



User Manual

D/L-2048 Camera Series

CMOS camera with GigE interface



MAN055 05/2015 V1.8

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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.

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' 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

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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. 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

Introduction

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

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

DR1 cameras DR1 cameras use a proprietary coding algorithm to double the maximal frame rate compared to a standard GigE camera over one GigE cable.

D-cameras Standard area scan cameras.

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

Monochrome Standard monochrome sensor

Color Colour sensor

NIR Cameras with NIR enhanced CMV2000/CMV4000 E12 image sensor

2.1 Camera Naming convention

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

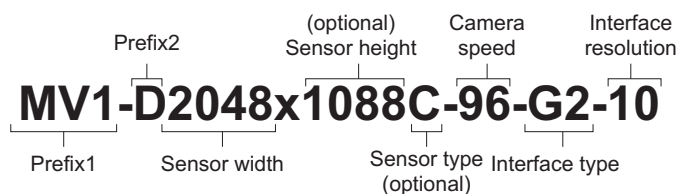


Figure 2.1: Camera naming convention

Prefix1 DR1 cameras have DR1 as Prefix1, whereas the other cameras have MV1 as Prefix1.

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

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

Sensor height This indication is optional to avoid ambiguity. The D-cameras that use the 2 MPix CMV2000 sensor have a height indicator of "1088". The DR1 and D-cameras that use the 4 MPix CMV4000 sensor don't have a height indication.

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

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

Interface type All cameras covered by this manual have a GigE interface denoted by "G2".

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

2.2 Camera list

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

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

2048 camera series All cameras covered in this manual

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

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

DR1 camera Camera that use a proprietary coding algorithm to double the maximal frame rate compared to a standard GigE camera over one GigE cable.

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

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

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

Color Cameras that have a colour sensor.

Name	Resolution	Camera Family	Abbreviation	NIR	Color
MV1-D2048x1088-80-G2-10	2 MPix	D-camera	D-80	no	no
MV1-D2048x1088I-80-G2-10	2 MPix	D-camera	D-80	yes	no
MV1-D2048x1088C-80-G2-10	2 MPix	D-camera	D-80	no	yes
MV1-D2048x1088-96-G2-10	2 MPix	D-camera	D-96	no	no
MV1-D2048x1088I-96-G2-10	2 MPix	D-camera	D-96	yes	no
MV1-D2048x1088C-96-G2-10	2 MPix	D-camera	D-96	no	yes
MV1-D2048-96-G2-10	4 MPix	D-camera	D-96	no	no
MV1-D2048I-96-G2-10	4 MPix	D-camera	D-96	yes	no
MV1-D2048C-96-G2-10	4 MPix	D-camera	D-96	no	yes
DR1-D2048x1088-192-G2-8	2 MPix	DR1 camera	DR1-192	no	no
DR1-D2048x1088I-192-G2-8	2 MPix	DR1 camera	DR1-192	yes	no
DR1-D2048x1088C-192-G2-8	2 MPix	DR1 camera	DR1-192	no	yes
DR1-D2048-192-G2-8	4 MPix	DR1 camera	DR1-192	no	no
DR1-D2048I-192-G2-8	4 MPix	DR1 camera	DR1-192	yes	no
DR1-D2048C-192-G2-8	4 MPix	DR1 camera	DR1-192	no	yes
MV1-L2048-96-G2-10	2 MPix	L-camera	L-96	no	no
MV1-L2048I-96-G2-10	2 MPix	L-camera	L-96	yes	no
MV1-L2048C-96-G2-10	2 MPix	L-camera	L-96	no	yes

Table 2.1: Camera models covered by this manual

How to get started (GigE G2)

3.1 Introduction

This guide shows you:

- How to install the required hardware (see Section 3.2)
- How to install the required software (see Section 3.3) and configure the Network Adapter Card (see Section 3.4 and Section 3.5)
- How to acquire your first images and how to modify camera settings (see Section 3.6)
- 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.

3.2 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.

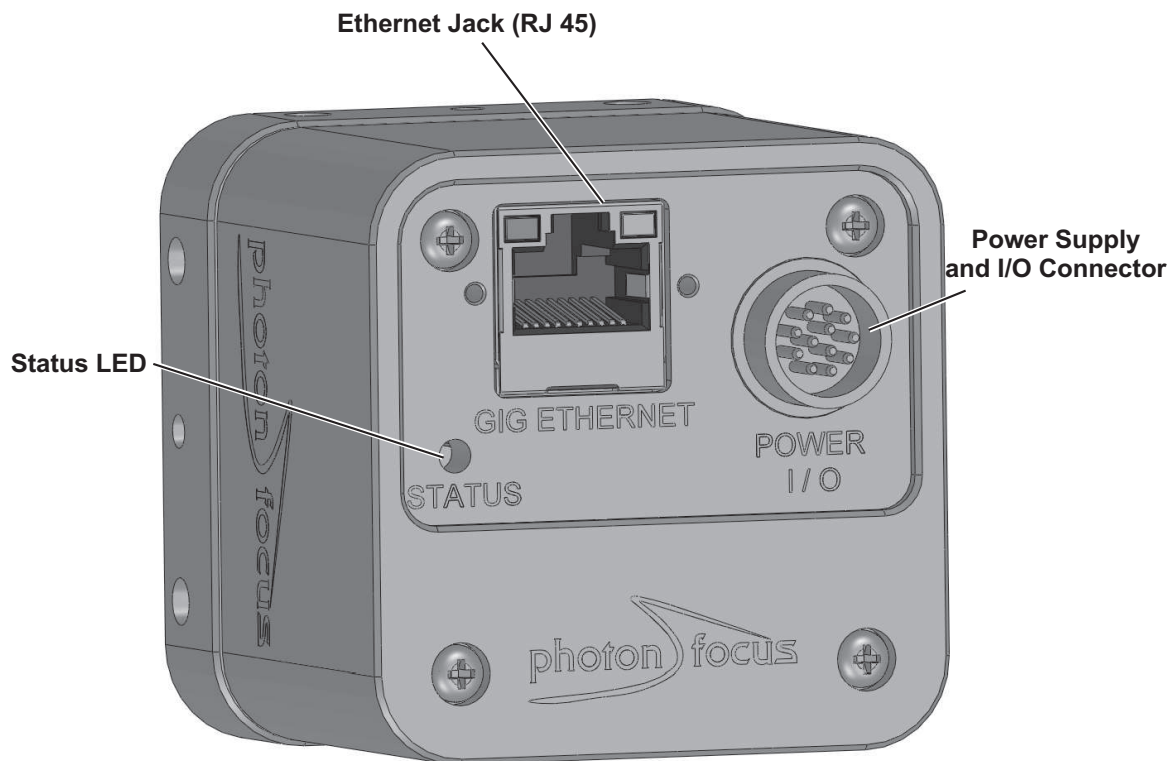


Figure 3.1: Rear view of the Photonfocus 2048 GigE camera series with power supply and I/O connector, Ethernet jack (RJ45) and status LED

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. 3.1).

3.3 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. 3.2). 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.

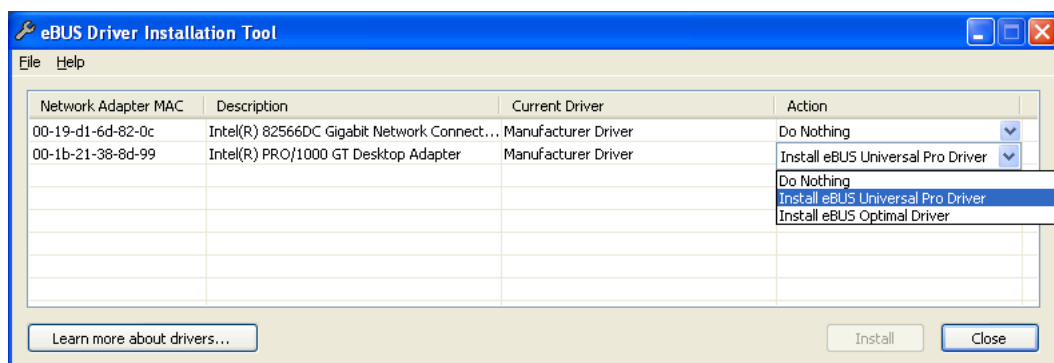


Figure 3.2: eBUS Driver Installation Tool

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. 3.3) 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.

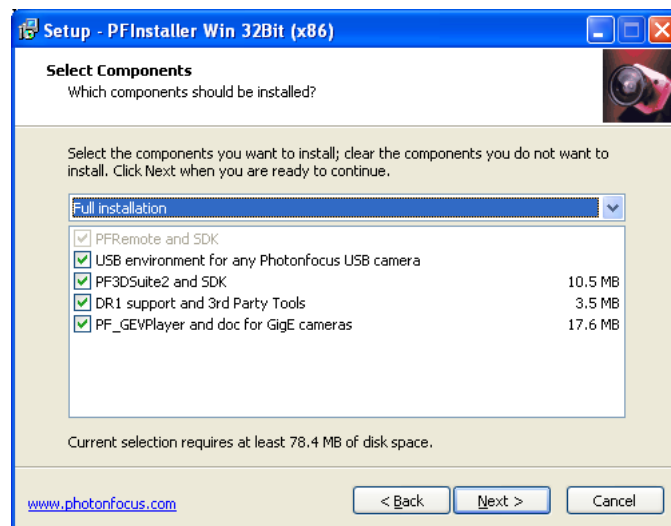


Figure 3.3: PFIInstaller components choice

3.4 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.

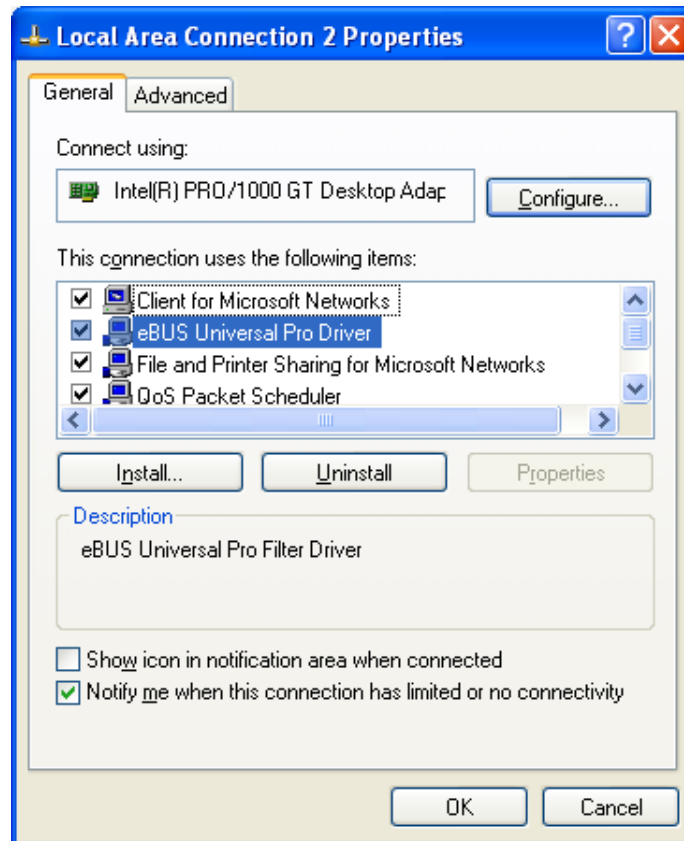


Figure 3.4: Local Area Connection Properties

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. 3.4), click the Properties button and select Obtain an IP address automatically (see Fig. 3.5).

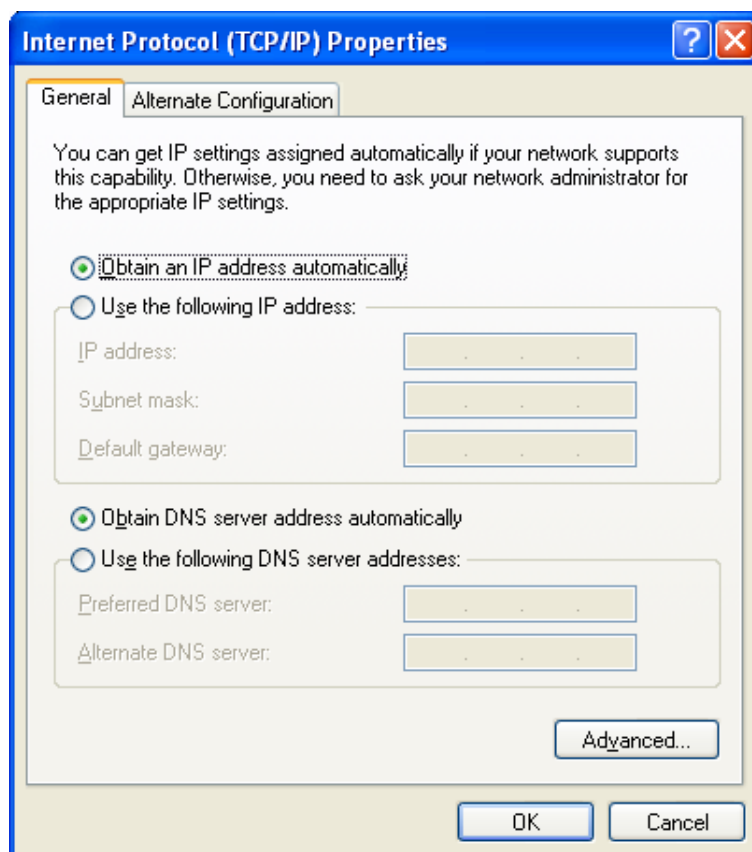


Figure 3.5: TCP/IP Properties

3. Open again the Local Area Connection Properties window (see Fig. 3.4) 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. 3.6). 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.

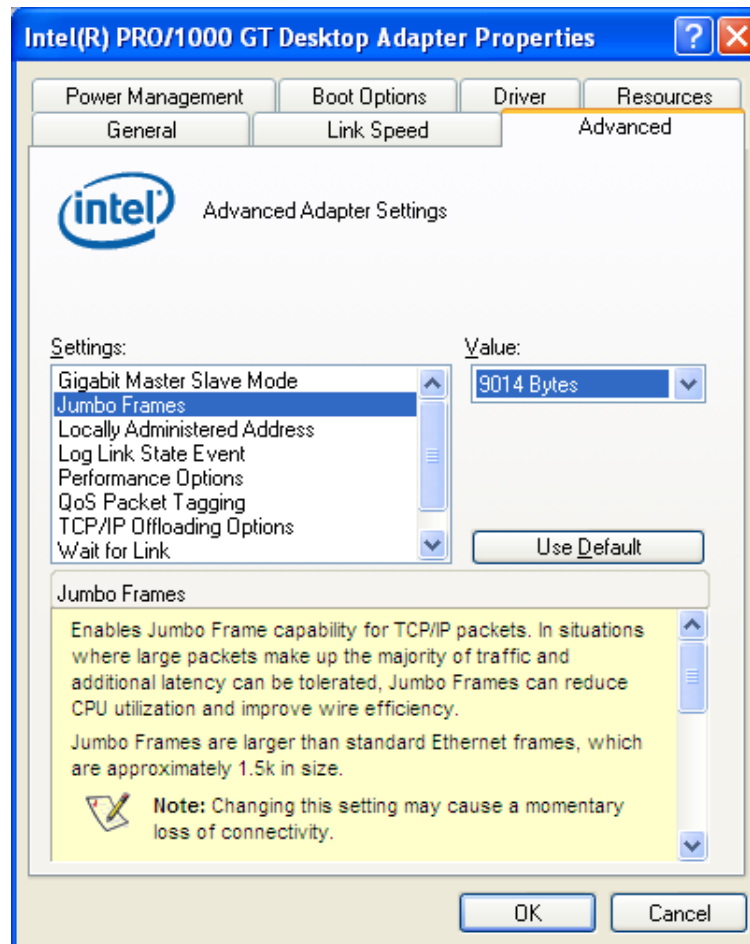


Figure 3.6: Advanced Network Adapter Properties

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. 3.7).

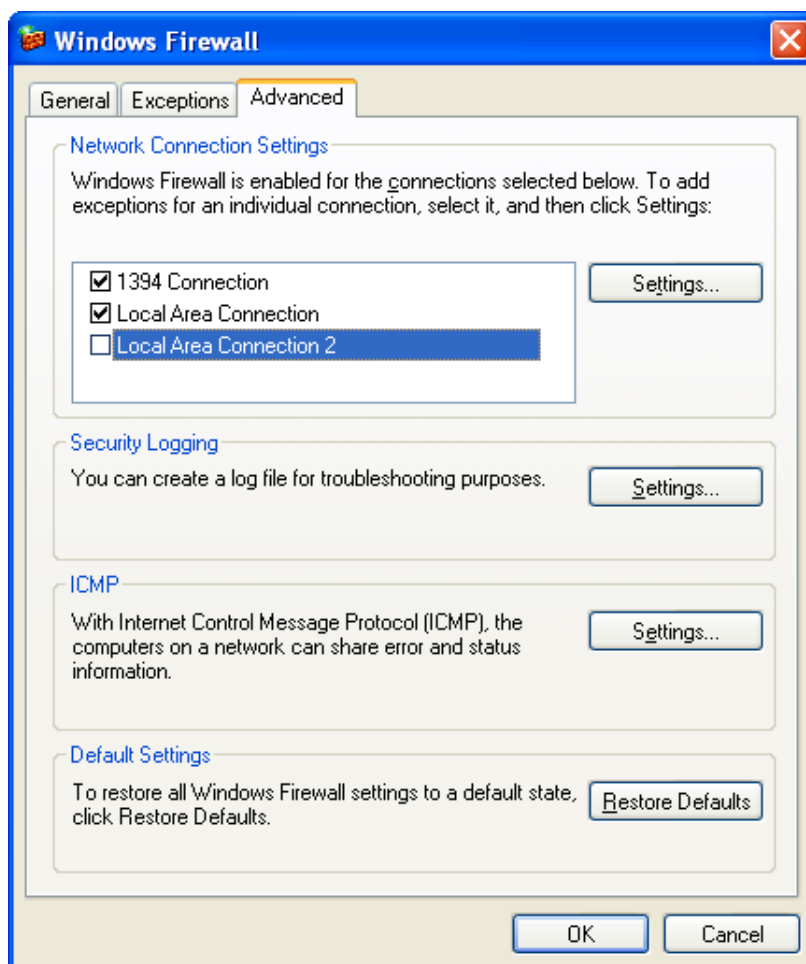


Figure 3.7: Windows Firewall Configuration

3.5 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. 3.8) for maximal performance. Recommended settings for the Network Adapter Card are described in Section 3.4.

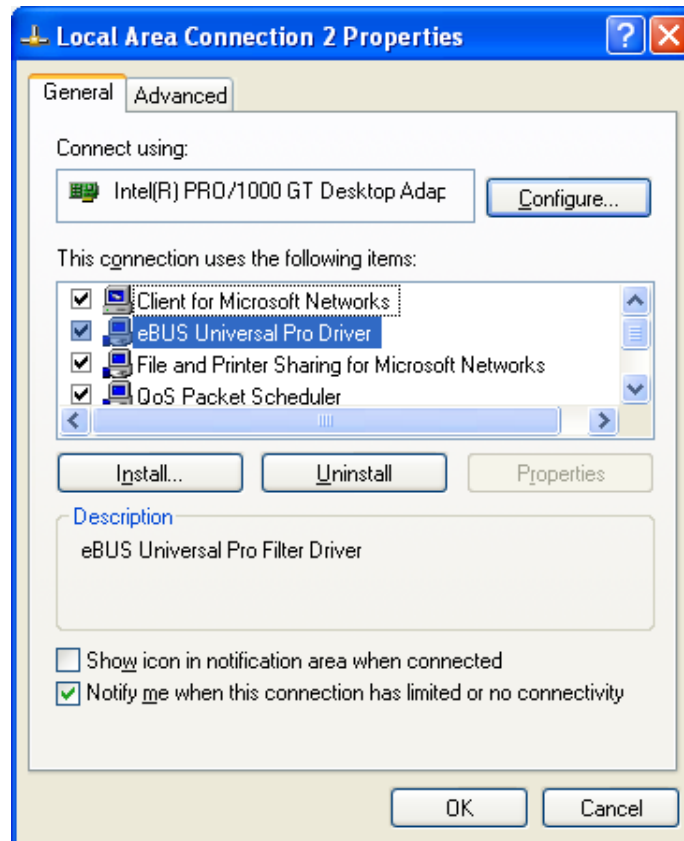


Figure 3.8: Local Area Connection Properties

3.6 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. 3.9).

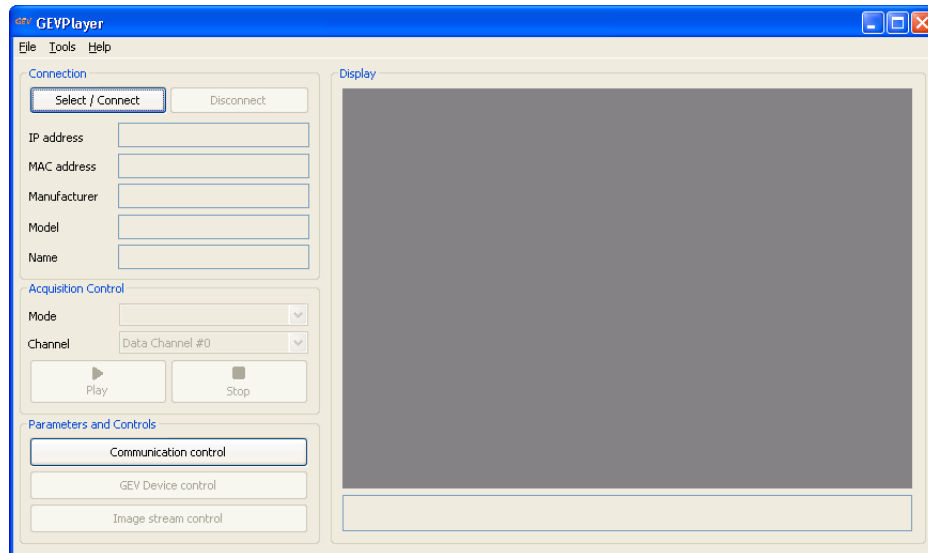


Figure 3.9: PF_GEVPlayer start screen

- Click on the Select / Connect button in the PF_GEVPlayer . A window with all detected devices appears (see Fig. 3.10). If your camera is not listed then select the box Show unreachable GigE Vision Devices.

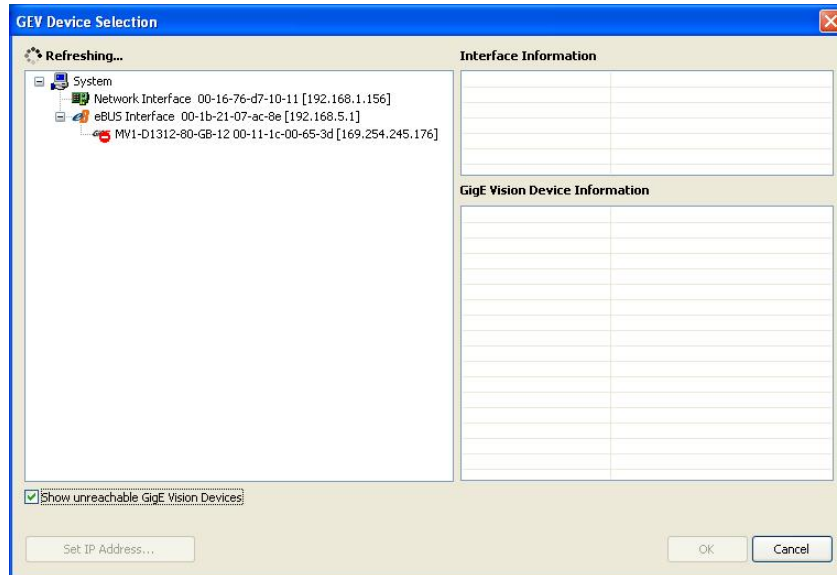


Figure 3.10: GEV Device Selection Procedure displaying the selected camera

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

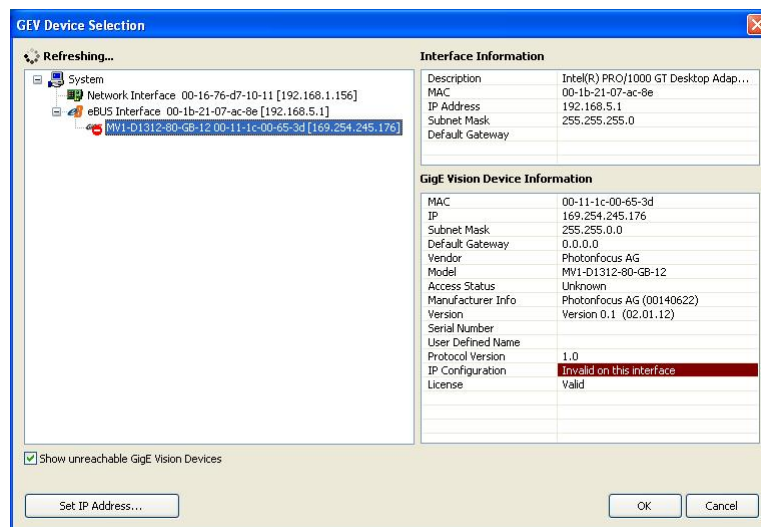


Figure 3.11: GEV Device Selection Procedure displaying GigE Vision Device Information

4. Select a valid IP address for selected camera (see Fig. 3.12). 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.

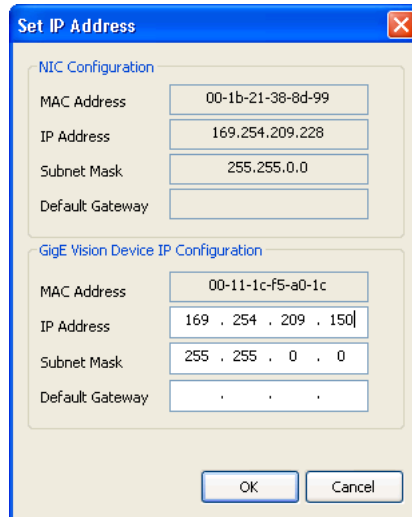


Figure 3.12: Setting IP address

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

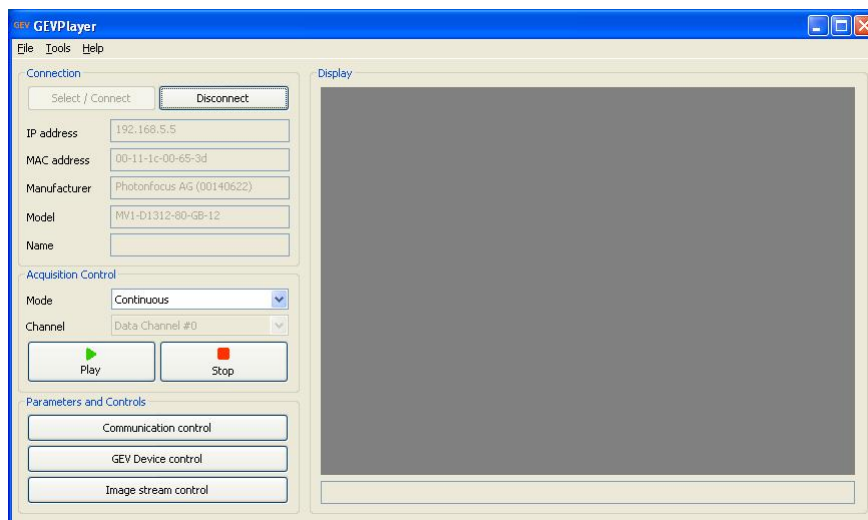


Figure 3.13: PF_GEVPlayer is readily configured

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 3.3) to a lower value and try again.

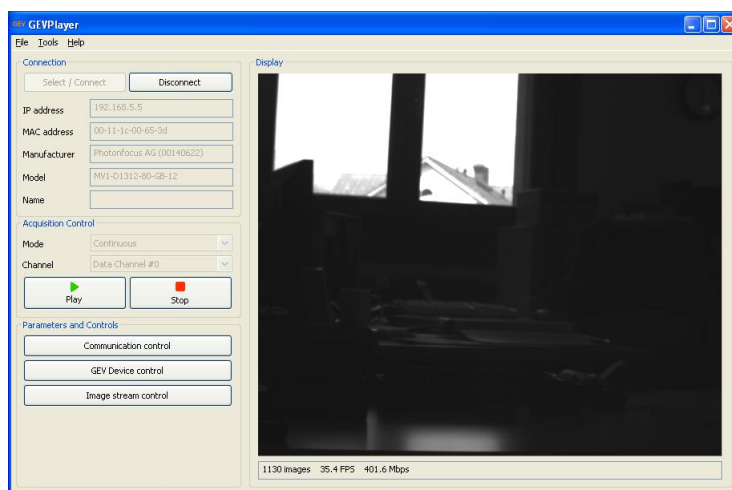


Figure 3.14: PF_GEVPlayer displaying live image stream

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. 3.15). 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.

