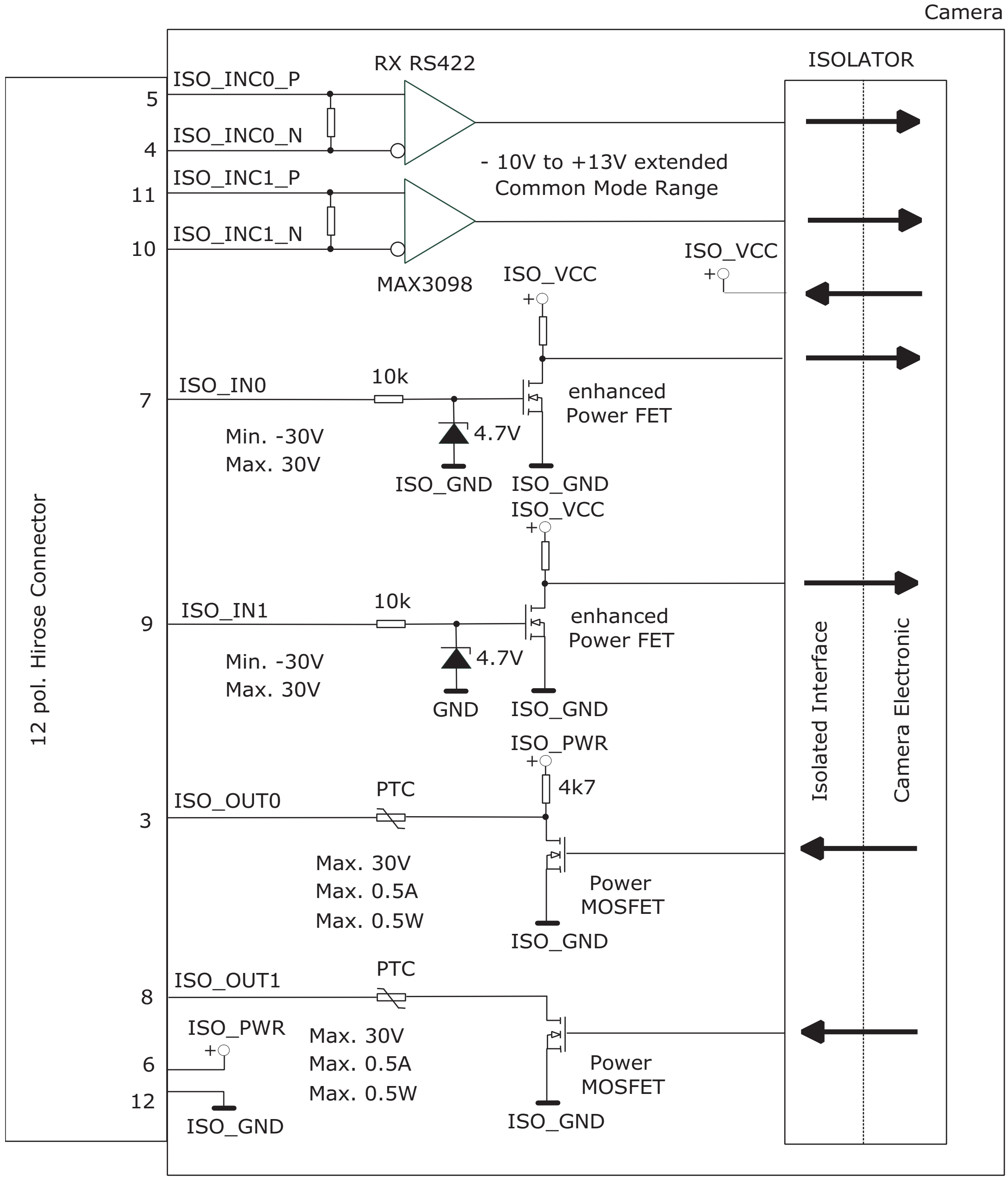


Figure 5.3: Schematic of inputs and output

Single-ended Inputs

ISO_IN0 and ISO_IN1 are single-ended isolated inputs. The input circuit of both inputs is identical (see Fig. 5.3).
Fig. 5.4 shows a direct connection to the ISO_IN inputs.

☞ In the camera default settings the PLC is configured to connect the ISO_IN0 to the PLC_Q4 camera trigger input. This setting is listed in Section 6.10.2.

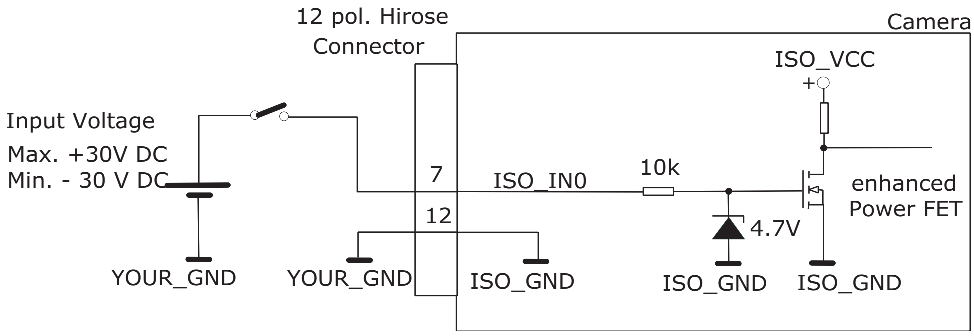


Figure 5.4: Direct connection to ISO_IN

Fig. 5.5 shows how to connect ISO_IN to TTL logic output device.

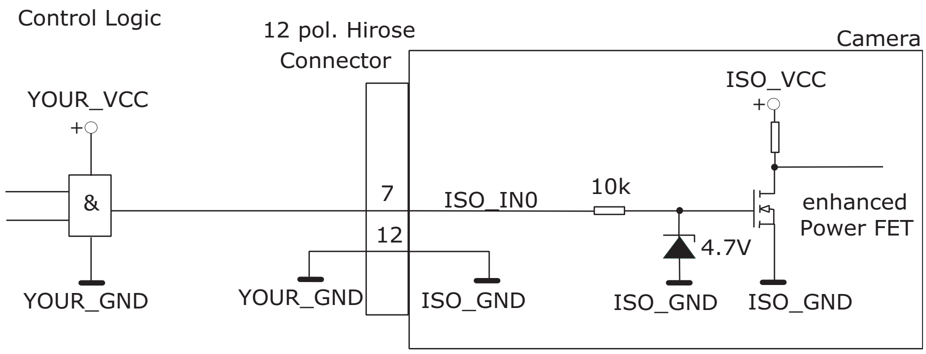


Figure 5.5: Connection to ISO_IN from a TTL logic device

Single-ended Outputs

ISO_OUT0 and ISO_OUT1 are single-ended isolated outputs.

ISO_OUT0 and ISO_OUT1 have different output circuits: ISO_OUT1 doesn't have a pullup resistor and can be used as additional Strobe out (by adding Pull up) or as controllable switch. Maximal ratings that must not be exceeded: voltage: 30 V, current: 0.5 A, power: 0.5 W.

Fig. 5.6 shows the connection from the ISO_OUT0 output to a TTL logic device. PTC is a current limiting device.

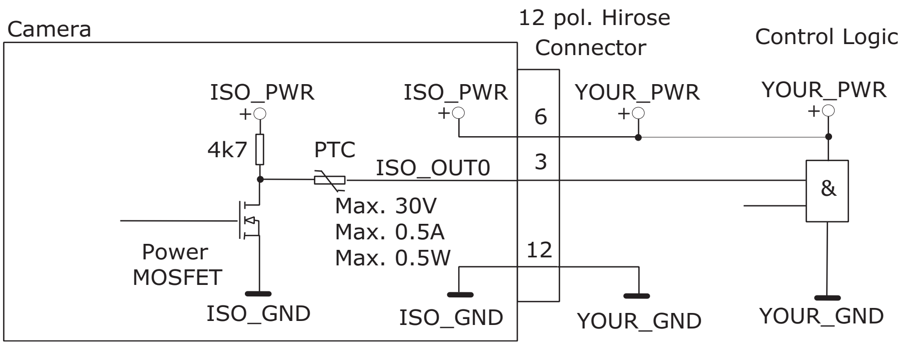


Figure 5.6: Connection example to ISO_OUT0

Fig. 5.7 shows the connection from ISO_OUT1 to a TTL logic device. PTC is a current limiting device.

