User Manual

Photonfocus

MV4 Luxima Camera Series

CMOS camera series with GigE Interface

MV4-D1280-L01-G2
MV4-D1280-L01-GT
MV4-D1280-L01-FB
DR4-D1280-L01-G2
DR4-D1280-L01-GT (available on request)
DR4-D1280-L01-FB (available on request)
MV4-D1952-L01-G2 (available on request)
MV4-D1952-L01-GT
MV4-D1952-L01-FB (available on request)
DR4-D1952-L01-G2 (available on request)
DR4-D1952-L01-GT
DR4-D1952-L01-FB (available on request)

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Contents

1 Preface

1.1 IMPORTANT NOTICE!

READ THE INSTRUCTIONS FOR USE BEFORE OPERATING THE CAMERA

STORE THE INSTRUCTIONS FOR USE FOR FURTHER READING

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1.2 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.

1.3 Contact

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Table 1.1: Photonfocus Contact

1.4 Sales Offices

Photonfocus products are available through an extensive international distribution network and through our key account managers. Find your local Photonfocus contact at our homepage (www.photonfocus.com) or contact us via email at sales@photonfocus.com.

1.5 Further information

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1.6 Legend

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

Important note, additional information

Important instructions

General warning, possible component damage hazard

Warning, electric shock hazard

Warning, fire hazard

2

Introduction

2.1 Introduction

This manual describes standard Photonfocus MV4 Luxima series cameras that have a Gigabit Ethernet (GigE) or a 10 Gigabit Ethernet Copper (GT) or Fibre (FB) interface. The cameras contain the CMOS image sensor LUX1310 and LUX2100 from Luxima.

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

2.2 Camera Naming Convention

The naming convention of the MV4 Luxima camera series is summarized in Fig. 2.1.

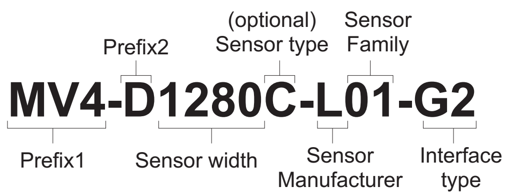

Figure 2.1: Camera naming convention

Prefix1 Camera platform and usage prefix. The following prefix are available for this camera series: MV4 with form factor 59mmx59mm. DR cameras have DR4 as Prefix1.

Prefix2 Camera family specifier. The following specifiers are used in this manual: "D": digital standard area scan cameras

Sensor width Width of image sensor of the camera in pixels.

Sensor type Sensor types specification: "C": color cameras. Cameras without sensor type specifier have a standard monochrome sensor.

Sensor Manufacturer Sensor manufacturer. "L": Luxima

Sensor Family Sensor family of the prior indicated manufacturer. "01": LUX series

Interface type Interface type specification: "CL": CameraLink® , "G2": Gigabit Ethernet (GigE Vision), "GT": 10 Gigabit Ethernet Copper (GigE Vision), "FB": 10 Gigabit Ethernet Fibre (GigE Vision).

2.3 Camera list

A list of all cameras covered in this manual is shown in Table 2.1.

Name	Resolution	Frame Rate	Notes
MV4-D1280-L01-G2	1280 x 1024	85 fps [1)]	Gigabit Ethernet 1.3 MP monochrome standard camera.
MV4-D1280-L01-GT	1280 x 1024	935 fps [1)]	10 Gigabit Ethernet Copper 1.3 MP monochrome standard camera.
MV4-D1280-L01-FB	1280 x 1024	935 fps [1)]	10 Gigabit Ethernet Fibre 1.3 MP monochrome standard camera.
DR4-D1280-L01-G2	1280 x 1024	165 fps [1)]	Gigabit Ethernet 1.3 MP monochrome standard camera.
DR4-D1280-L01-GT [2)]	1280 x 1024	1066 fps [1)]	10 Gigabit Ethernet Copper 1.3 MP monochrome standard camera.
DR4-D1280-L01-FB [2)]	1280 x 1024	1066 fps [1)]	10 Gigabit Ethernet Fibre 1.3 MP monochrome standard camera.
MV4-D1952-L01-G2 [2)]	1952 x 1080	53 fps [1)]	Gigabit Ethernet 2.1 MP monochrome standard camera.
MV4-D1952-L01-GT	1952 x 1080	581 fps [1)]	10 Gigabit Ethernet Copper 2.1 MP monochrome standard camera.
MV4-D1952-L01-FB [2)]	1952 x 1080	581 fps [1)]	10 Gigabit Ethernet Fibre 2.1 MP monochrome standard camera.
DR4-D1952-L01-G2 [2)]	1952 x 1080	TBD fps [1)]	Gigabit Ethernet 2.1 MP monochrome standard camera.
DR4-D1952-L01-GT	1952 x 1080	1000 fps [1)]	10 Gigabit Ethernet Copper 2.1 MP monochrome standard camera.
DR4-D1952-L01-FB [2)]	1952 x 1080	1000 fps [1)]	10 Gigabit Ethernet Fibre 2.1 MP monochrome standard camera.

Table 2.1: Camera models covered by this manual (Footnotes: [1)] frame rate at at full resolution [2)] available on request)

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Product Specification

3.1 Introduction

The Photonfocus MV4 Luxima GigE camera series is built around the CMOS image sensor LUX1310 and LUX2100 from Luxima. They provide a resolution of 1280 x 1024 and 1592 x 1080 pixels. The camera series is optimized for low light conditions. The cameras are aimed at standard applications in industrial image processing where high sensitivity and high frame rates are required.

The principal advantages are:

- Resolution of 1280x1024 (LUX1310) and 1952 x 1080 (LUX2100) pixels
- Optimized for low light conditions
- Spectral range: monochrome standard: 350 - 950 nm
- Global shutter high-speed CMOS image sensor
- Micro lenses
- Gigabit and 10-Gigabit Ethernet interfaces, GigE Vision and GenICam compliant
- Powered by Wall Adapter or Power Over Ethernet (PoE).
- Reverse voltage protection
- Frame rates MV4-D1280-L01 camera series at maximal resolution 85 fps (GigE) and 935 fps (10GigE)
- Frame rates MV4-D19520-L01 camera series at maximal resolution 53 fps (GigE) and 581 fps (10GigE)
- I/O capabilities: 4x Isolated inputs or shaft encoder A, B, Z, Y interface (RS422, TTL, D-HTL, HTL), 3x Isolated outputs (2x open drain, 1x TTL highspeed)
- Up to 8 regions of interest (MROI)
- 2 look-up tables (12-to-8 bit) on user-defined image region (Region-LUT)
- Dual Crosshairs overlay on the image
- Image Binning
- Image information and camera settings inside the image (status line)
- Software provided for setting and storage of camera parameters
- The rugged housing at a compact size of 59 x 59 x 89.6 mm^3 (GigE), 59 x 59 x 103.2 mm^3 (10GigE) and 59 x 59 x 101.8 mm^3 (10GigE Fibre) makes the Photonfocus MV4 Luxima GigE camera series the perfect solution for applications in which space is at a premium.
- Lens mount: C-Mount (LUX1310); M42 (LUX2100); C-mount adapter available
- Mechanically adjustable back focus ring
- Exchangeable optical filters available on request
- The DR models use a proprietary coding algorithm to double the maximal frame rate compared to a standard GigE camera over one GigE cable.

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

Figure 3.1: Photonfocus MV4 Luxima GigE camera series

Figure 3.2: Photonfocus MV4 Luxima 10 GigE camera series

Figure 3.3: Photonfocus MV4 Luxima 10 GigE fibre camera series

Figure 3.4: Photonfocus MV4 Luxima 10 GigE ruggedized fibre camera series

3.2 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 the following chapters.

Characteristics	**Photonfocus MV4 Luxima GigE Camera Series**
Interface	Gigabit and 10-Gigabit Ethernet (Copper & Fibre), GigE Vision and GenICam compliant
Camera Control	GigE Vision Suite
Trigger Modes	Software Trigger / External isolated trigger inputs / A/B Trigger
Features	• Greyscale / colour resolution 12 bit / 10 bit / 8 bit • Region of Interest (ROI) • Up to 8 regions of interest (MROI) • 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) • Dual Crosshairs overlay on the image • Image Binning • 4 isolated trigger inputs and 3 isolated outputs

Table 3.1: Feature overview

3.3 Technical Specification

	1.3 MPix Cameras	2.1 MPix Cameras
Sensor Manufacturer	Luxima	
Sensor Type	LUX1310	LUX2100
Technology	CMOS active pixel	
Scanning system	progressive scan	
Optical format / diagonal	2/3" / 10.82 mm	4/3" / 22.31 mm
Resolution	1280 x 1024 pixels	1952 x 1080 pixels
Pixel size	6.6 μm x 6.6 μm	10 μm x 10 μm
Active optical area	8.45 mm x 6.76 mm	19.52 mm x 10.8 mm
Full well capacity	15 ke^-	21 ke^-
Spectral range standard sensor	<350 to 950 nm [2]	
Responsivity (@ 560nm / 8bit)	994 x 10^3 DN / (J/m^2)	1600 x 10^3 DN / (J/m^2)
Quantum Efficiency	> 54 % @ 550nm	> 50 % @ 550nm
Optical fill factor	> 45 % [3]	>35 % [3]
Dark current	41100 e^-/s @ 25°C	17800 e^-/s @ 45°C
Dynamic range	57 dB	54 dB
Micro lenses	Yes	
Characteristic curve	Linear, Piecewise linear (multiple slope)	
Shutter mode	global shutter	
Sensor bit depth	12 bit	
Maximal frame rate MV4 GigE [1]	85 fps	53 fps
Maximal frame rate MV4 10GigE [1]	935 fps	581 fps
Maximal frame rate MV4 10GigE Fibre [1]	935 fps	581 fps
Maximal frame rate DR4 GigE models [1]	165 fps	TBD fps
Maximal frame rate DR4 10GigE [1]	1066 fps	1000 fps
Maximal frame rate DR4 10GigE Fibre [1]	1066 fps	1000 fps
Camera pixel formats MV4	12 / 10 / 8 bit	
Camera pixel formats DR4	8 bit	
Digital gain	0.1 to 15.99 (Fine Gain)	
Exposure time range	10 μs ... 186 ms	10 μs ... 223 ms

Table 3.2: General specification of the Photonfocus MV4 Luxima GigE camera series (Footnotes: [1]at full resolution; [2]to 10% of peak responsivity; [3]without micro lenses; [2]In trigger controlled exposure, the trigger pulse is extended by the camera by 3 μs (LUX1310) resp. 2.667 μs (LUX2100), meaning the minimum pulse width is 7 μs resp. 7.333 μs)

	MV4-D1280-L01 GigE Camera Series
Operating temperature / moisture	0°C ... 50°C / 20 ... 80 % (GigE) 0°C ... 40°C / 20 ... 80 % (10GigE) 0°C ... 45°C / 20 ... 80 % (10GigE Fibre)
Storage temperature / moisture	-25°C ... 60°C / 20 ... 95 %
Camera Power Supply	+12 V DC (- 10 %) ... +24 V DC (+ 10 %)
PoE Conformity	IEEE 802.3bt standard Class 4
Trigger signal input range	+5 V .. +30 V DC
Maximal power consumption	< 8.6 W (GigE) < 15.8 W (10GigE) < 11.9 W (10GigE Fibre)
Lens mount	C-Mount
I/O Inputs	4x Isolated inputs or shaft encoder A, B, Z, Y interface (RS422, TTL, D-HTL, HTL)
I/O Outputs	3x Isolated (2x open drain, 1x TTL highspeed)
I/O Control	1x Isolated RS485
Dimensions	59 x 59 x 89.6 mm^3 (GigE) 59 x 59 x 103.2 mm^3 (10GigE) 59 x 59 x 101.8 mm^3 (10GigE Fibre)
Mass	392 g (GigE) 465 g (10GigE) 495 g (10GigE Fibre)
Connector I/O	17-pin M12
Connector Interface Copper	X-coded M12
Connector Interface Fibre	LC connector for multimode fibre (through included SFP+ cage)
Conformity	CE / RoHS / WEEE
IP Code	IP40

Table 3.3: Physical characteristics and operating ranges MV4-D1280-L01 GigE Camera Series

	MV4-D1952-L01 GigE Camera Series
Operating temperature / moisture	0°C ... 50°C / 20 ... 80 % (GigE) 0°C ... 40°C / 20 ... 80 % (10GigE) 0°C ... 45°C / 20 ... 80 % (10GigE Fibre)
Storage temperature / moisture	-25°C ... 60°C / 20 ... 95 %
Camera Power Supply	+12 V DC (- 10 %) ... +24 V DC (+ 10 %)
PoE Conformity	IEEE 802.3bt standard Class 4
Trigger signal input range	+5 V .. +30 V DC
Maximal power consumption	< 12.2 W (GigE) < 19.4 W (10GigE) < 15.5 W (10GigE Fibre)
Lens mount	M42 / C-Mount Adapter available
I/O Inputs	4x Isolated inputs or shaft encoder A, B, Z, Y interface (RS422, TTL, D-HTL, HTL)
I/O Outputs	3x Isolated (2x open drain, 1x TTL highspeed)
I/O Control	1x Isolated RS485
Dimensions	59 x 59 x 94.1 mm^3 (GigE) 59 x 59 x 107.9 mm^3 (10GigE) 59 x 59 x 106.5 mm^3 (10GigE Fibre)
Mass	410 g (GigE) 480 g (10GigE) 510 g (10GigE Fibre)
Connector I/O	17-pin M12
Connector Interface Copper	X-coded M12
Connector Interface Fibre	LC connector for multimode fibre (through included SFP+ cage)
Conformity	CE / RoHS / WEEE
IP Code	IP40

Table 3.4: Physical characteristics and operating ranges MV4-D1952-L01 GigE Camera Series

3.3.1 Absolute Maximum Ratings

Parameter	Value
Power Supply Voltage	-50 V ... +50 V
ESD Contact Discharge Power Supply	4 kV
ESD Air Discharge Power Supply	8 kV
Fast Transients/Bursts Power Supply	2 kV
Surge immunity Power Supply	1 kV
Camera Control Input Signal Voltage Single Ended	-15 V ... +30 V
Camera Control Input Signal Voltage RS422	-15 V ... +40 V
Camera Control Input Signal Voltage HTL	-15 V ... +40 V
Common Mode Range Voltage RS422	-15 V ... +20 V
Camera Control Output Signal Voltage Single Ended	0 V ... +30 V
Camera Control Output Signal Output Current Single Ended	0.5 A
Camera Control Output Signal Output Power Single Ended	0.5 W
ESD Contact Discharge Camera Control Signals	10 kV
ESD Air Discharge Camera Control Signals	7 kV
Fast Transients/Bursts Data and Camera Control Signals	1 kV
Surge immunity Data and Camera Control Signals	1 kV

Table 3.5: Absolute Maximum Ratings

3.3.2 Electrical Characteristics

In the following tables, VIN is the input voltage for single ended input and VID is the input voltage for differential input.