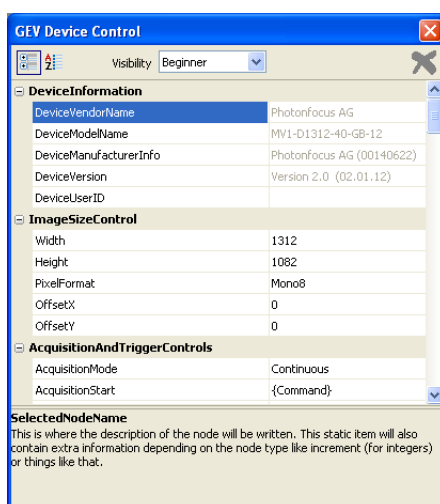


Figure 3.15: Control settings on the camera

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

Product Specification

4.1 Introduction

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

The DR1 models use a proprietary coding algorithm to double the maximal frame rate compared to a standard GigE camera over one GigE cable.

The L-cameras contain a dedicated line scan mode where up to 4 rows can be acquired at very high speeds (27550 fps for 2048x1 pixels), making them a cost-effective replacement for line scan cameras.

The principal advantages are:

- Resolution of 2048 x 1088 or 2048 x 2048 pixels
- Optimized for low light conditions
- Spectral range: monochrome standard: 350 - 900 nm, NIR enhanced: 350 ... 950 nm
- Global Shutter
- Micro lenses
- Colour cameras: Bayer pattern filter and cut off filter @ 660nm
- Gigabit Ethernet interface, GigE Vision and GenICam compliant
- Frame rates of the D-96 cameras: 22.6 fps (2048 x 2048 pixel, MV1-D2048(I/C)-96-G2 only), 42.6 fps (2048 x 1088), 90.4 fps (1024 x 1024).
- Frame rates of the DR1-192 cameras: 45 fps (2048 x 2048 pixel, DR1-D2048(I/C)-192-G2 only), 85 fps (2048 x 1088), 180 fps (1024 x 1024).
- L-96 line scan frame rates: 27550 fps (2048 x 1), 20350 fps (2048 x 2)
- Advanced I/O capabilities: 2 isolated trigger inputs, 2 differential isolated RS-422 inputs and 2 isolated outputs
- Up to 8 regions of interest (MROI)
- 2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT)
- Crosshairs overlay on the image
- Image information and camera settings inside the image (status line) (not available in all models, see Appendix B)
- Image Binning (not available in all models, see Appendix B)
- Software provided for setting and storage of camera parameters
- The DR1 cameras use a proprietary encoding algorithm to double the maximal frame rate compared to a standard GigE camera. It is available in monochrome and color versions.

4 Product Specification

- The rugged housing at a compact size of 55 x 55 x 51.5 mm³ makes the Photonfocus 2048 GigE camera series the perfect solution for applications in which space is at a premium.
- Programmable Logic Controller (PLC) for powerful operations on input and output signals.
- A/B RS-422 shaft encoder interface in some models (see Appendix B).
- Wide power input range from 12 V (-10 %) to 24V (+10 %).

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



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

4.2 Feature Overview

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

Characteristics	Photonfocus 2048 GigE Camera Series
Interface	Gigabit Ethernet, GigE Vision and GenICam compliant
Camera Control	GigE Vision Suite
Trigger Modes	Software Trigger / External isolated trigger input / PLC Trigger
Features	• Greyscale / colour resolution 10 bit / 8 bit (DR1, D-240: 8 bit only) • Region of Interest (ROI) • Up to 8 regions of interest (MROI) • Fast line scan mode (L-cameras only) • Binning (not available in all models, see Appendix B) • 2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT) • Test pattern (LFSR and grey level ramp) • Image information and camera settings inside the image (status line) (not available in all models, see Appendix B) • Crosshairs overlay on the image • 2 isolated trigger inputs, 2 differential isolated RS-422 inputs and 2 isolated outputs

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

4.3 Available Camera Models



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

Name	Resolution	FPS	Special	NIR ⁴⁾	Color
MV1-D2048x1088-80-G2-10	2048 x 1088	35.5 fps ¹⁾	n/a	no	no
MV1-D2048x1088I-80-G2-10	2048 x 1088	35.5 fps ¹⁾	n/a	yes	no
MV1-D2048x1088C-80-G2-10	2048 x 1088	35.5 fps ¹⁾	n/a	no	yes
MV1-D2048x1088-96-G2-10	2048 x 1088	42.6 fps ¹⁾	n/a	no	no
MV1-D2048x1088I-96-G2-10	2048 x 1088	42.6 fps ¹⁾	n/a	yes	no
MV1-D2048x1088C-96-G2-10	2048 x 1088	42.6 fps ¹⁾	n/a	no	yes
MV1-D2048-96-G2-10	2048 x 2048	22.6 fps ¹⁾	n/a	no	no
MV1-D2048I-96-G2-10	2048 x 2048	22.6 fps ¹⁾	n/a	yes	no
MV1-D2048C-96-G2-10	2048 x 2048	22.6 fps ¹⁾	n/a	no	yes
DR1-D2048x1088-192-G2-8	2048 x 1088	85 fps ¹⁾	DoubleRate	no	no
DR1-D2048x1088I-192-G2-8	2048 x 1088	85 fps ¹⁾	DoubleRate	yes	no
DR1-D2048x1088C-192-G2-8	2048 x 1088	85 fps ¹⁾	DoubleRate	no	yes
DR1-D2048-192-G2-8	2048 x 2048	45 fps ¹⁾	DoubleRate	no	no
DR1-D2048I-192-G2-8	2048 x 2048	45 fps ¹⁾	DoubleRate	yes	no
DR1-D2048C-192-G2-8	2048 x 2048	45 fps ¹⁾	DoubleRate	no	yes
MV1-L2048-96-G2-10	2048 x 1088	27550 fps ²⁾	LineScan	no	no
MV1-L2048-96I-G2-10	2048 x 1088	27550 fps ²⁾	LineScan	yes	no
MV1-L2048-96C-G2-10	2048 x 1088	20350 fps ³⁾	LineScan	no	yes

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

4.4 Technical Specification

	2 MPix Cameras	4 MPix Cameras
Sensor	CMOSIS CMV2000	CMOSIS CMV4000
Technology	CMOS active pixel	
Scanning system	progressive scan	
Optical format / diagonal	2/3" (12.75 mm diagonal)	1" (15.92 mm diagonal)
Resolution	2048 x 1088 pixels	2048 x 2048 pixels
Pixel size	5.5 μm x 5.5 μm	
Active optical area	11.26 mm x 5.98 mm	11.26 mm x 11.26 mm
Full well capacity	11 ke ⁻	
Spectral range standard sensor	< 350 to 900 nm (to 10 % of peak responsivity)	
Spectral range of (I) models	< 350 to 970 nm (to 10 % of peak responsivity)	
Spectral range of colour models	390 to 670 nm (to 10 % of peak responsivity)	
Conversion gain	0.075 LSB/e ⁻	
Sensitivity	5.56 V / lux.s (with micro lenses @ 550 nm)	
Optical fill factor	42 % (without micro lenses)	
Dark current	125 e ⁻ /s @ 25°C	
Dynamic range	60 dB	
Micro lenses	Yes	
Colour format (C) cameras	RGB Bayer Raw Data Pattern	
Characteristic curve	Linear, Piecewise linear (multiple slope)	
Shutter mode	global shutter	
Sensor bit depth	10 bit	
Maximal Frame rate ¹⁾ MV1 models	42.6 fps	22.6 fps
Maximal Frame rate ¹⁾ DR1 models	85 fps	45 fps
Maximal Frame rate ²⁾ line scan	27550 fps	n/a
Camera pixel formats	16 ³⁾ / 12 ³⁾ / 10 / 8 bit (DR1/D-240 models): 8 bit only)	
Digital Gain	0.1 to 15.99 (Fine Gain)	
Exposure Time MV1-...-80 models	15 μs ... 0.42 s / 25 ns steps	28 μs ... 0.42 s / 25 ns steps
Exposure Time MV1-...-96 models	13 μs ... 0.349 s / 20.8 ns steps	26 μs ... 0.349 s / 20.8 ns steps
Exposure Time DR1 models	13 μs ... 0.349 s / 20.8 ns steps	26 μs ... 0.349 s / 20.8 ns steps

Table 4.3: General specification of the Photonfocus 2048 GigE camera series (Footnotes: ¹⁾ at full resolution, ²⁾ L-96 at 2048x1 in line scan mode, ³⁾ not available in all models, see Appendix B)

	D-Cameras / L-Cameras	DR1 Cameras
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	
Maximal power consumption @ 12 V	< 5.1 W	< 5.5 W
Lens mount	C-Mount, CS-Mount (optional)	
Dimensions	55 x 55 x 51.5 mm ³	
Mass	260 g	
Conformity	RoHS, WEEE	

Table 4.4: Physical characteristics and operating ranges

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

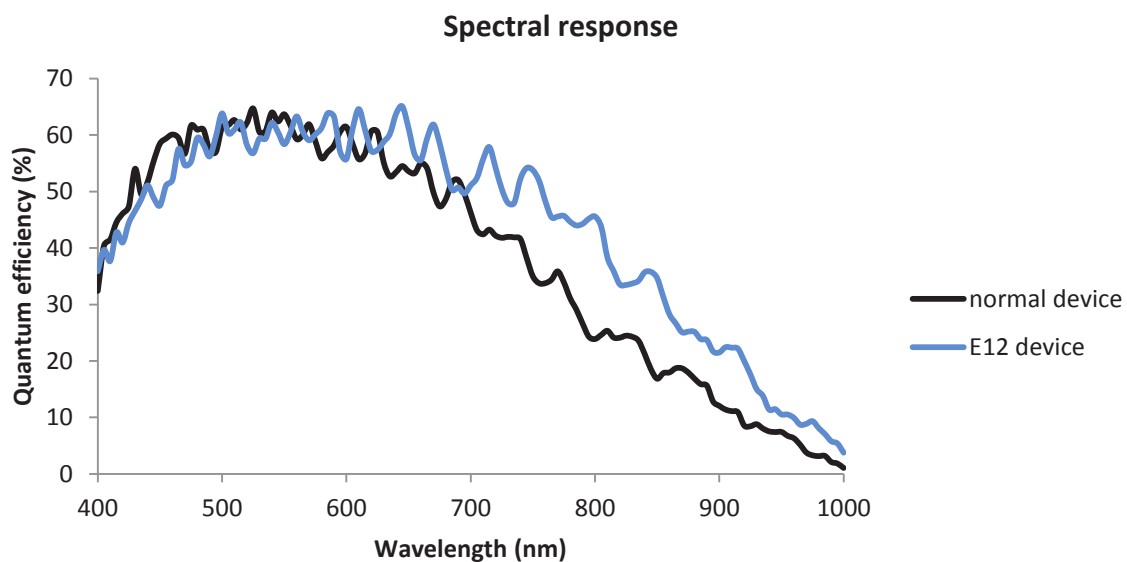


Figure 4.2: Spectral response of the CMV2000/4000 CMOS monochrome image sensors (with micro lenses); E12 device is contained in the (I) cameras

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

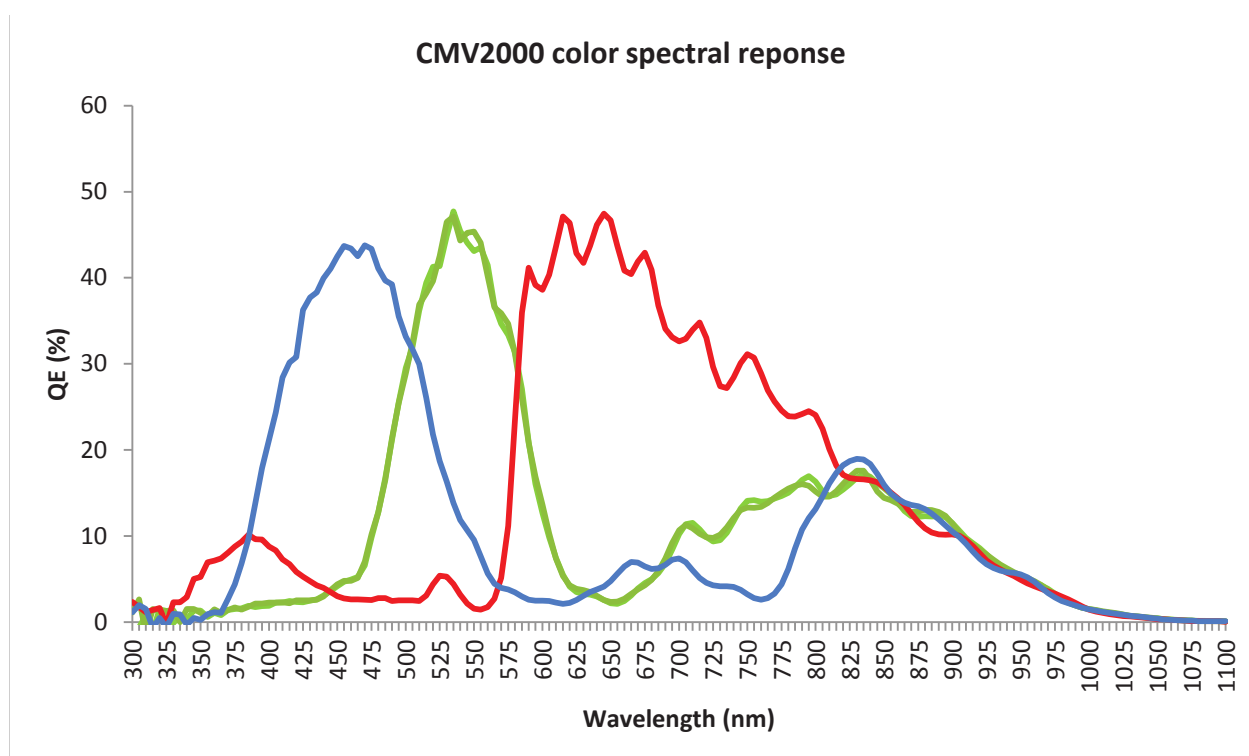


Figure 4.3: Spectral response of the CMV2000/4000 CMOS colour image sensors (with micro lenses)

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

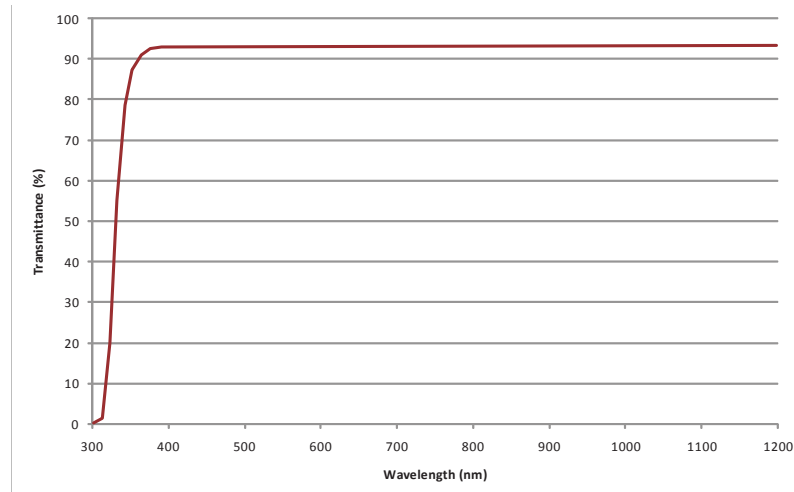


Figure 4.4: Transmittance curve of D263 cover glass

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

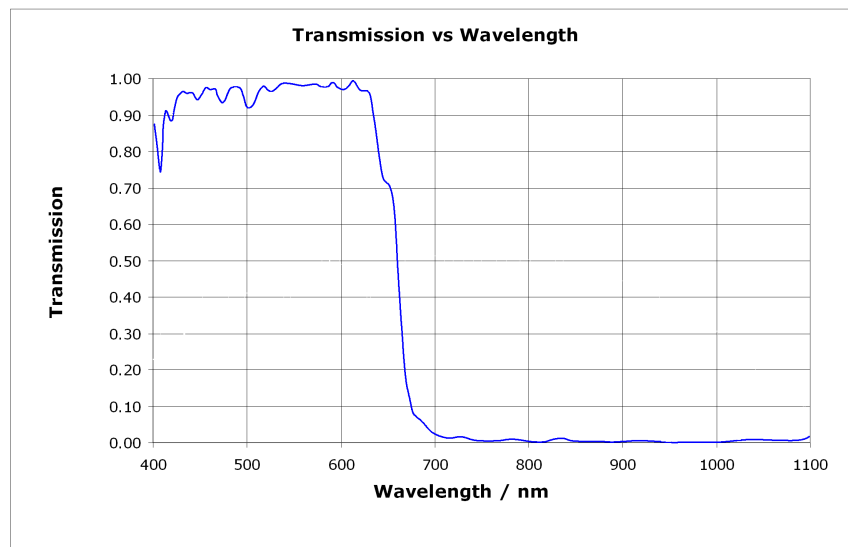


Figure 4.5: Transmission curve of the cut-off filter in the Photonfocus 2048 GigE cameras

4.5 RGB Bayer Pattern Filter

Fig. 4.6 shows the bayer filter arrangement on the pixel matrix in the Photonfocus 2048 GigE cameras which is often denoted as "Green - Blue" pattern.



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

		Column			
		0	1	2	3
Row	0	G	B	G	B
	1	R	G	R	G
	2	G	B	G	B
	3	R	G	R	G

Figure 4.6: Bayer Pattern Arrangement in the Photonfocus 2048 GigE cameras

Functionality

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

5.1 Reduction of Image Size

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

5.1.1 Region of Interest (ROI)

Some applications do not need full image resolution. By reducing the image size to a certain region of interest (ROI), the frame rate can be increased. A region of interest can be almost any rectangular window and is specified by its position within the full frame and its width (W) and height (H).



The ROI width must be a multiple of 2 in the D-cameras and L-cameras and a multiple of 32 in DR1 cameras.



The ROI height must be a multiple of 2 in the DR1 cameras.

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

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

ROI Dimension	D-80	D-96 / L-96	DR1-192
2048 x 2048 ¹⁾	18.9 fps	22.6 fps	45.3 fps
2048 x 1088	35.5 fps	42.6 fps	85.1 fps
1280 x 1024 (SXGA)	37.7 fps	45.2 fps	90.4 fps
1280 x 768 (WXGA)	50.2 fps	60.3 fps	120.4 fps
800 x 600 (SVGA)	128.2 fps	153.8 fps	306.3 fps
640 x 480 (VGA)	160 fps	191.9 fps	381.8 fps
480 x 640 (rot-VGA ⁴⁾)	239 fps	287.4 fps	570 fps
512 x 1	18903 fps	22598.8 fps	25723.4 fps ³⁾
256 x 256	1155.2 fps	1386 fps	1386 fps
512 x 512	298 fps	358.3 fps	709 fps
640 x 640	120.2 fps	144.3 fps	287.4 fps
1024 x 1024	75.3 fps	90.4 fps	180.4 fps

Table 5.1: Frame rates of different ROI settings (minimal exposure time). (Footnotes: ¹⁾4.2 MPix model only, ²⁾DR1-192 with double rate enabled, ³⁾512x2, ⁴⁾get VGA by rotating the camera and software image)

ROI Dimension	L-96
2048 x 1	27550 fps
2048 x 2	20350 fps
2048 x 3	14150 fps
2048 x 4	10850 fps

Table 5.2: Frame rates of line scan mode of L-96 cameras (minimal exposure time).

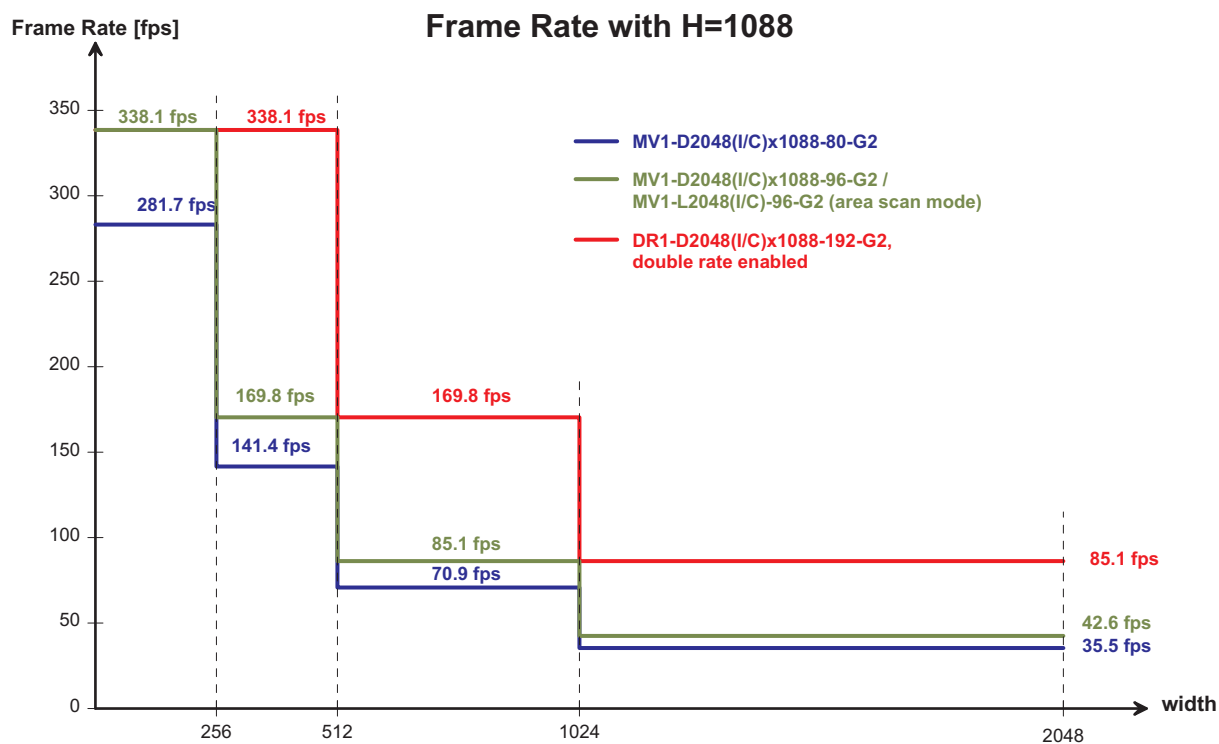


Figure 5.1: Frame rate in function of ROI width at H=1088 for 2.2 MPix models

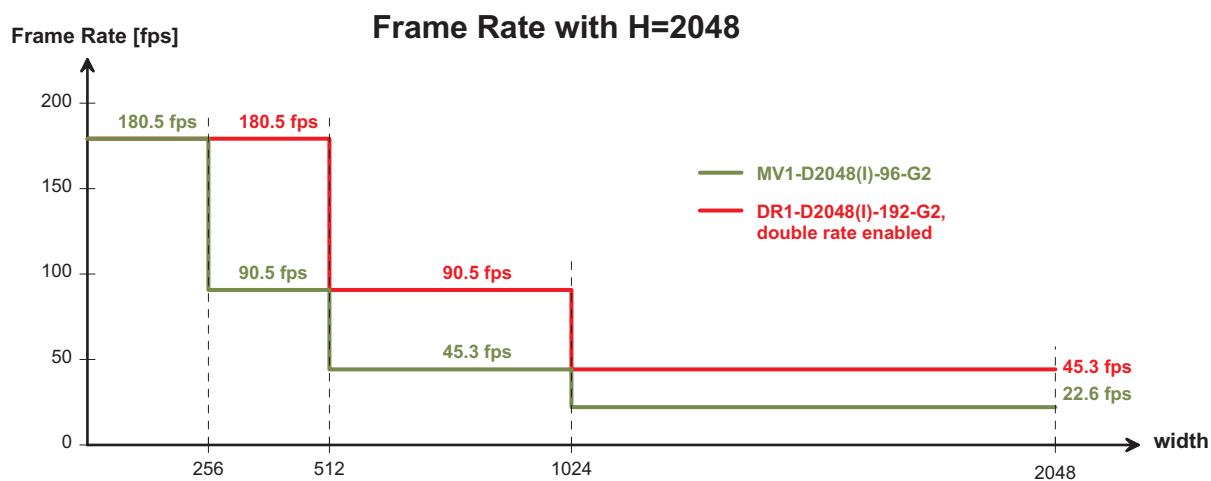


Figure 5.2: Frame rate in function of ROI width at H=2048 for 4.2 MPix models

5.1.2 Line Scan Mode (L-cameras only)

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

The LineScan mode can be enabled by setting `EnLinescanHighSpeedMode` to `True`.

Frame Combine

Very high frame rates that are well over 1000 fps, can be achieved in the LineScan mode. Every frame (image) activates an interrupt in the GigE software which will issue a high CPU load or the frame rate can not be handled at all by an overload of interrupts.

To solve this issue, the FrameCombine mode has been implemented in the L-cameras. In this mode, the data of n images are bundled into one frame. The value n (`=FrameCombine_NrOfFrames`) can be set by the user.



FrameCombine can only be enabled if `EnLinescanHighSpeedMode=True`.



The maximal value of the FrameCombine property is 1088 in older models and 16383 in newer models (see Appendix B).



If there is an error `MISSING_PACKETS` in the `PF_GEVPlayer` then the Request Timeout has to be increased in Image stream control -> Configuration -> RequestTimeout.

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

FrameCombine_Timeout A timeout can be specified after which the combined frame will be transmitted, regardless if there was enough data to fill it. The timeout counter is reset after each frame and counts until a new trigger has been detected or until the timeout is reached. A value of 0 disables the timeout features (applies an indefinite timeout).

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

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

FrameCombinePulse

The FrameCombinePulse feature generates a pulse on the PLC_A7 after the end of a combined frame. This signal can be used in the control of peripheral equipment by connecting this signal to a camera output (see Section 7.10.5).

Parameters to control the FrameCombinePulse feature:

FrameCombine_PulseWidth: Width of the generated pulse (μ s). A value of 0 turns off the generation of pulses.

FrameCombine_PulseInvert: False: pulse is active high. True: pulse is active low.



The FrameCombinePulse feature is not available in all camera revisions (see Appendix B).



The FrameCombinePulse feature can also be used when FrameCombine is turned off. In this case a pulse is generated after the readout of every image.

5.1.3 Multiple Regions of Interest

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

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



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



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

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

Fig. 5.4 shows another MROI drawing illustrating the effect of MROI on the image content.