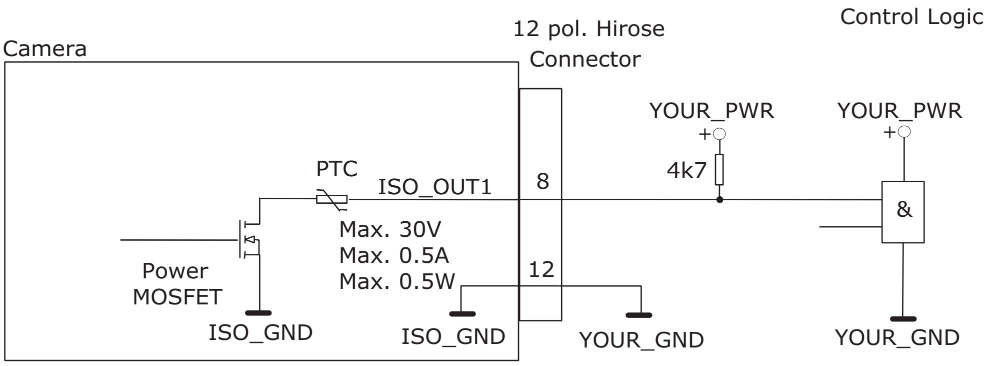


Figure 5.7: Connection from the ISO_OUT1 output to a TTL logic device

Fig. 5.8 shows the connection from ISO_OUT1 to a LED.

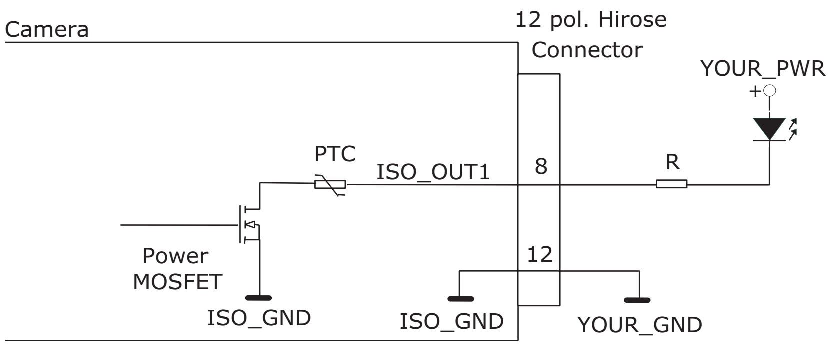


Figure 5.8: Connection from ISO_OUT1 to a LED

Respect the limits of the POWER MOSFET in the connection to ISEO_OUT1. Maximal ratings that must not be exceeded: voltage: 30 V, current: 0.5 A, power: 0.5 W. (see also Fig. 5.9). The type of the Power MOSFET is: International Rectifier IRLML0100TRPbF.

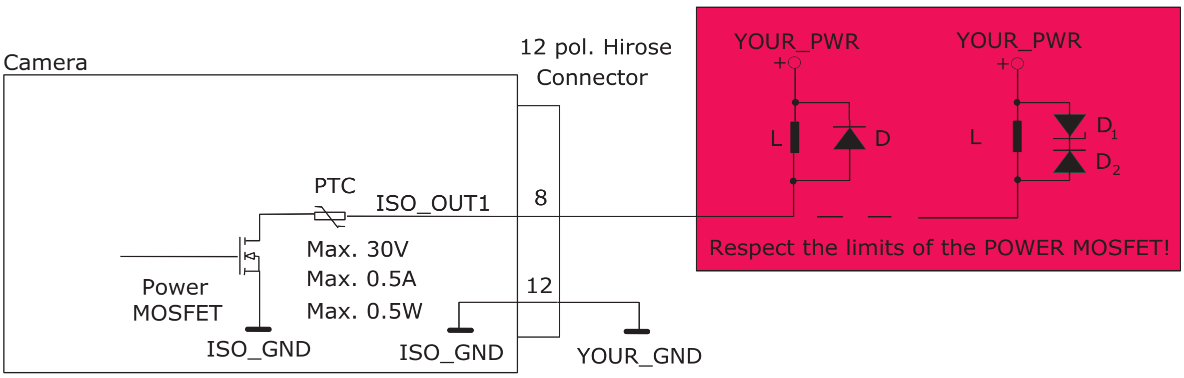


Figure 5.9: Limits of ISO_OUT1 output

Differential RS-422 Inputs

ISO_INC0 and ISO_INC1 are isolated differential RS-422 inputs (see also Fig. 5.3). They are connected to a Maxim MAX3098 RS-422 receiver device. Please consult the data sheet of the MAX3098 for connection details.

Don't connect single-ended signals to the differential inputs ISO_INC0 and ISO_INC1 (see also Fig. 5.10).

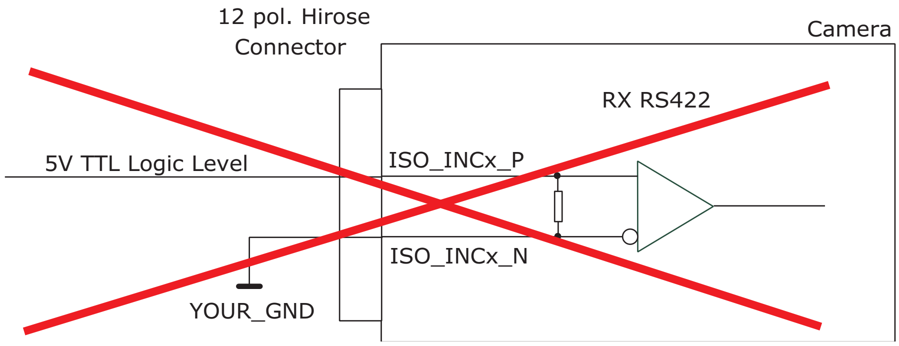


Figure 5.10: Incorrect connection to ISO_INC inputs

Master / Slave Camera Connection

The trigger input of one Photonfocus G2 camera can easily connected to the strobe output of another Photonfocus G2 camera as shown in Fig. 5.11. This results in a master/slave mode where the slave camera operates synchronously to the master camera.

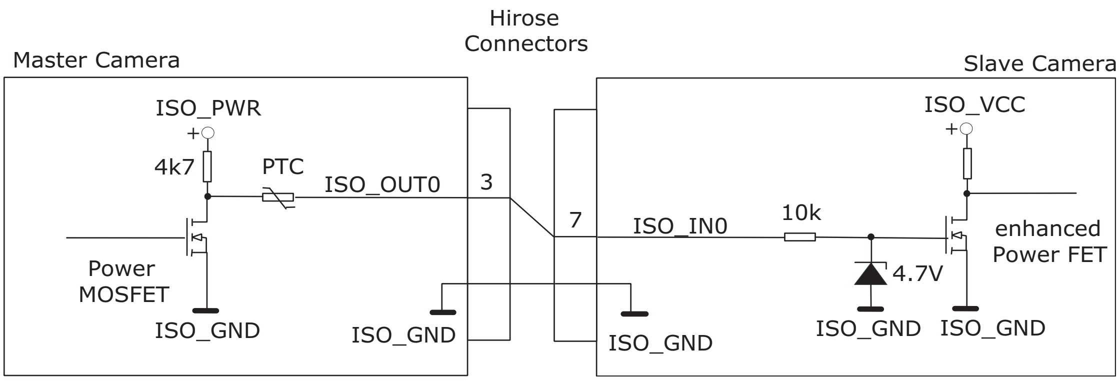


Figure 5.11: Master / slave connection of two Photonfocus G2 cameras

5.2.4 PLC connections

The PLC (Programmable Logic Controller) is a powerful device where some camera inputs and outputs can be manipulated and software interrupts can be generated. Sample settings and an introduction to PLC are shown in Section 6.10. PLC is described in detail in the document [PLC].