Single Ended Input Voltage	Logic Level	Fault Condition
-15V < VIN < +0.8V	Low	No Fault
+0.8V < VIN < +2.0V	Indeterminate	No Fault
+2.0V < VIN < +15V	High	No Fault
+15V < VIN < +18V	High	Indeterminate
+18V < VIN < +40V	High	High Input Fault

Table 3.6: Single-Ended TTL Mode Receiver Logic (LineIn0, LineIn1, LineIn2 & LineIn3)

Single Ended Input Voltage	Logic Level	Fault Condition
-15V < VIN < +6V	Low	No Fault
+6V < VIN < +8V	Indeterminate	No Fault
+8V < VIN < +40V	High	No Fault

Table 3.7: Single-Ended SE-HTL Low Threshold Mode Receiver Logic (LineIn0, LineIn1, LineIn2)

Single Ended Input Voltage	Logic Level	Fault Condition
-15V < VIN < +11V	Low	No Fault
+11V < VIN < +13V	Indeterminate	No Fault
+13V < VIN < +40V	High	No Fault

Table 3.8: Single-Ended SE-HTL High Threshold Mode Receiver Logic (LineIn0, LineIn1, LineIn2

Differential Input Voltage	Logic Level	Fault Condition
VID > +2V	High	No Fault
+1.2V < VID < +2V	High	Indeterminate
-0.9V ≤ VID ≤ +0.9V	Indeterminate	Low Differential Input Voltage Fault
-2V ≤ VID ≤ -1.2V	Low	Indeterminate
VID ≤ -2V	Low	No Fault

Table 3.9: Differential D-HTL Mode Receiver Logic (LineIn0, LineIn1, LineIn2)

Differential Input Voltage	Logic Level	Fault Condition
VID > +0.45V	High	No Fault
+0.27V < VID < +0.45V	High	Indeterminate
-0.2V ≤ VID ≤ +0.2V	Indeterminate	Low Differential Input Voltage Fault
-0.45V ≤ VID ≤ -0.27V	Low	Indeterminate
VID ≤ -0.45V	Low	No Fault

Table 3.10: Differential RS422 Mode Receiver Logic (LineIn0, LineIn1, LineIn2)

3.3.3 Spectral Response

Fig. 3.5 and Fig. 3.6 show the quantum efficiency curve of the monochrome LUX1310 and LUX2100 sensors from Luxima measured in the wavelength range from 350 nm to 1100 nm.

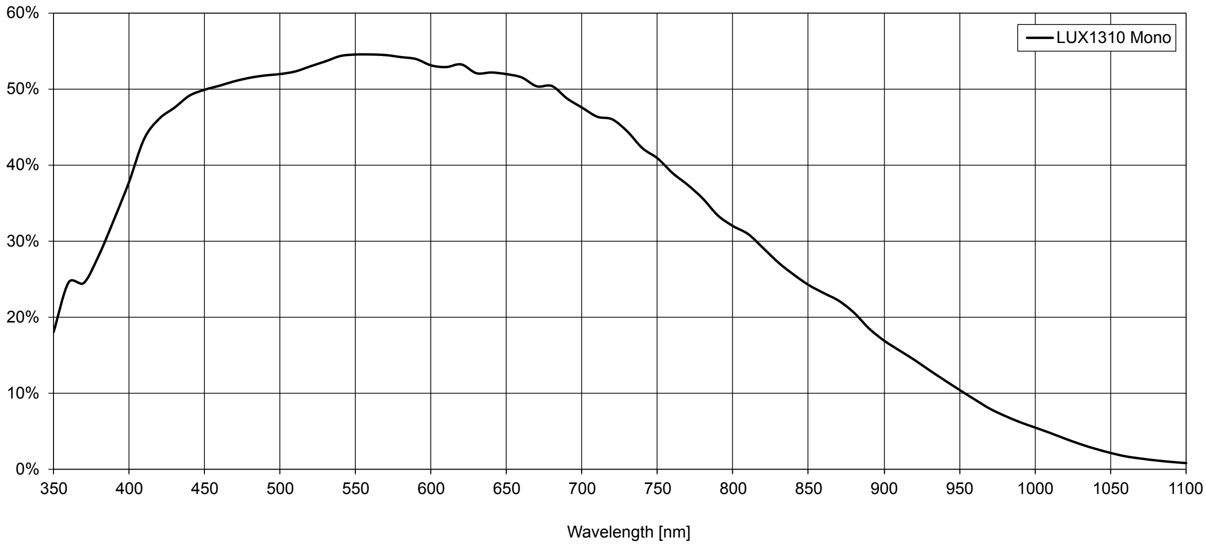

Figure 3.5: Quantum efficiency (QE) [%] of the LUX1310 monochrome image sensors (with micro lenses and cover glass)

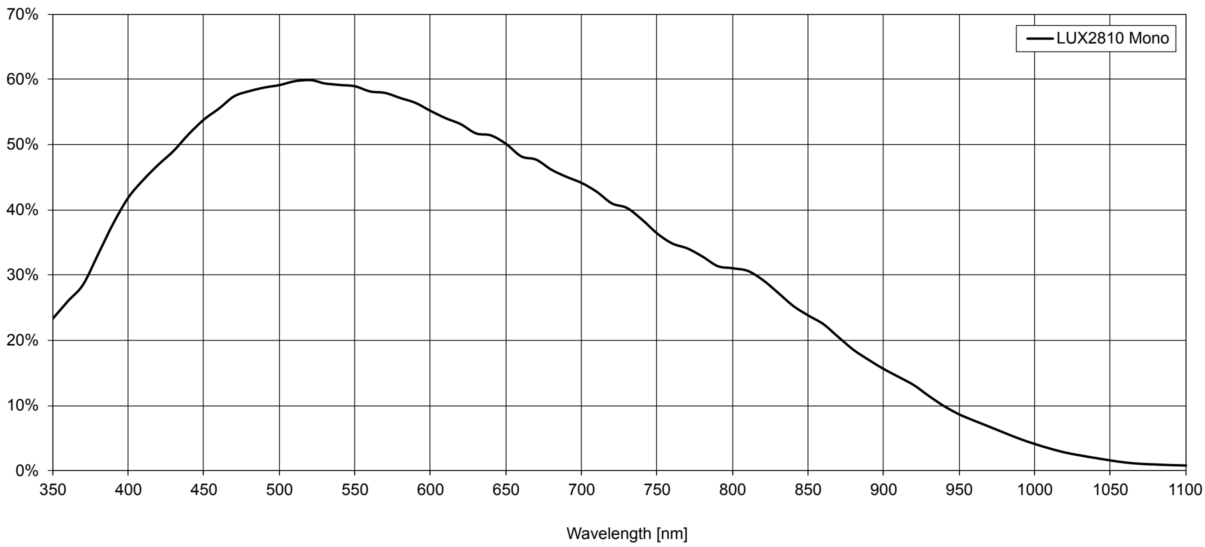

Figure 3.6: Quantum efficiency (QE) [%] of the LUX2100 monochrome image sensors (with micro lenses and cover glass)

4 Image Acquisition

This chapter gives detailed information about the controlling of the image acquisition. It shows how the camera can be triggered or run in free-running mode, and how the frame rate can be configured.

The structure offers a lot of flexibility in the configuration. It follows the GenICam naming convention. Typical camera configurations are included in the chapter "Use Cases" in the Appendix C.

4.1 Overview

The overview shows the major camera elements which are involved in the image acquisition. The section starts with a description of the vocabulary and terms, which are used to explain the acquisition related features.

4.1.1 Vocabulary

An acquisition is composed of one or many frames. A frame is a single acquired image which consists of an exposure time and an image read out. A burst of frame is defined as a capture of a group of one or many frames within an acquisition. An acquisition can be grouped in N single frames or N burst of frames.

4.1.2 Structure

The image acquisition is controlled by the three sub-blocks acquisition control, frame control and exposure control. Furthermore the camera contains controller blocks which take care of the I/O signals, the counters, the timers, the encoders, the action signals, the software signals and the user outputs. All of these elements can be connected through an interconnect, which allows controlling the image acquisition by these elements.

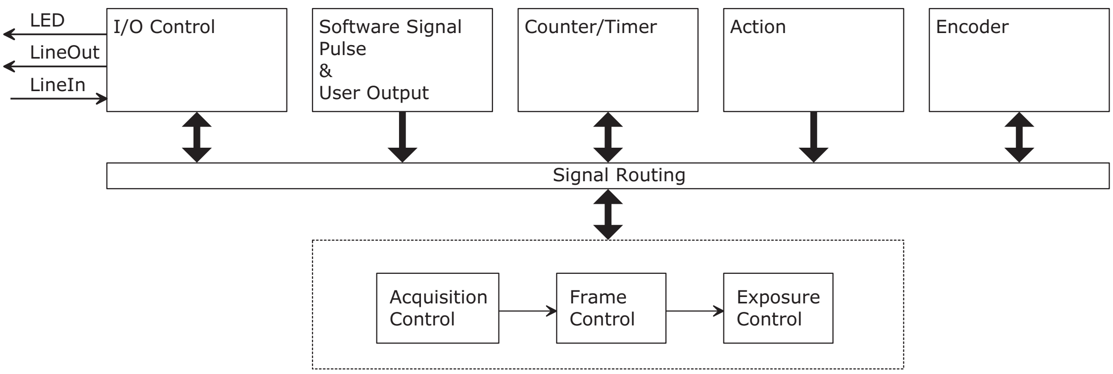

Figure 4.1: Structure

Acquisition Control The acquisition control block takes care of the acquisition function. The camera can only capture frames, when the acquisition has been started and is active (see Section 4.2 for more information).

Frame Control The frame control block takes care of the capturing of one or many frames and burst of frames (see Section 4.3 for more information).

Exposure Control The exposure control block takes care of the exposure time of a frame (see Section 4.4 for more information).

Counter The camera has four independent counters. They count events from a selectable source (see Section 5.1 for more information about counter configuration and usage).

Timer The camera has four independent timers. A timer delay and duration are configurable and the timers are triggered by a selectable source (see Section 5.2 for more information about timer configuration and usage).

Encoder The camera has a configurable encoder block. A/B trigger signals are decoded to generate internal trigger signals from selectable sources (see Chapter 6 for more information about encoder configuration and usage).

Action There are four actions, which can be used to trigger functions in the GigE camera, such like aquisition and frame capture or counter and timer. Action commands can be generated by the host application and are transmitted via GigE interface to the camera with low latency and low jitter.

I/O Control The I/O control unit manages physical camera inputs and outputs and LED. A switch matrix within this block allows connecting internal status signals to the output lines or LED. Status signals can come from the acquisition, frame or exposure control block, also from timer or counter, or even input lines can be routed to an output. The input lines can be used to control the acquisition, frame and/or exposure, also to start a timer or count events with a counter (see Chapter 7 for more information).

Software Signal Pulse and User Output The camera has user outputs, which can be set to 1 or 0 by software access, and a software signal pulse generator block (see Section 4.7). These user outputs and signal pulses can be used to control camera functions by software access, such like acquisition and frame capture or counter and timer.

Signal Routing All these elements are connected to each other by the signal routing block. The following sections show which signals are available and how they can be used in the others blocks.

4.1.3 Image Acquisition, Frame and Exposure Control Parameters

Mainly the following commands/settings are involved in order to control and configure the camera acquisition and frame capturing:

- Acquisition Start and Stop Command
- Acquisition Mode (Single Frame, Multi Frame, Continuous Frame)
- Acquisition Frame Count
- Acquisition Frame Burst Count
- Acquisition Frame Rate
- Exposure Mode (Timed, Trigger Controlled)
- Exposure Time

This list shows only an overview of available parameters. The function and usage of them are explained in the following chapters.

4.1.4 Image Acquisition, Frame and Exposure Trigger

The camera can run in "free-running" mode, which means that it captures images automatically in full frame rate once the acquisition has been started. However the acquisition and image capturing can be controlled by triggers. For this purposes, there are seven triggers available:

- Acquisition Start Trigger
- Acquisition End Trigger
- Frame Start Trigger
- Frame Burst Start Trigger
- Frame Burst End Trigger
- Exposure Start Trigger
- Exposure End Trigger

The source of these trigger can be set for every trigger individually; it can come from an external line, an internally generated pulse from the counters, the timers, the encoder , the action signals or from a pulse generated by a software command. Each of these triggers can be switched on or off individually. The camera generates the triggers pulses internally, which are switched off. The following sections (Acquisition, Frame & Exposure Control) show the usage of these triggers.

Each trigger has its own source signal processing path. Section 4.6 gives more information about the configuration.

4.1.5 Image Acquisition, Frame and Exposure Status

The following list shows the acquisition, frame and exposure related status signals:

- Acquisition Trigger Wait
- Acquisition Active
- Frame Trigger Wait
- Frame Active
- Exposure Active

These status signals are used within the camera to control the camera timing. The current state of these signals can be read out by software. Furthermore it can be connected to an output line or LED through the I/O control block (see Chapter 7), which allows tracking the status from an external device. The timing of these signals are explained in the following sections.

4.2 Acquisition Control

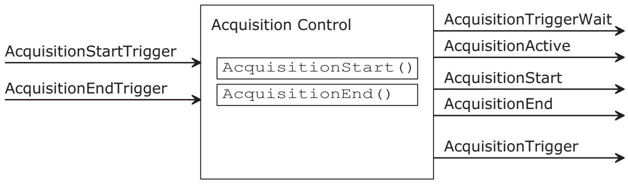

Figure 4.2: Acquisition Control Block

4.2.1 Acquisition Start and Stop Commands, Acquisition Mode and Acquisition Frame Count

The camera can only capture frames when the acquisition is started. The acquisition start command, which is executed by the software, starts the acquisition and prepares the camera to acquire frames. The acquisition is stopped, when the acquisition stop command is executed or - depending on the acquisition mode parameter - a certain number of frames is captured. Following acquisition mode parameters are available:

Acquisition Mode = Single Frame When the acquisition is started, the camera stops the acquisition automatically as soon as one frame has been captured. To capture another frame, the acquisition start command needs to be performed again.

Acquisition Mode = Multi Frame When the acquisition is started the camera stops the acquisition automatically after a certain number of frames, which are defined by acquisition frame count parameter, or when the acquisition stop command is executed.