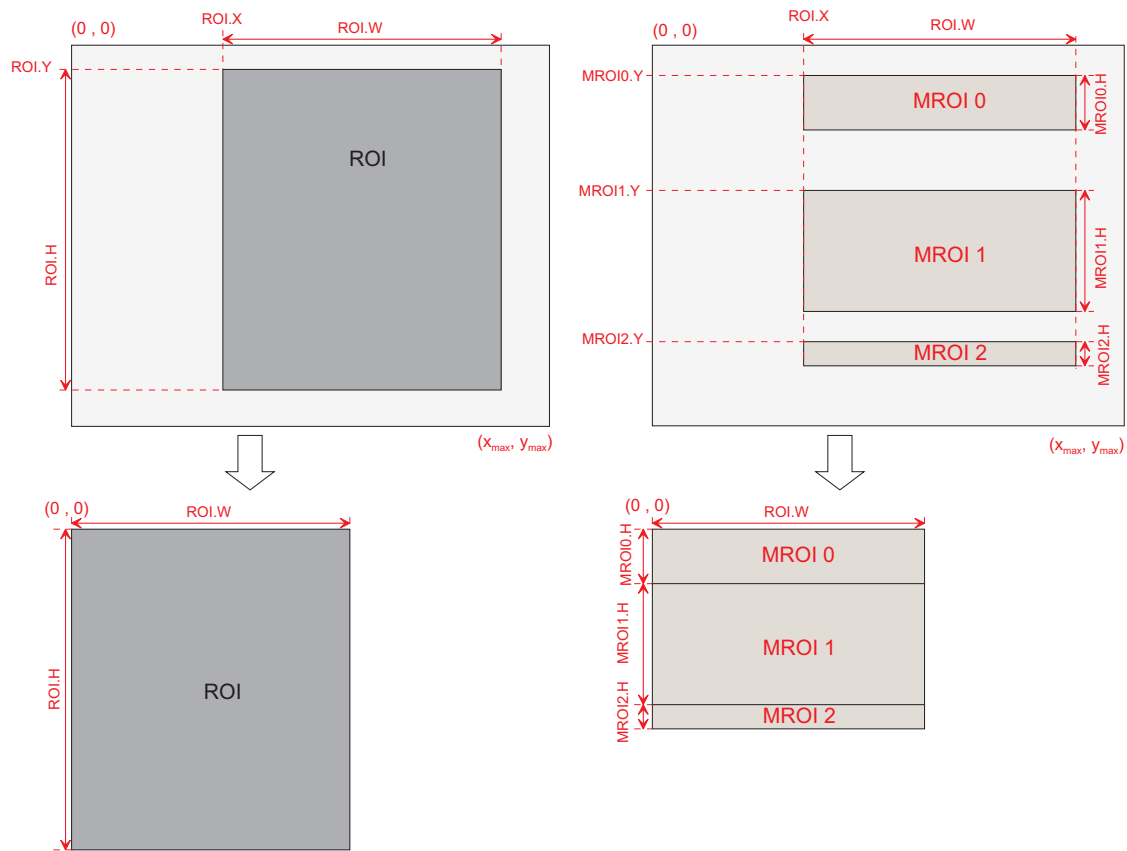


Figure 5.3: Multiple Regions of Interest

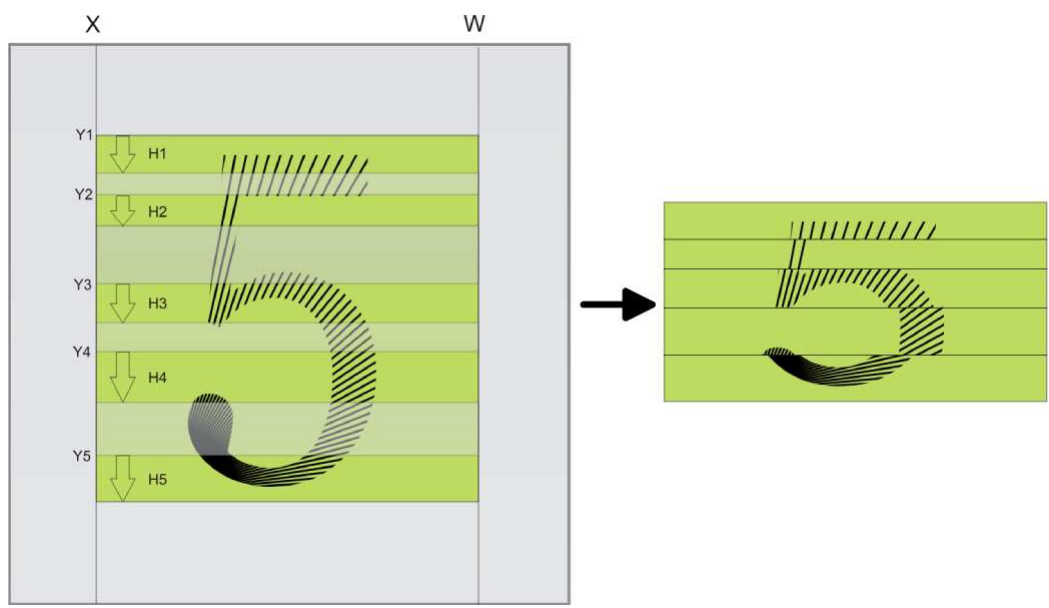


Figure 5.4: Multiple Regions of Interest with 5 ROIs

Fig. 5.5 shows an example from hyperspectral imaging where the presence of spectral lines at known regions need to be inspected. By using a MROI only a 636x54 region need to be readout and a frame rate of 1322 fps (D-80), 1586 fps (D-96 or L-96) or 3038 fps (DR1-192, double rate enabled) can be achieved. Without using MROI the resulting frame rate would be for a 636x1088 ROI 71 fps (D-80), 85 fps (D-96 or L-96) or 169 fps (DR1-192, double rate enabled).

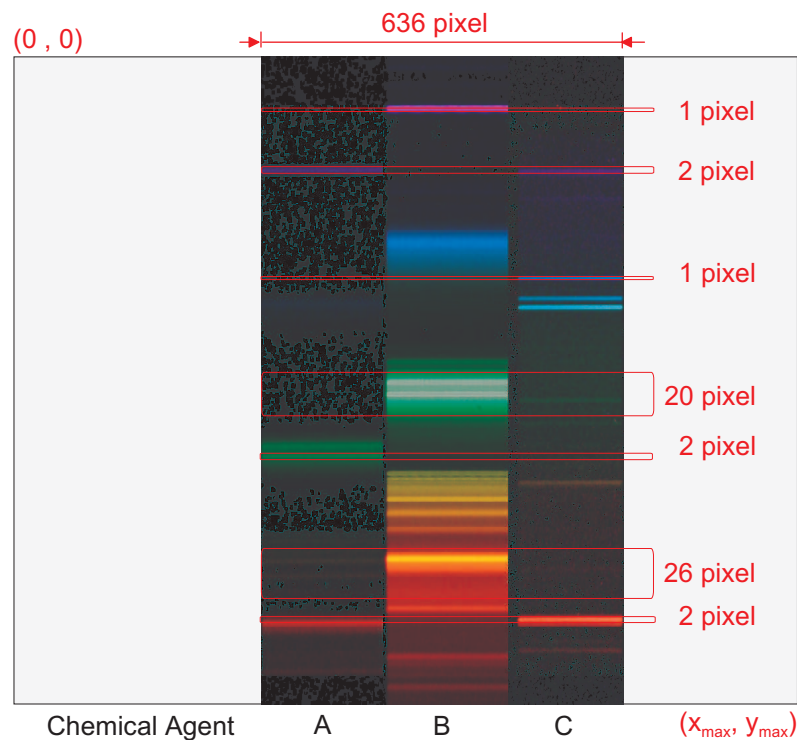


Figure 5.5: Multiple Regions of Interest in hyperspectral imaging

5.1.4 Decimation (monochrome cameras)

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



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

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

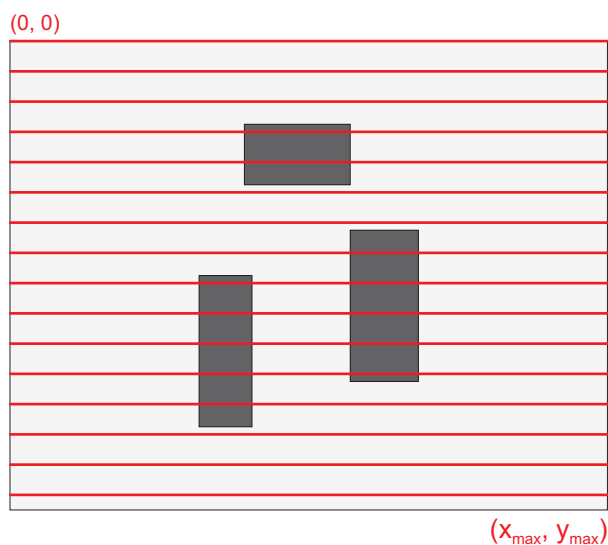


Figure 5.6: Decimation in full image

Fig. 5.7 shows decimation on a ROI. The row specified by the Window.Y setting is first read out and then every n^{th} row until the end of the ROI.

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

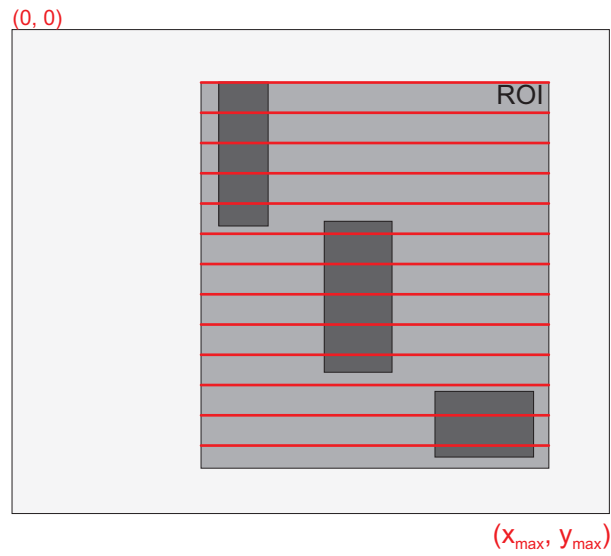


Figure 5.7: Decimation and ROI

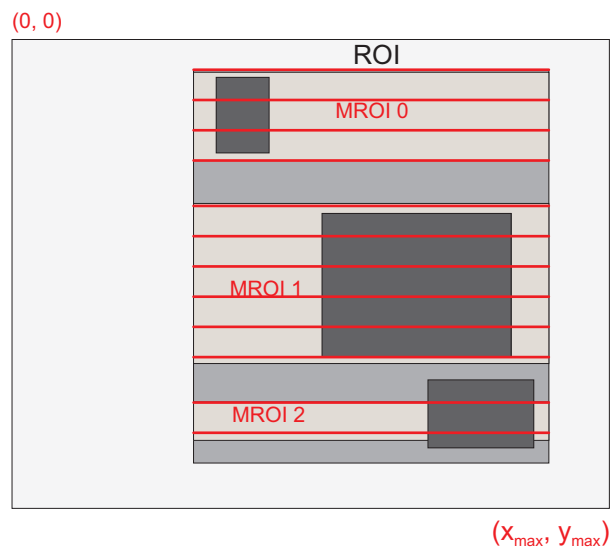


Figure 5.8: Decimation and MROI

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



Figure 5.9: Image example of decimation 3

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



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

5.1.5 Decimation (colour cameras)

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

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

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

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



The total number of rows can be read by the property HeightInterface.

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

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

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

Table 5.4: Examples of total rows in colour decimation

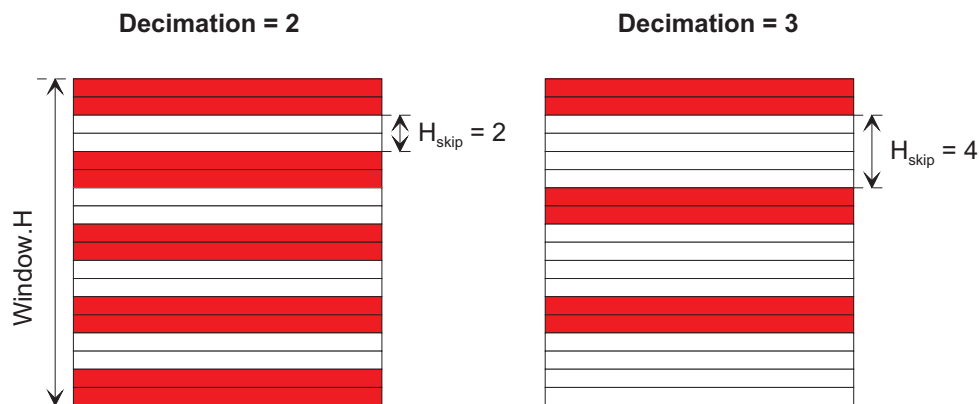


Figure 5.11: Example of decimation in colour cameras

5.1.6 Binning

Description

Binning sums the pixels in subsequent columns and rows, according to the binning configuration. The result is then divided by the number of binned pixels. The binning feature will result in images with lower resolution but significantly higher SNR. For instance, 2x2 binning will result in roughly twice the SNR (in bright areas of the image).

Binning is done in the digital domain of the camera.

Fig. 5.12 shows a schematic of 2x2 binning: pixels in a 2x2 neighbourhood (displayed as pixels with the same colour in the schematic) are binned together: their intensity values are summed and divided by four. The output image has half the height and half the width of the input image.

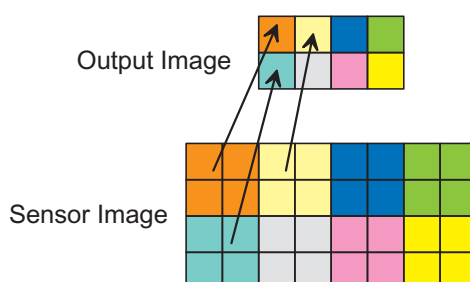


Figure 5.12: Example of 2x2 binning

Camera settings

The camera supports binning settings of 1, 2, 4 or 8 in horizontal and vertical direction. The relevant parameters for binning are shown in Table 5.5.



Binning is not available on all camera revisions and models, see Appendix B

Binning might increase the maximal frame rate. The dimension of the output image determines the maximal frame rate.

Property	Type	Description
BinningHorizontal	Integer	Number of pixels combined in binning in horizontal direction.
BinningVertical	Integer	Number of pixels combined in binning in vertical direction.
Binning_Bitshift	Integer	Additional left bitshift after binning (overflow is ignored)
PixelFormat	Enumeration	If BinningHorizontal or BinningVertical is set to a value bigger than 1 then the Mono16 (16 bit) pixel format is available (not available in DR1 models). Note that this reduces the maximal frame rate.
SensorDigitizationTaps	Enumeration	(not available in DR1 models) This property must be set to One if PixelFormat=Mono16 and set to Two otherwise.
Height	Integer	Height of the output image.
Width	Integer	Width of the output image. In DR1 models: value of the property WidthInterface must be copied to property Width.
Window_W	Integer	(applies only to DR1 models) This is the width of the input image. E.g. Window_W=2048 and BinningHorizontal=2 will result in a width of 1024 in the output image after demodulation.

Table 5.5: Binning parameters

5.1.7 Maximal Frame Rate

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

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

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

To have a rough idea about the maximal allowed frame rate for a given setting it is important to know the 3 possible frame timings that are described in the next sections. The parameter W in the following tables refer to the width of the output image (in DR1: after demodulation).



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

Camera	$W \leq 256$	$256 < W \leq 512$	$512 < W \leq 1024$	$W > 1024$
D-80	$3.225 \mu s$	$6.45 \mu s$	$12.9 \mu s$	$25.8 \mu s$
D-96 / L-96 ¹⁾	$2.6875 \mu s$	$5.375 \mu s$	$10.75 \mu s$	$21.5 \mu s$
DR1-192 ²⁾	$2.6875 \mu s$	$2.6875 \mu s$	$5.375 \mu s$	$10.75 \mu s$

Table 5.6: Time to read out 1 row (Footnotes: ¹⁾ double rate enabled, ¹⁾ `EnLinescanHighSpeedMode=False`)

Camera	$W \leq 256$	$256 < W \leq 512$	$512 < W \leq 1024$	$W > 1024$
D-80	$39.13 \mu s$	$45.58 \mu s$	$58.48 \mu s$	$84.28 \mu s$
D-96 / L-96 ¹⁾	$32.60 \mu s$	$37.98 \mu s$	$48.73 \mu s$	$70.23 \mu s$
DR1-192 ²⁾	$32.60 \mu s$	$32.60 \mu s$	$37.98 \mu s$	$48.73 \mu s$

Table 5.7: Value of $T_{ReadoutDel}$ (Footnotes: ¹⁾ double rate enabled, ¹⁾ `EnLinescanHighSpeedMode=False`)

Simultaneous Read out Timing 1

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

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

$$\text{MaxFrameRate} = 1 / (\text{ReadoutTime} + \text{TExpDel} + \text{TReadoutDel})$$

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

The ReadoutTime is the height of ROI multiplied by the read out time of one row (see Table 5.6).

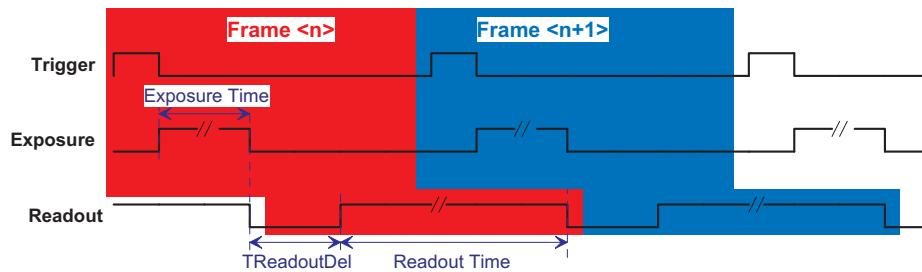


Figure 5.13: Simultaneous read out timing 1: exposure time smaller than read out time

Simultaneous Read out Timing 2

The exposure time is bigger than the read out time in this timing (see Fig. 5.14). Exposure is started during the sensor read out of the previous frame.

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

$$\text{MaxFrameRate} = 1 / (\text{ExposureTime} + \text{TExpDel1} + \text{TReadoutDel})$$

TExpDel1 is 1.25 μs for the D-80 cameras and 1.042 μs for D-96, DR1-192 and L-96 cameras.

The ReadoutTime is the height of the ROI multiplied by the read out time of one row (see Table 5.6).

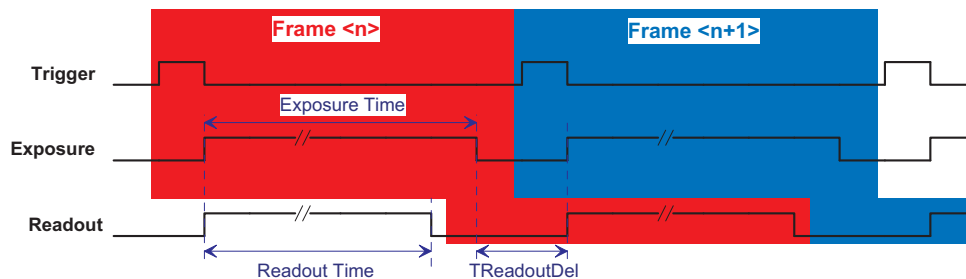


Figure 5.14: Simultaneous read out timing 2: exposure time bigger than read out time

Sequential Read out Timing

In this timing the exposure is started after the read out of the previous frame (see Fig. 5.15).

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

$$\text{MaxFrameRate} = 1 / (\text{ExposureTime} + \text{TReadoutDel} + \text{ReadoutTime})$$

The ReadoutTime is the height of the ROI multiplied by the read out time of one row (see Table 5.6).

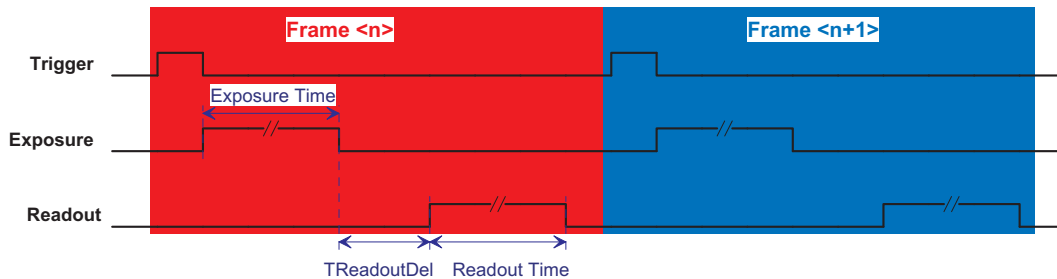


Figure 5.15: Sequential read out timing

5.2 Trigger and Strobe

5.2.1 Introduction

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

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

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

The exposure time in external trigger mode can be defined by the setting of the exposure time register (camera controlled exposure mode) or by the width of the incoming trigger pulse (trigger controlled exposure mode) (see Section 5.2.4).

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 5.2.7).

The start of the exposure is shortly after the active edge of the incoming trigger. An additional trigger delay can be applied that delays the start of the exposure by a user defined time (see Section 5.2.5). This is often used to start the exposure after the trigger to a flash lighting source.

5.2.2 Trigger Source

The trigger signal can be configured to be active high or active low 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. 5.16 and Fig. 5.17. The electrical interface of the trigger input and the strobe output is described in Section 6.5. 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 6.6). Settings for PLC_Q4 Trigger mode: `TriggerMode = On` and `TriggerSource = PLC_Q4`.

ABTrigger Trigger from incremental encoder (see Section 5.2.9). The A/B Trigger feature is not available on all camera revisions, see Appendix B for a list of available features.



Some trigger signals are inverted. A schematic drawing is shown in Fig. 7.4.

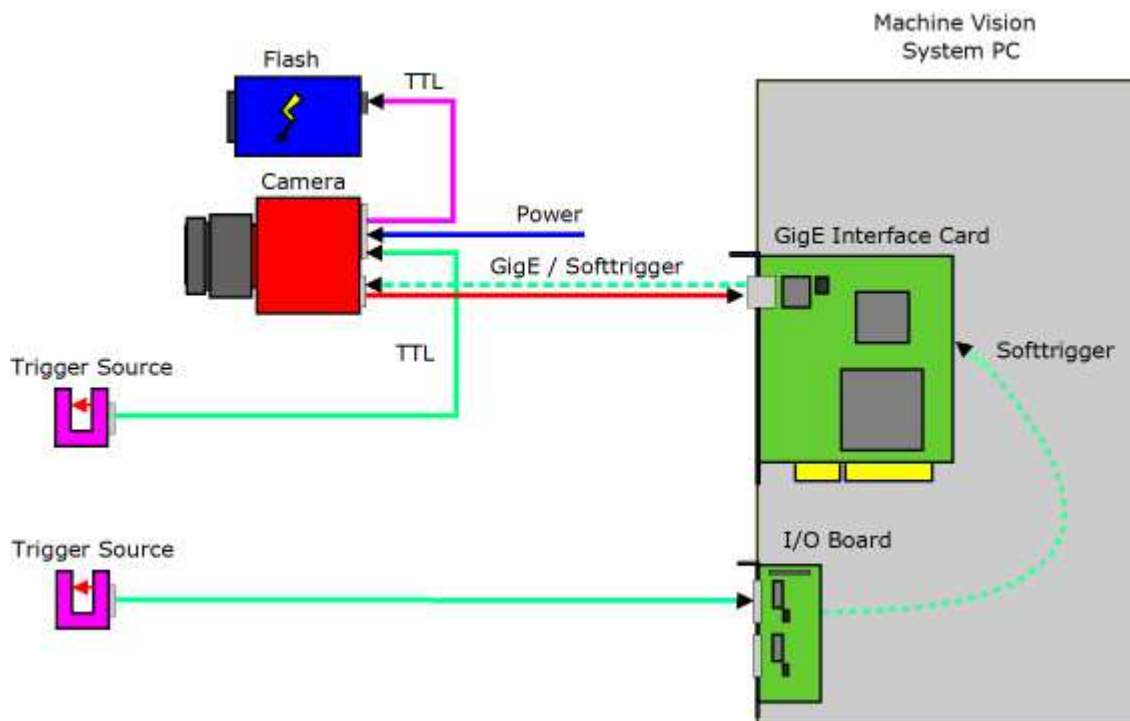


Figure 5.16: Trigger source

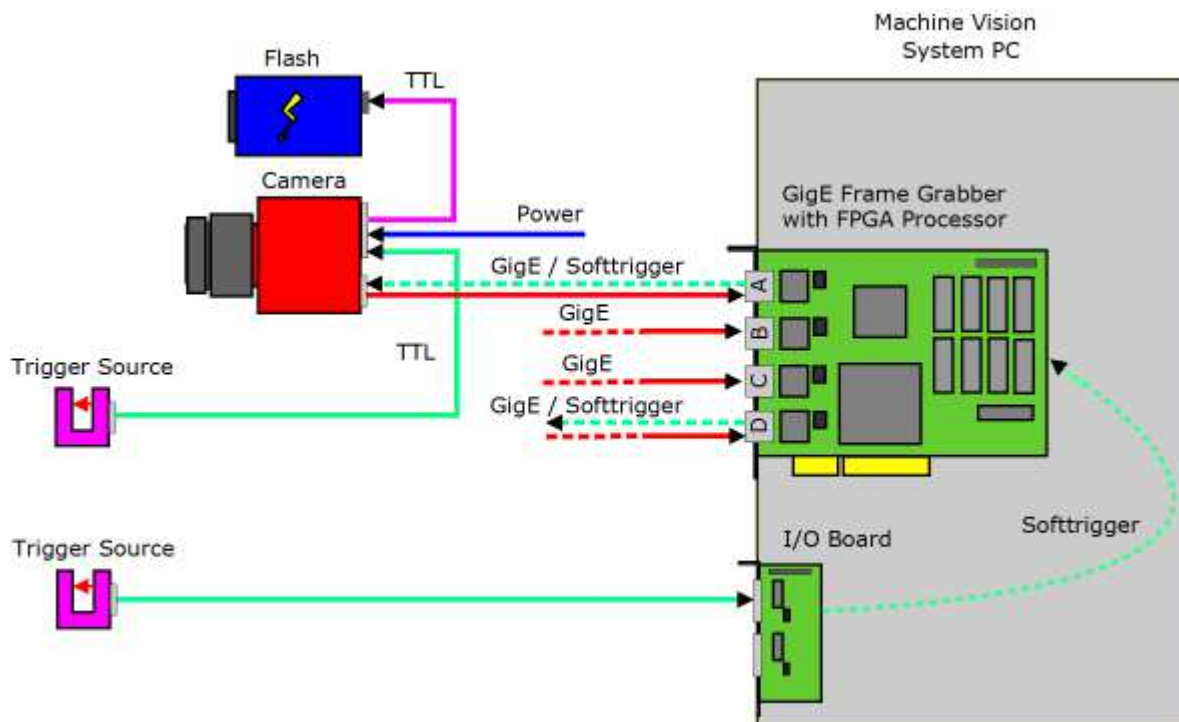


Figure 5.17: Trigger Inputs - Multiple GigE solution

5.2.3 Trigger and AcquisitionMode

The relationship between AcquisitionMode and TriggerMode is shown in Table 5.8. When TriggerMode=Off, then the frame rate depends on the AcquisitionFrameRateEnable property (see also under Free running in Section 5.2.2).



The ContinuousRecording and ContinuousReadout 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 ContinuousReadout from one camera at a time avoid network collisions and congestion.

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 5.8: AcquisitionMode and Trigger

5.2.4 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.

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. 5.18 shows the detailed timing diagram for the external trigger mode with camera controlled exposure time.

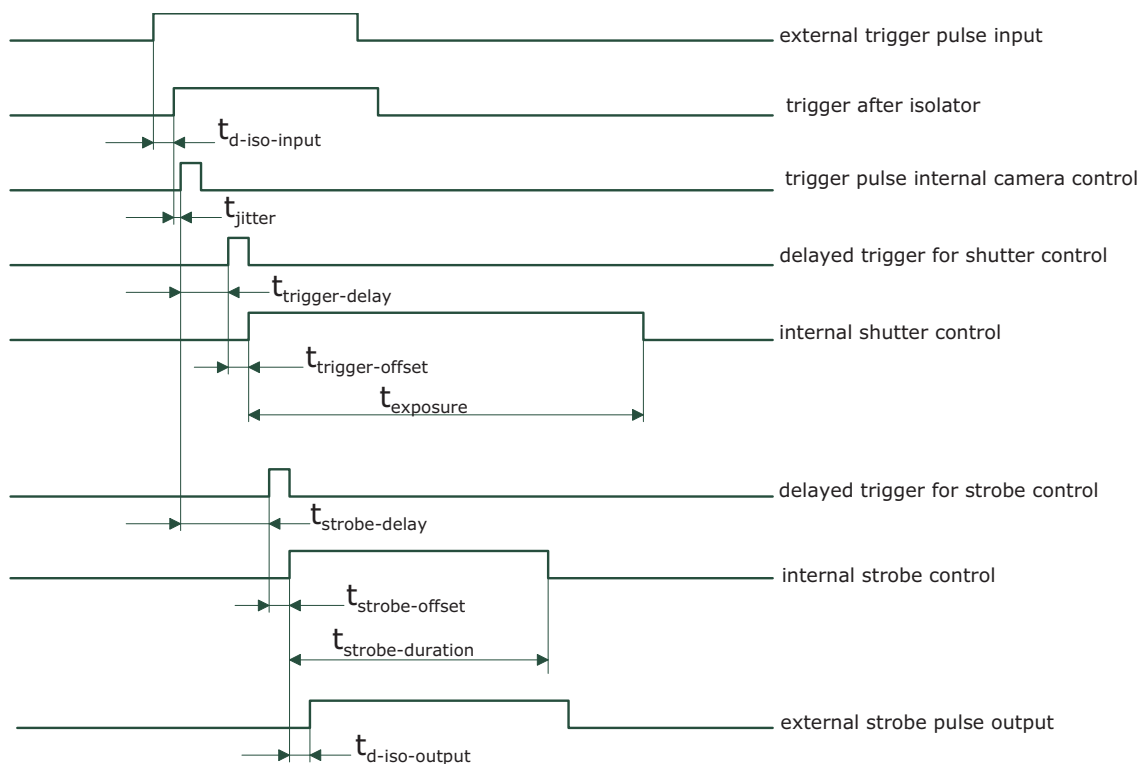


Figure 5.18: Timing diagram for the camera controlled exposure time

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

$t_{\text{trigger}-\text{offset}}$ results then from the synchronous design of the FPGA state machines and from the requirement to start an exposure at a fixed point from the start of the read out of a row. The exposure time t_{exposure} is controlled with an internal exposure time controller.