Name	Direction	Description
A0 (Line0)	Power connector -> PLC	ISO_IN0 input signal
A1(Line1)	Power connector -> PLC	ISO_IN1 input signal
A2 (Line2)	Power connector -> PLC	ISO_INC0 input signal
A3 (Line3)	Power connector -> PLC	ISO_INC1 input signal
A4	camera head -> PLC	FVAL (Frame Valid) signal
A5	camera head -> PLC	LVAL (Line Valid) signal
A6	camera head -> PLC	DVAL (Data Valid) signal
A7	camera head -> PLC	Reserved (CL_SPARE)
Q0	PLC ->	not connected
Q1	PLC -> power connector	ISO_OUT1 output signal (signal is inverted)
Q2	PLC ->	not connected
Q3	PLC ->	not connected
Q4	PLC -> camera head	PLC_Q4 camera trigger
Q5	PLC -> camera head	PLC_Q5 (only available on cameras with Counter Reset External feature, see Appendix B).
Q6	PLC -> camera head	Incremental encoder A signal (only available on cameras with AB Trigger feature, see Appendix B).
Q7	PLC -> camera head	Incremental encoder B signal (only available on cameras with AB Trigger feature, see Appendix B).

Table 5.2: Connections to/from PLC

6

Software

6.1 Software for Photonfocus GigE Cameras

The following packages for Photonfocus GigE (G2) cameras are available on the Photonfocus website (www.photonfocus.com):

eBUS SDK Contains the Pleora SDK and the Pleora GigE filter drivers. Many examples of the SDK are included.

PFInstaller Contains the PF_GEVPlayer, a property list for every GigE camera and additional documentation and examples. The option `GigE_Tools, PF_GEVPlayer, SDK examples and doc for GigE cameras` must be selected.

6.2 PF_GEVPlayer

The camera parameters can be configured by a Graphical User Interface (GUI) tool for Gigabit Ethernet Vision cameras or they can be programmed with custom software using the SDK.
A GUI tool that can be downloaded from Photonfocus is the PF_GEVPlayer. How to obtain and install the software and how to connect the camera is described in Chapter 2.
After connecting to the camera, the camera properties can be accessed by clicking on the `GEV Device control` button (see also Section 6.2.2).

☞ The PF_GEVPlayer is described in more detail in the GEVPlayer Quick Start Guide [GEVQS] which is included in the PFInstaller.

☞ There is also a GEVPlayer in the Pleora eBUS package. It is recommended to use the PF_GEVPlayer as it contains some enhancements for Photonfocus GigE cameras such as decoding the image stream in DR1 cameras.

6.2.1 PF_GEVPlayer main window

After connecting the camera (see Chapter 2), the main window displays the following controls (see Fig. 6.1):

Disconnect Disconnect the camera

Mode Acquisition mode

Play Start acquisition

Stop Stop acquisition

Acquisition Control Mode Continuous, Single Frame or Multi Frame modes. The number of frames that are acquired in Multi Frame mode can be set in the GEV Device Control with `AcquisitionFrameCount` in the `AcquisitionControl` category.

Communication control Set communication properties.

GEV Device control Set properties of the camera head, IP properties and properties of the PLC (Programmable Logic Controller, see also Section 5.2.4 and document [PLC]).

Image stream control Set image stream properties and display image stream statistics.

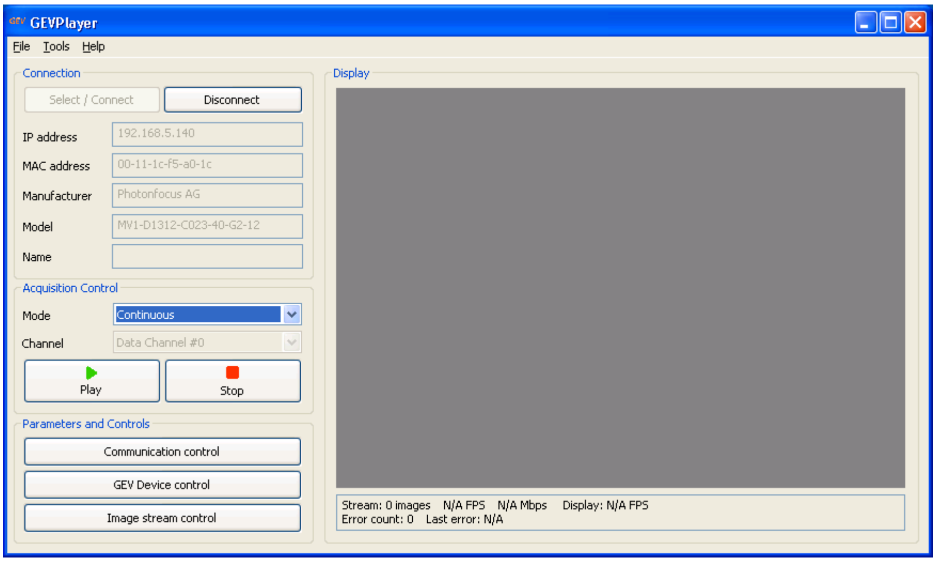


Figure 6.1: PF_GEVPlayer main window

Below the image display there are two lines with status information

6.2.2 GEV Control Windows

This section describes the basic use of the GEV Control windows, e.g. the `GEV Device Control` window.
The view of the properties in the control window can be changed as described below. At start the properties are grouped in categories which are expanded and whose title is displayed in bold letters. An overview of the available view controls of the GEV Control windows is shown in Fig. 6.2.

To have a quick overview of the available categories, all categories should be collapsed. The categories of interest can then be expanded again. If the name of the property is known, then the alphabetical view is convenient. If this is the first time that you use a Photonfocus GigE camera, then the visibility should be left to `Beginner`.
The description of the currently selected property is shown at the bottom ot the window.

After selecting a property from a drop-down box it is necessary to press <Enter> or to click with the mouse on the control window to apply the property value to the camera.

A red cross at the upper right corner of the GEV Control Window indicates a parameter error, i.e. a parameter is not correctly set. In this case you should check all properties. A red exclamation mark (!) at the right side of a parameter value indicates that this parameters has to be set correctly.