Acquisition Mode = Continuous Frame When the acquisition is started the camera captures images continuously until the acquisition stop command is executed.

4.2.2 Acquisition Frame Rate and Acquisition Frame Rate Enable

With frame start trigger mode=off (see Section 4.3.1) and frame burst start trigger mode=off (see Section 4.3.2), and when exposure mode is set to "timed" (see Section 4.4.1), the camera generates frame start triggers internally according to the acquisition frame rate enable and acquisition frame rate configuration:

Acquisition Frame Rate Enable = off The camera runs in the "free-running" mode. It means frame start triggers are generated internally as soon as the camera is ready to start a new image capture. The frame rate is defined by the exposure time and the ROI settings (see Chapter 11).

Acquisition Frame Rate Enable = on The camera generates frame start triggers internally according to the acquisition frame rate configuration. See Chapter 11 for more information about the range of supported frame rates.

Fig. 4.3 shows the procedure of a capture of N frames. The modes of acquisition start trigger, frame start trigger and frame burst start trigger is set to off and the exposure mode is timed. Once an acquisition start command has been executed, the camera starts capturing frames until the acquisition stop command is received.

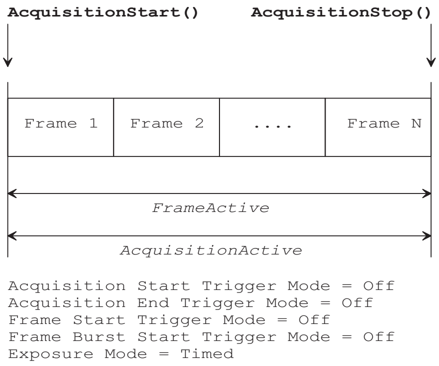

Figure 4.3: Free-running Image Capture, when Acquisition Start and End Trigger Mode is Off

4.2.3 Acquisition Start Trigger

The acquisition start trigger can be used to control the acquisition start procedure. The main property of this trigger is the trigger mode. It can be set to on or off:

Acquisition Start Trigger Mode = on As soon as the acquisition is started by executing of the acquisition start command, the camera goes into the state "Acquisition Trigger Wait". In this state, the camera can't start capturing images; it waits for an acquisition start trigger. As soon as the trigger has been received, the camera goes then into the state "Acquisition Active" and is ready to capture frames.

Acquisition Start Trigger Mode = off As soon as the acquisition is started by executing of the acquisition start command, the camera goes immediately into state "Acquisition Active" and is ready to capture frames.

Fig. 4.4 shows an example when the trigger mode of the acquisition start trigger is on. The acquisition status goes to acquisition trigger wait once an acquisition start command has been executed. As soon as an acquisition start trigger has been arrived, the acquisition status goes to acquisition active.

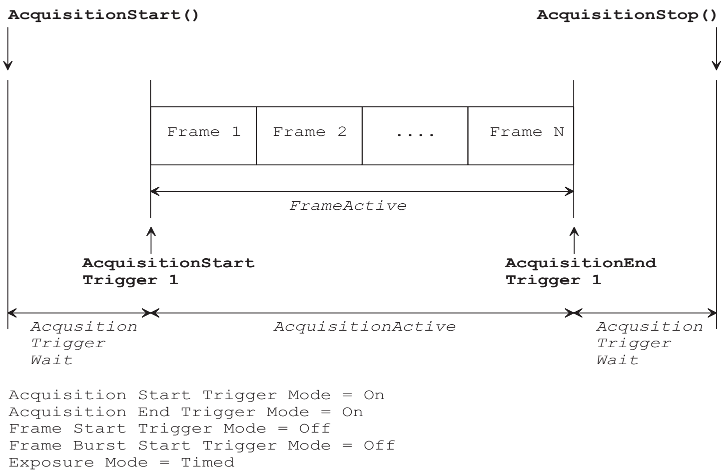

Figure 4.4: Free-running Image Capture, when Acquisition Start and End Trigger Mode is On

4.2.4 Acquisition End Trigger

The acquisition end trigger can be used to control the acquisition end procedure. The main property of this trigger is the trigger mode. It can be set to on or off:

Acquisition End Trigger Mode = on When the acquisition status is "Acquisition Active", it goes to "Acquisition Trigger Wait" as soon as an acquisition end trigger has been received. The camera stops capturing images and waits until an acquisition start trigger has been issued again.

Acquisition End Trigger Mode = off The acquisition end triggers are ignored and the acquisition status remains active until an acquisition stop command has been executed or the certain amount of frames has been captured, depending on the acquisition mode parameter (see Section 4.2.1)

4.2.5 Acquisition Control Output Signals

The acquisition control block has the following output signals:

Acquisition Trigger Wait An asserted acquisition trigger wait indicates, that the acquisition control is waiting for an acquisition start trigger (see Section 4.2.3).

Acquisition Active Acquisition active is a status signal, which is asserted, when the acquisition has been started and deasserted, when the acquisition is stopped.

Acquisition Start The acquisition start is an event, which is generated, when the acquisition is started.

Acquisition End The acquisition end is an event, which is generated, when the acquisition is stopped.

Acquisition Trigger The acquisition trigger is an event, which is generated, when the acquisition is started by the acquisition start trigger (see Section 4.2.3).

Acquisition trigger wait and acquisition active status signal are routed to the I/O control block and can there be selected for output on the physical output line or on one of the available leds (see Chapter 7). Acquisition start, acquisition end and acquisition trigger event can be used to trigger or to control other function in the camera, like counter or timer.

4.3 Frame Control

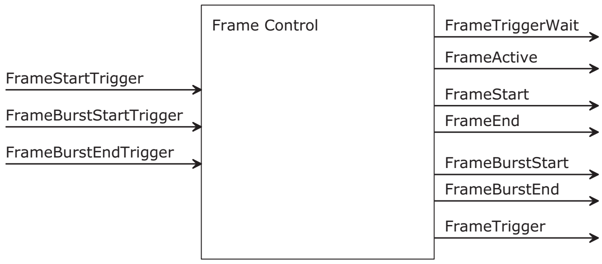

Figure 4.5: Frame Control Block

As soon as the acquisition is active the camera is ready to capture frames, which is controlled by the frame control block. The behaviour depends on the frame start trigger, frame burst start trigger and frame burst end trigger configuration.

4.3.1 Frame Start Trigger

The frame start trigger can be used to start a single frame capture. The main property of this trigger is the trigger mode. It can be set to on or off:

Frame Start Trigger Mode = on As soon as a frame start trigger has been received, a capture of one frame will be started and the frame status goes to "Frame Active". Once one frame has been processed, that camera status goes to "Frame Trigger Wait" again. The camera is ready to process frame start triggers, when the acquisition is active, showed by the "Acquisition Active" status, and when the "Frame Trigger Wait" status is asserted.

Frame Start Trigger Mode = off The frame start triggers are ignored.

The camera runs in free-running mode when the mode of both triggers, the frame start trigger and frame burst start trigger, is set to off and the exposure mode is set to "Timed" (see Section 4.4.1 for more information about the exposure mode).

Fig. 4.6 shows the procedure of a single frame capture started with a frame start trigger. The acquisition start trigger mode is off, so the camera waits for a frame start trigger once the acquisition command has been executed. Every receiving frame start trigger starts a capture of one single frame.

4.3.2 Frame Burst Start Trigger

The frame burst start trigger can be used to start a burst of frame capture. The main property of this trigger is the trigger mode. It can be set to on or off:

Frame Burst Start Trigger Mode = on As soon as a frame burst start trigger has been received, a capture of a burst of frames has been started and the frame status goes to "Frame Active". The number of frames is defined by the "Acquisition Burst Frame Count" value. The camera goes to "Frame Trigger Wait" again, when the configured number of burst frames has been captured. The camera is ready to process a frame burst start trigger, when the acquisition is active, showed by the "Acquisition Active" status, and when the "Frame Trigger Wait" status is asserted. The frame rate of a burst sequence is configured

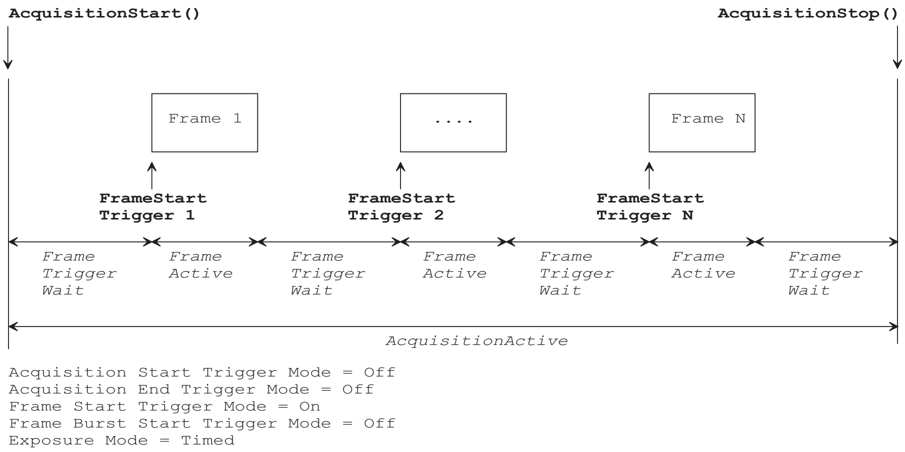

Figure 4.6: Triggered Image Acquisition of single Frames

by the acquisition frame rate value and the acquisition frame rate enable configuration (see Section 4.2.2 for more information)

Frame Burst Start Trigger Mode = off The frame burst start triggers are ignored. No capturing of burst of frames is started.

It is possible to set both, the mode of frame start trigger and frame burst start trigger, to on. In this case, the camera starts a single frame or a burst of frame capture, depending which trigger arrives first.

Fig. 4.7 shows the procedure of a burst of frames and a single frame capture. The Acquisition start and end trigger mode is on. So the camera waits for an acquisition trigger once the acquisition command has been executed. During this period any frame burst start or frame start triggers are ignored. As soon as an acquisition start trigger has been received, the camera waits for frame triggers. It can be a frame start trigger or a frame burst start trigger. Depending which trigger - frame start or frame burst start - arrives first, the camera starts a single frame or burst of frame acquisition.

4.3.3 Frame Burst End Trigger

The frame burst end trigger can be used to abort a current running burst capturing cycle. The main property of this trigger is the trigger mode. It can be set to on or off:

Frame Burst End Trigger Mode = on The frame burst end trigger is processed only, when burst acquisition cycle is active. Once this trigger has been received, it waits, until the current frame has been processed and then aborts the burst cycle. The camera status goes to "Frame Trigger Wait" again.

Frame Burst End Trigger Mode = off The frame burst end triggers are ignored.

The value "Acquisition Burst Frame Count" is ignored when the mode of the frame burst end trigger is set to on. It means, when a burst capture has been started, the camera captures frames until a frame burst end trigger arrives.

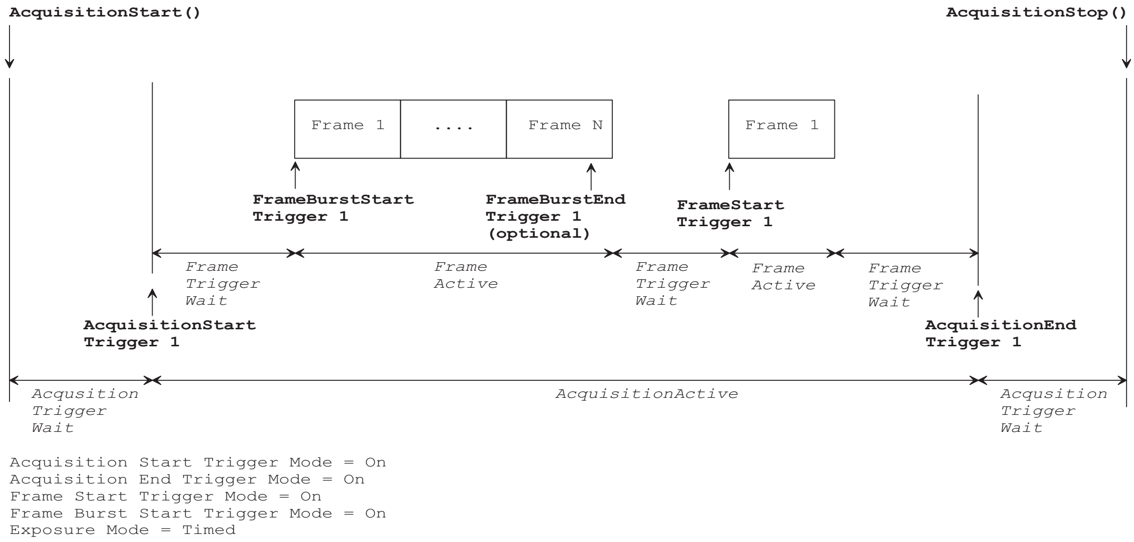

Figure 4.7: Triggered Acquisition of a Burst of Frame and of a single Frame

4.3.4 Frame Control Output Signals

The frame control block has the following output signals:

Frame Trigger Wait An asserted frame trigger wait indicates, that the frame control is waiting for a frame start trigger (see Section 4.3.1), frame burst start trigger (see Section 4.3.2) or an exposure start trigger (see Section 4.4.2).

Frame Active An asserted frame active signal indicates, that one or more frames are being captured.

Frame Start The frame start is an event, which is generated, when a new frame starts.

Frame End The frame end is an event, which is generated, when a frame is finished.

Frame Burst Start The frame burst start is an event, which is generated, when a new burst of frame starts.

Frame Burst End The frame burst end is an event, which is generated, when a burst of frame is finished.

Frame Trigger The frame trigger is an event, which is generated, when a frame is started by a frame start trigger (see Section 4.3.1), by a frame burst start trigger (see Section 4.3.2) or by an exposure start trigger (see Section 4.4.2).

Frame trigger wait and frame active status signal are routed to the I/O control block and can there be selected for output on the physical output line or on one of the available leds. Frame start, frame end and frame trigger event can be used to trigger or to control other function in the camera, like counter and timer.

4.4 Exposure Control

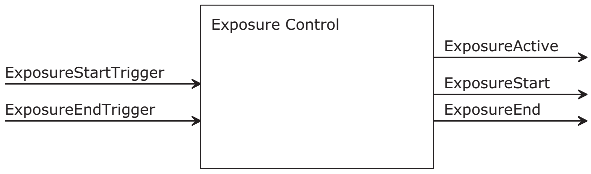

Figure 4.8: Exposure Control Block

A frame consists of an exposure cycle and an image read out. The exposure control block takes care of the exposure cycle. The camera has two modes of exposure time operations, which are defined by the exposure mode settings:

- Timed Exposure
- Trigger Controlled Exposure

4.4.1 Exposure Mode

The exposure mode configuration defines, if the exposure time is controlled by the exposure time registers or by the triggers. Following configurations are available:

Timed Exposure The exposure time is defined by the exposure time register. The value will determine the exposure time for each frame.