The trigger pulse from the internal camera control starts also the strobe control state machines. The strobe can be delayed by $t_{\text{strobe}-\text{delay}}$ with an internal counter which can be controlled by the customer via software settings. The strobe offset delay $t_{\text{strobe}-\text{delay}}$ results then from the synchronous design of the FPGA state machines. A second counter determines the strobe duration $t_{\text{strobe}-\text{duration}}$ (strobe-duration). For a robust system design the strobe output is also isolated from the camera electronic which leads to an additional delay of $t_{\text{d-iso-output}}$. Table 5.9 gives an overview over the minimum and maximum values of the parameters.

External Trigger with Pulsewidth controlled Exposure Time

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

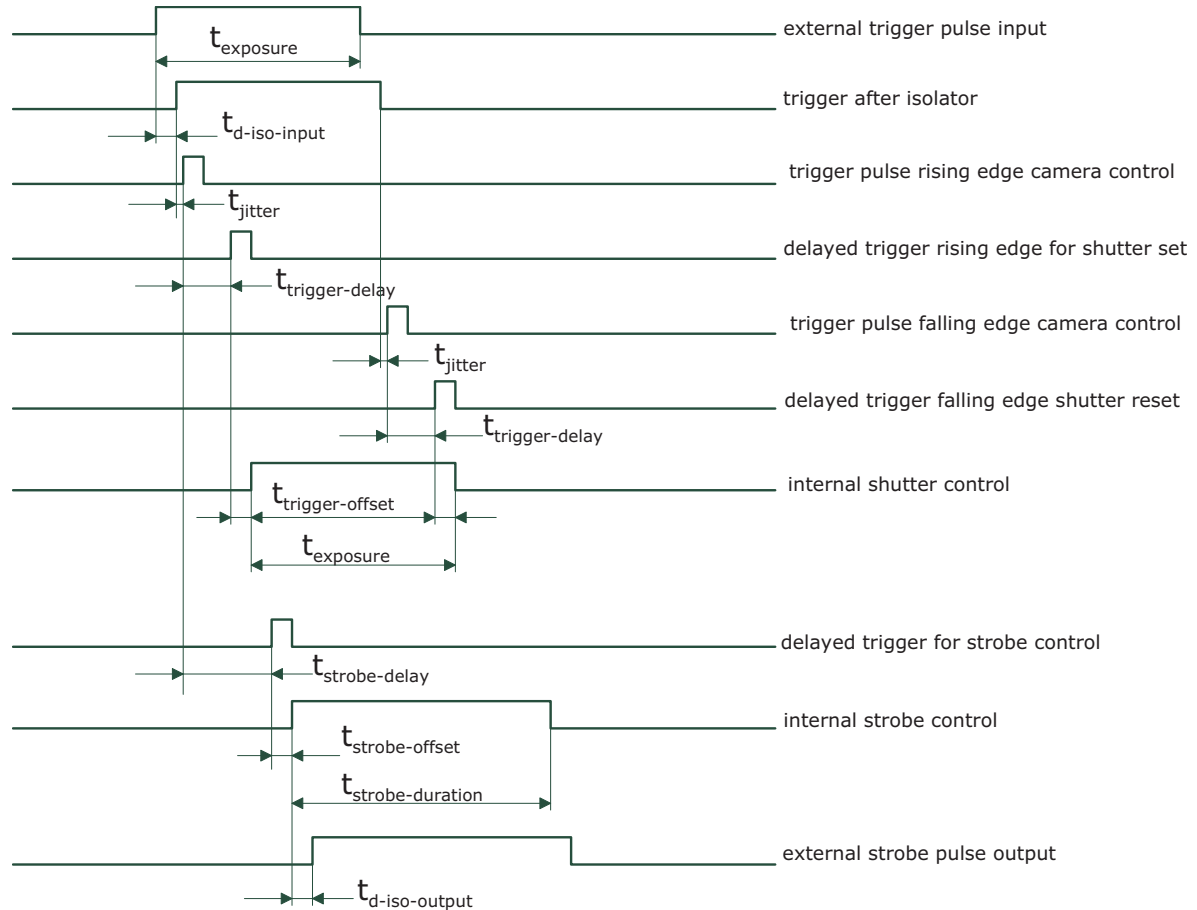


Figure 5.19: Timing diagram for the Pulsewidth controlled exposure time

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



In the trigger pulse width controlled exposure mode the image sensor operates in sequential read out mode (see Section 5.1.7). The maximal frame rate is therefore lower than normal as the exposure start is only allowed after the read out of the previous frame.

5.2.5 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.

5.2.6 Strobe Output

The strobe output is an isolated output located on the power supply connector that can be used to trigger a strobe. The strobe output can be used both in free-running and in trigger mode. Strobe settings:

Strobe_Delay Programmable delay from the active input trigger edge to the rising edge of the strobe output signal.

Strobe_PulseWidth Width of the trigger pulse in μs . A setting of 0 turns off the strobe output.

Strobe_Invert Inverts the strobe output signal. Strobe_Invert=False: strobe signal active high, Strobe_Invert=True: strobe signal active low.



The strobe output needs a separate power supply. Please see Section 6.5, Fig. 5.16 and Fig. 5.17 for more information.

5.2.7 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. 5.20.

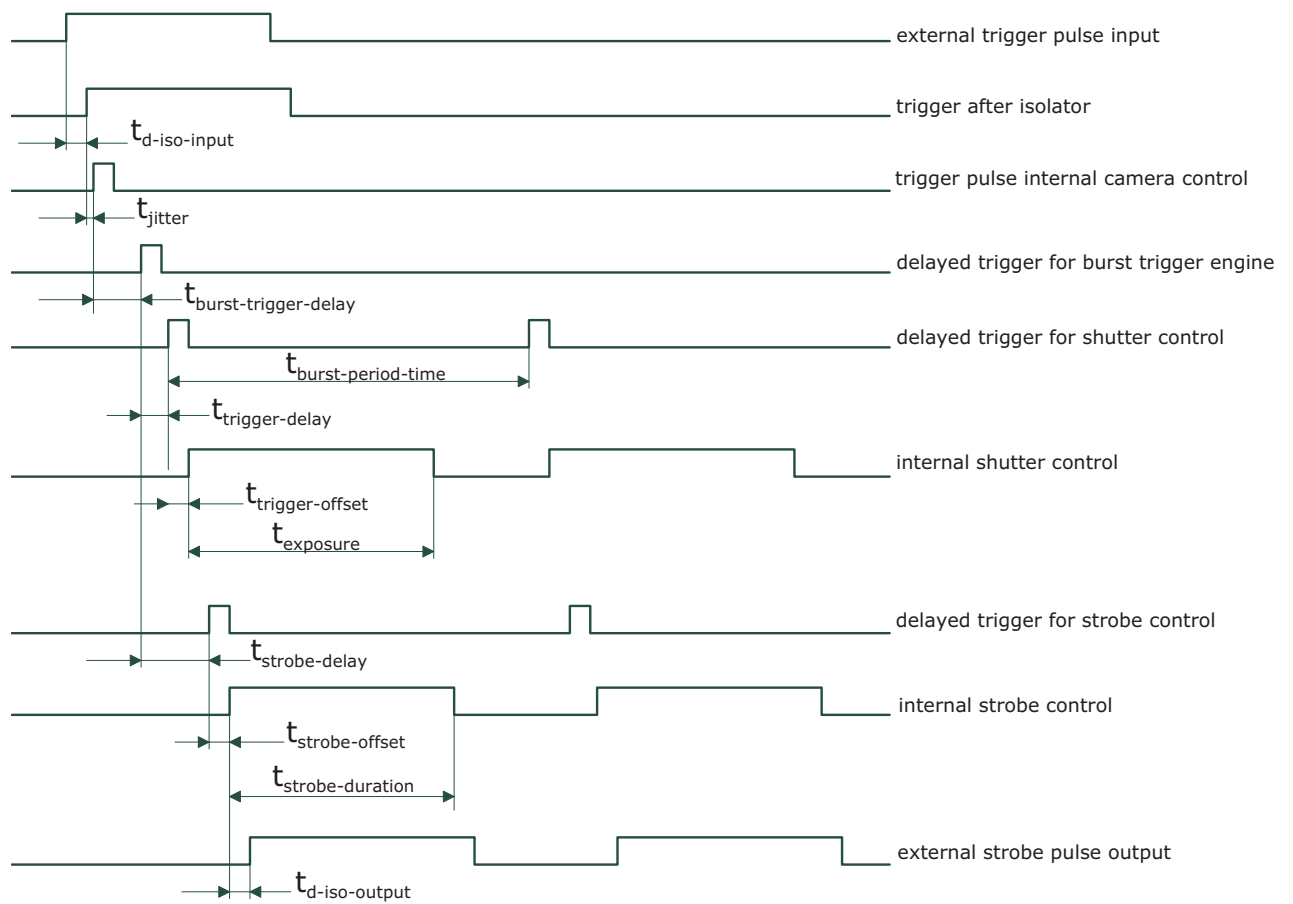


Figure 5.20: Timing diagram for the burst trigger mode

5.2.8 Trigger Timing Values

Table 5.9 and Table 5.10 show the values of the trigger timing parameters.

	D-80	D-80
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)	200 ns	duration of 1 row
$t_{trigger-offset}$ (burst mode)	250 ns	250 ns
$t_{exposure}$	15 μs ¹⁾ / 28 μs	0.42 s
$t_{strobe-delay}$	600 ns	0.42 s
$t_{strobe-offset}$ (non burst mode)	200 ns	200 ns
$t_{strobe-offset}$ (burst mode)	250 ns	250 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 5.9: Summary of timing parameters relevant in the external trigger mode using camera D-80 (Footnotes: ¹⁾ 2 MPix cameras)

	D-96 / L-96 / DR1-192	D-96 / L-96 / DR1-192
Timing Parameter	Minimum	Maximum
$t_{d-iso-input}$	1 μs	1.5 μs
$t_{d-RS422-input}$	65 ns	185 ns
t_{jitter}	0	20.8 ns
$t_{trigger-delay}$	0	0.35 s
$t_{burst-trigger-delay}$	0	0.35 s
$t_{burst-period-time}$	depends on camera settings	0.35 s
$t_{trigger-offset}$ (non burst mode)	166 ns	duration of 1 row
$t_{trigger-offset}$ (burst mode)	208 ns	208 ns
$t_{exposure}$	13 μs ¹⁾ / 26 μs	0.35 s
$t_{strobe-delay}$	600 ns	0.35 s
$t_{strobe-offset}$ (non burst mode)	166 ns	166 ns
$t_{strobe-offset}$ (burst mode)	208 ns	208 ns
$t_{strobe-duration}$	200 ns	0.35 s
$t_{d-iso-output}$	150 ns	350 ns
$t_{trigger-pulsewidth}$	200 ns	n/a
Number of bursts n	1	30000

Table 5.10: Summary of timing parameters relevant in the external trigger mode using camera D-96, L-96 or DR1-192(Footnotes: ¹⁾ 2 MPix cameras)

5.2.9 A/B Trigger for Incremental Encoder

An incremental encoder with A/B outputs can be used to synchronize the camera triggers to the speed of a conveyor belt. These A/B outputs can be directly connected to the camera and appropriate triggers are generated inside the camera.



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

In this setup, the output A is connected to the camera input ISO_INC0 (see also Section 6.5.4 and Section A.1) and the output B to ISO_INC1.

In the camera default settings the PLC is configured to connect the ISO_INC inputs to the A/B camera inputs. This setting is listed in Section 7.10.3.

The following parameters control the A/B Trigger feature:

TriggerSource Set TriggerSource to ABTrigger to enable this feature

ABMode Determines how many triggers should be generated. Available modes: single, double, quad (see description below)

ABTriggerDirection Determines in which direction a trigger should be generated: fwd: only forward movement generates a trigger; bkwd: only backward movement generates a trigger; fwdBkwd: forward and backward movement generate a trigger.

ABTriggerDeBounce Suppresses the generation of triggers when the A/B signal bounce. ABTriggerDeBounce is ignored when ABTriggerDirection=fwdbkwd.

ABTriggerDivider Specifies a division factor for the trigger pulses. Value 1 means that all internal triggers should be applied to the camera, value 2 means that every second internal trigger is applied to the camera.

EncoderPosition (read only) Counter (signed integer) that corresponds to the position of incremental encoder. The counter frequency depends on the ABMode. It counts up/down pulses independent of the ABTriggerDirection. Writing to this property resets the counter to 0.

A/B Mode

The property ABMode takes one of the following three values:

Single A trigger is generated on every A/B sequence (see Fig. 5.21). TriggerFwd is the trigger that would be applied if ABTriggerDirection=fwd, TriggerBkwd is the trigger that would be applied if ABTriggerDirection=bkwd, TriggerFwdBkwd is the trigger that would be applied if ABTriggerDirection=fwdbkwd. GrayCounter is the Gray-encoded BA signal that is shown as an aid to show direction of the A/B signals. EncoderCounter is the representation of the current position of the conveyor belt. This value is available as a camera register.

Double Two triggers are generated on every A/B sequence (see Fig. 5.22).

Quad Four triggers are generated on every A/B sequence (see Fig. 5.23).



There is a bug in the single A/B trigger mode in some camera revisions (see Appendix B, A/B Trigger Bug). In this case when the encoder position moves back and forth by a small amount, the EncoderCounter is incremented and the decrement is sometimes omitted, leading to a wrong EncoderPosition indication in the camera. Therefore the single A/B trigger mode should not be used in the affected versions. To have the same behaviour as the single trigger mode, but without the bug, use the double A/B mode and double the value of ABTriggerDivider.

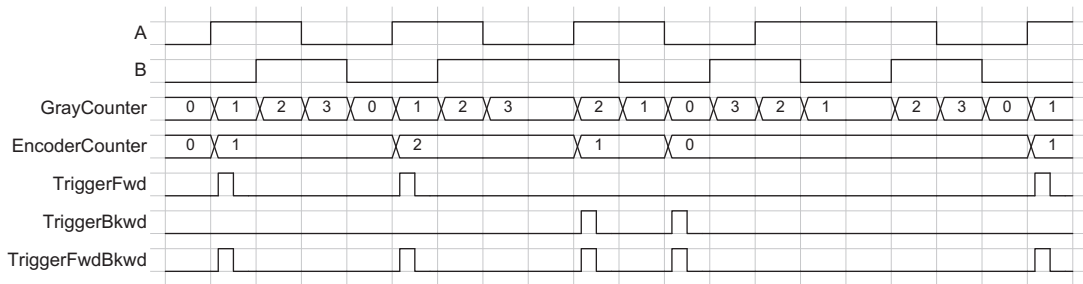


Figure 5.21: Single A/B Mode

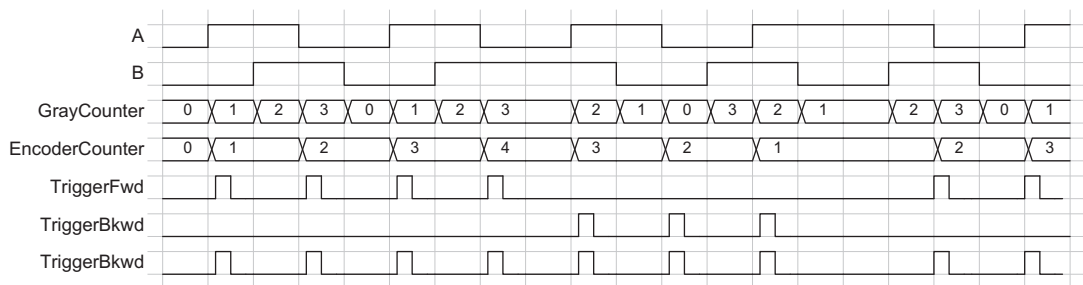


Figure 5.22: Double A/B Mode

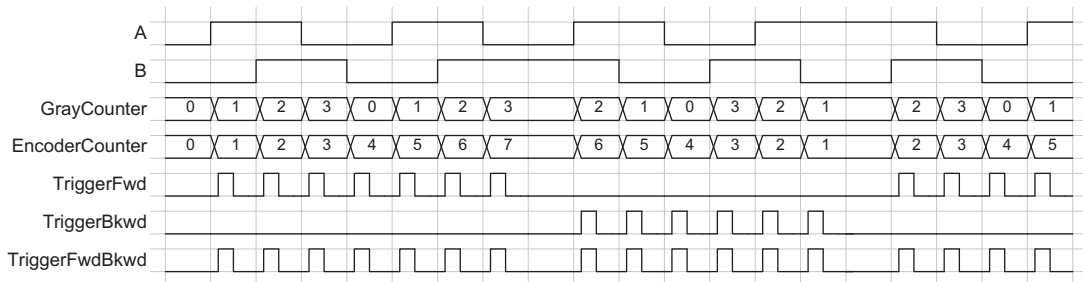


Figure 5.23: Quad A/B Mode

A/B Trigger Debounce

A debouncing logic can be enabled by setting `ABTriggerDeBounce=True`. It is implemented with a watermark value of the EncoderCounter (see Fig. 5.24). Suppose `ABTriggerDirection=fwd`, then the watermark value is increased with the increments of the EncoderCounter. If EncoderCounter decreases, e.g. Due to bouncing problems, the watermark value is hold unchanged. Triggers are then only generated when the watermark value increases.

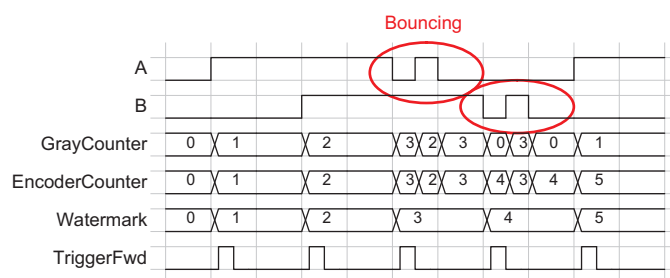


Figure 5.24: A/B Trigger Debouncing, example with `ABMode=quad`

The A/B Trigger Debounce mode can also be used for another issue:

In some applications the conveyor belt may stop between parts. In practice the conveyor belt stops and retraces by a small amount which may cause a misalignment in the system. If `ABTriggerDirection=fwd` is used and the Debounce mode is enabled and the conveyor belt starts again in forward direction, no triggers are generated for the amount that the conveyor belt retraced (see Fig. 5.25). The highest value of the EncoderCounter is stored as the watermark. Triggers are only generated when the EncoderCounter is at the watermark level.

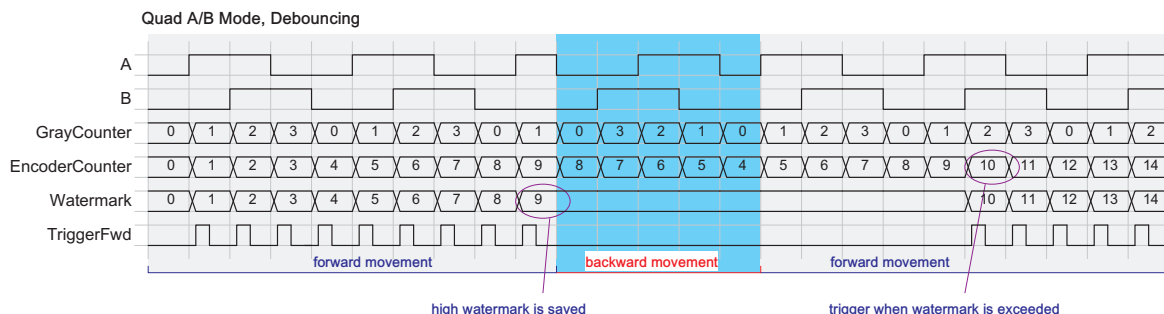


Figure 5.25: A/B Trigger Debouncing, example with `ABMode=quad`; example for encoder retracing

A/B Trigger Divider

if `ABTriggerDivider>1` then not all internally generated triggers are applied to the camera logic. E.g. If `ABTriggerDivider=2`, then every second trigger is applied to the camera (see Fig. 5.26).

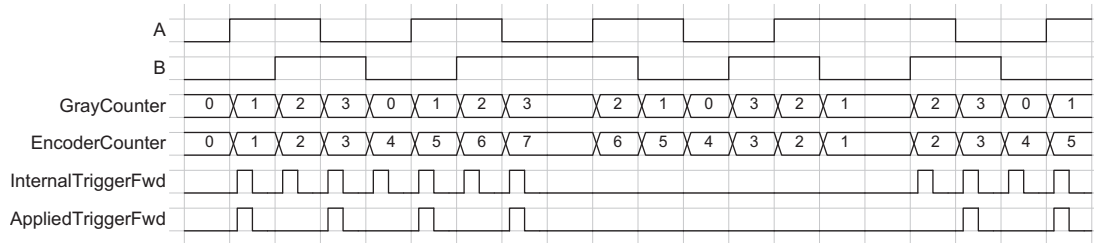


Figure 5.26: A/B Trigger Divider, example with `ABTriggerDivider=1`, `ABMode=quad`

A Only Trigger

The camera supports the use of simple incremental decoders that only provide one input, by enabling the property `ABTriggerAOnly`. The B-signal is ignored in this mode and information about direction of the object movement is not available: if `ABTriggerAOnly` is enabled then the encoder position is always incremented. Detailed diagrams are shown in Fig. 5.27 and Fig. 5.28. Note that the quad mode is not available when `ABTriggerAOnly=true`.

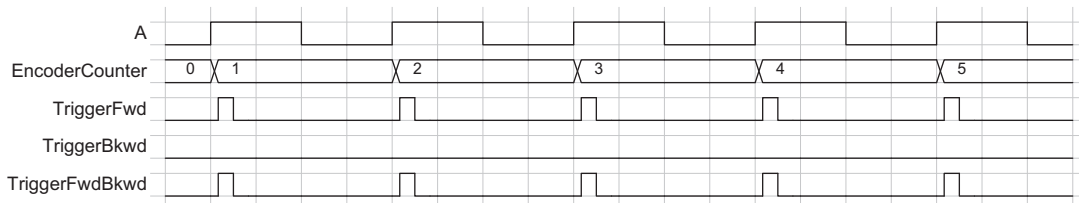


Figure 5.27: AOnly Trigger in Single A/B Mode

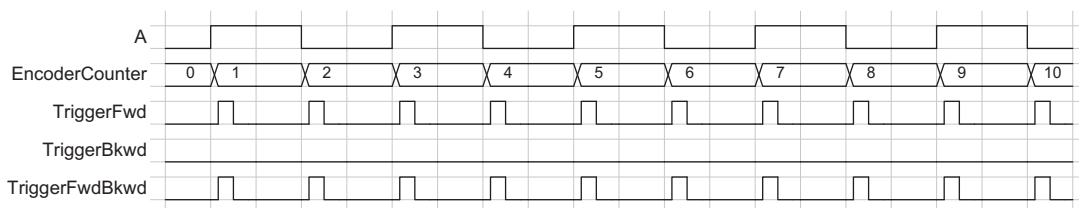


Figure 5.28: AOnly Trigger in Double A/B Mode

Encoder Position

The internal `ABTrigger` signal before the `ABTriggerDivider` is processed for the Encoder Position: every `TriggerFwd` pulse increments the Encoder Position and every `TriggerBkwd` pulse decrements its value. For details refer to the diagram of the corresponding mode.

The Encoder Position value can be accessed through the `EncoderPosition` property or through the status info that is inserted into the image (see Section 5.8).

By default the Encoder Position is only generated when `TriggerMode=On` and `TriggerSource=ABTrigger`. When the property `ABTriggerCountAlways=True`, then the Encoder Position is generated regardless of the trigger mode.

5.2.10 Missed Trigger Counters

The missed trigger counters are important tools to make sure that the frequency of an external trigger can be processed by the camera. A value bigger than 0 indicates that not all applied triggers were processed.

The missed trigger counters are reset by writing the value 0 to the counter register. The counter value can be read out by a property or it can be embedded in the camera image by the status line (see Section 5.8.2):



It is recommended to reset the missed trigger counters after modifying trigger-related settings.

Missed Trigger Counter If an external trigger (`TriggerMode=On`) is applied while the camera is not ready to accept a new trigger, a counter (Missed Trigger Counter) is incremented and the trigger is rejected. The value of the Missed Trigger Counter can be read out from the camera property (`Counter_MissedTrigger`). When the Missed Trigger Counter reaches its maximal value it will not wrap around. The user can reset the Missed Trigger Counter by writing the value 0 to `Counter_MissedTrigger`. In Burst Trigger Mode (see Section 5.2.7), an increment of the missed burst trigger value indicates that the burst trigger period time (`Trigger_BurstTriggerPeriodTime`) is too short for the applied camera settings.

Missed Burst Trigger Counter When the camera is in burst trigger mode (see Section 5.2.7), a missed burst trigger counter will be incremented, when a subsequent external trigger (`TriggerMode=On`) is applied while a burst sequence is running. The value of the Missed Burst Trigger Counter can be read out from the camera property (`Counter_MissedBurstTrigger`). When the Missed Burst Trigger Counter reaches its maximal value it will not wrap around. The user can reset the Missed Burst Trigger Counter.

5.2.11 Counter Reset by an External Signal

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

The external signal to reset the above mentioned counters is selected by the property `Counter_ResetCounterSource`. Available choices are `PLC_Q4` to `PLC_Q7` (see Section 7.10), `Line1` (`ISO_IN1`) and `ExposureStart`. `ExposureStart` resets the counters at the start of an exposure.

The property `Counter_ResetCounterMode` determines how often the selected source should reset the counters. The setting `Once` works together with the property `Counter_ResetCounterOnNextTrigger`.

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

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

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



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



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

Reset of Individual Counters (`ResetCounter_Dual`)

If the property `ResetCounter_Dual` is set to `False` or if this property is not available, then the `ResetCounter` settings apply to the image counter and to the real time counter together.

If `ResetCounter_Dual` is set to `True` then `CounterReset` can be set separately for the image counter and for the real time counter. In this case the settings without 'RTC' are applied to the image counter and the settings with 'RTC' in its name are applied to the real time counter.



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

5.3 High Dynamic Range (multiple slope) Mode

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

The HDR (multi slope) mode clips illuminated pixels which reach a programmable voltage, while leaving the darker pixels untouched (see Fig. 5.29). The clipping level can be adjusted once (2 slopes) or twice (3 slopes) within the exposure time.

Parameters:

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

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

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

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

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

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

The red line in Fig. 5.29 shows a pixel with high illumination. Without the HDR (3 slopes) mode, the pixel would have reached its saturated value. With HDR mode, the pixel reaches value P1 which is below the saturation value. The resulting pixel response in this case is shown in Fig. 5.30. The blue line (P2) shows a pixel with low illumination. Its value never reaches Vlow2 or Vlow1 at the kneepoints and the resulting response is linear.



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

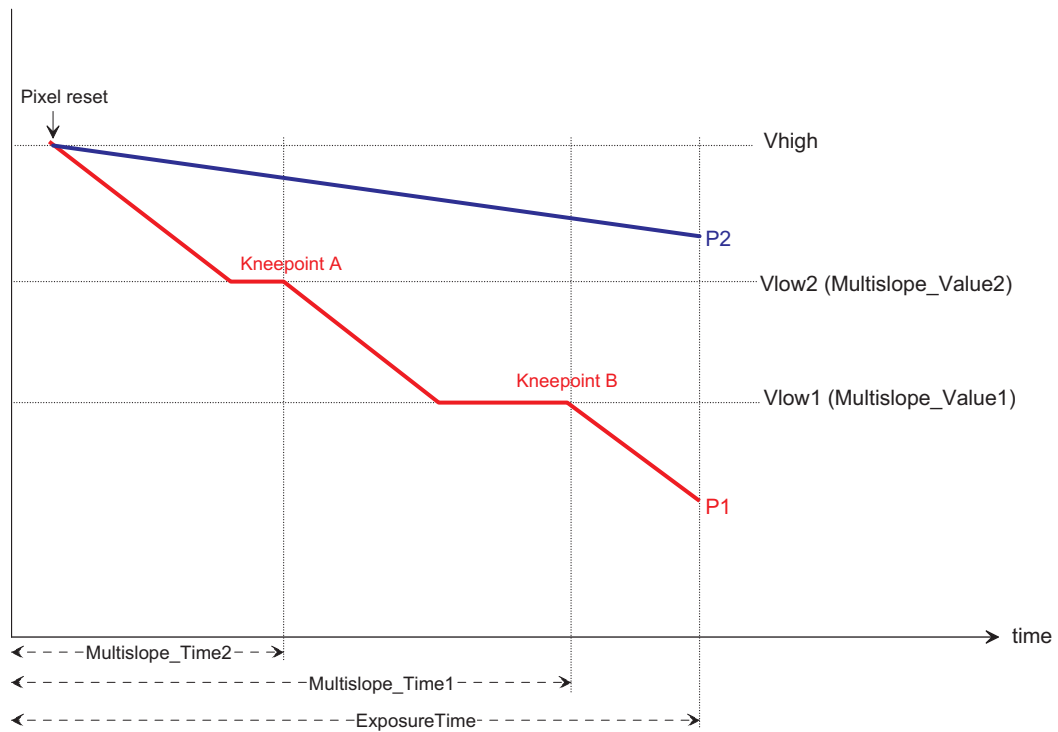


Figure 5.29: Multi Slope (HDR mode)

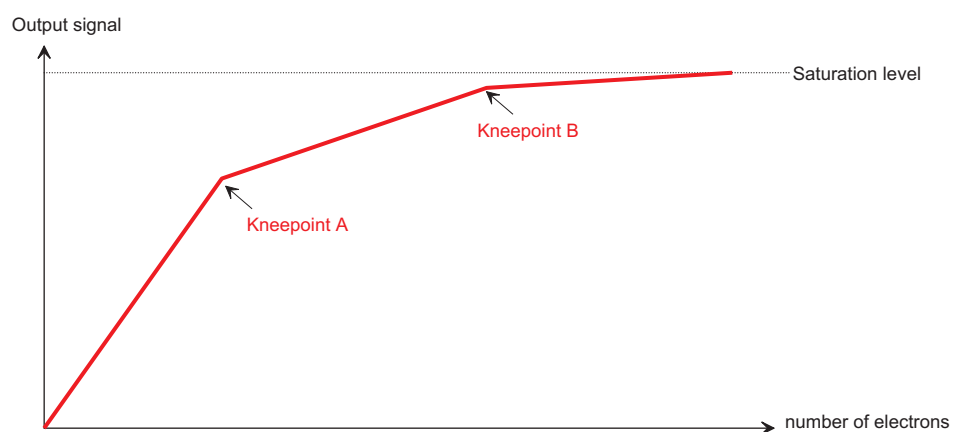


Figure 5.30: Piecewise linear response

5.4 Data Path Overview

The data path is the path of the image from the output of the image sensor to the output of the camera. The sequence of blocks is shown in figure Fig. 5.31.