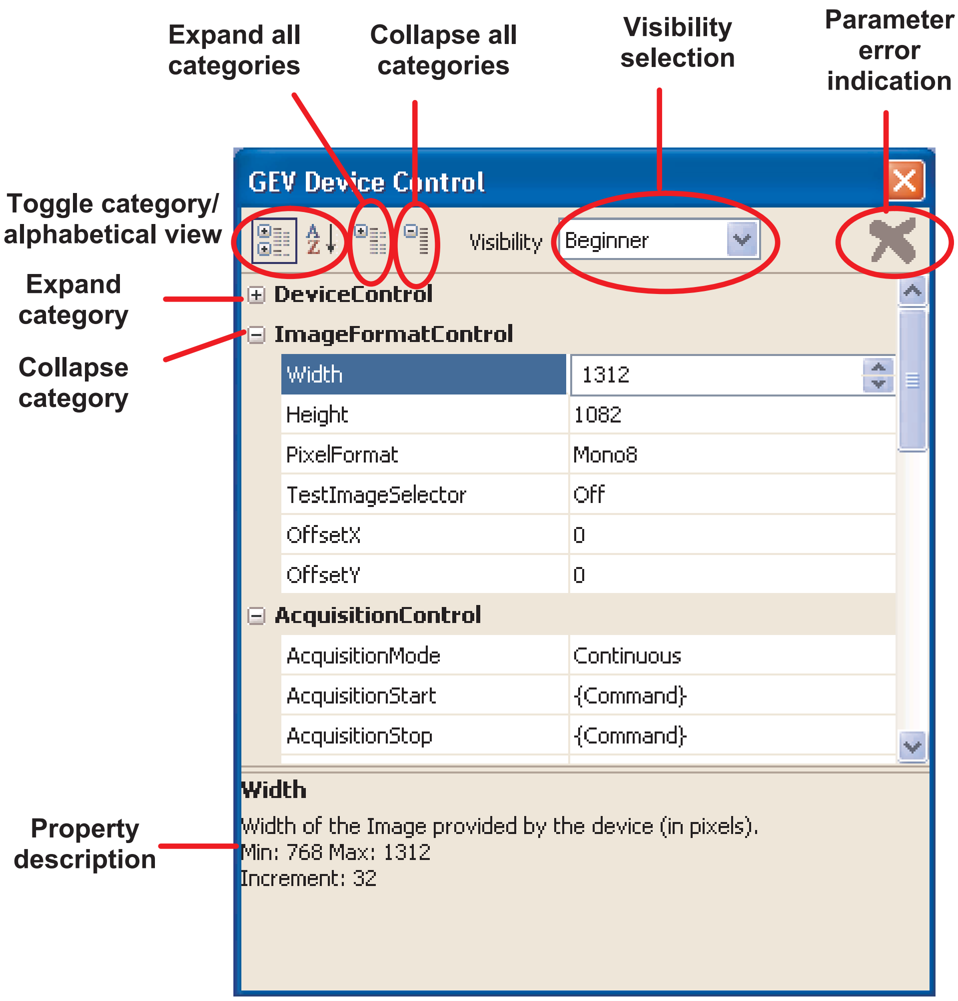


Figure 6.2: PF_GEVPlayer Control Window

6.2.3 Display Area

The images are displayed in the main window in the display area. A zoom menu is available when right clicking in the display area. Another way to zoom is to press the Ctrl button while using the mouse wheel.

6.2.4 White Balance (Colour cameras only)

A white balance utility is available in the PF_GEVPlayer in `Tools -> Image Filtering` (see Fig. 6.3). The gain of the colour channels can be adjusted manually by sliders or an auto white balance of the current image can be set by clicking on the `White Balance` button. To have a correct white balance setting, the camera should be pointed to a neutral reference (object that reflects all colours equally), e.g. a special grey reference card while clicking on the White Balance button.

The white balance settings that were made as described in this section, are applied by the PF_GEVPlayer software and are not stored in the camera. To store the colour gain values in the camera, the Gain settings in the GEV Device Control (in AnalogControl) must be used. If the gain properties in the camera are used, then the PF_GEVPlayer RGB Filtering should be disabled.

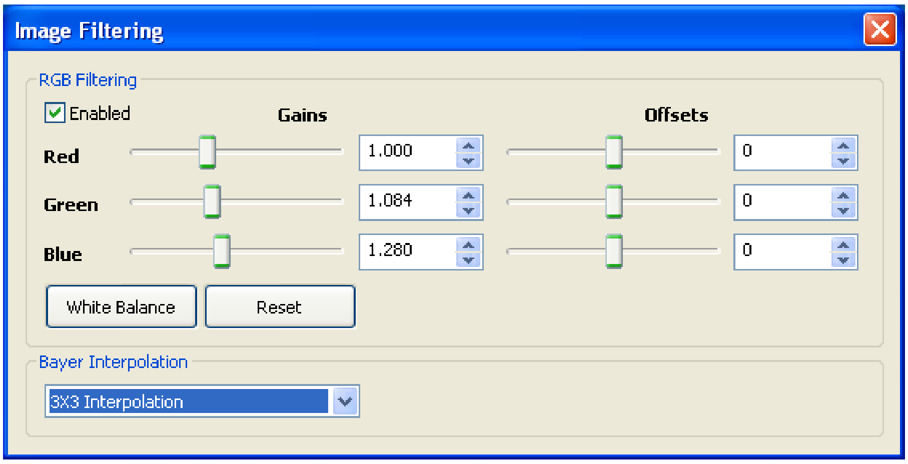


Figure 6.3: PF_GEVPlayer image filtering dialog

6.2.5 Save camera setting to a file

The current camera settings can be saved to a file with the PF_GEVPlayer (`File` -> `Save` or `Save As...`). This file can later be applied to camera to restore the saved settings (`File` -> `Open`), Note, that the Device Control window must not be open to do this.

The MROI and LUT settings are not saved in the file.

6.2.6 Get feature list of camera

A list of all features of the Photonfocus G2 cameras in HTML format can be found in the `GenICam_Feature_Lists` sub-directory (in `Start -> All Programs -> Photonfocus -> GigE_Tools`). Alternatively, the feature list of the connected camera can be retrieved with the PF_GEVPlayer (`Tools -> Save Camera Features as HTML...`).

6.3 Pleora SDK

The eBUS package provides the PureGEV C++ SDK for image acquisition and the setting of properties. A help file is installed in the Pleora installation directory, e.g. `C:\Program Files\Pleora Technologies Inc\eBUS SDK\Documentation`.
Various code samples are installed in the installation directory, e.g. `C:\Program Files\Pleora Technologies Inc\eBUS SDK\Samples`. The sample `PvPipelineSample` is recommended to start with. Samples that show how to set device properties are included in the PFInstaller that can be downloaded from the Photonfocus webpage.

6.4 Frequently used properties

A property list for every camera is included in the PFInstaller that can be downloaded from the Photonfocus webpage.
The following list shows some frequently used properties that are available in the Beginner mode. The category name is given in parenthesis.

Width (ImageFormatControl) Width of the camera image ROI (region of interest)

Height (ImageFormatControl) Width of the camera image ROI

OffsetX, OffsetY (ImageFormatControl) Start of the camera image ROI

ExposureTime (AcquisitionControl) Exposure time in microseconds

TriggerMode (AcquisitionControl) External triggered mode

TriggerSource (AcquisitionControl) Trigger source if external triggered mode is selected

Header_Serial (Info / CameraInfo) (Visiblity: Guru) Serial number of the camera

UserSetSave (UserSetControl) Saves the current camera settings to non-volatile flash memory.

6.5 Calibration of the FPN Correction

The following procedures can be most easily done with the PF_GEVPlayer.

6.5.1 Offset Correction (CalibrateBlack)

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.
Procedure to achieve a good correction:

1. Setup the camera width to the mode where it will be usually used. (Exposure time, ROI, ...) Due to the internal structure of the camera, best performance of calibration will be achieved when calibrating under "real conditions".

   ✎ If different ROI's will be used, calibrate image under full ROI.

   ✎ If different exposure times will be used, calibrate the camera under the longest exposure time.

2. Set the following properties: `Gain` (in category `AnalogControl`) to 1, `DigitalOffset` (in category `AnalogControl`) to 0, `DigitalGain` (in category `DataOutput`) to 1 and `Convolver_3x3_0_Enable` (in category `Convolver`) to 0. Due to the internal structure of the camera these settings are required for correct calibration.
3. Wait until the camera has achieved working temperature.
4. Set the property `Correction_Mode` (in category `Correction`) to Off. This is not mandatory but recommended.
5. Close the lens of the camera.
6. Check the value of the property `Average_Value` (in category `PhotonfocusMain`). Change the property `BlackLevel` (in category `AnalogControl`) until `Average_Value` is between 240 and 400 DN. The property `Average_Value` can be updated by clicking on the property `Average_Update(in category PhotonfocusMain)`.
7. Click on `CalibrateBlack` (in category `Calibration`). Wait until the command has been finished, i.e.the property `Correction_Busy` (in category `Calibration`) is 0. `Correction_Busy` can be updated by clicking on the property Correction_BusyUpdate (in category `Calibration`).

6.5.2 Gain Correction (CalibrateGrey)

The gain correction is based on a gray reference image, which is taken at uniform illumination to give an image with a mid gray level. Gain correction is not a trivial feature. The quality of the gray reference image is crucial for proper gain correction.

☞ The calibration of the gain correction can be skipped if gain correction will not be used.

Procedure to achieve a good correction:

1. The procedure to calibrate the offset correction (see Section 6.5.1) must be run just before calibrating the gain correction.