Trigger Controlled Exposure The exposure time is controller by exposure start and exposure end triggers (see Section 4.4.2 and Section 4.4.3 for more information).

4.4.2 Exposure Start Trigger

The exposure start trigger is used to start an exposure.

Exposure Start Trigger Mode = on As soon as a exposure start trigger has been received, the camera starts with the exposure cycle, which is showed by the "Exposure Active" status. The exposure remains until an exposure end trigger has been received (see Section 4.4.3). The camera is ready to process exposure start triggers, when the acquisition is active, showed by the "Acquisition Active" status, and when the "Frame Trigger Wait" status is asserted.

Exposure Start Trigger Mode = off The exposure start triggers are ignored.

The exposure start trigger is only available, when the exposure mode is set to "trigger controlled". The camera sets the trigger modes of this trigger automatically to on, when the exposure mode is set to "trigger controlled" and vice versa to off when the exposure mode is set to "timed".

4.4.3 Exposure End Trigger

The exposure end trigger is used to terminate an active exposure cycle.

Exposure End Trigger Mode = on An activated exposure cycle will be terminated and the image read out will be started, as soon as an exposure end trigger has been received. The "Exposure Active" status goes to inactive. Exposure end triggers are only processed, when an exposure start trigger has started a trigger controlled exposure cycle previously.

Exposure End Trigger Mode = off The exposure end triggers are ignored.

The exposure end trigger is only available, when the exposure mode is set to "trigger controlled". The camera sets the trigger modes of this trigger automatically to on, when the exposure mode is set to "trigger controlled" and vice versa to off when the exposure mode is set to "timed".

Fig. 4.9 shows procedure of a trigger controlled exposure mode. The Acquisition start trigger mode is off. The camera goes directly into status "Frame Trigger Wait" once the acquisition status has been executed. An exposure of a new frame is started as soon as an exposure start trigger has been received. The exposure ends with an exposure end trigger.

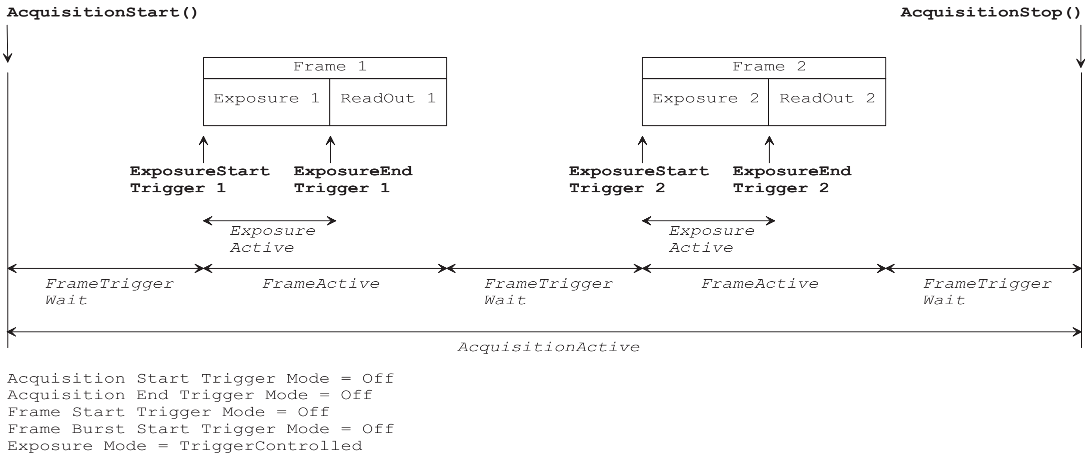

Figure 4.9: Trigger Controlled Exposure Mode

4.4.4 Exposure Control Output Signals

The frame control block has the following output signals:

Exposure Active An asserted exposure active signal indicates, that an exposure time of a current frame is active.

Exposure Start The exposure start is an event, which is generated, when a new exposure time has been started.

Exposure End The exposure end is an event, which is generated, when a currently running exposure time is finished.

Exposure active status signal is routed to the I/O control block and can there be selected for output on the physical output line or on one of the available leds. Exposure start and exposure end event can be used to trigger or to control other function in the camera, like acquisition, frame and exposure control or counter and timer.

4.5 Overlapped Image Acquisition Timing

The camera is able to perform an overlapped image acquisition. It means, a new exposure can be started during the image readout of the previous image. Fig. 4.10 shows an image acquisition procedure when images are captured in overlapped mode. The status "Frame Active" remains active during the acquisition of the three frames since there is no gap between two frames. The "Frame Trigger Wait" is asserted during the frame read out in order to indicate, that a new exposure can be started.

All examples in the previous sections show a non overlapping frame timing. A new frame is always started after the previous image read out has been finished. All these examples work also in the overlap mode. It doesn't show the overlap mode in order to simplify the diagrams.

The overlapped image acquisition is not available, when the triggered controlled exposure mode is configured.

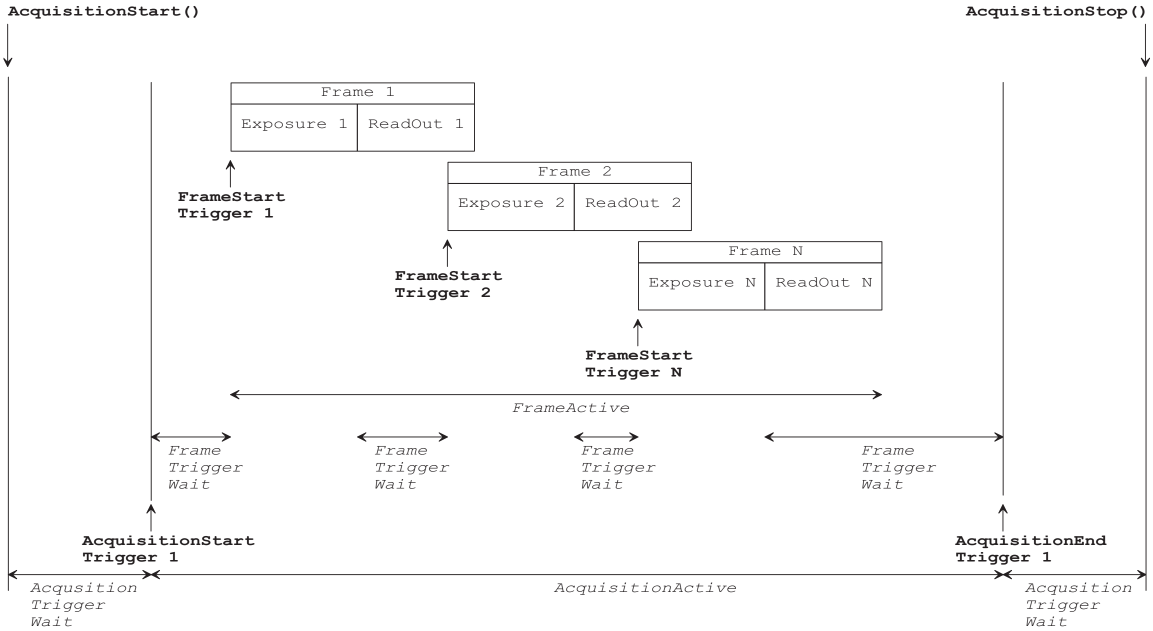

Figure 4.10: Overlapped Image acquisition Timing

There are two restrictions of the overlapped image acquisition: A new exposure cycle must not start prior the end of a previous exposure cycle, and must not end prior to the end of the read out of the previous frame. Two different timing situation needs to be distinguished:

Exposure Time > Read Out Time An new exposure cycle can be started as soon as the read out of the previous frame has been started (See Fig. 4.11).

Exposure Time < Read Out Time The start of a new exposure has to be delayed by a certain amount of time in order to ensure, that the exposure doesn't end prior to the image read out end of the previous frame (See Fig. 4.12).

The camera adjusts the timing automatically, and ensures that it complies with this restriction. Frame start or frame burst start triggers which arrive too early and which violates the overlapping restriction, will be ignored by the camera and indicated by a missed trigger event, which can be counted by a counter (see Section 5.1.5 for more information how to count missed triggers). Fig. 4.11 and Fig. 4.12 shows both timing situations, when the exposure time longer than the read out time and when the exposure time is shorter than the read out time.

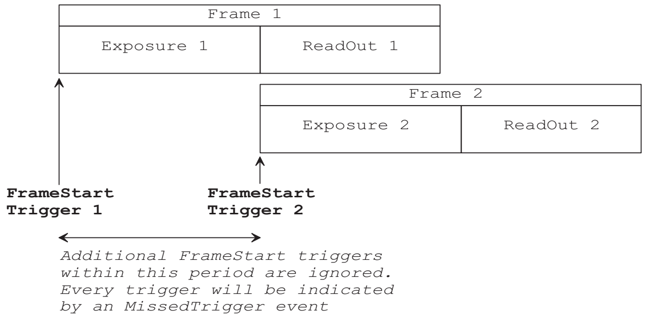

Figure 4.11: Overlapped Image acquisition when exposure time > read out time

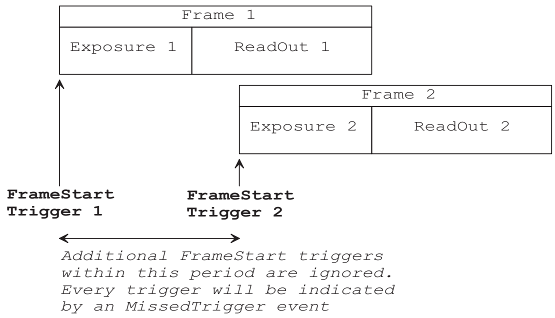

Figure 4.12: Overlapped Image acquisition when exposure time < read out time

4.6 Acquisition-, Frame- and Exposure-Trigger Configuration

The acquisition-, frame- and exposure timing can be controlled by 7 triggers:

- Acquisition Start Trigger
- Acquisition End Trigger
- Frame Start Trigger
- Frame Burst Start Trigger
- Frame Burst End Trigger
- Exposure Start Trigger
- Exposure End Trigger

Fig. 4.13 shows the signal path which is available for every of the 7 triggers. It contains:

- Trigger Source Selection
- Trigger Software
- Trigger Mode
- Trigger Activation
- Trigger Divider
- Trigger Delay

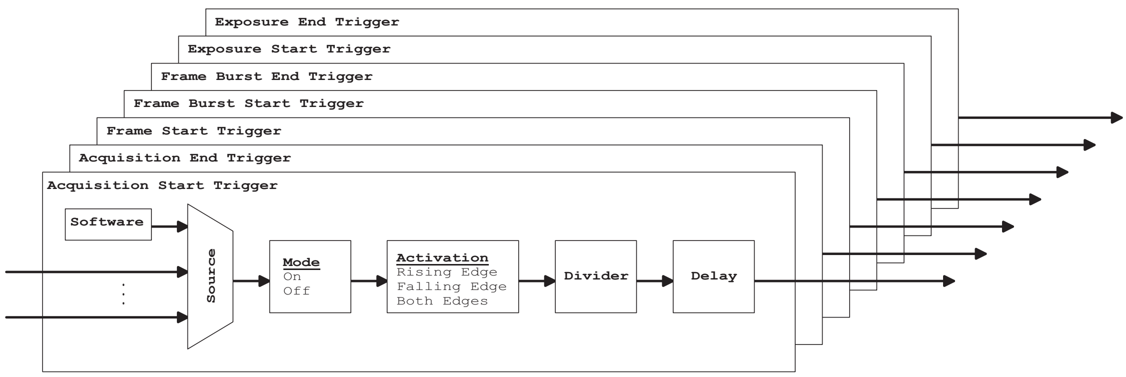

Figure 4.13: Trigger Path

4.6.1 Trigger Source Selection

The user can select the source which is used to generate the corresponding trigger. The source can come from an external line input, internal pulse generated by a counter or timer or a pulse, which is generated by software. The following list shows the signal sources, which are available:

Line In A trigger is generated by a line input signal. The activation configuration defines, if the rising edge, the falling edge or both edges are taken into account (see Section 4.6.4).

Software A trigger is generated by the locally trigger software command register (see Section 4.6.2 for more information).

Software Signal Pulse A trigger is generated by the software signal pulse, which comes from a common software signal pulse register (see Section 4.7 for more information).

Counter Start A trigger signal is generated by the counter start event (see Section 5.1.3 for more information about the counter start event).

Counter End A trigger signal is generated by the counter end event (see Section 5.1.3 for more information about the counter end event).

Timer Start A trigger signal is generated by the timer start event (see Section 5.2.3 for more information about the timer start event).

Timer End A trigger signal is generated by the timer end event (see Section 5.2.3 for more information about the timer end event).

Encoder A trigger signal is generated by the encoder (see Chapter 6 for more information about the encoder).

Action A trigger signal is generated by the action control block (see Chapter 8 for more information about the action control).

4.6.2 Trigger Software

The trigger software is a software command register, which is available in the signal path of each trigger. Accessing to this register generates an internal trigger, which will be processed in the signal path.

Trigger source must be set to software in order that a trigger software command will be processed.

4.6.3 Trigger Mode

The trigger mode defines, if the trigger is active. Following settings are available:

- On
- Off

4.6.4 Trigger Activation

The trigger activation defines, which edge of the selected trigger is processed in the trigger signal path. Following configuration is available:

- Rising Edge
- Falling Edge
- Both Edges

The trigger activation configuration is only available, when the trigger source is set to Line In.

4.6.5 Trigger Divider

The trigger divider specifies a division factor of the incoming trigger pulses. A division factor of 1 processes every incoming trigger. A division factor of 2 processes every second trigger and so on.

4.6.6 Trigger Delay

The trigger delay lets the user specify a delay, that will be applied between the reception of a trigger event and when the trigger becomes active.