Status line and binning is not available on all camera revisions, see Appendix B for a list of available features.



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

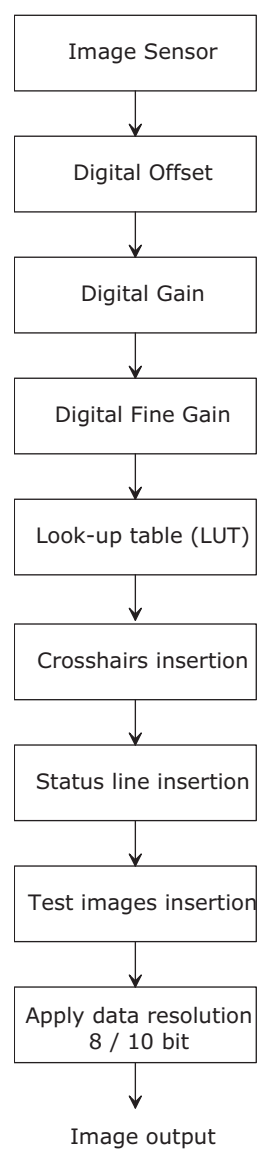


Figure 5.31: camera data path for camera revisions smaller than 3.0

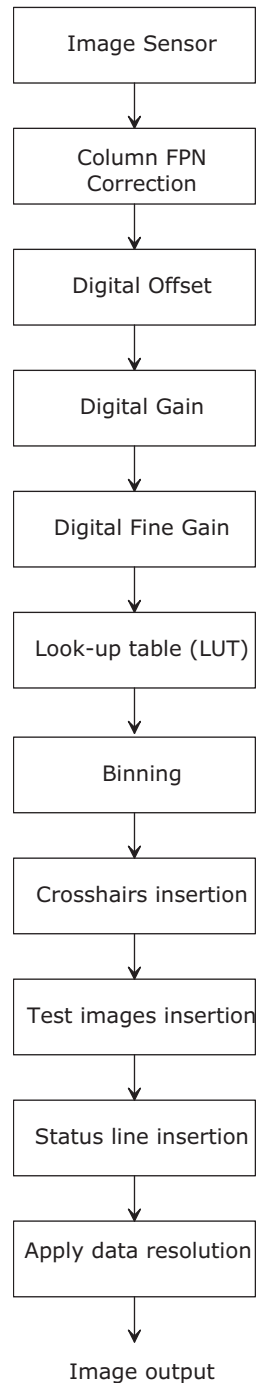


Figure 5.32: camera data path for camera revisions 3.0 and bigger

5.5 Gain and Offset

There are three different gain settings on the camera:

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

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

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

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



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

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

5.6 Grey Level Transformation (LUT)

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



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



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



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

Some commonly used transfer curves are shown in Fig. 5.33. Line a denotes a negative or inverse transformation, line b enhances the image contrast between grey values x0 and x1.

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

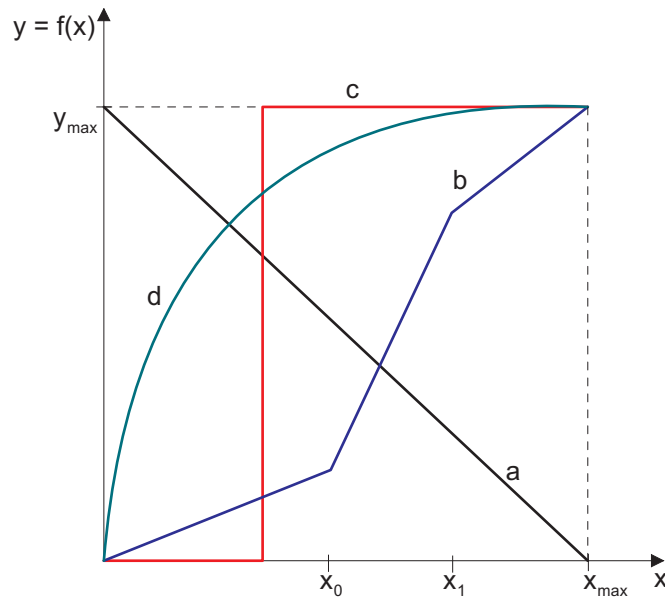


Figure 5.33: Commonly used LUT transfer curves

5.6.1 Gain

The 'Gain' mode performs a digital, linear amplification with clamping (see Fig. 5.34). It is configurable in the range from 1.0 to 4.0 (e.g. 1.234).

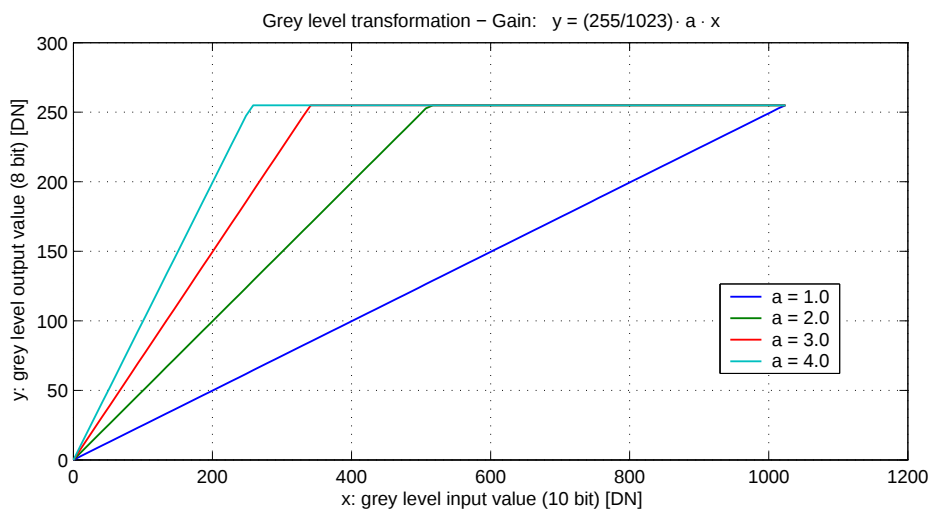


Figure 5.34: Applying a linear gain with clamping to an image

5.6.2 Gamma

The 'Gamma' mode performs an exponential amplification, configurable in the range from 0.4 to 4.0. Gamma > 1.0 results in an attenuation of the image (see Fig. 5.35), gamma < 1.0 results in an amplification (see Fig. 5.36). Gamma correction is often used for tone mapping and better display of results on monitor screens.

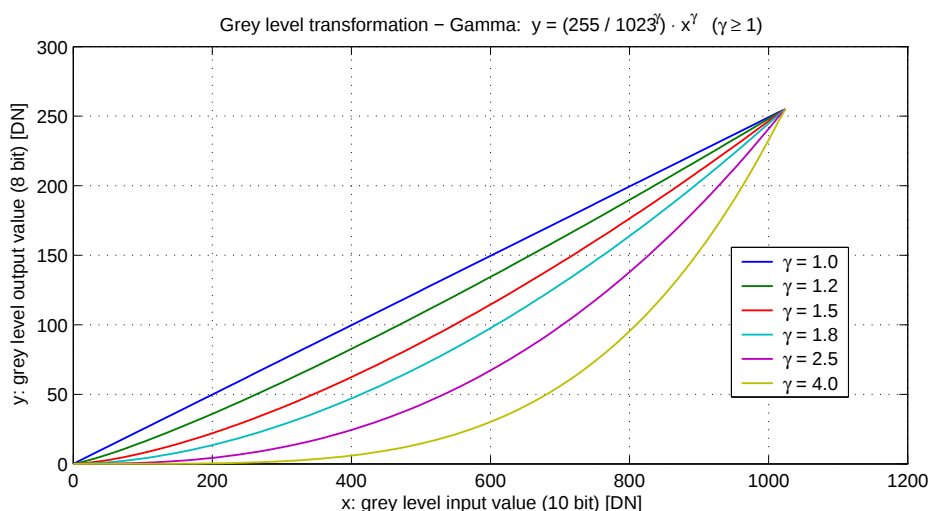


Figure 5.35: Applying gamma correction to an image (gamma > 1)

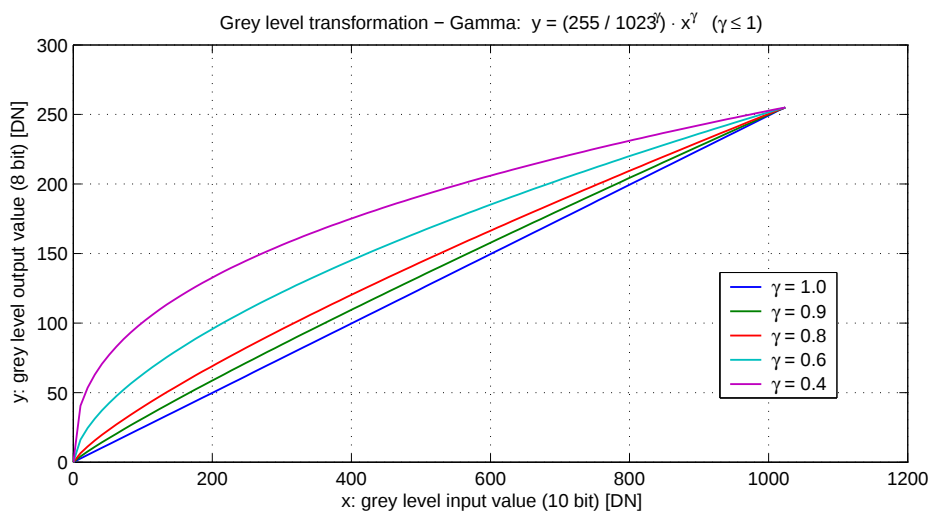


Figure 5.36: Applying gamma correction to an image (gamma < 1)

5.6.3 User-defined Look-up Table

In the 'User' mode, the mapping of input to output grey levels can be configured arbitrarily by the user. This procedure is explained in Section 7.6.

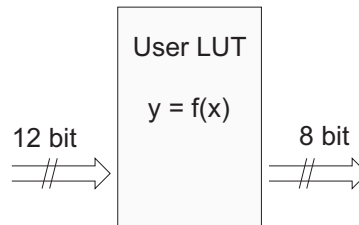


Figure 5.37: Data path through LUT

5.6.4 Region LUT and LUT Enable

Two LUTs and a Region-LUT feature are available in the Photonfocus 2048 GigE camera series. Both LUTs can be enabled independently (see Table 5.11). LUT 0 superseeds LUT1.

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

Table 5.11: LUT Enable and Region LUT

When Region-LUT feature is enabled, then the LUTs are only active in a user defined region. Examples are shown in Fig. 5.38 and Fig. 5.39.

Fig. 5.38 shows an example of overlapping Region-LUTs. LUT 0, LUT 1 and Region LUT are enabled. LUT 0 is active in region 0 ((x00, x01), (y00, y01)) and it supersedes LUT 1 in the overlapping region. LUT 1 is active in region 1 ((x10, x11), (y10, y11)).

Fig. 5.39 shows an example of keyhole inspection in a laser welding application. LUT 0 and LUT 1 are used to enhance the contrast by applying optimized transfer curves to the individual regions. LUT 0 is used for keyhole inspection. LUT 1 is optimized for seam finding.

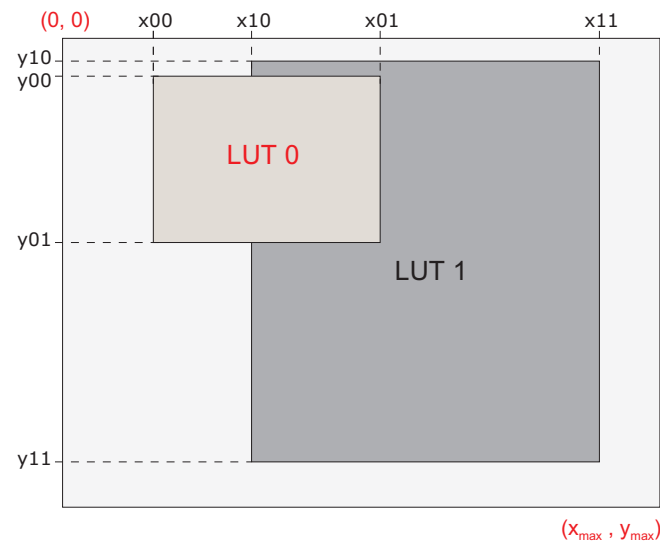


Figure 5.38: Overlapping Region-LUT example

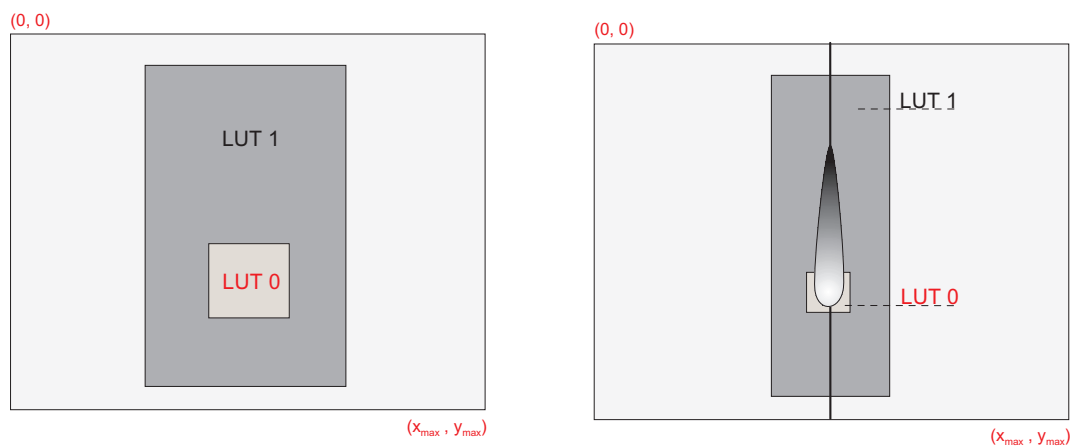


Figure 5.39: Region-LUT in keyhole inspection

Fig. 5.40 shows the application of the Region-LUT to a camera image. The original image without image processing is shown on the left-hand side. The result of the application of the Region-LUT is shown on the right-hand side. One Region-LUT was applied on a small region on the lower part of the image where the brightness has been increased.

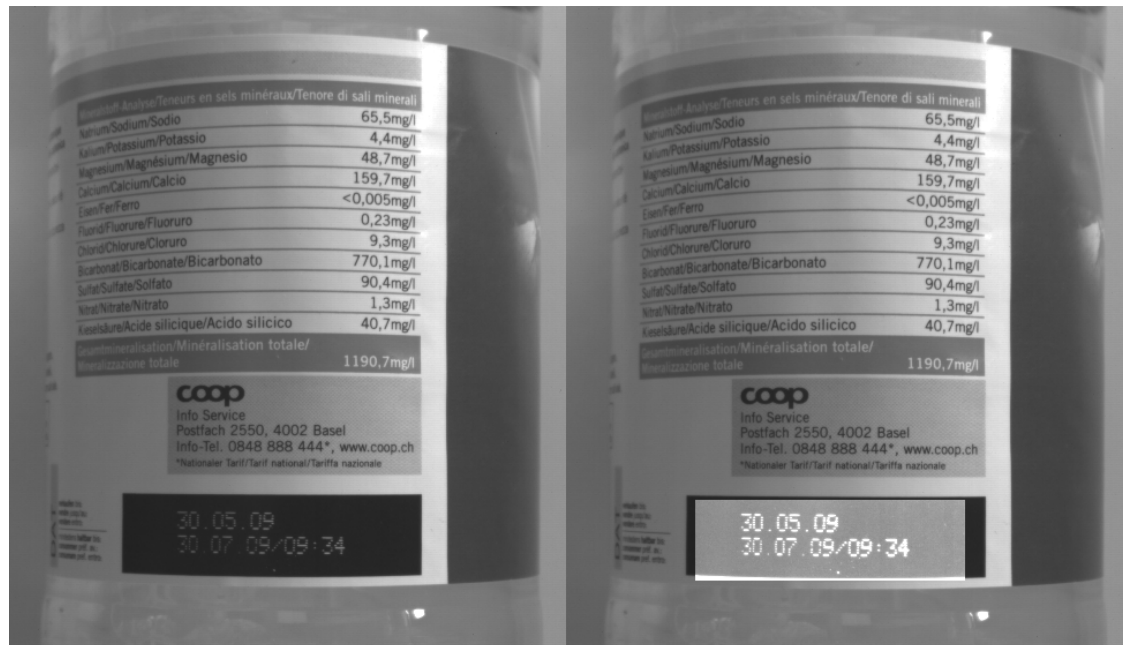


Figure 5.40: Region-LUT example with camera image; left: original image; right: gain 4 region in the area of the date print of the bottle

5.7 Crosshairs

5.7.1 Functionality

The crosshairs inserts a vertical and horizontal line into the image. The width of these lines is one pixel. The grey level is defined by a 12 bit value (0 means black, 4095 means white). This allows to set any grey level to get the maximum contrast depending on the acquired image. The x/y position and the grey level can be set via the camera software. Figure Fig. 5.41 shows two examples of the activated crosshairs with different grey values. One with white lines and the other with black lines.



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

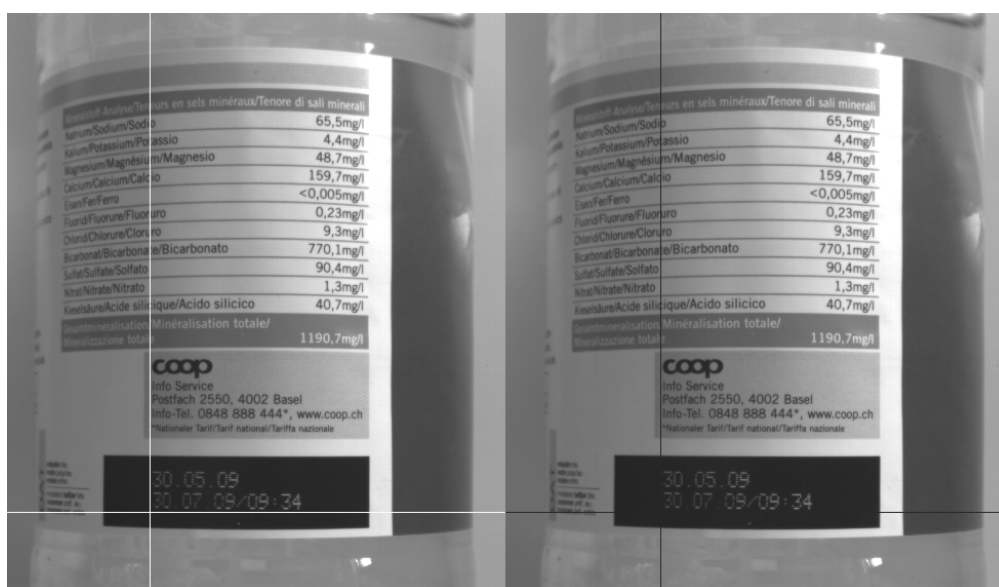


Figure 5.41: Crosshairs Example with different grey values



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



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

The x- and y-position is absolute to the sensor pixel matrix. It is independent on the ROI, MROI or decimation configurations. Figure Fig. 5.42 shows two situations of the crosshairs configuration. The same MROI settings is used in both situations. The crosshairs however is set differently. The crosshairs is not seen in the image on the right, because the x- and y-position is set outside the MROI region.

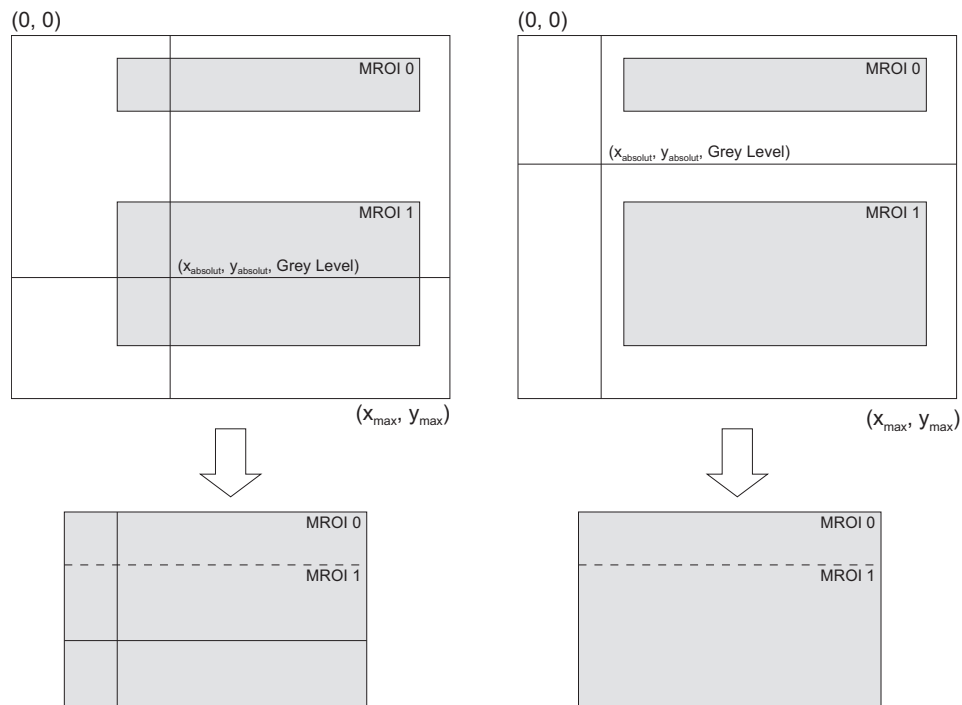


Figure 5.42: Crosshairs absolute position

5.8 Image Information and Status Line

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



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



The status line is transmitted uncompressed in double rate mode (see also Section 7.13.1).

5.8.1 Counters and Average Value

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

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

Missed trigger counter The missed trigger counter counts trigger pulses that were ignored by the camera because they occurred within the exposure or read-out time of an image. In free-running mode it counts all incoming external triggers (counter width 8 bit / no wrap around) (see also Section 5.2.10).

Missed burst trigger counter When the camera is in burst trigger mode (see Section 5.2.7), a missed burst trigger counter will be incremented, when a subsequent external trigger (TriggerMode=On) is applied while a burst sequence is running (see also Section 5.2.10).

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

5.8.2 Status Line

If enabled, the status line replaces the last row of the image with camera status information. Every parameter is coded into fields of 4 pixels (LSB first) and uses the lower 8 bits of the pixel value, so that the total size of a parameter field is 32 bit (see Fig. 5.43). The assignment of the parameters to the fields is listed in Table 5.12.

 The status line is available in all camera modes.

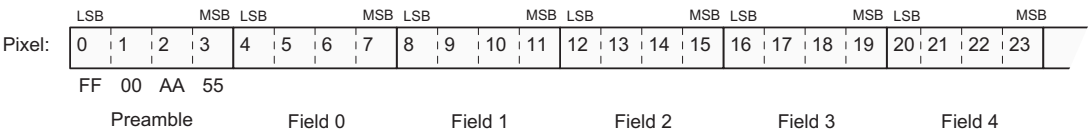


Figure 5.43: Status line parameters replace the last row of the image

Start pixel index	Parameter width [bit]	Parameter Description
0	32	Preamble: 0x55AA00FF
4	24	Image Counter (see Section 5.8.1)
8	32	Real Time Counter (see Section 5.8.1)
12	8	Missed Trigger Counter (see Section 5.8.1)
16	12	Image Average Value("raw" data without taking in account gain settings) (see Section 5.8.1)
20	24	Integration Time in units of clock cycles (see Table 4.3)
24	16	Reserved (Burst Trigger Number)
28	8	Missed Burst Trigger Counter
32	11	Horizontal start position of ROI (OffsetX)
36	11	Horizontal end position of ROI (= OffsetX + Width - 1)
40	11	Vertical start position of ROI (OffsetY). In MROI-mode this parameter is the start position of the first ROI.
44	11	Number of rows - 1 (HeightInterface - 1)
48	2	Trigger Source. 0: TriggerMode=Off; 1: TriggerMode=On, TriggerSource=PLC_Q4; 2: TriggerMode=On, TriggerSource=Line1; 3: TriggerMode=On, TriggerSource=Software; 4: TriggerMode=On, TriggerSource=ABTrigger.
52	2	Digital Gain
56	2	Digital Offset
60	16	Camera Type Code (see Table 5.13)
64	32	Camera Serial Number
68	32	Reserved
72	32	Custom value: value of register StatusLineCustomValue that can be set by the user
76	16	FineGain. This is fixed a point value in the format: 4 digits integer value, 12 digits fractional value.
80	24	Encoder Position (only available in some models, see Appendix B).
84	32	Reserved
88	32	Reserved
92	4	Trigger Level: signal level of the trigger input signal (only available in some models, see Appendix B). Bit 0: PLC_Q4; Bit 1: Line1; Bit 2: PLC_Q6 (A-Trigger); Bit 3: PLC_Q7 (B-Trigger). This entry is only available in some models, see Appendix B.

5.8.3 Camera Type Codes

Camera Model	Camera Type Code
MV1-D2048x1088-80-G2-10	411
MV1-D2048x1088I-80-G2-10	415
MV1-D2048x1088C-80-G2-10	414
MV1-D2048x1088-96-G2-10	410
MV1-D2048x1088I-96-G2-10	419
MV1-D2048x1088C-96-G2-10	409
MV1-D2048-96-G2-10	455
MV1-D2048I-96-G2-10	456
MV1-D2048C-96-G2-10	457
DR1-D2048x1088-192-G2-8	416
DR1-D2048x1088I-192-G2-8	418
DR1-D2048x1088C-192-G2-8	417
DR1-D2048-192-G2-8	TBD
DR1-D2048I-192-G2-8	TBD
DR1-D2048C-192-G2-8	TBD
MV1-L2048-96-G2-10	421
MV1-L2048I-96-G2-10	TBD
MV1-L2048C-96-G2-10	423

Table 5.13: Type codes of Photonfocus 2048 GigE camera series

5.9 Test Images

Test images are generated in the camera FPGA, independent of the image sensor. They can be used to check the transmission path from the camera to the 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 a flat histogram only if the image width is a multiple of 1024 (in 10 bit mode) or 256 (in 8 bit mode).

5.9.1 Ramp

Depending on the configured grey level resolution, the ramp test image outputs a constant pattern with increasing grey level from the left to the right side (see Fig. 5.44).

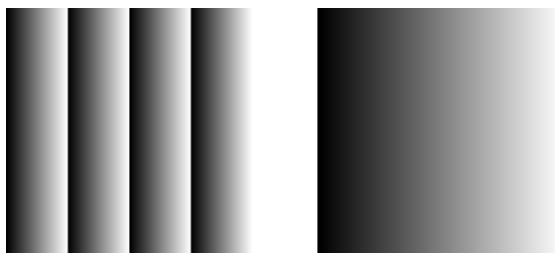


Figure 5.44: Ramp test images: 8 bit output (left), 10 bit output (right)

5.9.2 LFSR

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

In the histogram you can see that the number of pixels of all grey values are the same.

Please refer to application note [AN026] for the calculation and the values of the LFSR test image.