   👁 Don't turn off the camera between the calibration of the offset correction (CalibrateBlack) and the calibration of the gain correction (CalibrateGrey).

2. Illuminate the camera homogeneously to produce a gray image with an `Average_Value` (in category `PhotonfocusMain`) between 2200 and 3600 DN. Increase or decrease illumination if `Average_Value` is outside this range. The property `Average_Value` can be updated by clicking on the property `Average_Update(in category PhotonfocusMain)`.

3. Click on CalibrateBlack (in category Calibration). Wait until the command has been finished, i.e.the property Correction_Busy (in category Calibration) is 0. Correction_Busy can be updated by clicking on the property Correction_BusyUpdate (in category Calibration).

6.5.3 Storing the calibration in permanent memory

After running calibration procedures (see Section 6.5.1 and Section 6.5.2) the calibration values are stored in RAM. When the camera is turned off, their values are deleted.
To prevent this, the calibration values must be stored in flash memory. This can be done by clicking on the property Correction_SaveToFlash (in category Calibration). Wait until the command has been finished, i.e.the property Correction_Busy (in category Calibration) is 0. Correction_Busy can be updated by clicking on the property Correction_BusyUpdate (in category Calibration).

6.6 Look-Up Table (LUT)

6.6.1 Overview

The LUT is described in detail in Section 4.8. All LUT settings can be set in the GUI (PF_GEVPlayer). There are LUT setting examples in the PFInstaller, that can be downloaded from the Photonfocus webpage.

☞ To manually set custom LUT values in the GUI is practically not feasable as up to 4096 values for every LUT must set. This task should be done with the SDK.

If LUT values should be retained in the camera after disconnecting the power, then they must be saved with UserSetSave

6.6.2 Full ROI LUT

This section describe the settings for one LUT that is applied to the full ROI.

1. Set LUT_EnRegionLUT (in category RegionLUT) to False. This is required to use the full ROI LUT.
2. Set LUTEnable (in category LUTControl) to False. This is not mandatory but recommended.
3. Select LUT 0 by setting LUTSelector (in category LUTControl) to 0.
4. Set LUT content as described in Section 6.6.4.
5. Turn on LUT by setting LUTEnable to True.

6.6.3 Region LUT

The Region LUT feature is described in Section 4.8.4. Procedure to set the Region LUT:

1. Set LUT_EnRegionLUT (in category RegionLUT) to False. This is not mandatory but recommended.
2. Set LUTEnable (in category LUTControl) to False. This is not mandatory but recommended.
3. Select LUT 0 by setting LUTSelector (in category LUTControl) to 0.
4. Set properties LUT_X, LUT_W, LUT_Y and LUT_H (all in category RegionLUT) to desired value.

5. Set LUT content as described in Section 6.6.4.
6. If two Region LUT are required, then select LUT 1 by setting `LUTSelector` (in category `LUTControl`) to 1 and repeat steps 4 and 5.
7. Turn on LUT by setting `LUTEnable` to True.
8. Turn on Region LUT by setting `LUT_EnRegionLUT` (in category `RegionLUT`) to False.

6.6.4 User defined LUT settings

This section describes how to set user defined LUT values. It is assumed that the LUT was selected as described in Section 6.6.2 or Section 6.6.3.
For every LUT value the following steps must be done:

1. Set `LUTIndex` (in category `LUTControl`) to desired value. The `LUTIndex` corresponds to the grey value of the 12 bit input signal of the LUT.
2. Set `LUTValue` (in category `LUTControl`) to desired value. The `LUTValue` corresponds to the grey value of the 8 bit output signal of the LUT.

☞ The `LUTIndex` is auto incremented internally after setting a `LUTValue`. If consecutive `LUTIndex` are written, then it is required to set `LUTIndex` only for the first value. For the next values it is sufficient to set only the `LUTValue`.

6.6.5 Predefined LUT settings

Some predefined LUT are stored in the camera. To activate a predefined LUT:

1. Select LUT and RegionLUT (if required) as described in Section 6.6.2 and Section 6.6.3.
2. Set `LUTAutoMode` (in category `LUTControl`) to the desired value. The available settings are described in property list of the camera which is contained in the PFInstaller.
3. If the `LUTAutoMode` requires additional settings (e.g. Gamma `LUTAutoMode`), then it can be set with `LUTAutoValue`.

6.7 MROI

The MROI feature is described in Section 4.3.3. This section describes how to set the MROI values.
When MROI is enabled, then the camera internally processes the MROI entries sequentially, starting at `MROI_Index` 0. The processing is stopped when either the last `MROI_Index` is reached or when an entry with `MROI_Y`=2079 is reached.
Procedure to write MROI entries:

1. Disable MROI by setting `MROI_Enable` to False. This is mandatory otherwise setting the MROI entries will be ignored.
2. Set `MROI_Index`. In the first run it is set to 0 and then incremented in every run.
3. Set `MROI_Y` to the starting row of the MROI.
4. Set `MROI_H` to the height of the MROI.
5. Proceed with step 2, incrementing the `MROI_Index`. If no more MROI should be set, then run the steps 2 to 4 again (incrementing `MROI_Index`) but set `MROI_Y` to the value 2079.
6. Enable MROI by setting `MROI_Enable` to True.

7. Read the property `MROI_Htot`. Set the property `Height` (in category `ImageFormatControl`) to the value of `MROI_Htot`. This is mandatory as this value is not automatically updated.

Example pseudo-code to set two MROI: The resulting total height of the example will be 400.

```
SetFeature('MROI_Enable', false);
SetFeature('MROI_Index', 0);
SetFeature('MROI_Y', 50);
SetFeature('MROI_H', 100);
SetFeature('MROI_Index', 1);
SetFeature('MROI_Y', 600);
SetFeature('MROI_H', 300);
SetFeature('MROI_Index', 2);
SetFeature('MROI_Y', 2079);
SetFeature('MROI_H', 1);
SetFeature('MROI_Enable', true);
int heightTot;
GetFeature('MROI_Htot', &heightTot);
SetFeature('Height', heightTot);
```

6.8 Permanent Parameter Storage / Factory Reset

The property `UserSetSave` (in category `UserSetControl`) stores the current camera settings in the non-volatile flash memory. At power-up these values are loaded.
The property `UserSetSave` (in category `UserSetControl`) overwrites the current camera settings with the settings that are stored in the flash memory.
The command `CameraHeadFactoryReset` (in category `PhotonfocusMain`) restores the settings of the camera head

☞ The property `CameraHeadStoreDefaults` (in category `PhotonfocusMain`) stores only the settings of the camera head in the flash memory. It is recommended to use `UserSetSave` instead, as all properties are stored.

☞ The calibration values of the FPN calibration are not stored with `UserSetSave` (or `CameraHeadStoreDefaults`). Use the command `Correction_SaveToFlash` for this (see `Correction_SaveToFlash`).

6.9 Persistent IP address

It is possible to set a persistent IP address:

1. Set `GevPersistentIPAddress` (in category `TransportLayerControl`) to the desired IP address.
2. Set `GevPersistentSubnetMask` (in category `TransportLayerControl`) to the sub net mask.
3. Set `GevCurrentIPConfigurationPersistent` (in category `TransportLayerControl`) to True.
4. Set `GevCurrentIPConfigurationDHCP` (in category `TransportLayerControl`) to False.
5. The selected persistent IP address will be applied after a reboot of the camera.

6.10 PLC

6.10.1 Introduction

The Programmable Logic Controller (PLC) is a powerful tool to generate triggers and software interrupts. A functional diagram of the PLC tool is shown in Fig. 6.4. THE PLC tool is described in detail with many examples in the [PLC] manual which is included in the PFInstaller.