4.7 Software Signal Pulse and User Output

The software signal pulse block contains eight general purpose registers which allow generating internal pulse signals by software access. These pulse signals are internally connected to following functions, where it can be used to start a procedure:

- Acquisition Start Trigger
- Acquisition End Trigger
- Frame Start Trigger
- Frame Burst Start Trigger
- Frame Burst End Trigger
- Exposure Start Trigger
- Exposure End Trigger
- Counter Trigger
- Counter Event
- Encoder Reset
- Counter Reset
- Timer Trigger

The user output block is an eight bit status register. The bits can be set to 0 or 1 by software. The bits are available in the following firmware blocks/functions:

- Counter Trigger
- Counter Reset
- Encoder Reset
- LED S0 and S1
- Line Out

5

Counter & Timer

5.1 Counter

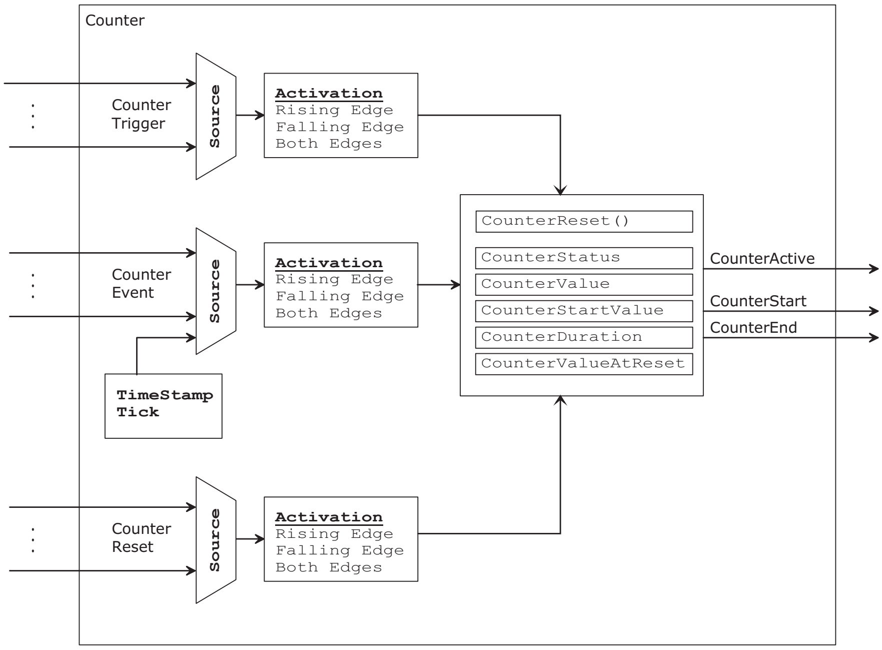

Figure 5.1: Counter Structure

Four general purpose counters are available (Counter0 . . . Counter3) which are used for counting events. Each counter can be individually configured by software and controlled by counter trigger, counter event and counter reset signals. This section describes the configuration and the function of the counters.

Fig. 5.1 shows the structure of one counter. Along with the counter function itself it contains a counter trigger source, a counter event source and a counter reset source selection and activation block. Furthermore there is a counter active status signal, which is available in the I/O control block (see Chapter 7). And the counter generates counter start and counter end events, which can be used to trigger other blocks, like counter, timer, acquisition, frame or exposure control.

5.1.1 Counter Usage

In a basic usage, at least a counter event source needs to be selected (see Section 5.1.5 for more information about the counter event source selection). Once an event source has been selected, the counter needs to be reset in order to start the counter. When started it counts from a defined start value, which is configurable by the CounterStartValue property, and ends counting events after a certain number of events, which is configurable by the CounterDuration property.

If additionally a trigger source is selected, the counter is waiting for a trigger. It ignores counter events until a valid trigger event has been received. A valid trigger signal on the selected trigger source starts the counter, which means, that it counts the predefined number of events from the start value according to the counter start value and duration configuration.

The current counter value is readable by the property CounterValue.

5.1.2 Counter Status

The counter has different states, which depends on the configuration and usage. The current state can be read out by the register CounterStatus. The following list shows the available states:

Counter Idle Counter is idle, and doesn't count any events.

Counter Trigger Wait As soon as a counter trigger source is selected (counter trigger source $\neq$ OFF), the counter goes into the counter trigger wait state and waits for a trigger signal on the selected source. In this state, the counter does not count any events.

Counter Active Counter is active and is ready to count every event. The counter can be temporarely stopped by setting the counter event source to OFF .

Counter Completed Counter has stopped as it reached its programmed duration.

Counter Overflow Counter has reached its counter limit, which is 2^32-1, and an additional counter event signal has been received. Once the counter is in the state overflow, it has to be reset by software or by counter reset signal in order to recover it from this state.

5.1.3 Counter Active, -Start and -End Signal

Each counter has the following output signals:

Counter Active An asserted counter active signal indicates, that the counter is active and is counting events. The counter active signal is internally routed to the I/O control block and can there be selected for output on the physical output line or on one of the available leds.

Counter Start The counter start is an event, which is generated, when the counter goes into the counter active state or is restarted during counter active period.

Counter End The counter end is an event, which is generated, when the counter arrives its configured end condition; and changes to the state counter completed.

The counter start and end event can be used to trigger or to control other function in the camera, like acquisition, frame and exposure control or counter and timer. It can also be used to cascade counters in order to get a bigger counting range.

5.1.4 Counter Reset

There are two ways how to reset a counter: Either by a software reset command or by a hardware reset source signal. The reset behaviour depends on the current counter event and trigger source configuration:

Counter Trigger Source = Off and Counter Event Source = Off The state of the counter changes to "idle".

Counter Trigger Source = Off and Counter Event Source $\neq$ Off The state of the counter changes to "active".

Counter Trigger Source $\neq$ Off The state of the counter changes to "trigger wait".

The counter reset source can be set to the counter end signal of the same counter. This allows to restart the counter automatically as soon as it arrives its end condition.

The current counter value at the time, when the reset is performed, is stored to the CounterValueAtReset property, which can be read out by software.

5.1.5 Counter Event Source

The counter event source selects the signal event, which will be the used to increment the counter. The following signal sources are available:

Off Counter is idle or has been stopped temporarely and doesn't count any events.

Acquisition Trigger Counts the number of acquisition triggers.

Acquisition Start Counts the number of acquisition start events.

Acquisition End Counts the number of acquisition end events.

FrameTrigger Counts the number of frame triggers.

Frame Start Counts the number of frame start events.

Frame End Counts the number of frame end events.

Frame Burst Start Counts the number of frame burst start events.

Frame Burst End Counts the number of frame burst end events.

Exposure Start Counts the number of exposure start events.

Exposure End Counts the number of exposure end events.

Counter 0 ... 3 Start Counts the number of the chosen counter start events.

Counter 0 ... 3 End Counts the number of the chosen counter end events.

Timer 0 ... 3 Start Counts the number of the chosen timer start events.

Timer 0 ... 3 End Counts the number of the chosen timer end events.

Encoder Counts the number of the encoder trigger events.

Action 0 ... 3 Counts the number of the chosen action signal events.

Software Signal Pulse 0 ... 7 Counts the number of the chosen software signal pulse events (see Section 4.7).

Line Input Counts the number of transitions on the line input according to the signal input activation configuration.

MissedAcqStartTrigger Count the number of missed acquisition start triggers. A missed acquisition start trigger event is generated, when a acquisition start trigger cannot be processed.

MissedFrameStartTrigger Count the number of missed frame start triggers. A missed frame start trigger event is generated, when a frame start trigger cannot be processed.

MissedFrameBurstStartTrigger Count the number of missed frame burst start triggers. A missed frame burst start trigger event is generated, when a frame burst start trigger cannot be processed.

MissedExposureStartTrigger Count the number of missed exposure start triggers. A missed exposure start trigger event is generated, when an exposure start trigger cannot be processed.

Missed Trigger Counts the number of any generated missed triggers. The missed trigger is the logical OR connection of MissedAcqStartTrigger, MissedFrameStartTrigger, MissedFrameBurstStartTrigger and MissedExposureStartTrigger.

Time Stamp Tick Counts the number of time stamp ticks. A time stamp tick generator is available for every counter. It generates events with a rate, which can be configured. For instances if the rate is set to 1 us and the counter event source is set to count time stamp ticks, the counter increments every 1 us.

Line input source has additionally an activation configuration, which needs to be set accordingly. Following configuration values are available:

Rising Edge Counter counts rising edges on the selected line input.

Falling Edge Counter counts falling edges on the selected line input

Both Edges Counter counts both edges on the selected line input

Activation configuration has only effect when line input is selected as a counter event source, otherwise this configuration is ignored.

The counter can be temporarely switched off, if the counter event source is set to off. It continue counting events as soon as counter event source has been selected again.

5.1.6 Counter Trigger Source

The counter trigger source selects the signal which will be used to start the counter. The following signals sources are available:

Off Disables the counter trigger.

Acquisition Trigger Starts with the reception of the acquisition trigger event.

Acquisition Start Starts with the reception of the acquisition start event.

Acquisition End Starts with the reception of the acquisition end event.

FrameTrigger Starts with the reception of the frame trigger event.

Frame Start Starts with the reception of the frame start event.

Frame End Starts with the reception of the frame end event.

Frame Burst Start Starts with the reception of the frame burst start event.

Frame Burst End Starts with the reception of the frame burst end event.

Exposure Start Starts with the reception of the exposure start event.

Exposure End Starts with the reception of the exposure end event.

User Output 0 ... 7 Starts and counts events as long as the selected user output bit is asserted. When the counter is started, it ignores counter events as long as the corresponding user output bit is deasserted (see Section 4.7).

Counter 0 ... 3 Start Starts with the reception of the chosen counter start event.

Counter 0 ... 3 End Starts with the reception of the chosen counter end event.

Timer 0 ... 3 Start Starts with the reception of the chosen timer start event.

Timer 0 ... 3 End Starts with the reception of the chosen timer end event.

Encoder Starts with the reception of the encoder trigger event.

Action 0 ... 3 Starts with the receiption of the chosen action signal event.

Software Signal Pulse 0 ... 7 Starts with the reception of chosen software signal pulse event (see Section 4.7).

Line Input Starts when the specified counter trigger activation condition is met on the chosen line.

Line input source has additionally an activation configuration, which needs to be set accordingly. Following configuration values are available:

Rising Edge Counter starts with the rising edge on the selected line input.

Falling Edge Counter starts with the falling edge on the selected line input.

Both Edges Counter starts with any edge on the selected line input.

Level High Counter starts and is counting events as long as the level is high. When the counter is started, it ignores counter events as long as the corresponding line input is low.

Level Low Counter starts and is counting events as long as the level is low. When the counter is started, it ignores counter events as long as the corresponding line input is high.

Activation configuration has only effect when line input is selected as a counter trigger source, otherwise this configuration is ignored.

5.1.7 Counter Reset Source

The counter reset source selects the signal which will be the used to reset the counter. The following signals sources are available:

Off Disables the counter reset.

Counter Trigger Resets with the reception of a trigger on the counter trigger source (see Section 5.1.6).

Acquisition Trigger Resets with the reception of the acquisition trigger.

Acquisition Start Resets with the reception of the acquisition start event.

Acquisition End Resets with the reception of the acquisition end event.

FrameTrigger Resets with the reception of the frame trigger.

Frame Start Resets with the reception of the frame start event.

Frame End Resets with the reception of the frame end event.

Frame Burst Start Resets with the reception of the frame burst start event.

Frame Burst End Resets with the reception of the frame burst end event.

Exposure Start Resets with the reception of the exposure start event.

Exposure End Resets with the reception of the exposure end event.

User Output 0 ... 7 Resets the counter as long as the selected user output bit is asserted. The counter remains in reset state until the selected user output bit is deasserted again (see Section 4.7).

Counter 0 ... 3 Start Resets with the reception of the chosen counter start event.

Counter 0 ... 3 End Resets with the reception of the chosen counter end event.

Timer 0 ... 3 Start Resets with the reception of the chosen timer start event.

Timer 0 ... 3 End Resets with the reception of the chosen timer end event.

Encoder Resets with the reception the encoder trigger event.

Action 0 ... 3 Resets with the reception of the chosen action signal event.

Software Signal Pulse 0 ... 7 Resets with the reception of chosen software signal pulse event (see Section 4.7).

Line Input Resets when the specified counter trigger activation condition is met on the chosen line.

Line input source has additionally a activation configuration, which needs to be set accordingly. Following configuration values are available:

Rising Edge Resets with the rising edge on the selected line input.

Falling Edge Resets with the falling edge on the selected line input.

Both Edges Resets with any edge on the selected line input.

Activation configuration has only effect when line input is selected as a counter reset source, otherwise this configuration is ignored.

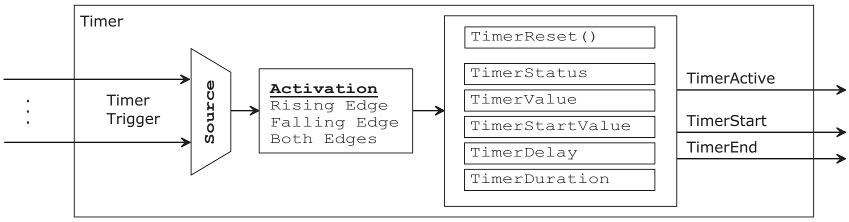

Figure 5.2: Timer Structure

5.2 Timer

Four general purpose timers are available in the camera (Timer0 ... Timer3). A timer can be used to generate a timed pulse - for instances a strobe signal - or to generate an event after a predetermined duration. Each timer can be configured individually by software and controlled by timer trigger events. This section describes the configuration and the function of the timers.

Fig. 5.2 shows the structure of one timer. It contains a timer trigger source and activation block. Furthermore it has three output signals: A timer active status signal, which is routed to the I/O control block (see Chapter 7) and timer start and end event signals, which can be used to trigger other blocks, like counter, timer, acquisition, frame or exposure control (see Section 5.2.3).

5.2.1 Timer Usage

Timer delay and timer duration value needs to be configured accordingly. When a timer trigger source is selected the timer is waiting for a trigger signal. Once this trigger signal has been received, the timer starts first with the timer delay period, if the timer delay value is > 0, and counts then for the specified timer duration.

When the timer trigger source is set to off (see Section 5.2.5), a software timer reset command starts the timer immediately (see Section 5.2.4).

The current timer value can be read via software. A start value can also be set, which means, that the timer starts from this configured value instead from zero.

5.2.2 Timer Status

The timer has different states, which depends on the configuration and usage. The current state can be read out by the register TimerStatus. The following list shows the available states:

Timer Idle Timer is idle, and trigger source selection is set to off.

Timer Trigger Wait Timer is waiting for a timer trigger signal.

Timer Delay Timer is in timer delay count period.

Timer Active Time is active and counts for the specified timer duration.

Timer Completed Timer completed indicates, that the timer reached the timer duration count. The timer remains in this state, until a new timer trigger event has been received, or the timer is reset by a software command (see Section 5.2.4)

5.2.3 Timer Active, -Start and -End Signal

Timer Active An asserted timer active signal indicates, that the timer has started counting the configured duration period. The timer active signal is internally routed to the I/O control block and can there be selected for output on the physical output line or on one of the available leds.