5.9.3 Troubleshooting using the LFSR

To control the quality of your complete imaging system enable the LFSR mode, set the camera window to 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. 5.46). On the other hand, a non-flat

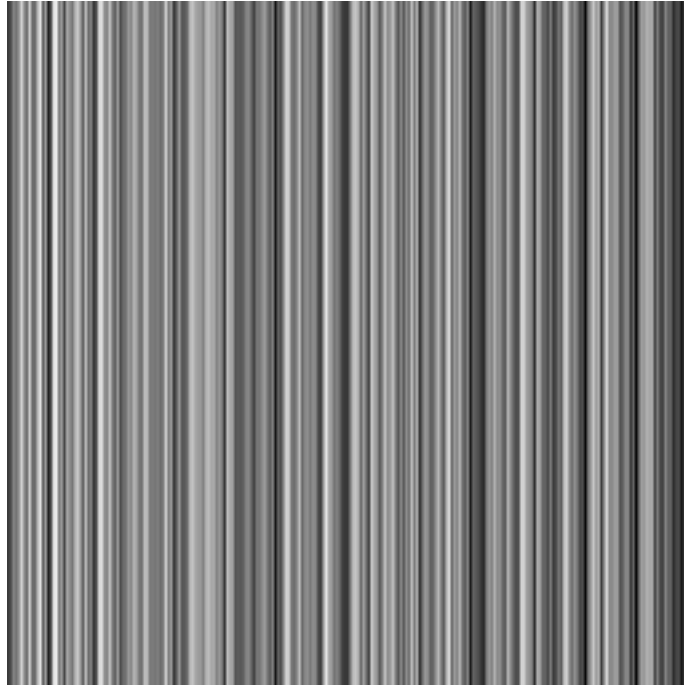


Figure 5.45: LFSR (linear feedback shift register) test image

histogram (Fig. 5.47) indicates problems, that may be caused either by a defective camera, by problems in the acquisition software or in the transmission path.

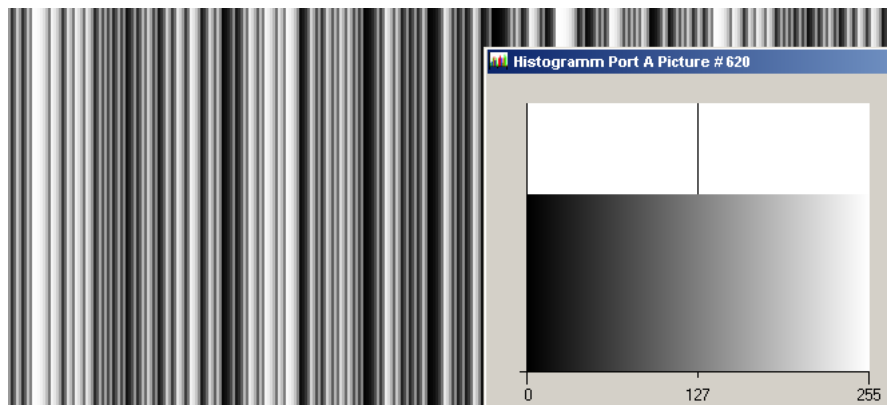


Figure 5.46: LFSR test pattern received and typical histogram for error-free data transmission

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.

5.10 Double Rate (DR1 cameras only)

The Photonfocus DR1 cameras use a proprietary coding algorithm to cut the data rate by almost a factor of two. This enables the transmission of high frame rates over just one Gigabit Ethernet connection, avoiding the complexity and stability issues of Ethernet link aggregation.

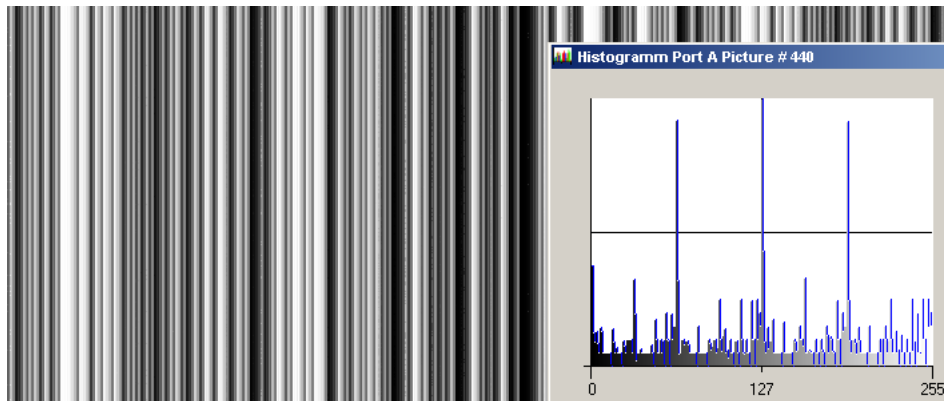


Figure 5.47: LFSR test pattern received and histogram containing transmission errors

The algorithm is lossy but no image artefacts are introduced, unlike for example the JPEG compression. It is therefore very well suited for most machine vision applications except for measuring tasks where sub-pixel precision is required.



Double rate modulation can be turned off for debugging purposes.

The encoded image is transmitted in mono 8 bit data resolution.

The encoding is run in real-time in the camera's FPGA. A DLL for the demodulation of the image for SDK applications is included in the PFInstaller software package that can be downloaded from Photonfocus (see also 7).

The compression factor is independent of the image content. The encoded image has the same number of rows as the raw image. The required image width (number of bytes in a row) for the modulated image can be calculated as follows (value can also be read from a camera property) (oh=2 for monochrome cameras, oh=3 for colour cameras):

$$w_{\text{mod}} = \text{ceil}(w/64) + w/2 + \text{oh}$$

Hardware Interface

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

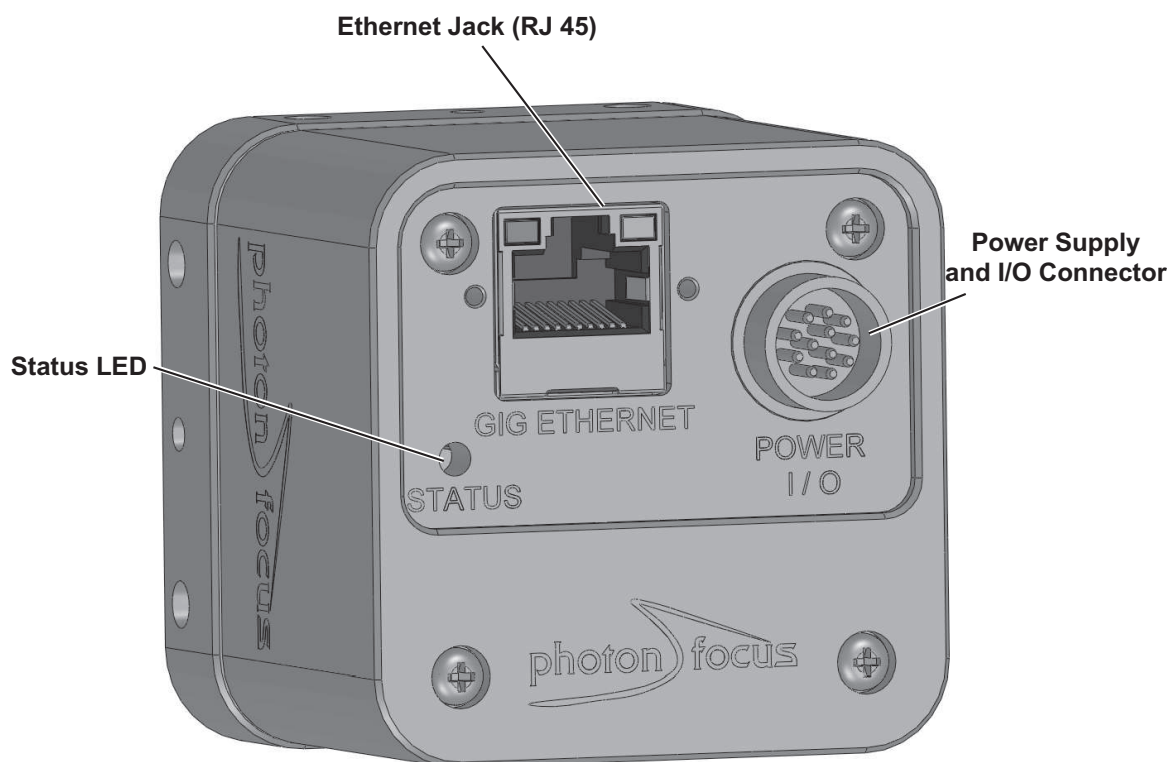


Figure 6.1: Rear view of the GigE camera

6.2 Power Supply Connector

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



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



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

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

6.3 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	It blinks slowly when the camera is not grabbing images. When the camera is grabbing images the LED blinks at a rate equal to the frame rate. At slow frame rates, the LED blinks. At high frame rates the LED changes to an apparently continuous green light, with intensity proportional to the ratio of readout time over frame time.
LED Red	Red indicates an active serial communication with the camera.

Table 6.1: Meaning of the LED of the GigE CMOS cameras

6.4 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. 6.2 shows a schematic of the power and ground connections in the G2 camera models.

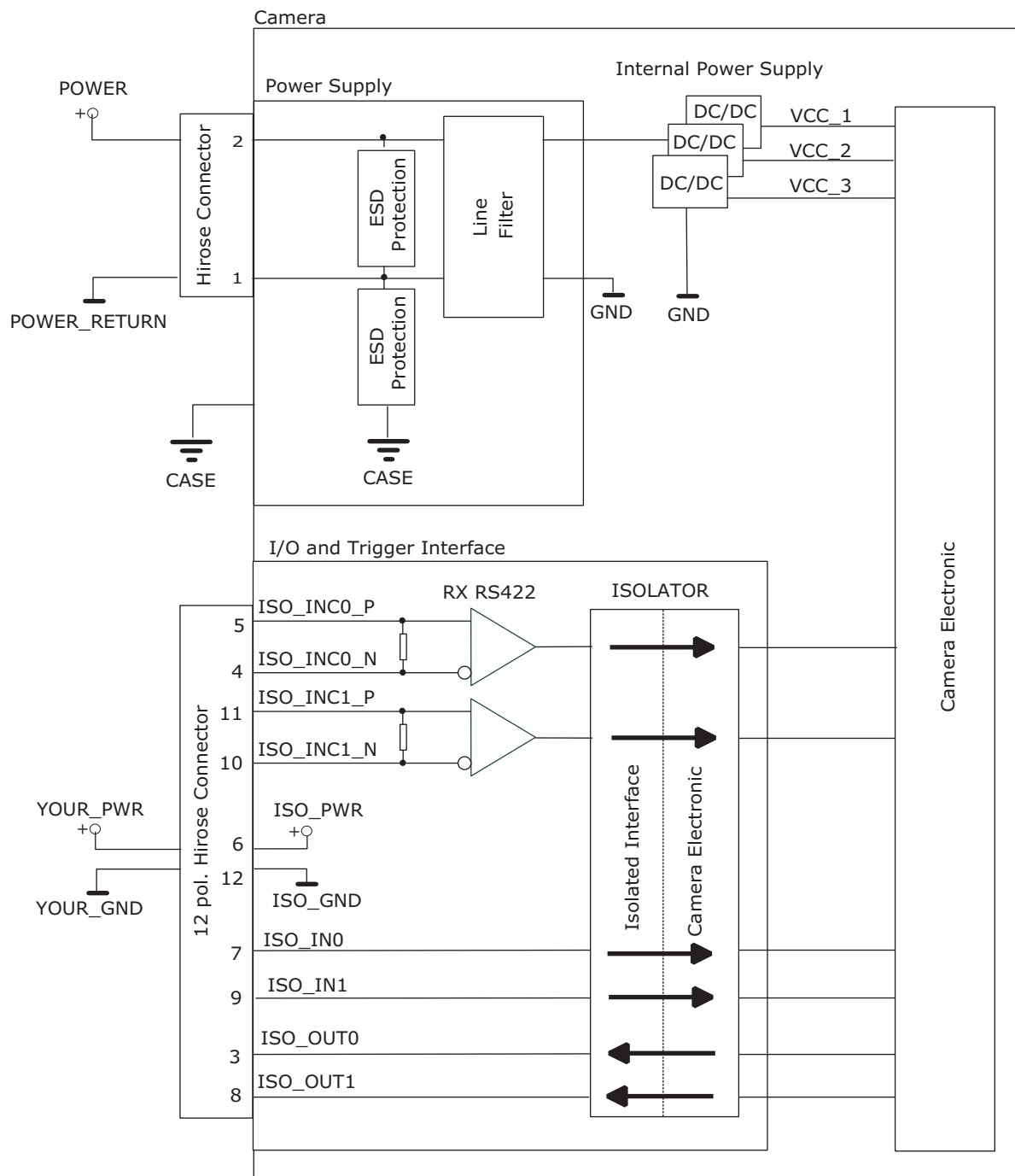


Figure 6.2: Schematic of power and ground connections in G2 camera models

6.5 Trigger and Strobe Signals for GigE Cameras

6.5.1 Overview

The 12-pol. Hirose power connector contains two external trigger inputs, two strobe outputs and two differential inputs (G2 models: RS-422, H2 models: HTL). All inputs and outputs are connected to the Programmable Logic Controller (PLC) (see also Section 6.6) that offers powerful operations.



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



G2 models: ISO_INC0 and ISO_INC1 RS-422 inputs have -10 V to +13 V extended common mode range.



H2 models: The voltage level for the HTL interface should be given by the user by means of connecting the encoder power pin (HTL_ENC_PWR) and the ISO_PWR pin to the same power supply within a range between 10 and 30V. In the same way, encoder ground (HTL_ENC_GND) and ISO_GND signals should be connected to the same ground in order to guarantee the good reception of the differential signals.



ISO_OUT0 and ISO_OUT1 have different output circuits (see also Section 6.5.2).



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".



Don't connect single-ended signals to the differential inputs ISO_INC0 and ISO_INC1.

Fig. 6.3 shows the schematic of the inputs and outputs for the G2 models and Fig. 6.4 for the H2 models. All inputs and outputs are isolated. ISO_VCC is an isolated, internally generated voltage.

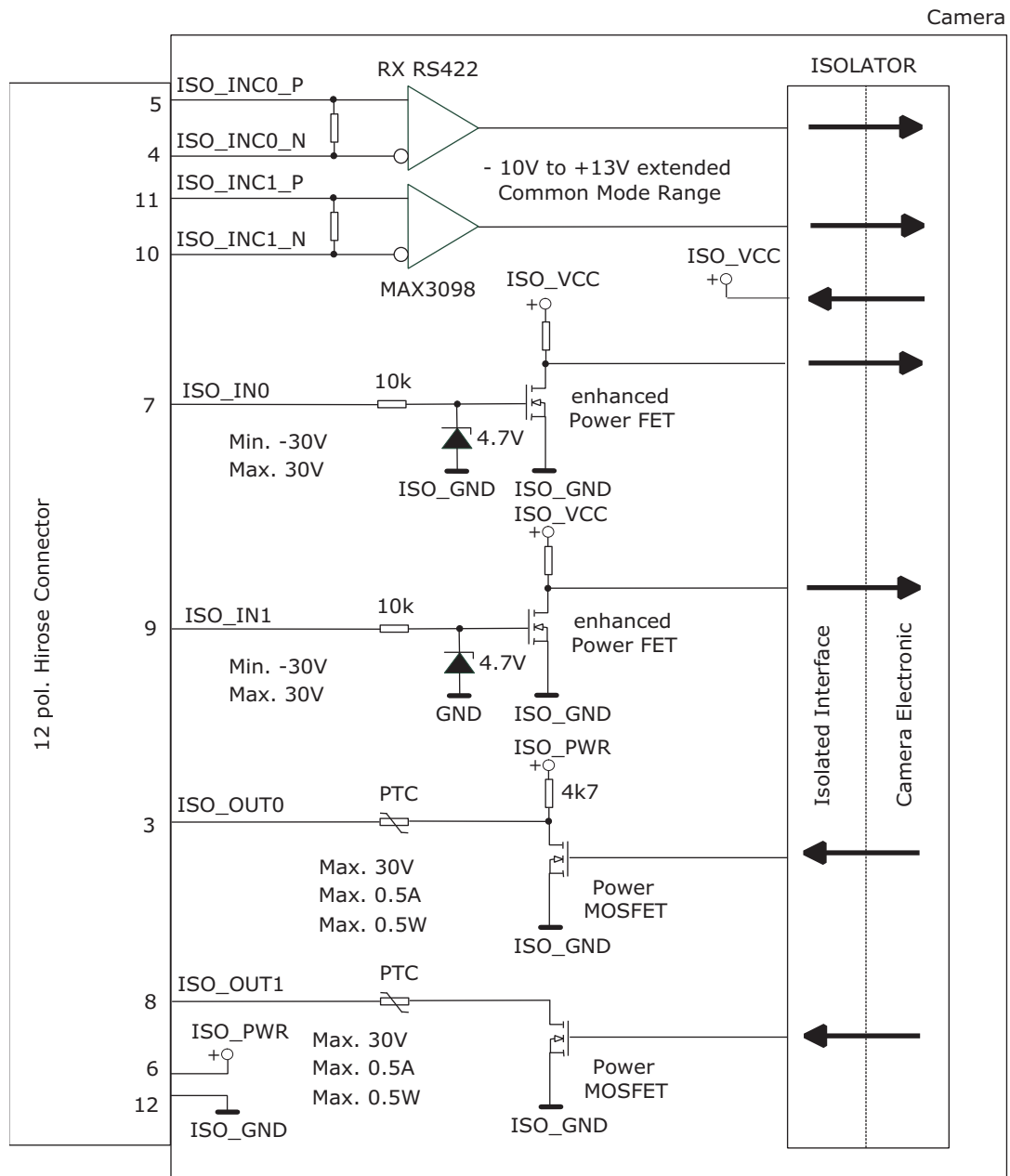


Figure 6.3: Schematic of inputs and output (G2 models)

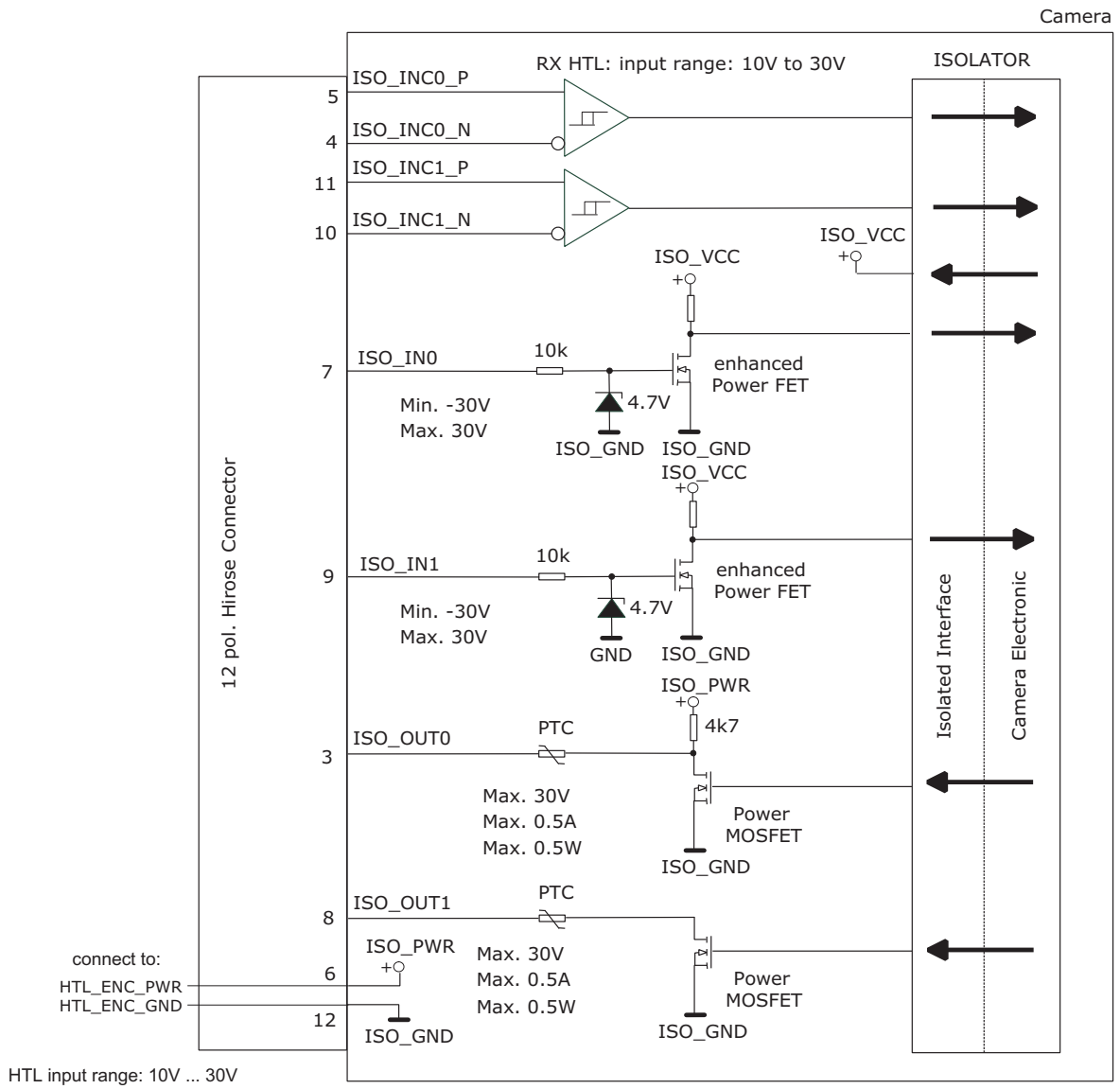


Figure 6.4: Schematic of inputs and output (H2 models)

6.5.2 Single-ended Inputs

ISO_IN0 and ISO_IN1 are single-ended isolated inputs. The input circuit of both inputs is identical (see Fig. 6.3).

Fig. 6.5 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 7.10.2.

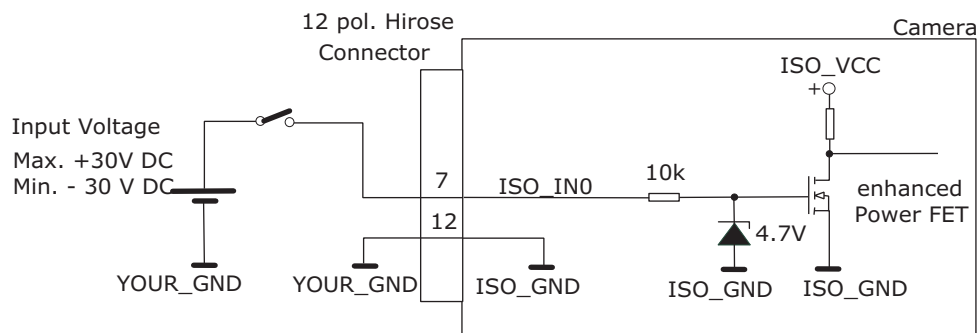


Figure 6.5: Direct connection to ISO_IN

Fig. 6.6 shows how to connect ISO_IN to TTL logic output device.

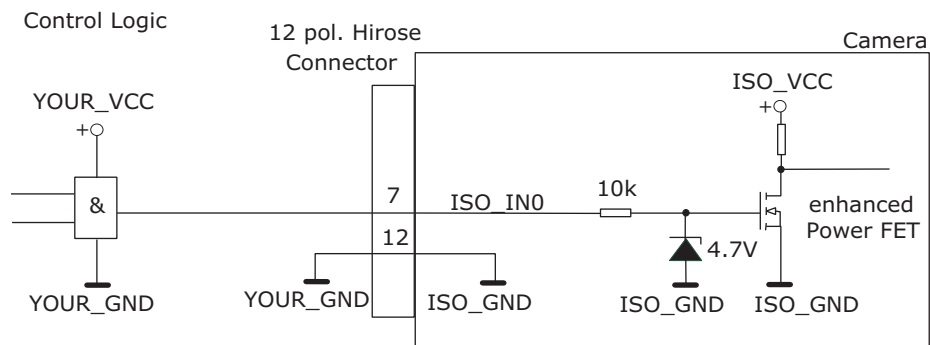


Figure 6.6: Connection to ISO_IN from a TTL logic device

6.5.3 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. 6.7 shows the connection from the ISO_OUT0 output to a TTL logic device. PTC is a current limiting device.

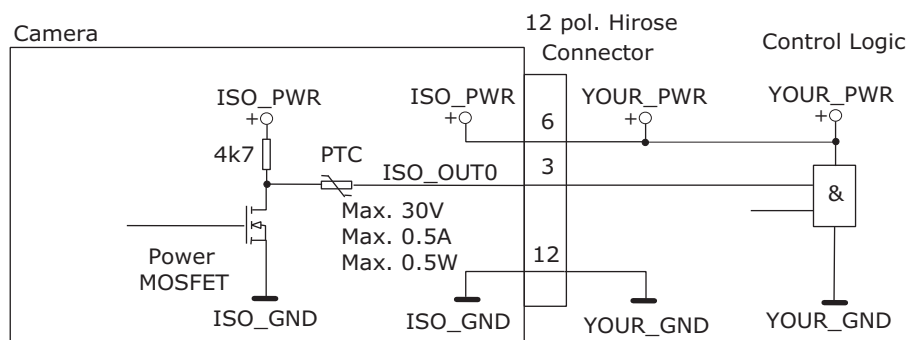


Figure 6.7: Connection example to ISO_OUT0

Fig. 6.8 shows the connection from ISO_OUT1 to a TTL logic device. PTC is a current limiting device.

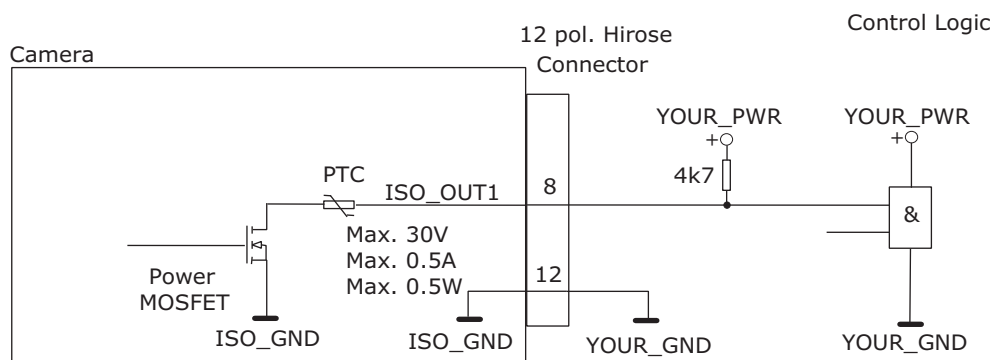


Figure 6.8: Connection from the ISO_OUT1 output to a TTL logic device

Fig. 6.9 shows the connection from ISO_OUT1 to a LED.

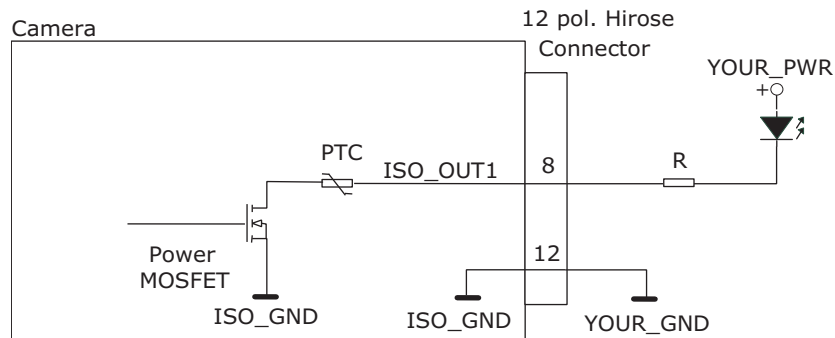


Figure 6.9: Connection from ISO_OUT1 to a LED



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. 6.10). The type of the Power MOSFET is: International Rectifier IRLML0100TRPbF.

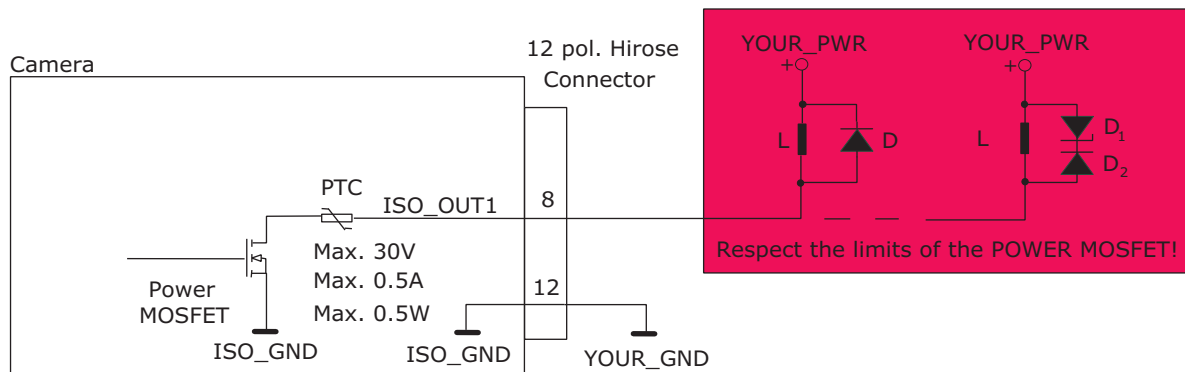


Figure 6.10: Limits of ISO_OUT1 output

6.5.4 Differential RS-422 Inputs (G2 models)

ISO_INC0 and ISO_INC1 are isolated differential RS-422 inputs (see also Fig. 6.3). 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. 6.11).