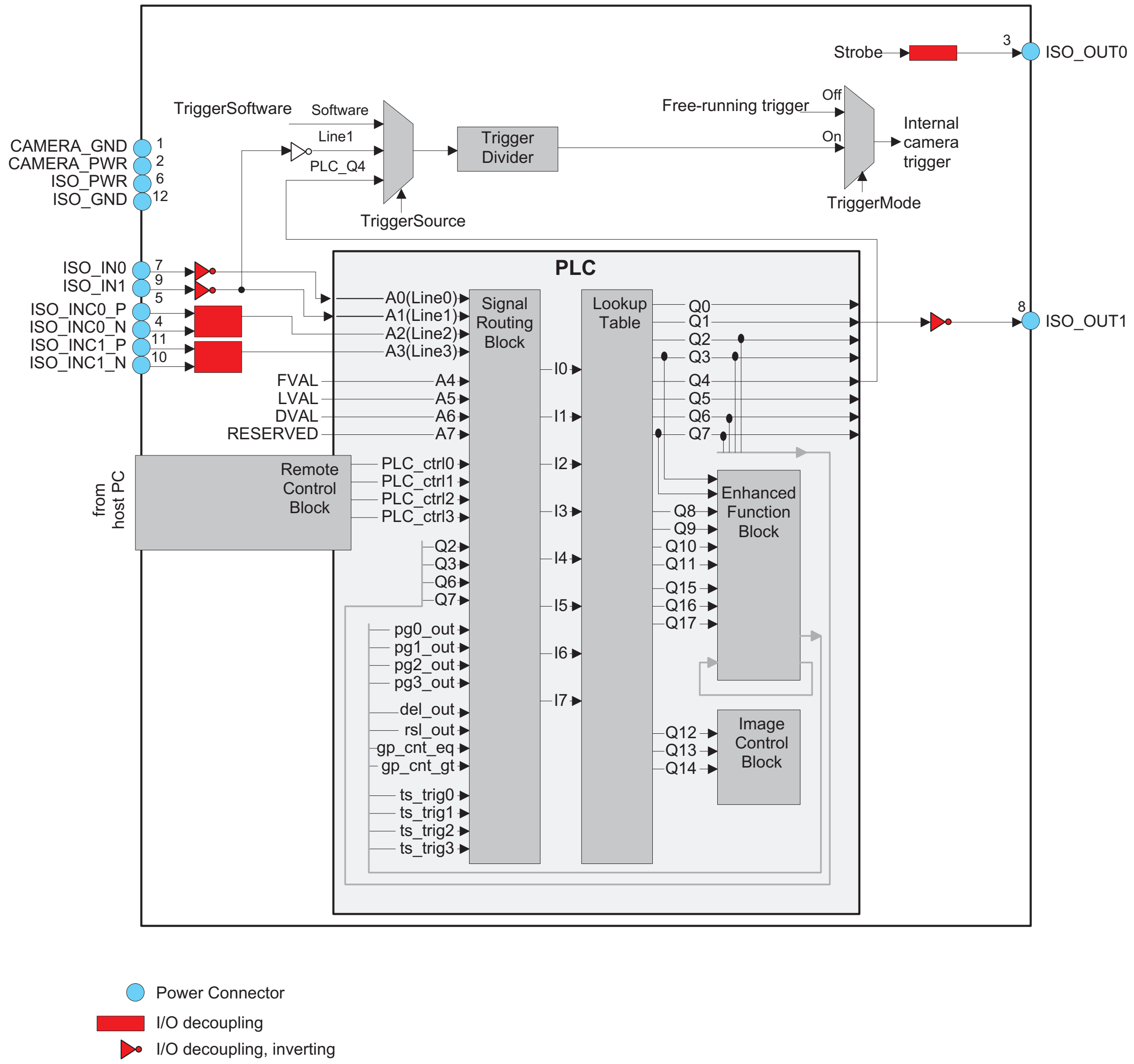


Figure 6.4: PLC functional overview

The simpliest application of the PLC is to connect a PLC input to a PLC output. The connection of the ISO_IN0 input to the PLC_Q4 camera trigger is given as an example. The resulting configuration is shown in Section 6.10.2.

1. Identify the PLC notation of the desired input in Fig. 6.4. In our example, ISO_IN0 maps to A0 or Line0.
2. Select a Signal Routing Block (SRB) that has a connection to the desired PLC input and connect it to the PLC input. In our example, SRB PLC_I0 will be used as it has a connection

to Line0. To connect the SRB to input, set PLC_I<x> to the input. In the example, set PLC_I0 to Line0.

3. Identify the PLC notation of the desired output. A table of the PLC mapping is given in Section 5.2.4. In the example Q4 is the desired output.
4. Connect the LUT that corresponds to the desired output to the SRB from step 2. In the example, PLC_Q4 is connected to PLC_I0. ISO_IN0 has an inverter in the I/O decoupling block, therefore it is better to invert it again in the PLC: set `PLC_Q4_Variable0` to `PLC_I0_Not`. Note that every LUT has the capability to connect up to 4 inputs. In the example only the first input (`PLC_Q4_Variable0`) is used. The other inputs are ignored by setting the `PLC_Q4_Variable` to `Zero` and the `PLC_Q4_Operator` to `Or` for inputs 1 to 3.
5. If a PLC output is used to connect to a camera trigger, then the corresponding Trigger Source must be activated. In the example, `TriggerSource` is set to `PLC_Q4` and `TriggerMode` is set to `On`.

6.10.2 PLC Settings for ISO_IN0 to PLC_Q4 Camera Trigger

This setting connects the ISO_IN0 to the internal camera trigger, see Section 6.10.2 (the visibility in the PF_GEVPlayer must be set to `Guru` for this purpose).

Feature	Value	Category
TriggerMode	On	AcquisitionControl
TriggerSource	PLC_Q4	AcquisitionControl
PLC_I0	Line0	<PLC>/SignalRoutingBlock
PLC_Q4_Variable0	PLC_I0_Not	<PLC>/LookupTable/Q4
PLC_Q4_Operator0	Or	<PLC>/LookupTable/Q4
PLC_Q4_Variable1	Zero	<PLC>/LookupTable/Q4
PLC_Q4_Operator1	Or	<PLC>/LookupTable/Q4
PLC_Q4_Variable2	Zero	<PLC>/LookupTable/Q4
PLC_Q4_Operator2	Or	<PLC>/LookupTable/Q4
PLC_Q4_Variable3	Zero	<PLC>/LookupTable/Q4

Table 6.1: PLC Settings for ISO_IN0 to PLC_Q4 Camera Trigger (<PLC> = in category IPEngine/ProgrammableLogicController)

6.11 Miscellaneous Properties

6.11.1 PixelFormat

The property `PixelFormat` (in category `ImageFormatControl`) sets the pixel format. Table 6.2 shows the number of bits per pixel to are required for a pixel format. Fig. 6.5 shows the bit alignment of the packed pixel formats.

The Mono10 and Mono12 must not be selected as these settings don't produce valid images.

DataFormat	Bits per pixel
Mono8	8
Mono10Packed	10
Mono12Packed	12

Table 6.2: GigE pixel format overview

Mono10Packed																								
Byte	0								1								2							
BitNr	9	8	7	6	5	4	3	2	-	-	1	0	-	-	1	0	9	8	7	6	5	4	3	2
Pixel	Pixel A										Pixel B				Pixel A		Pixel B							

Mono12Packed																								
Byte	0								1								2							
BitNr	11	10	9	8	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	7	6	5	4
Pixel	Pixel A								Pixel B				Pixel A				Pixel B							

Figure 6.5: Packed Pixel Format

6.11.2 Readout Mode

The readout mode (see also Section 4.1.1) can be set by the property `Trigger_Interleave` in category `AcquisitionControl`. Generally there is a slightly better image quality with sequential readout (`Trigger_Interleave`=False). For maximal frame rate `Trigger_Interleave` should be set to True. For maximal image quality it is recommended to only use one `Trigger_Interleave` setting and calibrate the FPN Correction (see Section 6.5) for this setting.

7 Mechanical and Optical Considerations

7.1 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.

7.1.1 Cameras with GigE Interface

Fig. 7.1 shows the mechanical drawing of the camera housing for the MV1-D2080-G2 CMOS cameras with GigE interface.