Timer Start The timer start is an event, which is generated, when the timer starts with the timer duration period.

Timer End The timer end is an event, which is generated, when the timer arrives its configured timer duration value.

The timer start and end event signals can be used to trigger other blocks, like counter, timer, acquisition, frame or exposure control.

5.2.4 Timer Reset

The timer can be reset by a software command. It performs a software reset of the timer counter and starts the timer immediately (change to state timer active), when trigger source is set to off; otherwise it goes into the state timer trigger wait.

5.2.5 Timer Trigger Source

The timer trigger source selects the events that will be the used to reset and to start the timer. The following list of signals are available:

Off Disables the timer trigger.

Acquisition Trigger Starts with the reception of the acquisition trigger event.

Acquisition Start Starts with the reception of the acquisition start event.

Acquisition End Starts with the reception of the acquisition end event.

FrameTrigger Starts with the reception of the frame trigger event.

Frame Start Starts with the reception of the frame start event.

Frame End Starts with the reception of the frame end event.

Frame Burst Start Starts with the reception of the frame burst start event.

Frame Burst End Starts with the reception of the frame burst end event.

Exposure Start Starts with the reception of the exposure start event.

Exposure End Starts with the reception of the exposure end event.

User Output 0 ... 7 Starts when the selected user output bit is set to 1.

Counter 0 ... 3 Start Starts with the reception of the chosen counter start event.

Counter 0 ... 3 End Starts with the reception of the chosen counter end event.

Timer 0 ... 3 Start Starts with the reception of the chosen timer start event.

Timer 0 ... 3 End Starts with the reception of the chosen timer end event.

Encoder Starts with the reception of the encoder trigger event.

Action 0 ... 3 Starts with the reception of the chosen action signal event.

Software Signal Pulse 0 ... 7 Starts with the reception of chosen software signal pulse event (see Section 4.7).

Line Input Starts when the specified counter trigger activation condition is met on the chosen line.

Line input source has additionally a activation configuration, which needs to be set accordingly. Following configuration values are available:

Rising Edge Timer starts with the rising edge on the selected line input.

Falling Edge Timer starts with the falling edge on the selected line input.

Both Edges Timer starts with any edge on the selected line input.

A self re-trigger timer can be configured, when the trigger source is set to its own timer end event. The timer needs a software reset in order to start the self re-trigger mode.

6 Encoder

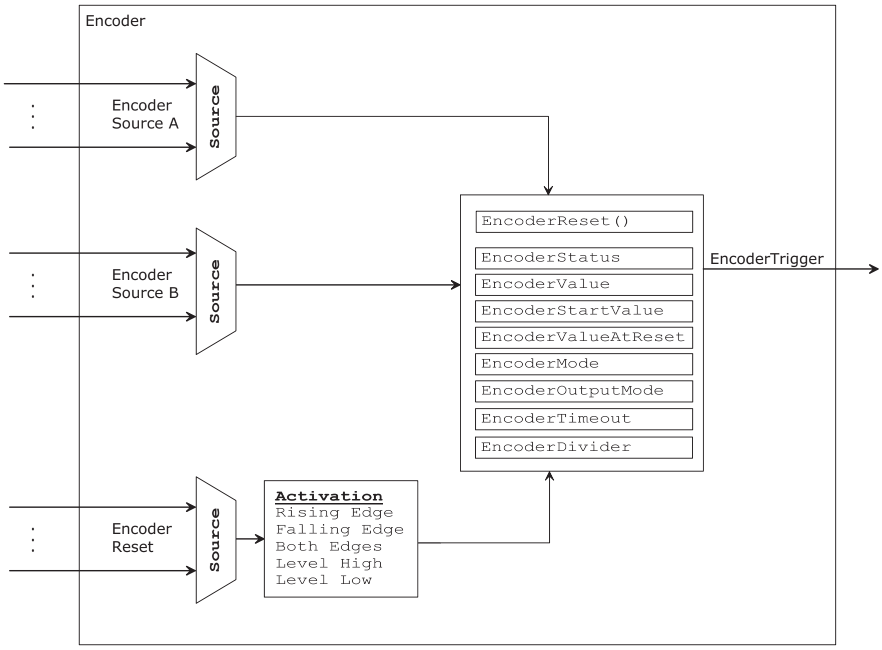

Figure 6.1: Encoder Structure

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 with the help of the encoder block. See Section 14.6.4 for more information, how to connect an encoder interface to the camera.

Fig. 6.1 shows the structure of the encoder. The trigger sources for the A and B inputs can be mapped to any of the line inputs of the camera, while the reset source can also be mapped to a multitude of other triggers. The encoder signals are used to track the position of the target using a counter. The block generates trigger signals based on the input, these can be used to trigger other blocks, like counter, timer, acquisition, frame or exposure control.

6.1 Encoder Usage

In order to enable the encoder, both trigger sources A and B need to be mapped to an input line. The encoder then starts tracking the position as soon as it is reset. Depending on the EncoderMode, the position counter reacts to either every input signal transition (HighResolution mode) or only to every full cycle of state transitions (FourPhase mode), see Fig. 6.2.
A start position can be configured through the EncoderStartValue property, the current position can be read through the EncoderValue property. Whenever the encoder is reset via input signal or software command, the current encoder value gets stored in the EncoderValueAtReset property.

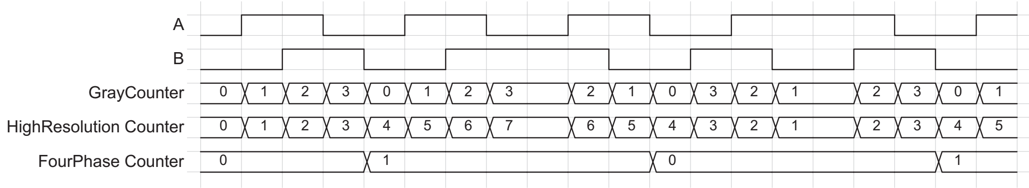

Figure 6.2: Encoder Modes

6.2 Encoder trigger output

The trigger output of the encoder reacts to changes of the position counter. Triggers are generated according to the EncoderOutputMode property:

Off Disables the encoder output trigger.

PositionUp Triggers are generated whenever the position counter increments and the position value has not previously been reached.

PositionDown Triggers are generated whenever the position counter decrements and the position value has not previously been reached.

DirectionUp Triggers are generated whenever the position counter increments.

DirectionDown Triggers are generated whenever the position counter decrements.

Motion Triggers are generated whenever the position counter value changes.

In order to keep track of the highest respectively lowest position in the PostionUp and -Down modes, a watermark counter is used. The counter resets whenever the output mode changes, the encoder is reset or a new start value is written. See Fig. 6.3 for a comparison of the modes. The number of generated output triggers can be reduced by setting the EncoderDivider

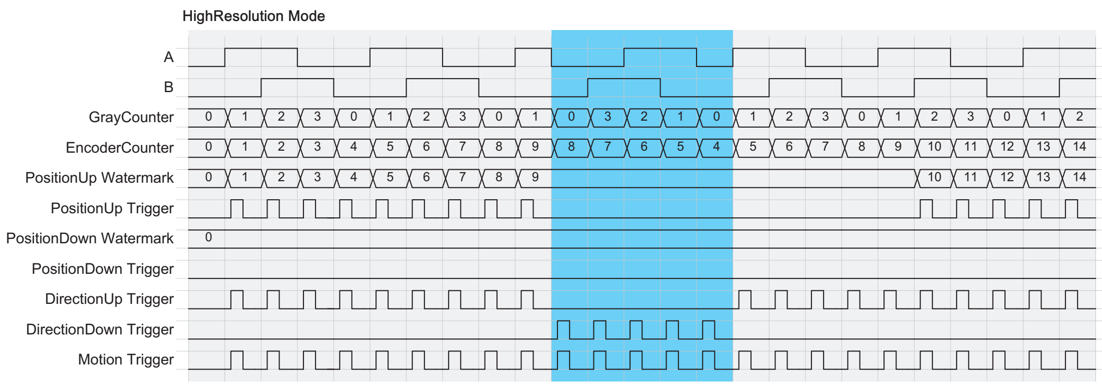

Figure 6.3: Encoder Output Modes

property accordingly. This property only affects the trigger output, the position is tracked exactly the same independent of the divider value.

6.3 Encoder Status

The encoder has different states which reflect on the A/B input signals. The current state can be read out by the EncoderStatus register. The following list shows the available states:

Encoder Idle Encoder is idle, either no trigger sources are configured or the encoder is waiting on the reset.

Encoder Up The position counter last incremented.

Encoder Down The position counter last decremented.

Encoder Static The position counter hasn't changed in the EncoderTimeout period. The encoder also switches to this state when it is reset while in the idle state.

The EncoderTimeout is configurable by the user. If set to zero, no timeout is applied and the encoder simply stays in the Up respectively Down state until the direction reverses. The EncoderTimeout property only affects the encoder status.

6.4 Encoder Reset Source

The encoder reset source selects the signal which will be the used to reset the encoder. The following signals sources are available:

Off Disables the encoder reset.

Acquisition Trigger Resets with the reception of the acquisition trigger.

Acquisition Start Resets with the reception of the acquisition start event.

Acquisition End Resets with the reception of the acquisition end event.

FrameTrigger Resets with the reception of the frame trigger.

Frame Start Resets with the reception of the frame start event.

Frame End Resets with the reception of the frame end event.

Frame Burst Start Resets with the reception of the frame burst start event.

Frame Burst End Resets with the reception of the frame burst end event.

Exposure Start Resets with the reception of the exposure start event.

Exposure End Resets with the reception of the exposure end event.

User Output 0 ... 7 Resets the encoder as long as the selected user output bit is asserted. The encoder remains in reset state until the selected user output bit is deasserted again (see Section 4.7).

Counter 0 ... 3 Start Resets with the reception the chosen counter start event.

Counter 0 ... 3 End Resets with the reception the chosen counter end event.

Timer 0 ... 3 Start Resets with the reception the chosen timer start event.

Timer 0 ... 3 End Resets with the reception the chosen timer end event.

Software Signal Pulse 0 ... 7 Resets with the reception of chosen software signal pulse event (see Section 4.7).

Line Input Resets when the specified encoder trigger activation condition is met on the chosen line.

Line input source has additionally a activation configuration, which needs to be set accordingly. Following configuration values are available:

Rising Edge Encoder starts with the rising edge on the selected line input.

Falling Edge Encoder starts with the falling edge on the selected line input

Both Edges Encoder starts with any edge on the selected line input

Level High Resets the encoder as long as the level is high. The encoder remains in reset state until the level is low again.

Level Low Resets the encoder as long as the level is low. The encoder remains in reset state until the level is high again.

Activation configuration has only effect when line input is selected as an encoder reset source, otherwise this configuration is ignored.

7

I/O Control

This chapter shows the structure of the physical input and physical output lines. It describes the signal path and how to configure it.

The I/O control block contains a signal input path and a signal output path.

7.1 Input Signal Path

The camera has four physical signal input lines, which come from the input opto-isolator of the camera hardware interface (see Section 14.6) and which are fed into the input signal path of the camera. Fig. 7.1 shows the structure of the input signal path. The user can invert this signal and its current status can be read by software.

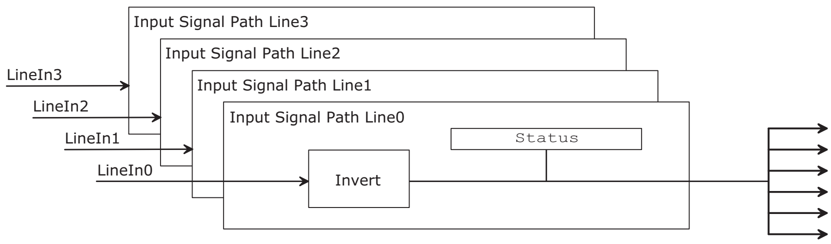

Figure 7.1: Input Signal Path

The output of the signal input path is distributed to following camera function:

- Acquisition Start Trigger
- Acquisition End Trigger
- Frame Start Trigger
- Frame Burst Start Trigger
- Frame Burst End Trigger
- Exposure Start Trigger
- Exposure End Trigger
- Counter Trigger
- Counter Event
- Counter Reset
- Encoder Reset
- Timer Trigger
- Line Out
- LED0 or LED1

7.2 Output Signal Path

The camera has three physical signal output line and two LEDs. The physical output lines are connected to the output opto-isolator in the camera hardware interface (see Section 14.6). The output lines, LED0 and LED1 have their own output signal path which is shown in Fig. 7.2. The source can be selected and the selected signal can be invert before it is sent out of the camera. Furthermore the current status of the output signal can read by software.

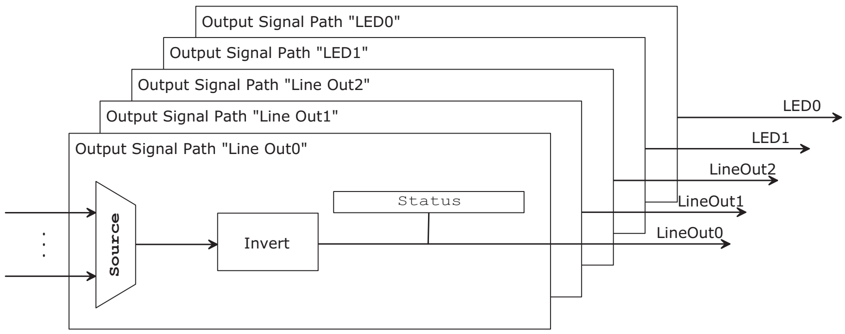

Figure 7.2: Output Signal Path

Following signals are available and can be selected for the output:

- Input Lines
- Counter Active Status
- Timer Active Status
- User Output
- Acquisition Trigger Wait Status
- Acquisition Active Status
- Frame Trigger Wait Status
- Frame Active Status
- Exposure Active Status
- Frame Valid Status
- Line Valid Status
- Heartbeat
- Serial Communication
- Constant 0 Value
- Constant 1 Value

If the source heartbeat is selected, the led shows a pulsating behaviour, when the camera is idle (no image capturing is active). It means, the intensity starts from dark and goes slowly to bright and slowly to dark again. Every time, when the camera is acquiring and sending images, the LED changes to a blinking characteristic.

If the source serial communication is selected, the led flashes every time when the host communicates with the camera, due to changing or reading of camera parameters.