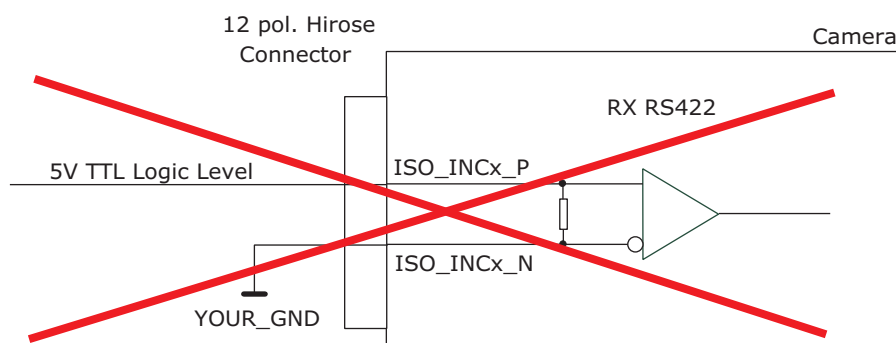


Figure 6.11: Incorrect connection to ISO_INC inputs

6.5.5 Master / Slave Camera Connection

The trigger input of one Photonfocus G2 camera can easily be connected to the strobe output of another Photonfocus G2 camera as shown in Fig. 6.12. This results in a master/slave mode where the slave camera operates synchronously to the master camera.

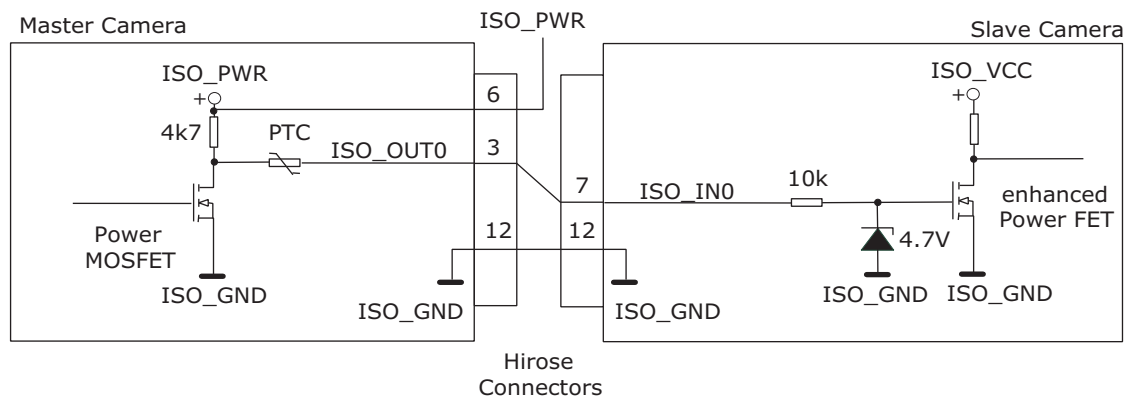


Figure 6.12: Master / slave connection of two Photonfocus G2 cameras

6.5.6 I/O Wiring

The Photonfocus cameras include electrically isolated inputs and outputs. Take great care when wiring trigger and strobe signals to the camera, specially over big distances (a few meters) and in noisy environments. Improper wiring can introduce ground loops which lead to malfunction of triggers and strobes.

There are two roads to avoid ground loops:

- Separating I/O ground and power supply (ISO_GND and ISO_PWR) from camera power (CAM_GND, CAM_PWR)
- Using a common power supply for camera and I/O signals with star-wiring

Separate Grounds

To separate the signal and ground connections of the camera (CAM_GND, CAM_PWR, data connections) from the I/O connections (ISO_GND, ISO_PWR, ISO_IN, ISO_OUT) is one way to avoid ground loops. Fig. 6.13 shows a schematic of this setup. In this setup the power supplies for the camera and for ISO power must be separate devices.

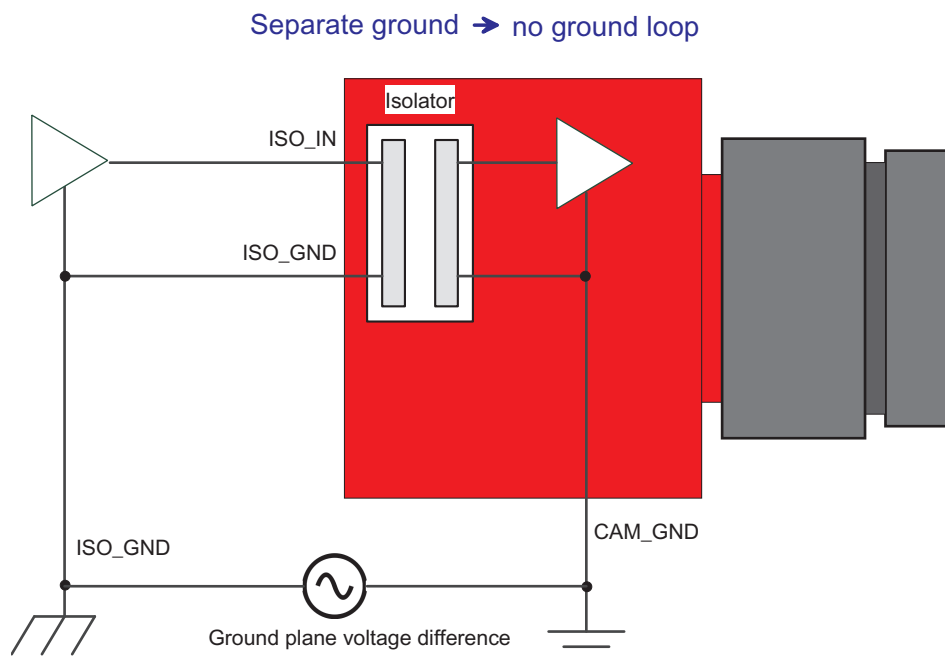


Figure 6.13: I/O wiring using separate ground

Common Grounds with Star Wiring

Ground loops can be avoided using "star wiring", i.e. the wiring of power and ground connections originate from one "star point" which is typically a power supply. Fig. 6.14 shows a schematic of the star-wiring concept.

Fig. 6.15 shows a schematic of the star-wiring concept applied to a Photonfocus GigE camera. The power supply and ground connections for the camera and for the I/O are connected to the same power supply which acts as the "Star Point".

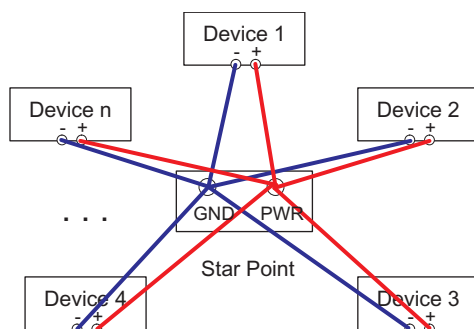


Figure 6.14: Star-wiring principle

Star wiring → no ground loop

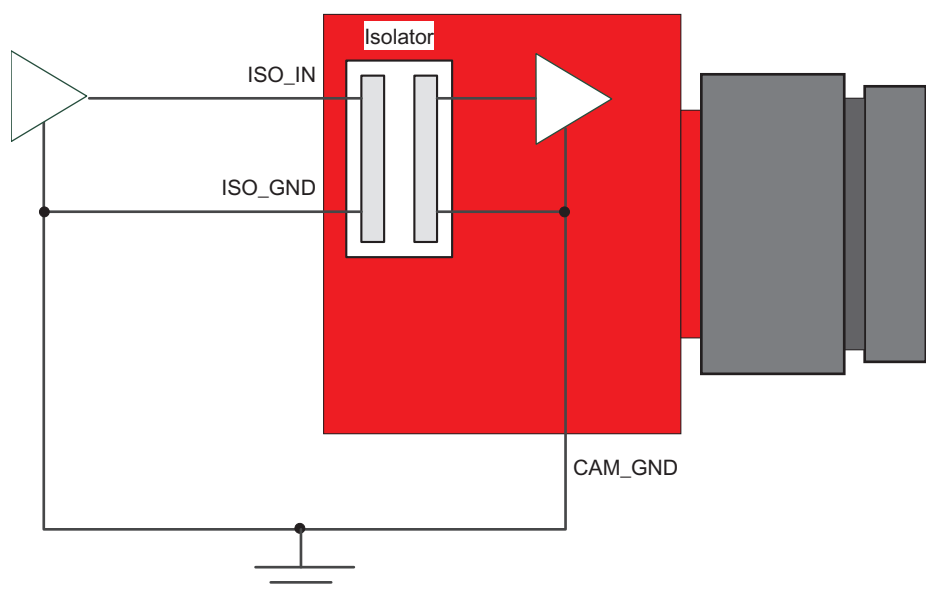


Figure 6.15: I/O wiring using star-wiring

Fig. 6.16 shows an example of how to connect a flash light and a trigger source to the camera using star-wiring. The trigger in this example is generated from a light barrier. Note how the power and ground cables are connected to the same power supply.

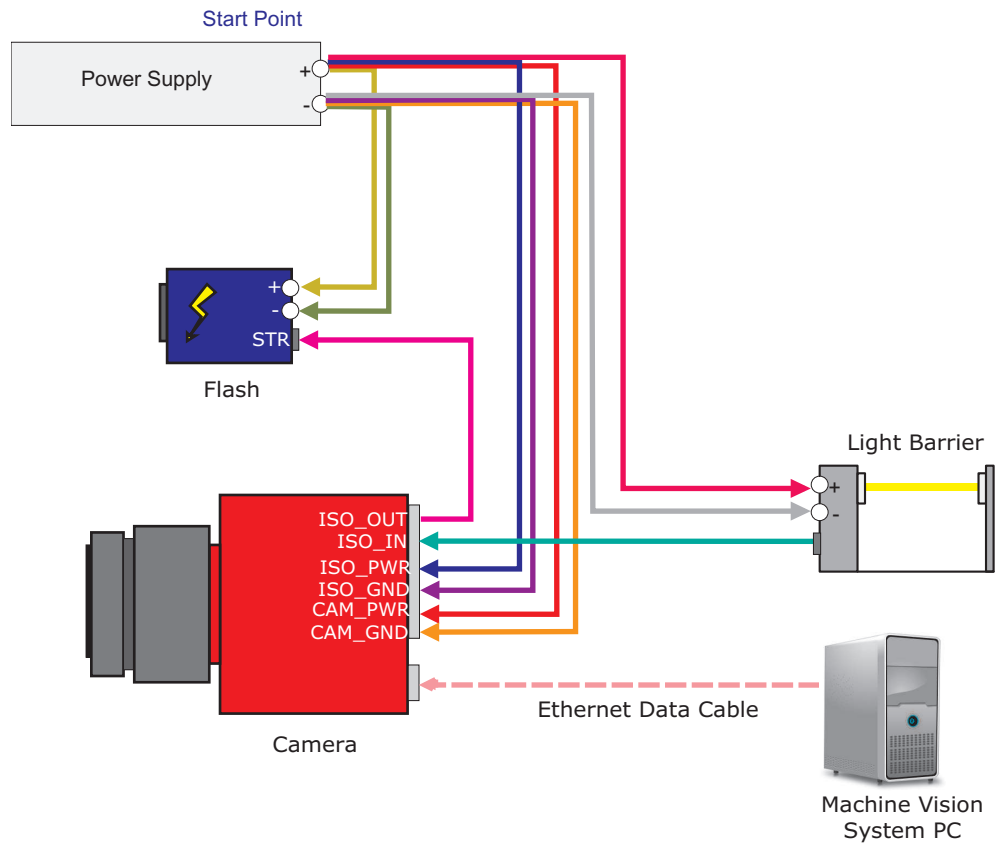


Figure 6.16: I/O wiring using star-wiring example

An example of improper wiring that causes a ground loop is shown in Fig. 6.17.

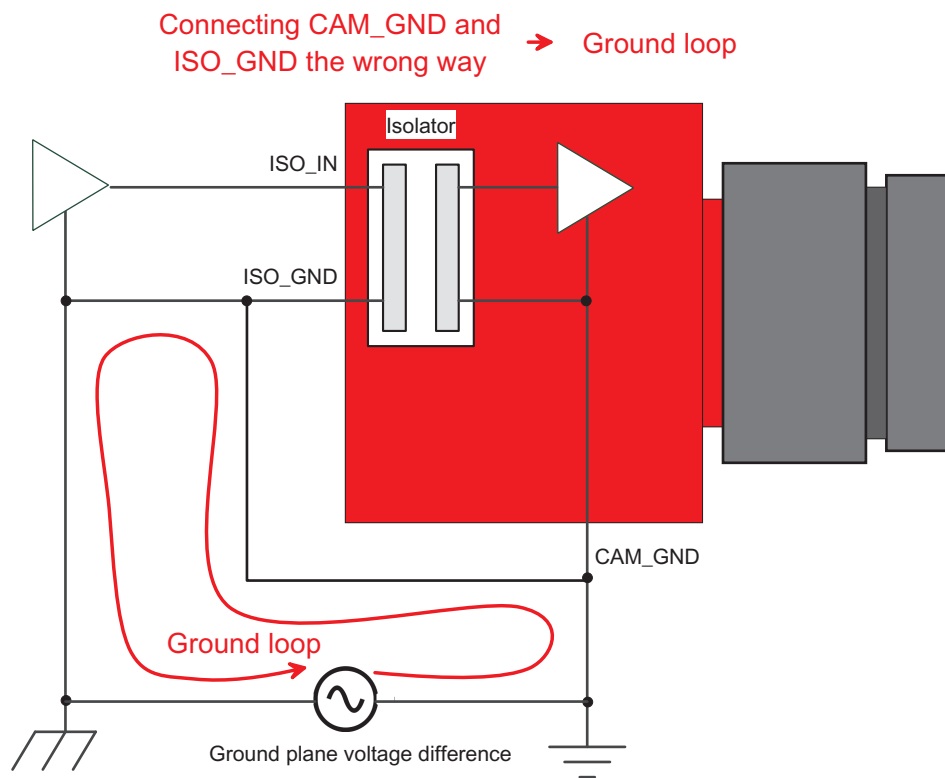


Figure 6.17: Improper I/O wiring causing a ground loop

6.6 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 7.10. 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)
Q6	PLC -> camera head	Incremental encoder A signal (only available on cameras with AB Trigger feature)
Q7	PLC -> camera head	Incremental encoder B signal (only available on cameras with AB Trigger feature)

Table 6.2: Connections to/from PLC

Software

7.1 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.

PFIInstaller Contains the PF_GEVPlayer, the DR1 decoding DLL, 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. For DR1 cameras the option `DR1_Tools`, support for DR1 cameras must be selected additionally.

DR1 HALCON extension package pf_demod (DR1 cameras only) Extension package that adds DR1 demodulation to the HALCON image processing library. It is contained in the PFIInstaller. The following options must at least be selected in the installation of the PFIInstaller: `DR1_Tools`, support for DR1 cameras and `Halcon Extensions`. In the next step the correct HALCON version (10 or 11) must be selected.

7.2 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 3.

After connecting to the camera, the camera properties can be accessed by clicking on the `GEV Device control` button (see also Section 7.2.2).



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



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.

7.2.1 PF_GEVPlayer main window

After connecting the camera (see Chapter 3), the main window displays the following controls (see Fig. 7.1):

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 6.6 and document [PLC]).

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

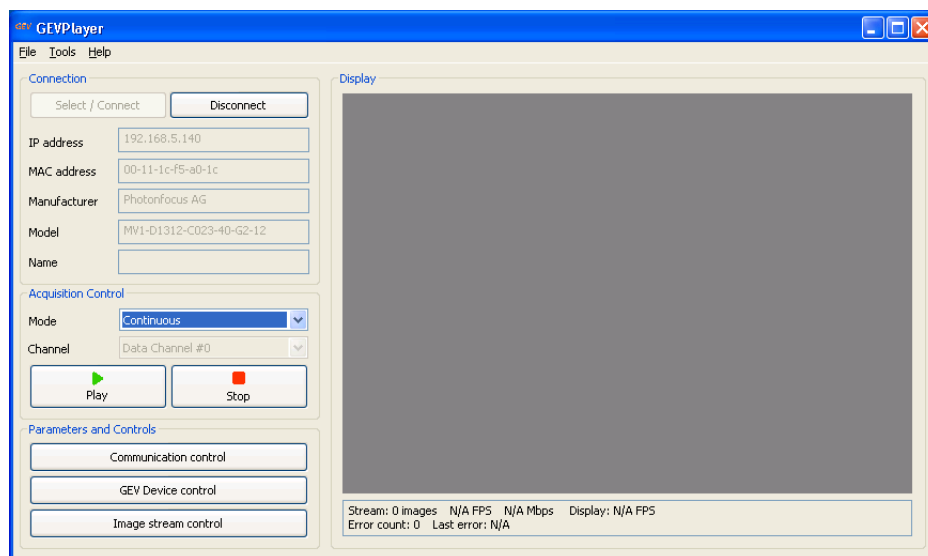


Figure 7.1: PF_GEVPlayer main window

Below the image display there are two lines with status information

7.2.2 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. 7.2.

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 of 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.

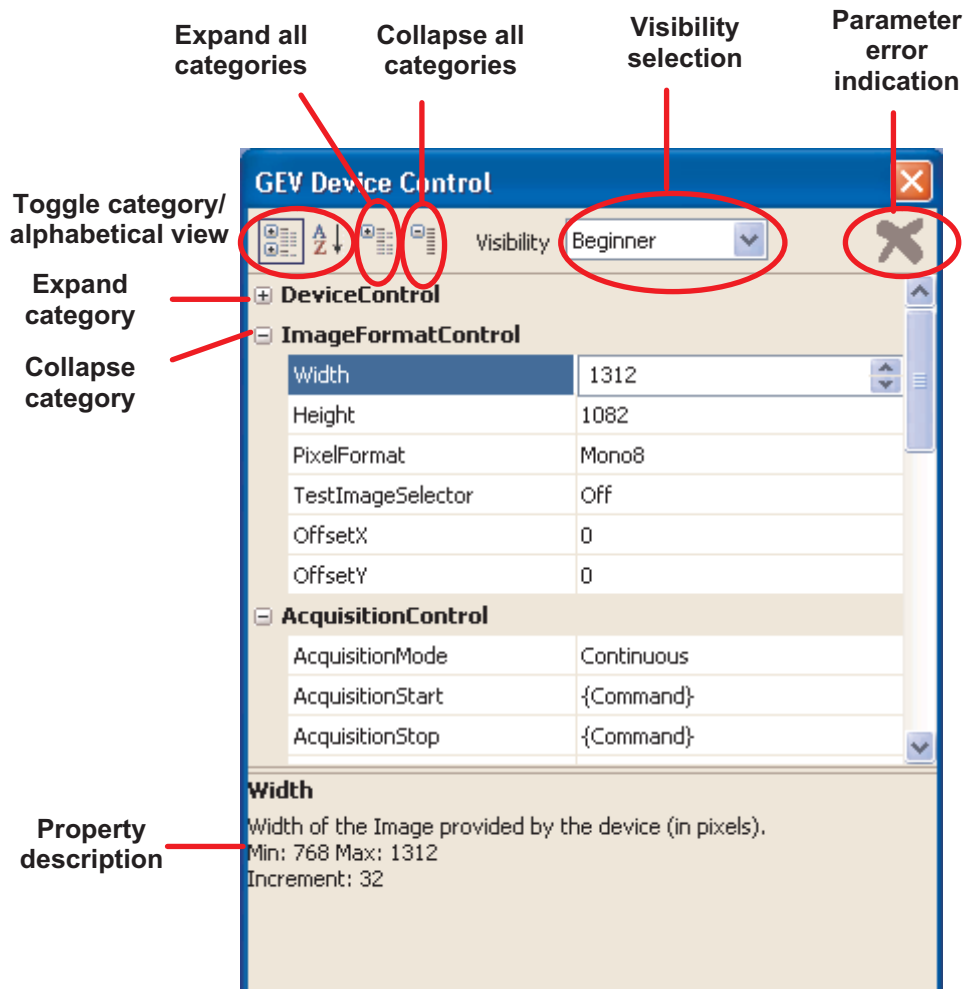


Figure 7.2: PF_GEVPlayer Control Window

7.2.3 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.

7.2.4 White Balance (Colour cameras only)

A white balance utility is available in the PF_GEVPlayer in Tools -> Image Filtering (see Fig. 7.3). 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.

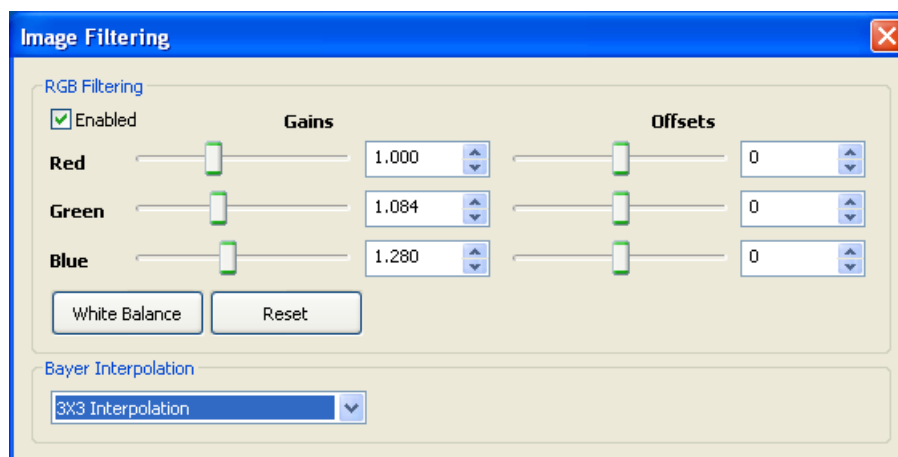


Figure 7.3: PF_GEVPlayer image filtering dialog

7.2.5 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.

7.2.6 Get feature list of camera

A list of all features of the Photonfocus GigE 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...).

7.3 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.

7.4 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) (Visibility: Guru) Serial number of the camera

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

7.5 ROI setting in L-96 cameras

The height in the L-96 cameras must be set by 2 properties:

1. Set the Window_H property to the desired height.
2. Set the Height property to the value indicated by the property HeightInterface.

Note that the above procedures must be followed in the same order also when using the SDK.

7.6 Look-Up Table (LUT)

7.6.1 Overview

The LUT is described in detail in Section 5.6. 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 feasible as up to 4096 values for every LUT must be 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

7.6.2 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 7.6.4.
5. Turn on LUT by setting LUTEnable to True.

7.6.3 Region LUT

The Region LUT feature is described in Section 5.6.4. 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 7.6.4.
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.

7.6.4 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 7.6.2 or Section 7.6.3.

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`.

7.6.5 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 7.6.2 and Section 7.6.3.
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 `PFIInstaller`.
3. If the `LUTAutoMode` requires additional settings (e.g. Gamma `LUTAutoMode`), then it can be set with `LUTAutoValue`.