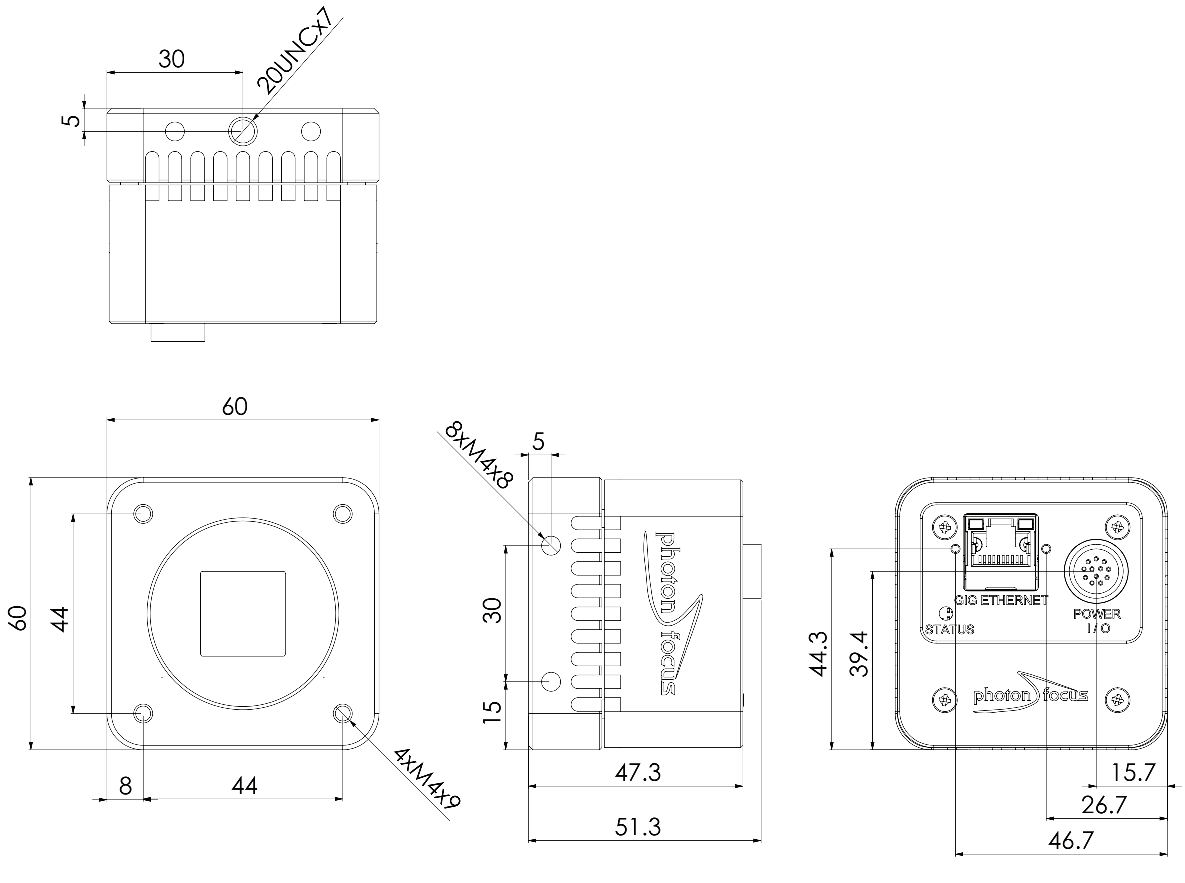


Figure 7.1: Mechanical dimensions of the MV1-D2080-G2 GigE camera with M42x1 mounting (no adapter)

7.1.2 Lens mounting options

The MV1-D2080(IE)-G2 cameras have a M42x1 mounting as default. Additional adapters for F-Mount and C-Mount (see Fig. 7.2) can be ordered. Drawing for the adapters can be found in Fig. 7.3 and Fig. 7.4.

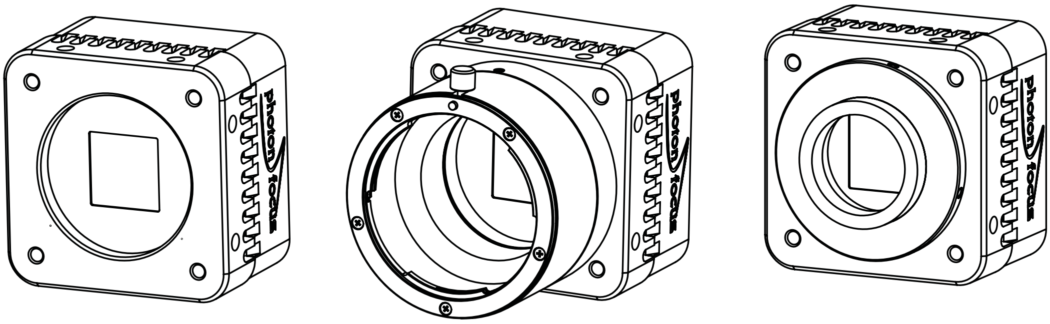


Figure 7.2: Left: M42, Middle: F-Mount, Right: C-Mount

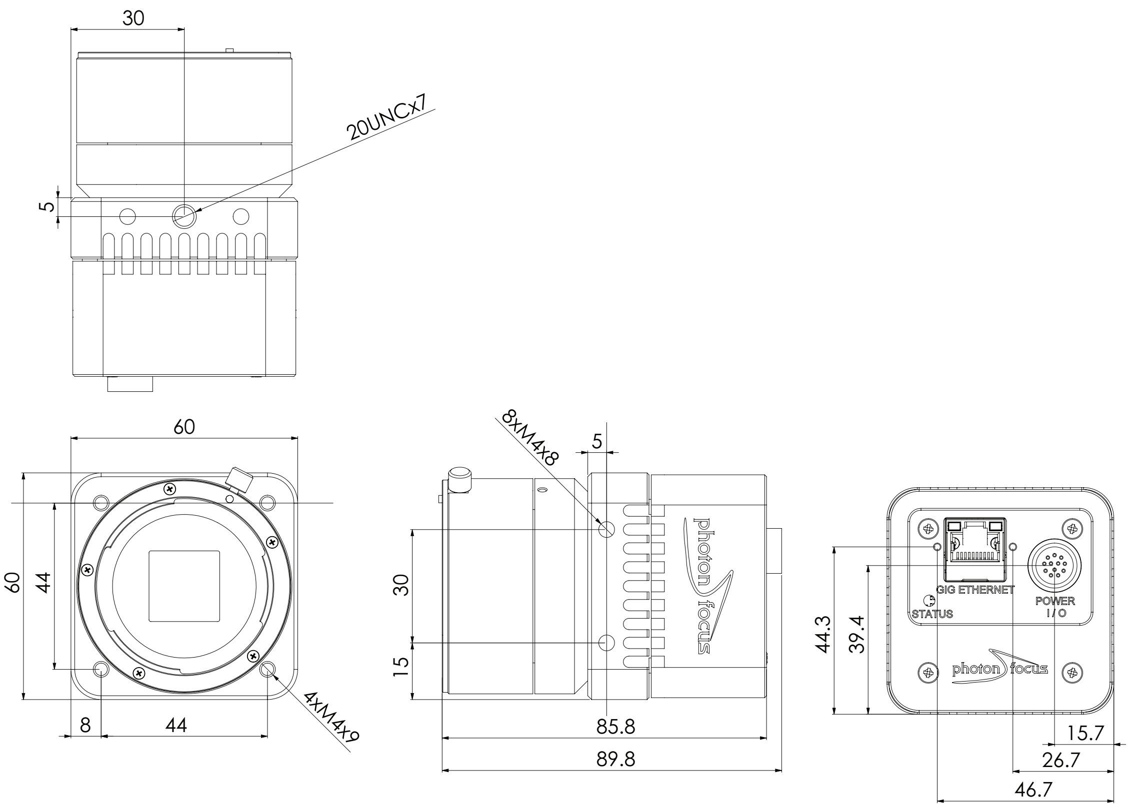


Figure 7.3: Mechanical dimensions of the MV1-D2080-G2 GigE camera with F-Mount adapter