8 Action Control

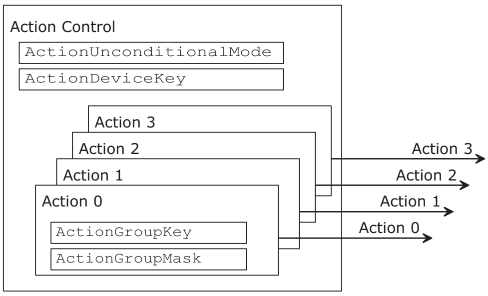

Figure 8.1: Action Control Structure

Action signals are a method to send triggers to multiple cameras in a common network at the same time. Four action signals are available in the Photonfocus GigE cameras. Each of them can be used as a trigger for the image acquisition, counter and/or timer. The commands are sent via the transport layer as a broadcast protocol message. The configuration parameters ActionDeviceKey, ActionGroupKey and ActionGroupMask in the camera allow filtering of these broadcast messages: The corresponding action signal is only asserted, when the received broadcast message matches to its key and mask configuration.

The action command enables triggering of the camera with low latency and low jitter.

8.1 Action Command Usage

Each action command message comes with the following key and mask information, which is necessary to validate the requested action signal:

ActionUnconditionalMode Enables the unconditional action command mode where action commands are processed even when the primary control channel is closed.

ActionDeviceKey The ActionDeviceKey authorize the action in the camera. The camera reacts only, when the received action message includes the correct action device key value. In the camera ActionDeviceKey value is configured once and applied globally to all four action signals..

ActionGroupKey The ActionGroupKey defines a group of devices on which the action has to be executed. This enables an action command to be applied to a specific subset of devices. Each action signal has its own group key, which need to be defined in the camera.

ActionGroupMask The ActionGroupMask filters out some of the devices of the group, which are selected by the action group key. Each action signal has its own group mask, which need to be defined in the camera.

The corresponding action signal is only asserted if:

- the configured ActionDeviceKey is equal to the action device key in the message.
- the configured ActionGroupKey is equal to the action group key in the message.
- the logical AND-wise operation of the action group mask in the message against the selected ActionGroupMask is non-zero.

8.2 Action Control Output

The action output signals can be used to trigger other blocks, like counter, timer, acquisition, frame or exposure control.

9

Image Format Control

The focus on the interesting parts of an image can be set by setting the region of interest (ROI) (see Section 9.1).

The ROI influences the image size which leads into an increased frame rate (see Chapter 11 for more information about the available frame rate).

9.1 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).

In MV4 cameras, the ROI width must be a multiple of 16. The ROI height is not restricted.

In DR4 cameras, the ROI width must be a multiple of 32. The ROI height must be a multiple of 4.

9.2 Multiple Regions of Interest

The Photonfocus Luxima GigE camera series can handle up to 8 different regions of interest. This feature can be used to reduce the amount of 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 color 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. 9.1 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.

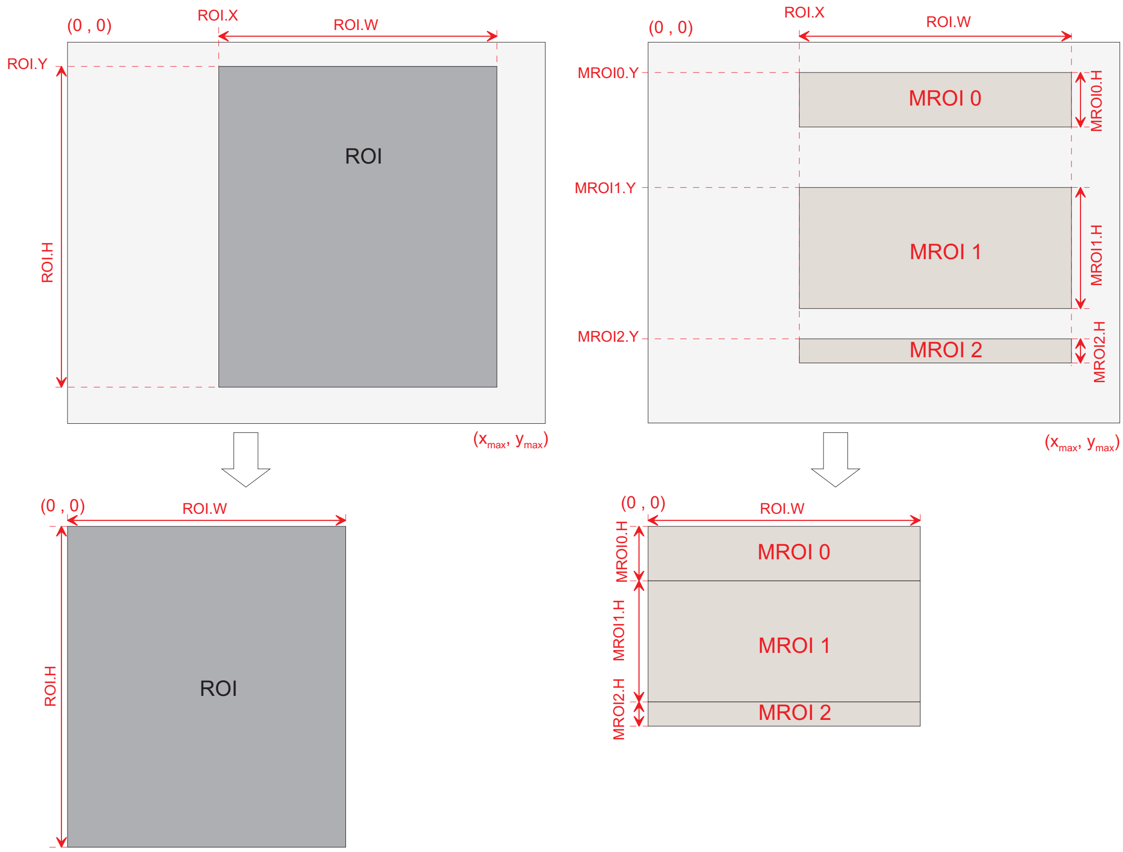

Figure 9.1: Multiple Regions of Interest

Fig. 9.2 shows another MROI drawing illustrating the effect of MROI on the image content.

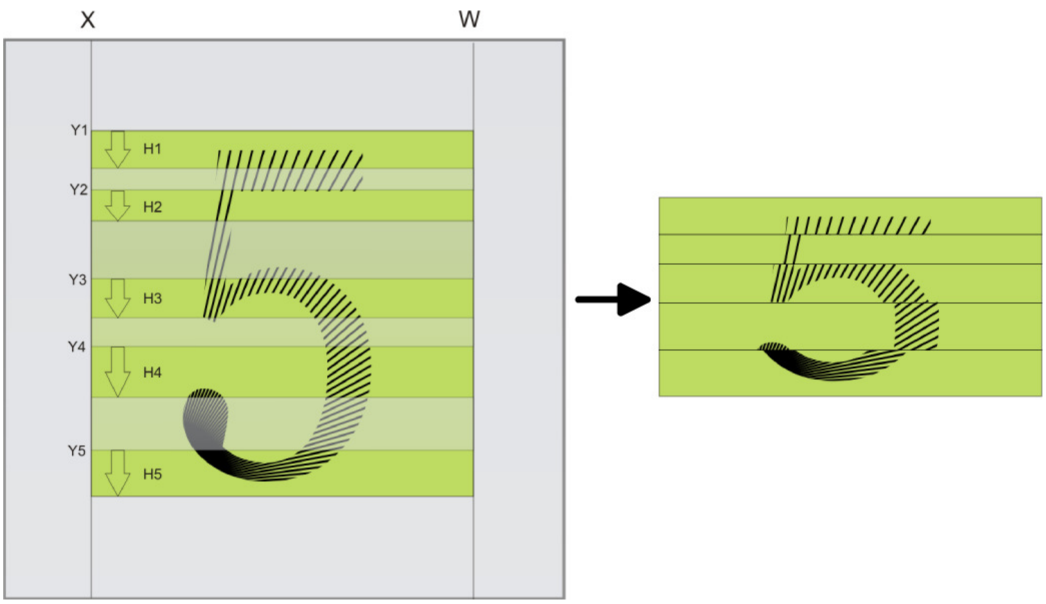

Figure 9.2: Multiple Regions of Interest with 5 ROIs

Fig. 9.3 shows an example from hyperspectral imaging where the presence of spectral lines at known regions need to be inspected. By using MROI only a 640x54 region need to be readout, and a much higher frame rate is possible, which can't be achieved without using MROI.

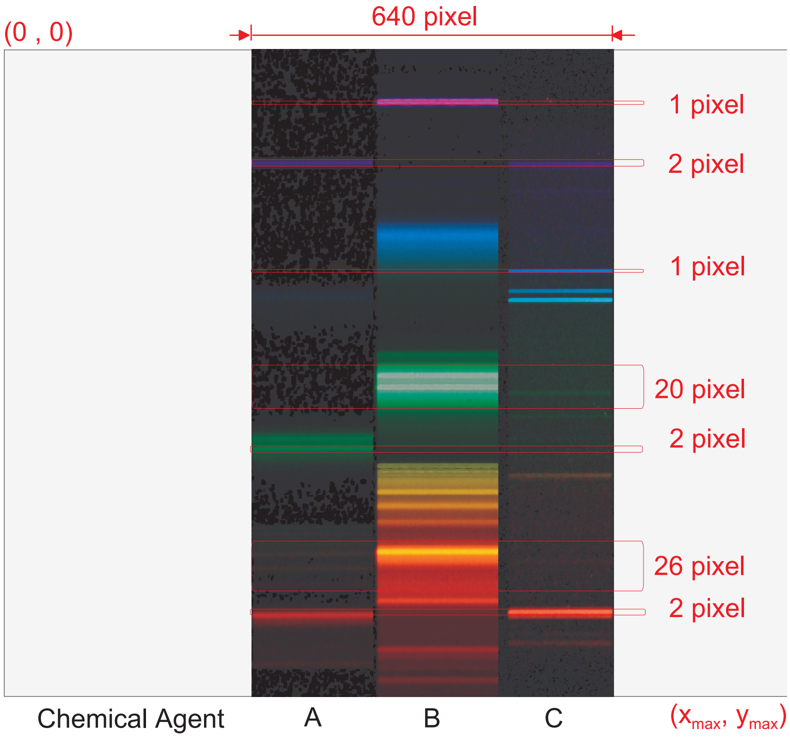

Figure 9.3: Multiple Regions of Interest in hyperspectral imaging

9.3 Pixel format

The pixel format defines the output format of the pixels in the image. Following pixel formats are available.

Mono 8

Mono10

Mono12

Mono10 Packed

Mono12 Packed

However, not all formats are available in all cameras and with each feature. Available pixel formats are dependant on the settings of the double rate algorithm and the binning algorithm. On Table 9.1 each camera and its available pixel formats are listed.

9.4 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. 9.4 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.

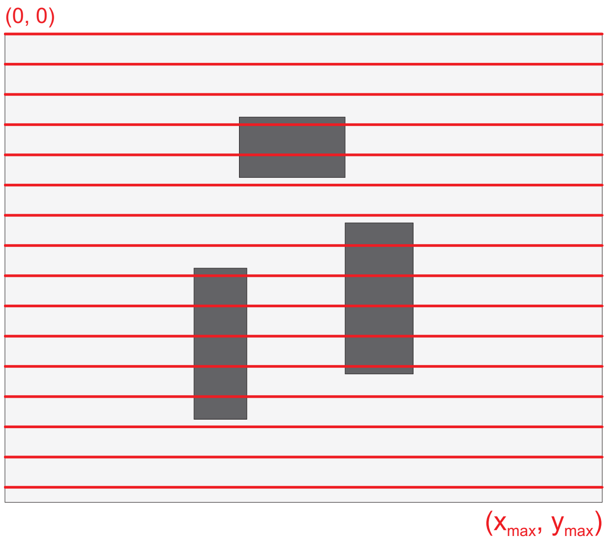

Figure 9.4: Decimation in full image

Fig. 9.5 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. 9.6 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.

Double Rate	Binning	Mono8	Mono10	Mono12	Mono10 Packed	Mono12 Packed
MV4-D1280-L01-G2						
Not Available	Enabled or Disabled	✓	✓	✓	✓	✓
MV4-D1280-L01-GT						
Not Available	Enabled or Disabled	✓	✓	✓	✓	✓
MV4-D1280-L01-FB						
Not Available	Enabled or Disabled	✓	✓	✓	✓	✓
DR4-D1280-L01-G2						
Enabled	Enabled or Disabled	✓	-	-	-	-
Disabled	Enabled or Disabled	✓	✓	✓	✓	✓
DR4-D1280-L01-GT						
Enabled	Enabled or Disabled	✓	-	-	-	-
Disabled	Enabled or Disabled	✓	✓	✓	✓	✓
DR4-D1280-L01-FB						
Enabled	Enabled or Disabled	✓	-	-	-	-
Disabled	Enabled or Disabled	✓	✓	✓	✓	✓

Table 9.1: Available pixel formats for different cameras and available double rate and binning settings

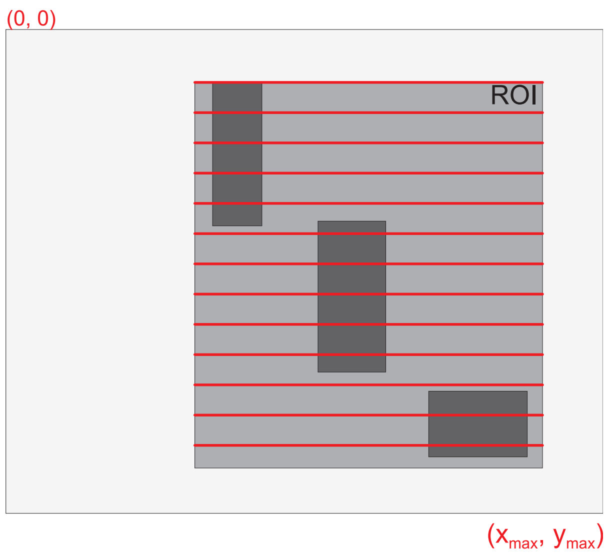

Figure 9.5: Decimation and ROI

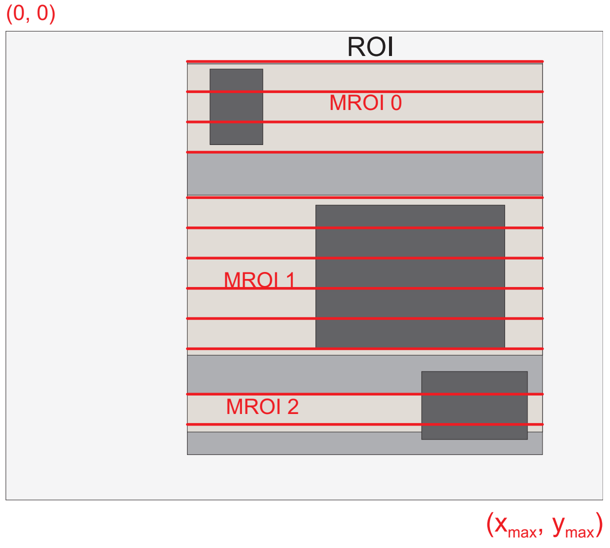

Figure 9.6: Decimation and MROI

The image in Fig. 9.7 on the right-hand side shows the result of decimation 3 of the image on the left-hand side.