7.7 MROI

The MROI feature is described in Section 5.1.3. 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_H` = 0 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_H` to 0.
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_H', 0);
SetFeature('MROI_Enable', true);
int heightTot;
GetFeature('MROI_Htot', &heightTot);
SetFeature('Height', heightTot);
```

7.8 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`).

7.9 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.

7.10 PLC

7.10.1 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. 7.4. The PLC tool is described in detail with many examples in the [PLC] manual which is included in the PFIInstaller.



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

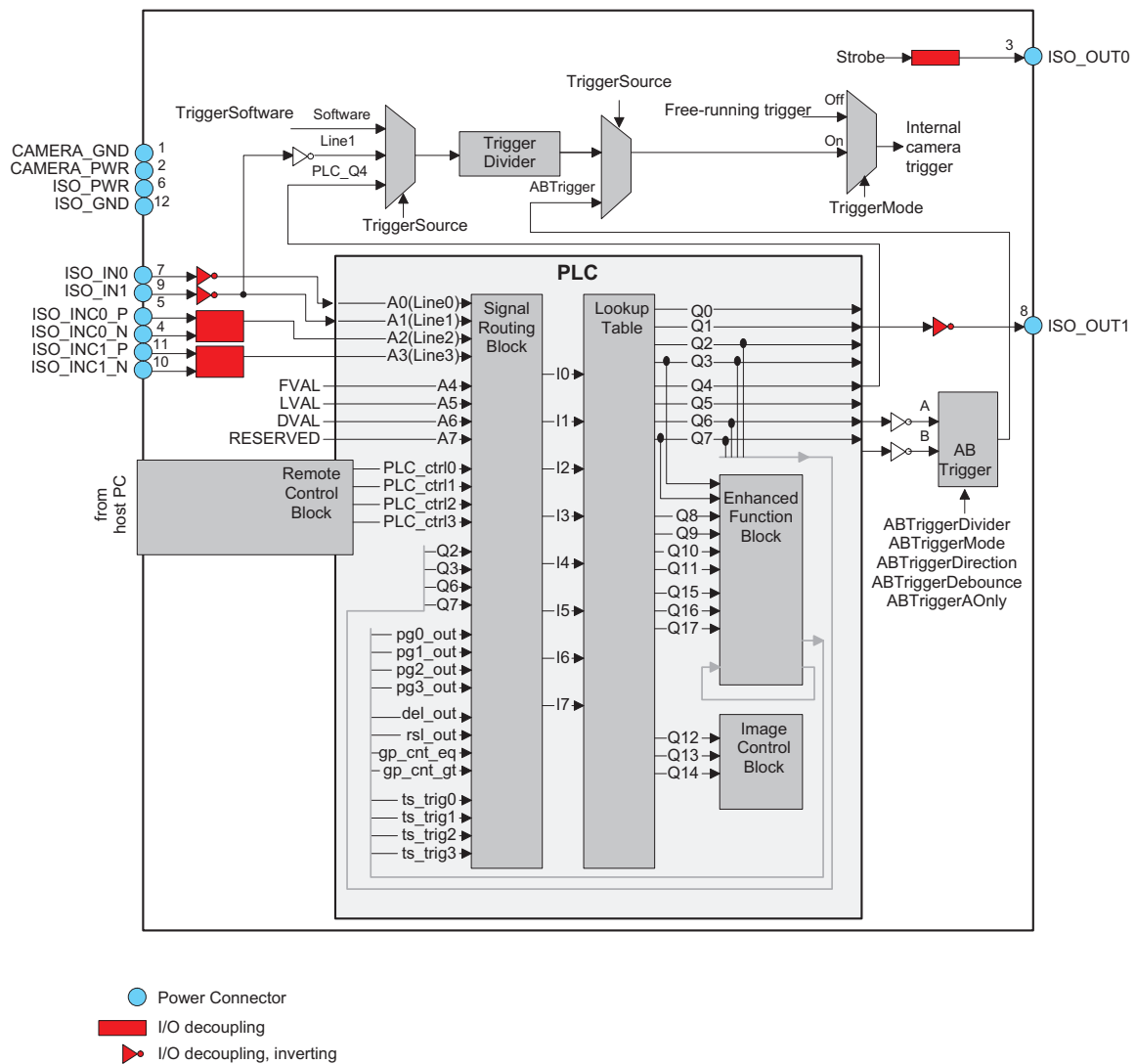


Figure 7.4: PLC functional overview and trigger connections

The simplest 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 7.10.2.

1. Identify the PLC notation of the desired input. A table of the PLC mapping is given in Section 6.6. 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 6.6. 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. 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.

7.10.2 PLC Settings for ISO_IN0 to PLC_Q4 Camera Trigger

This setting connects the ISO_IN0 to the internal camera trigger, see Table 7.1 (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 7.1: PLC Settings for ISO_IN0 to PLC_Q4 Camera Trigger (<PLC> = in category IPEngine/ProgrammableLogicController)

7.10.3 PLC Settings for A/B Trigger from differential inputs

This settings connects the ISO_INC differential inputs to the A/B camera inputs. ISO_INC0 is mapped to the A signal and ISO_INC1 to the B signal, see Table 7.2 (the visibility in the PF_GEVPlayer must be set to Guru for this purpose).



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

Feature	Value	Category
TriggerMode	On	AcquisitionControl
TriggerSource	ABTrigger	AcquisitionControl
PLC_I2	Line2	<PLC>/SignalRoutingBlock
PLC_I3	Line3	<PLC>/SignalRoutingBlock
PLC_Q6_Variable0	PLC_I2	<PLC>/LookupTable/Q6
PLC_Q6_Operator0	Or	<PLC>/LookupTable/Q6
PLC_Q6_Variable1	Zero	<PLC>/LookupTable/Q6
PLC_Q6_Operator1	Or	<PLC>/LookupTable/Q6
PLC_Q6_Variable2	Zero	<PLC>/LookupTable/Q6
PLC_Q6_Operator2	Or	<PLC>/LookupTable/Q6
PLC_Q6_Variable3	Zero	<PLC>/LookupTable/Q6
PLC_Q7_Variable0	PLC_I3	<PLC>/LookupTable/Q7
PLC_Q7_Operator0	Or	<PLC>/LookupTable/Q7
PLC_Q7_Variable1	Zero	<PLC>/LookupTable/Q7
PLC_Q7_Operator1	Or	<PLC>/LookupTable/Q7
PLC_Q7_Variable2	Zero	<PLC>/LookupTable/Q7
PLC_Q7_Operator2	Or	<PLC>/LookupTable/Q7
PLC_Q7_Variable3	Zero	<PLC>/LookupTable/Q7

Table 7.2: PLC Settings for A/B Trigger from differential inputs (<PLC> = in category IPEngine/ProgrammableLogicController)

7.10.4 PLC Settings for A/B Trigger from single-ended inputs

This configuration maps the single-ended inputs to the A/B camera inputs: ISO_IN0 is mapped to the A signal and ISO_IN1 to the B signal see Table 7.3 (the visibility in the PF_GEVPlayer must be set to Guru for this purpose).



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

Feature	Value	Category
TriggerMode	On	AcquisitionControl
TriggerSource	ABTrigger	AcquisitionControl
PLC_I0	Line0	<PLC>/SignalRoutingBlock
PLC_I1	Line1	<PLC>/SignalRoutingBlock
PLC_Q6_Variable0	PLC_I0	<PLC>/LookupTable/Q6
PLC_Q6_Operator0	Or	<PLC>/LookupTable/Q6
PLC_Q6_Variable1	Zero	<PLC>/LookupTable/Q6
PLC_Q6_Operator1	Or	<PLC>/LookupTable/Q6
PLC_Q6_Variable2	Zero	<PLC>/LookupTable/Q6
PLC_Q6_Operator2	Or	<PLC>/LookupTable/Q6
PLC_Q6_Variable3	Zero	<PLC>/LookupTable/Q6
PLC_Q7_Variable0	PLC_I1	<PLC>/LookupTable/Q7
PLC_Q7_Operator0	Or	<PLC>/LookupTable/Q7
PLC_Q7_Variable1	Zero	<PLC>/LookupTable/Q7
PLC_Q7_Operator1	Or	<PLC>/LookupTable/Q7
PLC_Q7_Variable2	Zero	<PLC>/LookupTable/Q7
PLC_Q7_Operator2	Or	<PLC>/LookupTable/Q7
PLC_Q7_Variable3	Zero	<PLC>/LookupTable/Q7

Table 7.3: PLC Settings for A/B Trigger from single-ended inputs (<PLC> = in category IPEngine/ProgrammableLogicController)

7.10.5 PLC Settings for FrameCombinePulse to ISO_OUT1

This setting connects the FrameCombinePulse signal (see Section 5.1.2) to the output ISO_OUT1, see Table 7.2 (the visibility in the PF_GEVPlayer must be set to Guru for this purpose).

Feature	Value	Category
PLC_I5	PLC_A7	<PLC>/SignalRoutingBlock
PLC_Q1_Variable0	PLC_I5_Not	<PLC>/LookupTable/Q1
PLC_Q1_Operator0	Or	<PLC>/LookupTable/Q1
PLC_Q1_Variable1	Zero	<PLC>/LookupTable/Q1
PLC_Q1_Operator1	Or	<PLC>/LookupTable/Q1
PLC_Q1_Variable2	Zero	<PLC>/LookupTable/Q1
PLC_Q1_Operator2	Or	<PLC>/LookupTable/Q1
PLC_Q1_Variable3	Zero	<PLC>/LookupTable/Q1

Table 7.4: PLC Settings for FrameCombinePulse to ISO_OUT1 (<PLC> = in category IPEngine/ProgrammableLogicController)

7.11 Miscellaneous Properties

7.11.1 PixelFormat

The property PixelFormat (in category ImageFormatControl) sets the pixel format. For 10 bits and 12 bits there is a selection of plain or packed format. The plain format uses more bandwidth than the packed format, but is easier to process in the software. Table 7.5 shows the number of bits per pixel to are required for a pixel format. Fig. 7.5 shows the bit alignment of the packed pixel formats.

DataFormat	Bits per pixel
Mono8 / BayerGB8	8
Mono10 / BayerGB10	16
Mono10Packed / BayerGB10Packed	12
Mono12 / BayerGB12	16
Mono12Packed / BayerGB12Packed	12
Mono16	16

Table 7.5: GigE pixel format overview



The DR1 colour camera models have the BayerGB8 format. This should be used to display the debayered colour image in the PF_GEVPlayer display. To demodulate the image by the SDK the format Mono8 must be used.

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

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

Figure 7.5: Packed Pixel Format

7.11.2 Colour Fine Gain (Colour cameras only)

To set the colour fine gain:

1. Set the GainSelector (in AnalogControl) to the desired position (see also below).
2. Set the Gain value to the desired value.

The GainSelector can have the following settings:

DigitalAll Overall gain applied to all colour channels

DigitalRed Gain applied to the red channel

DigitalGreen Gain applied to the green channel on the same row as the blue channel

DigitalBlue Gain applied to the blue channel

DigitalGreen2 Gain applied to the green channel on the same row as the red channel

To obtain colour gain values using the PF_GEVPlayer, follow could use the following procedure:

1. Open the camera in the PF_GEVPlayer, apply the desired settings and start the grabbing of the camera.
2. Set all colour gains of the camera (DigitalRed, DigitalGreen, DigitalBlue, DigitalGreen2) to 1.
3. Point the camera to a neutral reference (object that reflects all colours equally), e.g. a special grey reference card.
4. Do a white balancing in the PF_GEVPlayer as described in Section 7.2.4.
5. Copy the values to the camera DigitalGain settings, i.e. copy the value of the Red channel in the Image Filtering window of the PF_GEVPlayer to the DigitalRed value value of the camera (see above), copy the Green value to both DigitalGreen and DigitalGreen2 and copy the Blue value to DigitalBlue. These values could also be stored in the camera's non-volatile storage (see Section 7.8).
6. Disable RGB Filtering in the Image Filtering dialog of the PF_GEVPlayer as the colour channel correction is now made in the camera.

7.12 Width setting in DR1 cameras

To set the width in DR1 cameras, please follow this procedure:

1. Set property `Window_W` to target width.
2. Read value of property `WidthInterface`.
3. Set property `Width` to the value of property `WidthInterface`.

When double rate is enabled (property `DoubleRate_Enable=True`), `WidthInterface` shows the width of the modulated image. When double rate is disabled (property `DoubleRate_Enable=False`), `WidthInterface` has the same value as `Window_W`.

7.13 Decoding of images in DR1 cameras

The images arrive in an encoded (compressed) format in the DR1 cameras if `EnDoubleRate=True`. There are functions in the `pfDoubleRate` package to decode the images. The package documentation is located in the `SDK\doc` sub-directory of `PFRemote` installation directory. Examples are located in the `SDK\Example\pfDoubleRate` sub-directory. The package is installed with the `PFInstaller` that can be downloaded from the Photonfocus web page. During the installation process, the option `DR1 support` must be checked.



There are separate decoding functions for monochrome and for colour DR1 cameras.

7.13.1 Status line in DR1 cameras

The newer revisions of the DR1 camera series contain the status line feature (see Section 5.8). The status line is supported in the `pfDoubleRate.dll` from the `PFInstaller` Rev. 2.38 and later. The whole image, including the status line, can be applied to the demodulation functions. The status line is copied unmodified to the demodulated image, which is the correct behaviour as the status line is never sent in modulated format.

7.14 DR1Evaluator

The `DR1Evaluator` is a tool to evaluate the effect of the encoding algorithm that is implemented in the DR1 cameras. It is included in the `PFInstaller` that can be downloaded from the Photonfocus website.

The main window of the tool is shown in Fig. 7.6.

An input file can be selected by clicking on the button `Select Input File`.



Suitable images for evaluation of the monochrome encoding algorithm can be downloaded from the website http://www.imagecompression.info/test_images. Download the Gray 8 bit images. The best images for evaluation are the images that were taken by a camera. The artificial images don't reflect a "real-world" situation.



Only 8 bit monochrome images can be processed by the `DR1 Evaluator` tool.

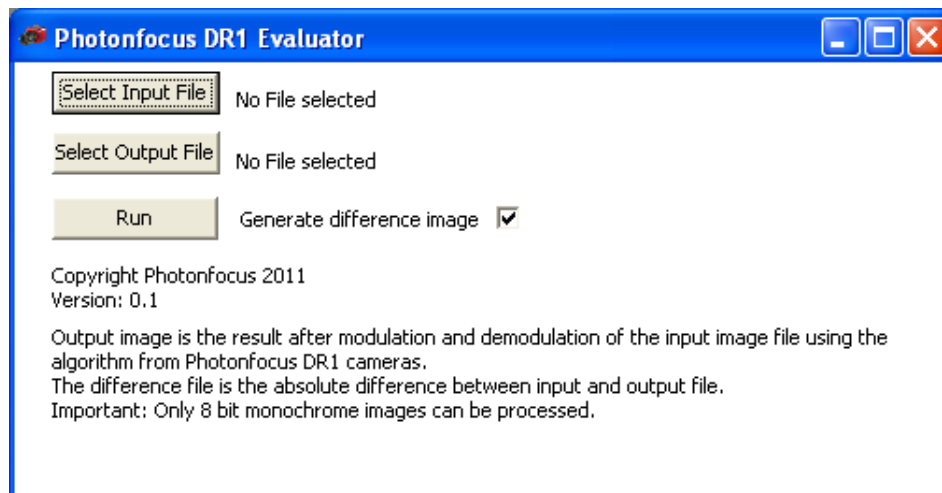


Figure 7.6: DR1Evaluator



Only raw colour images, i.e. taken before debayering, can be used as input.

Optionally an output file can be selected by clicking on the button `Select Output File`. This is the resulting file after modulation and demodulation of the input image.

Additionally a difference file can be generated by enabling the corresponding checkbox. The value of every pixel is the absolute value of the difference $\text{InputFile} - \text{OutputFile}$.

The output images are produced by clicking on the `Run` button.

Mechanical Considerations

8.1 Mechanical Interface

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

8.1.1 Cameras with GigE Interface

Fig. 8.1 shows the mechanical drawing of the camera housing for the Photonfocus D/L2048 GigE camera series.

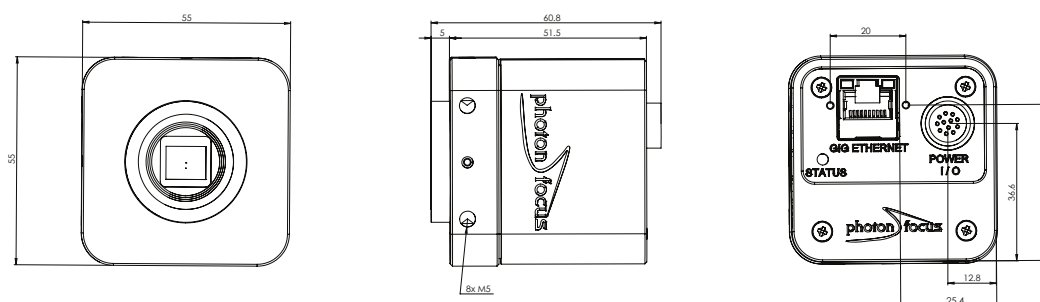


Figure 8.1: Mechanical dimensions of the Photonfocus 2048 GigE cameras



For long life and high accuracy operation, we highly recommend to mount the camera thermally coupled, so that the mounting acts as a heat sink. To verify proper mounting, camera temperature can be monitored using the GeniCam command `DeviceTemperature` under `GEVDeviceControl`.

8.2 Adjusting the Back Focus

The back focus of your Photonfocus camera is correctly adjusted in the production of the camera.

This section describes the procedure to adjust the back focus if you require that because e.g. you are using a special lens.

1. Screw a lens strongly into the camera's C-mount ring.
2. Unscrew the 3 small screws that lock the C-mount ring with a hex-wrench of size 0.89 mm. The position of the screws is shown in Fig. 8.2. The ring can now be screwn upwards or downwards by turning the lens.
3. To adjust the back focus fully open the aperture of the lens and set the focus to infinite.
4. Start the image acquisition and point the camera to a straight edge/line in a distance x (x = infinite distance of your lens) from the camera, e.g. a door frame.
5. Screw the ring upwards or downwards until the straight edge/line (distance: infinite) is also straight on the camera image.
6. Tighten the small screws. As the ring is locked, the lens can now be easily removed.



Figure 8.2: Position of the 3 small screws that lock C-mount.ring

8.3 CE compliance

The Photonfocus camera series DR1/MV1-D2048(x1088)(I/C)-G2 and MV1-L2048(I/C)-G2 are in compliance with the below mentioned standards according to the provisions of European Standards Directives:

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

Warranty

The manufacturer alone reserves the right to recognize warranty claims.

9.1 Warranty Terms

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

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

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

9.2 Warranty Claim



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

References

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

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

GEVQS GEVPlayer Quick Start Guide, Pleora Technologies. Included in eBUS installer.

MAN051 Manual "Photonfocus GigE Quick Start Guide", Photonfocus

PLC iPORT Programmable Logic Controller Reference Guide, Pleora Technologies. Included in GigE software package.

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

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

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 6.5.



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)

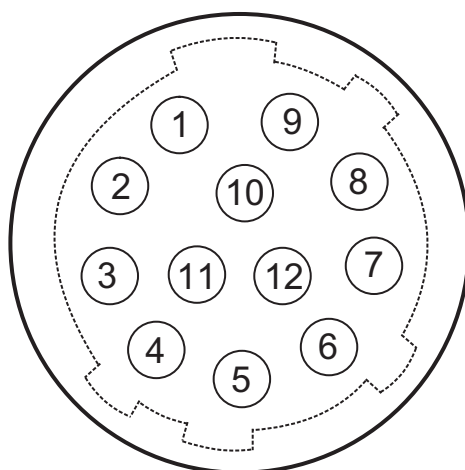


Figure A.1: Power supply connector, 12-pole female (rear view of connector, solder side)

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 input (G2: RS-422, H2: HTL), negative polarity
5	I	ISO_INC0_P	INC0 differential input (G2: RS-422, H2: HTL), 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 input (G2: RS-422, H2: HTL), negative polarity
11	I	ISO_INC1_P	INC1 differential input (G2: RS-422, H2: HTL), positive polarity
12	PWR	ISO_GND	I/O GND, 0V

Table A.2: Power supply connector pin assignment

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.

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

Status Line V1.1 All fields of Status Line V1.0 plus additional fields: Encoder Position and Trigger Level. Values are sampled at the start of exposure.

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

Grabbing Bug Bug where the camera is not able to grab images with some third-party software that read and write all properties, including hidden properties. Please contact <support@photonfocus.com> if you have a camera version containing this bug and the camera does not grab images.

Image Width Bug Bug in a revision of the DR1 colour camera where the image width of camera is not correctly calculated in double rate mode with some width settings. In this case the last 2 pixels of every row are not correct. Please contact <support@photonfocus.com> if you have a camera version containing this bug.

A/B Trigger Bug In the affected revisions, in single A/B trigger mode when the encoder position moves back and forth by a small amount, the EncoderCounter is incremented and the decrement is sometime omitted, leading to a wrong EncoderPosition indication in the camera. Therefore the single A/B trigger mode should not be used in the affected versions. A workaround to have the same behaviour as the single trigger mode, but without the bug, use the double A/B mode and double the value of ABTriggerDivider.

B.2 2MP Area Scan Cameras Speedgrade 80

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

D80 MV1-D2048X1088-80-G2-10

I80 MV1-D2048X1088I-80-G2-10

C80 MV1-D2048X1088C-80-G2-10

	D80 V1.0	D80 V1.1	I80 V1.0	I80 V1.1	C80 V1.0	C80 V1.1
ROI	yes	yes	yes	yes	yes	yes
Double Rate	no	no	no	no	no	no
Line Scan Mode	no	no	no	no	no	no
Frame Combine	no	no	no	no	no	no
MROI	yes	yes	yes	yes	yes	yes
Decimation	yes	yes	yes	yes	yes	yes
Binning	no	no	no	no	no	no
Standard Trigger	yes	yes	yes	yes	yes	yes
AB Trigger	no	no	no	no	no	no
A/B Trigger Bug	no	no	no	no	no	no
Counter Reset External	no	no	no	no	no	no
ResetCounter_Dual	no	no	no	no	no	no
Multiple Slope	yes	yes	yes	yes	yes	yes
Digital Gain / Offset	yes	yes	yes	yes	yes	yes
Analog Gain	no	no	no	no	no	no
LUT	yes	yes	yes	yes	yes	yes
Crosshairs	yes	yes	yes	yes	no	no
Status Line V1.0	yes	yes	yes	yes	yes	yes
Status Line V1.1	no	no	no	no	no	no
Test Images	yes	yes	yes	yes	yes	yes
Grabbing Bug	yes	no	yes	no	yes	no

Table B.1: Revisions GigE 2 MP Area Scan Cameras Speedgrade 80

B.3 2MP Area Scan Cameras Speedgrade 96

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

D96 MV1-D2048X1088-96-G2-10

I96 MV1-D2048X1088I-96-G2-10

C96 MV1-D2048X1088C-96-G2-10

	D96 V1.0	I96 V1.0	C96 V1.0
ROI	yes	yes	yes
Double Rate	no	no	no
Line Scan Mode	no	no	no
Frame Combine	no	no	no
MROI	yes	yes	yes
Decimation	yes	yes	yes
Binning	no	no	no
Standard Trigger	yes	yes	yes
AB Trigger	no	no	no
A/B Trigger Bug	no	no	no
Counter Reset External	no	no	no
ResetCounter_Dual	no	no	no
Multiple Slope	yes	yes	yes
Digital Gain / Offset	yes	yes	yes
Analog Gain	no	no	no
LUT	yes	yes	yes
Crosshairs	yes	yes	no
Status Line V1.0	yes	yes	yes
Status Line V1.1	no	no	no
Test Images	yes	yes	yes
Grabbing Bug	no	no	no

Table B.2: Revisions GigE 2 MP Area Scan Cameras Speedgrade 96

B.4 2MP Area Scan Cameras Speedgrade 192

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

D192 DR1-D2048X1088-192-G2-8

I192 DR1-D2048X1088I-192-G2-8

C192 DR1-D2048X1088C-192-G2-8

	D192 V1.0	D192 V1.1	I192 V1.0	I192 V1.1
ROI	yes	yes	yes	yes
Double Rate	yes	yes	yes	yes
Line Scan Mode	no	no	no	no
Frame Combine	no	no	no	no
MROI	yes	yes	yes	yes
Decimation	yes	yes	yes	yes
Binning	no	no	no	no
Standard Trigger	yes	yes	yes	yes
AB Trigger	no	yes	no	yes
A/B Trigger Bug	no	yes	no	yes
Counter Reset External	no	yes	no	yes
ResetCounter_Dual	no	no	no	no
Multiple Slope	yes	yes	yes	yes
Digital Gain / Offset	yes	yes	yes	yes
Analog Gain	no	yes	no	yes
LUT	yes	yes	yes	yes
Crosshairs	yes	yes	yes	yes
Status Line V1.0	no	no	no	no
Status Line V1.1	no	yes	no	yes
Test Images	yes	yes	yes	yes
PixelFormat Mono12 and Mono16	no	no	no	no
Grabbing Bug	no	no	no	no
Image Width Bug	no	no	no	no

Table B.3: Revisions GigE 2 MP Area Scan Cameras Speedgrade 192 (1)

	C192 V1.0	C192 V1.1	C192 V1.2
ROI	yes	yes	yes
Double Rate	yes	yes	yes
Line Scan Mode	no	no	no
Frame Combine	no	no	no
MROI	yes	yes	yes
Decimation	yes	yes	yes
Binning	no	no	no
Standard Trigger	yes	yes	yes
AB Trigger	no	no	yes
A/B Trigger Bug	no	no	yes
Counter Reset External	no	no	yes
ResetCounter_Dual	no	no	no
Multiple Slope	yes	yes	yes
Digital Gain / Offset	yes	yes	yes
Analog Gain	no	no	yes
LUT	yes	yes	yes
Crosshairs	no	no	yes
Status Line V1.0	no	no	no
Status Line V1.1	no	no	yes
Test Images	yes	yes	yes
PixelFormat Mono12 and Mono16	no	no	no
Grabbing Bug	no	no	no
Image Width Bug	yes	no	no

Table B.4: Revisions GigE 2 MP Area Scan Cameras Speedgrade 192 (2)

B.5 4MP Area Scan Cameras Speedgrade 96 and 192

Table B.5 shows revision information for the following models:

D96 MV1-D2048-96-G2-10

I96 MV1-D2048I-96-G2-10

C96 MV1-D2048C-96-G2-10

D192 DR1-D2048-192-G2-8

I192 DR1-D2048I-192-G2-8

C192 DR1-D2048C-192-G2-8

	D96 / I96 / C96 V1.0	D96 / I96 / C96 V2.0	D192 / I192 / C192 V1.0
ROI	yes	yes	yes
Double Rate	no	no	yes
Line Scan Mode	no	no	no
Frame Combine	no	no	no
MROI	yes	yes	yes
Decimation	yes	yes	yes
Binning	no	no	no
Standard Trigger	yes	yes	yes
AB Trigger	no	yes	no
A/B Trigger Bug	no	yes	no
Counter Reset External	no	yes	no
ResetCounter_Dual	no	no	no
Multiple Slope	yes	yes	yes
Digital Gain / Offset	yes	yes	yes
Analog Gain	no	yes	no
LUT	yes	yes	yes
Crosshairs	yes (C96: no)	yes	yes (C192: no)
Status Line V1.0	yes	no	no
Status Line V1.1	no	yes	no
Test Images	yes	yes	yes
PixelFormat Mono12 and Mono16	no	no	no
Grabbing Bug	no	no	no
Image Width Bug	no	no	no

Table B.5: Revisions GigE 4 MP Area Scan Cameras Speedgrades 96 and 192 (1)

	D192 / I192 / C192 V2.0	D192 / I192 V3.0	C192 V3.0
ROI	yes	yes	yes
Double Rate	yes	yes	yes
Line Scan Mode	no	no	no
Frame Combine	no	no	no
MROI	yes	yes	yes
Decimation	yes	yes	yes
Binning	no	yes	no
Standard Trigger	yes	yes	yes
AB Trigger	yes	yes	yes
A/B Trigger Bug	yes	no	no
Counter Reset External	yes	yes	yes
ResetCounter_Dual	no	yes	yes
Multiple Slope	yes	yes	yes
Digital Gain / Offset	yes	yes	yes
Analog Gain	yes	yes	yes
LUT	yes	yes	yes
Crosshairs	yes	yes	yes
Status Line V1.0	no	no	no
Status Line V1.1	yes	yes	yes
Test Images	yes	yes	yes
PixelFormat Mono12 and Mono16	no	no	no
Grabbing Bug	no	no	no
Image Width Bug	no	no	no

Table B.6: Revisions GigE 4 MP Area Scan Cameras Speedgrades 96 and 192 (2)

B.6 Line Scan Cameras

Table B.7 shows revision information for the following models:

L96 MV1-L2048-96-G2-10

L96I MV1-L2048I-96-G2-10

L96C MV1-L2048C-96-G2-10

	L96 V1.0	L96 V1.1	L96 V2.0	L96I V1.1	L96C V1.0
ROI	yes	yes	yes	yes	yes
Double Rate	no	no	no	no	no
Line Scan Mode	yes	yes	yes	yes	yes
Frame Combine	yes ¹⁾	yes ²⁾	yes ²⁾	yes ²⁾	yes ¹⁾
FrameCombinePulse	no	no	yes	no	no
MROI	yes	yes	yes	yes	yes
Decimation	yes	yes	yes	yes	yes
Binning	no	no	no	no	no
Standard Trigger	yes	yes	yes	yes	yes
AB Trigger	no	yes	yes	yes	no
A/B Trigger Bug	no	yes	no	yes	no
Counter Reset External	no	yes	yes	yes	no
ResetCounter_Dual	no	no	no	no	no
Multiple Slope	yes	yes	yes	yes	yes
Digital Gain / Offset	yes	yes	yes	yes	yes
Analog Gain	no	no	yes	no	no
LUT	yes	yes	yes	yes	yes
Crosshairs	yes	yes	yes	yes	no
Status Line V1.0	yes	no	no	no	yes
Status Line V1.1	no	yes	yes	yes	no
Test Images	yes	yes	yes	yes	yes
PixelFormat Mono12 and Mono16	no	no	no	no	no
Grabbing Bug	yes	yes	no	yes	yes
Analog Gain	no	no	yes	no	no

Table B.7: Revisions GigE Line Scan Cameras (1) (Footnotes: ¹⁾ Maximal height in FrameCombine Mode = 1088, ²⁾ Maximal height in FrameCombine Mode = 16383)

	L96C V1.1	L96C V2.0
ROI	yes	yes
Double Rate	no	no
Line Scan Mode	yes	yes
Frame Combine	yes ²⁾	yes ²⁾
FrameCombinePulse	no	yes
MROI	yes	yes
Decimation	yes	yes
Binning	no	no
Standard Trigger	yes	yes
AB Trigger	yes	yes
A/B Trigger Bug	yes	no
Counter Reset External	yes	yes
ResetCounter_Dual	no	no
Multiple Slope	yes	yes
Digital Gain / Offset	yes	yes
Analog Gain	no	yes
LUT	yes	yes
Crosshairs	no	yes
Status Line V1.0	no	no
Status Line V1.1	yes	yes
Test Images	yes	yes
PixelFormat Mono12 and Mono16	no	no
Grabbing Bug	yes	no
Analog Gain	no	yes

Table B.8: Revisions GigE Line Scan Cameras (2) (Footnotes: ¹⁾ Maximal height in FrameCombine Mode = 1088, ²⁾ Maximal height in FrameCombine Mode = 16383)

Document Revision History

Revision	Date	Changes
1.0	May 2012	First version
1.1	August 2012	DR1 models added; Section Software/PLC Settings: PLC drawing improved; Sections Hardware Interface/Power and Ground Connection for GigE G2 Cameras and Trigger and Strobe Signals for GigE G2 Cameras: minor modifications. Minimal exposure time corrected.
1.2	February 2013	Adding power consumption information. Power supply voltage range and external trigger voltage range corrected. MV1-D2048(x1088)(I/C)-96-G2 models added. MV1-D2048(I/C)-80-G2 models removed. Chapter Functionality, section Region of Interest (ROI): frame rates of 640x480 and 480x640 were exchanged. Section Save camera setting to a file added to chapter Software / PF_GEVPlayer.
1.3	March 2013	MV1-L2048(I/C)-96-G2 cameras added. Chapter Introduction added and abbreviated camera names used in the manual.
1.4	August 2013	Minimal exposure time for 4 MPix models corrected. Section "Strobe Output" added. Section "Counter Reset by an External Signal" added Section "Frame Combine": note about maximal value added. Section "Status Line": encoding of TriggerSource described. Additional fields "Encoder Position" and "Trigger Level" described. Comment added that Analog Gain is only available in some models. Information corrected: color camera models don't contain crosshairs feature. PLC diagram (in Software / PLC / Introduction): A/B trigger added. Image of bit alignment in packed pixel format added. Section "Adjusting the Back Focus" added Appendix "Camera Revisions" added.

Revision	Date	Changes
1.5	November 2013	Section "Region of Interest (ROI)": corrected frame rate value of DR1-192 for ROI of 256x256. New version of DR1 camera with more functionality added: ABTrigger, reset counters by external signal, status line Notes about status line in DR1 models added.
1.6	November 2013	Added revision 2.0 of line scan cameras.
1.7	May 2014	Section "A/B Mode": diagram of single mode adapted to new revision. Added note about a bug in the A/B trigger single mode. Section "A/B Trigger Debounce": more detailed explanation added Added sections "PLC Settings for FrameCombinePulse to ISO_OUT1" and "FrameCombinePulse"
1.8	May 2015	Section "Binning" added Section "ResetCounter_Dual" added Section "I/O Wiring" added Camera revisions DR1 V3.0 added