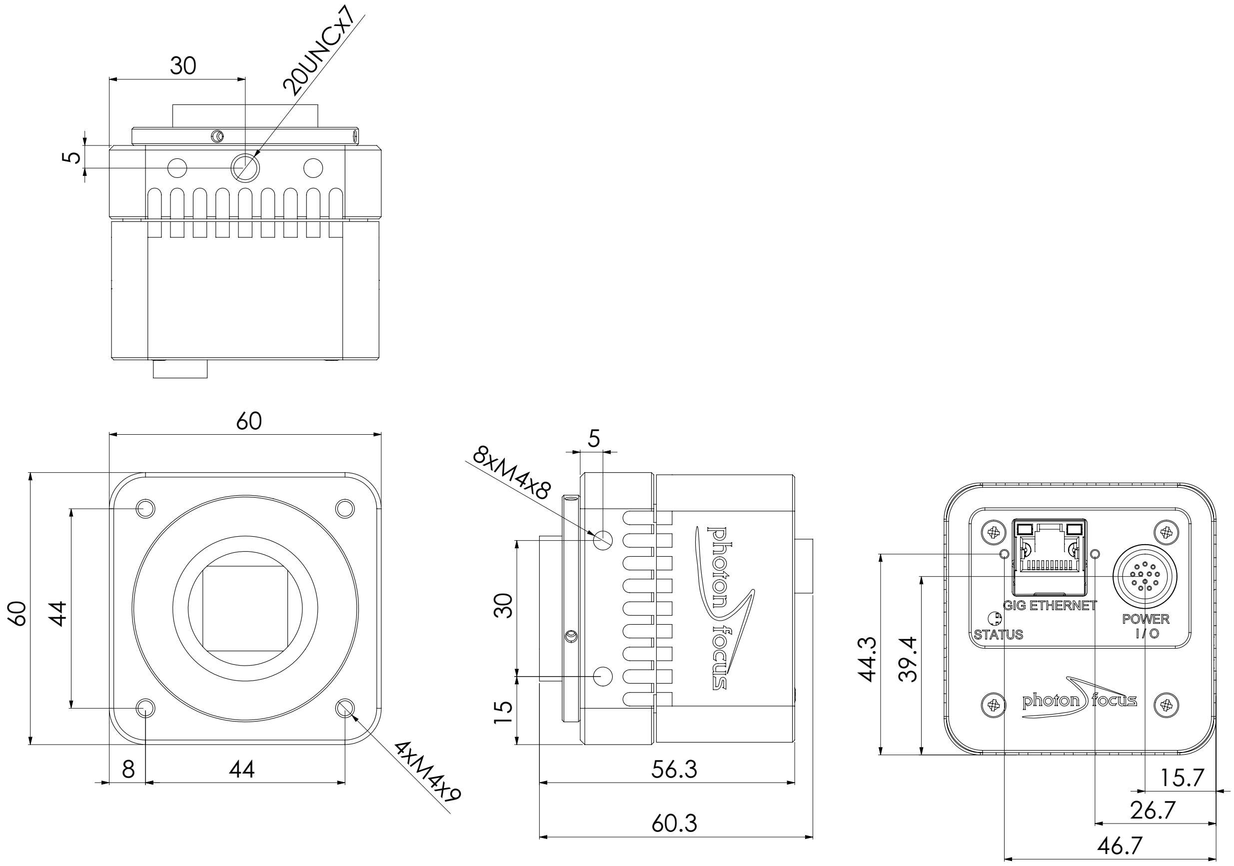


Figure 7.4: Mechanical dimensions of the MV1-D2080-G2 GigE camera with C-Mount adapter

7.2 Optical Interface

7.2.1 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 7.1. 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-reinraum.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 7.1: Recommended materials for sensor cleaning

For cleaning the sensor, Photonfocus recommends the products available from the suppliers as listed in Table 7.1.

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

8 Warranty

The manufacturer alone reserves the right to recognize warranty claims.

8.1 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.

8.2 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.

9

References

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

AN001 Application Note "LinLog", Photonfocus, December 2002

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

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

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

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

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

A Pinouts

A.1 Power Supply Connector

The power supply connectors are available from Hirose connectors at www.hirose-connectors.com. Fig. A.1 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.

The connection of the input and output signals is described in Section 5.2.3.

A suitable power supply can be ordered from your Photonfocus dealership.

Connector Type	Order Nr.
12-pole Hirose HR10A-10P-12S soldering	110-0402-0
12-pole Hirose HR10A-10P-12SC crimping	110-0604-4

Table A.1: Power supply connectors (Hirose HR10 series, female connector)

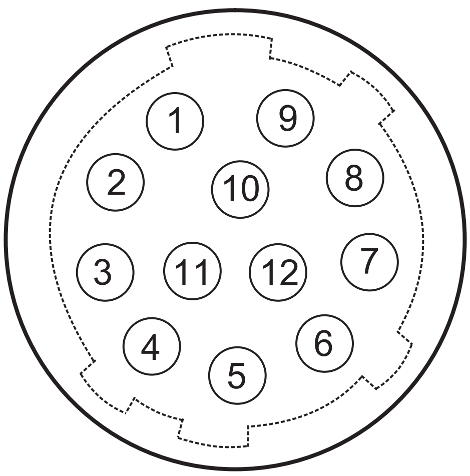


Figure A.1: Power supply connector, 12-pole female (rear view of connector, solder side)

Pin	I/O Type	Name	Description
1	PWR	CAMERA_GND	Camera GND, 0V
2	PWR	CAMERA_PWR	Camera Power 12V..24V
3	O	ISO_OUT0	Default Strobe out, internally Pulled up to ISO_PWR with 4k7 Resistor
4	I	ISO_INC0_N	INC0 differential RS-422 input, negative polarity
5	I	ISO_INC0_P	INC0 differential RS-422 input, positive polarity
6	PWR	ISO_PWR	Power supply 5V..24V for output signals; Do NOT connect to camera Power
7	I	ISO_IN0	IN0 input signal
8	O	ISO_OUT1 (MISC)	Q1 output from PLC, no Pull up to ISO_PWR ; can be used as additional output (by adding Pull up) or as controllable switch (max. 100mA, no capacitive or inductive load)
9	I	ISO_IN1(Trigger IN)	Default Trigger IN
10	I	ISO_INC1_N	INC1 differential RS-422 input, negative polarity
11	I	ISO_INC1_P	INC1 differential RS-422 input, positive polarity
12	PWR	ISO_GND	I/O GND, 0V; Do NOT connect to CAMERA_GND!

Table A.2: Power supply connector pin assignment

B

Camera Revisions

B.1 General Remarks

This chapter lists differences between the revisions of the camera models.
List of terms used in this chapter:

Standard Trigger Standard trigger features. Trigger Source: Free running, Software Trigger, Line1 Trigger, PLC_Q4 Trigger. Exposure Time Control: Camera-controlled, Trigger-controlled. Additional features: Trigger Delay, Burst Trigger and Strobe.

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

B.2 MV1-D2080(IE)-160-G2-12

Table B.1 shows revision information for the MV1-D2080-160-G2-12 camera (abbr. D2080).

	D2080 V1.1
ROI	yes
Line Scan Mode	no
Frame Combine	no
MROI	yes
Decimation	yes
Standard Trigger	yes
AB Trigger	no
Counter Reset External	no
LinLog	yes
Digital Gain / Offset	yes
FPN Correction	yes
LUT	yes
Crosshairs	yes
Status Line	yes
Test Images	yes

Table B.1: Revisions MV1-D2080(IE)-160-G2-12

C

Revision History

Revision	Date	Changes
1.0	April 2013	First release
1.1	September 2013	Appendix "Camera Revisions" added. Section "Mechanical Interface": drawing corrected and drawings of lens adapters added.