Figure 9.7: Image example of decimation 3

An example of a high-speed measurement of the elongation of an injection needle is given in Fig. 9.8. 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.

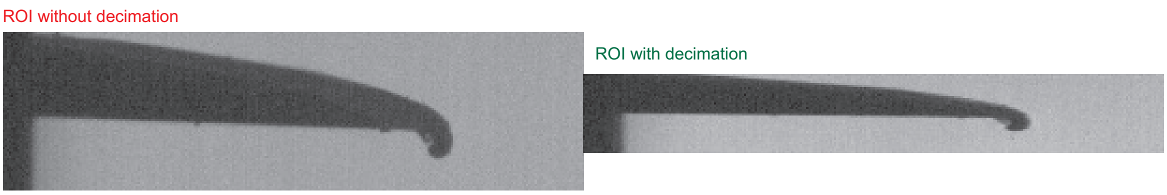

Figure 9.8: Example of decimation 2 on image of injection needle

10 High Dynamic Range Mode (HDR)

10.1 Multiple Slope Mode (High Dynamic Range)

The Multiple Slope 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 multiple slope mode is also called multiple slope mode or piecewise linear mode.

The multiple slope mode clips illuminated pixels which reach a programmable voltage, while leaving the darker pixels untouched (see Fig. 10.1). The clipping level can be adjusted once (2 slopes) or twice (3 slopes) within the exposure time.

Parameters:

Multislope_Mode There are 3 predefined multiple slope 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. 10.1 shows a pixel with high illumination. Without the multiple slope mode, the pixel would have reached its saturated value. With multiple slope mode, the pixel reaches value P1 which is below the saturation value. The resulting pixel response in this case is shown in Fig. 10.2. 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.

Changing the Exposure time or `Multislope_Time1` and `Multislope_Time2` requires the Acquisition to be stopped when Multislope Mode is active. Otherwise, the first image after updating any of these values could be prone to artefacts.

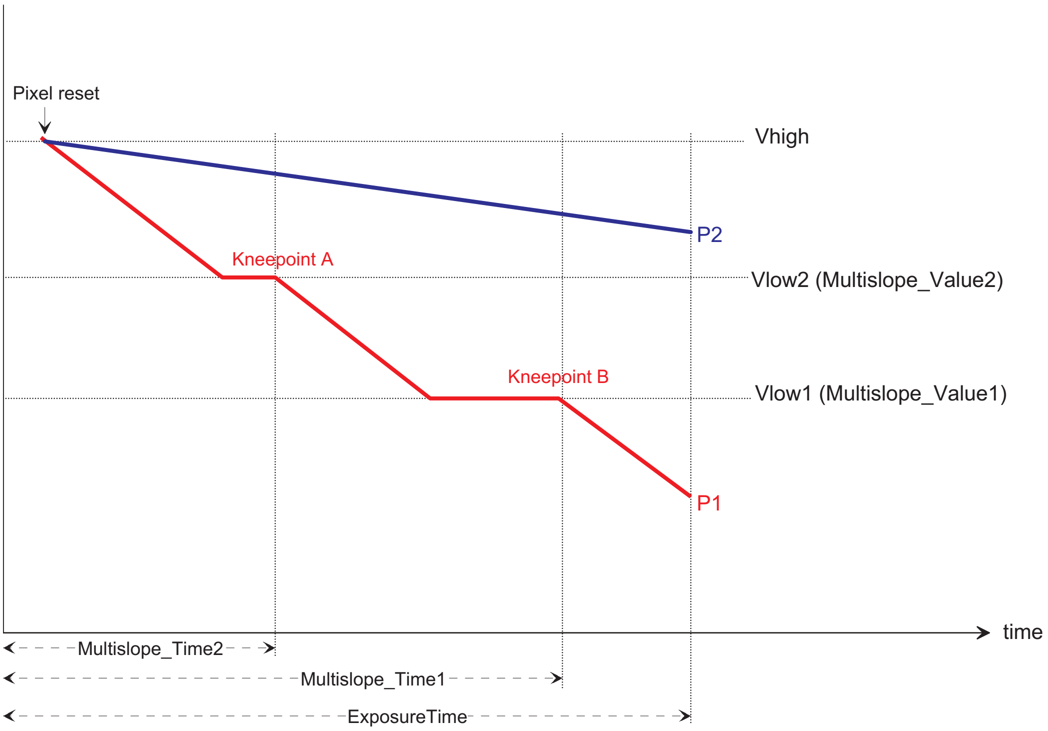

Figure 10.1: Multi Slope Mode

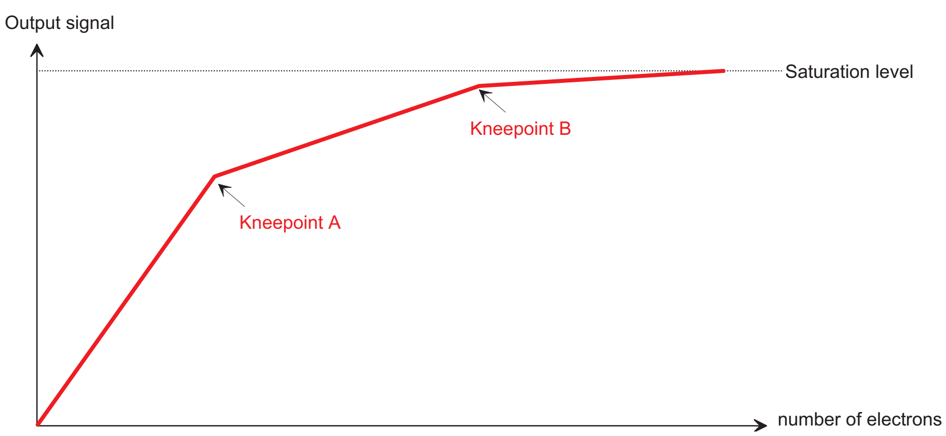

Figure 10.2: Piecewise linear response

11 Frame Rate

The frame rate depends on the image size, the used exposure time and the max data rate of the GigE interface (MaxDataRateInterface). Table 11.1 and Table 11.2 show the maximum frame rates for some common image dimensions.

11.1 Maximum Frame Rate

A list of commonly used image dimensions and its frame rates is shown on Table 11.1 for standard cameras and on Table 11.2 for DR cameras. It shows the maximum possible frame rates when the exposure time is smaller than the read out time.

There is a frame rate calculator in the support section of the Photonfocus web page www.photonfocus.com, which allows to determine the frame rates for any available image dimensions and expsoure time settings.

ROI Dimension [Standard]	MV4-D1280-L01-G2	MV4-D1280-L01-GT/FB
1280 x 1024 (SXGA)	85 fps	935 fps
1024 x 1024	106 fps	1066 fps
1280 x 768 (WXGA)	113 fps	1244 fps
800 x 600 (SVGA)	233 fps	1813 fps
640 x 640	273 fps	1701 fps
640 x 480 (VGA)	364 fps	2262 fps
480 x 480	486 fps	2262 fps

Table 11.1: Frame rates of different ROI settings (minimal exposure time) for MV4-D1280-L01 standard cameras.

ROI Dimension [Standard]	DR4-D1280-L01-G2	DR4-D1280-L01-GT/FB
1280 x 1024 (SXGA)	165 fps	1066 fps
1024 x 1024	206 fps	1066 fps
1280 x 768 (WXGA)	220 fps	1419 fps
800 x 600 (SVGA)	448 fps	1810 fps
640 x 640	526 fps	1700 fps
640 x 480 (VGA)	702 fps	2260 fps
480 x 480	932 fps	2260 fps

Table 11.2: Frame rates of different ROI settings (minimal exposure time) for DR4-D1280-L01 cameras.

ROI Dimension [Standard]	MV4-D1952-L01-G2	MV4-D1952-L01-GT/FB
1952 x 1080	53 fps	581 fps
1920 x 1080 (HD)	54 fps	590 fps
1280 x 1024 (SXGA)	85 fps	934 fps
1024 x 1024	106 fps	1057 fps
1280 x 768 (WXGA)	113 fps	1246 fps
800 x 600 (SVGA)	233 fps	1800 fps
640 x 640	273 fps	1688 fps
640 x 480 (VGA)	364 fps	2247 fps
480 x 480	486 fps	2247 fps

Table 11.3: Frame rates of different ROI settings (minimal exposure time) for MV4-D1952-L01 cameras.

ROI Dimension [Standard]	DR4-D1952-L01-G2	DR4-D1952-L01-GT/FB
1952 x 1080	TBD fps	1000 fps
1920 x 1080 (HD)	TBD fps	1000 fps
1280 x 1024 (SXGA)	TBD fps	1056 fps
1024 x 1024	TBD fps	1056 fps
1280 x 768 (WXGA)	TBD fps	1405 fps
800 x 600 (SVGA)	TBD fps	1796 fps
640 x 640	TBD fps	1685 fps
640 x 480 (VGA)	TBD fps	2240 fps
480 x 480	TBD fps	2240 fps

Table 11.4: Frame rates of different ROI settings (minimal exposure time) for DR4-D1952-L01 cameras.

12

Pixel Data Processing

12.1 Overview

The pixel, which are read out of the image sensor, are processed in the cameras data path. The sequence of blocks is shown in figure Fig. 12.1.

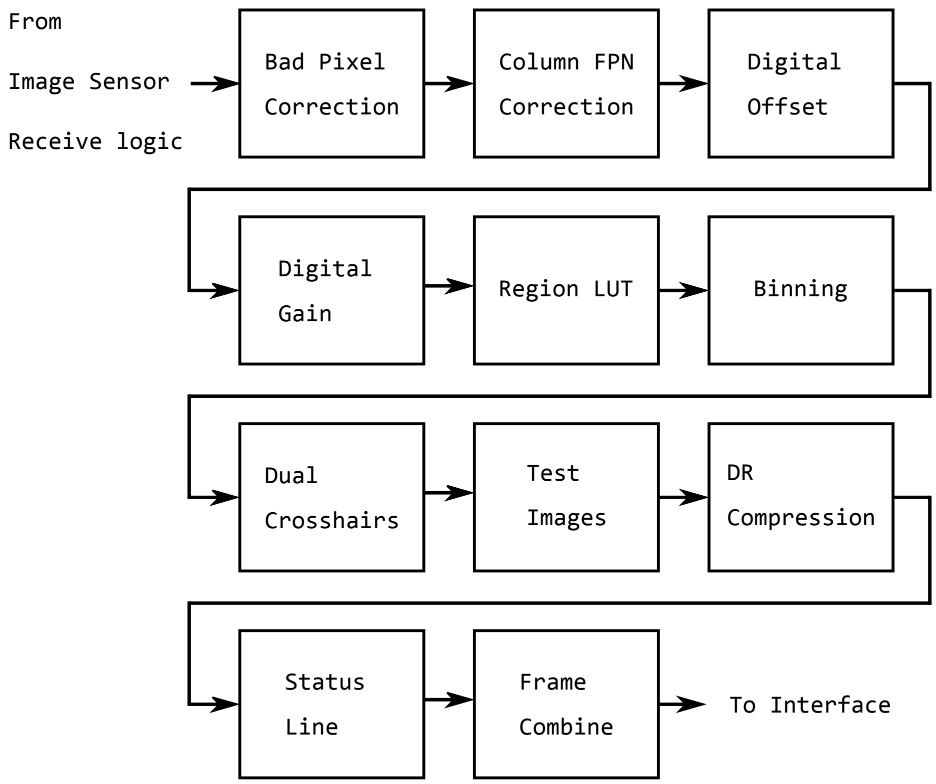

Figure 12.1: Camera data path

12.2 Bad Pixel Correction

The Bad Pixel Correction corrects single pixel defects of the image sensor. If a pixel is marked as "bad" (defect) then its value is replaced by the mean of the two neighbouring pixels on the same image row.

12.2.1 Enable / Disable the Bad Pixel Correction

The Bad Pixel Correction can be enabled or disabled with the property `BadPixelCorrection_Enable` (in category `Correction/BadPixelCorrection`). By default the correction is enabled.

12.2.2 Calibration of the Bad Pixel Correction

The calibration of the Bad Pixel Correction is based on a grey reference image, which is taken at uniform illumination to give an image with a mid grey level. The Bad Pixel Correction is calibrated in the production of the camera. More defect pixels may appear due to normal aging of the image sensor. It is possible to recalibrate the Bad Pixel Correction with the following instructions:

1. Setup the camera to the mode where it will be usually used. (Exposure time, ...). The width and height should be set to its maximal value.

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

2. Put the camera in free-running mode by setting the property `TriggerMode` to `Off`.
3. Start grabbing of the camera by clicking on the `Play` button.
4. Wait until the camera has achieved working temperature.
5. The image sensor must be uniformly illuminated to give an image with a mid grey level. Check this before you proceed with the instructions.
6. Set the visibility of the Device Control window of the PF_GEVPlayer to `Expert`.
7. Every pixel that is above the higher threshold or below the lower threshold is marked as a bad (defect) pixel. The values of these thresholds can be set by the properties `BadPixelCorrection_LowThreshold` and `BadPixelCorrection_HighThreshold`. These values must match with acquired image used for calibration: only defect pixels should have a value below `BadPixelCorrection_LowThreshold` or above `BadPixelCorrection_HighThreshold`. The image could be saved to a file and viewed with an image viewer that has the ability to show the histogram of the image as a list. A free tool with this feature is ImageJ. In the list of histogram values check that there are only a few pixels above or below the thresholds.
8. Run the command `BadPixelCorrection_Calculate` (category `BadPixelCorrection`) by clicking on the corresponding button. The camera transmits a test image during calibration.
9. The Bad Pixel Correction is now calibrated. The calibration values are stored in the camera's RAM and these values are lost when the camera power is turned off. To store the calibration values to permanent memory see Section 12.2.3.

It is recommended to do the calibration without a lens. The quality of the grey reference image is crucial for proper Bad Pixel Correction.

12.2.3 Storing the calibration in permanent memory

After running the calibration procedure (see Section 12.2.2) the calibration values are stored in RAM. When the camera is turned off, their values are lost.

To prevent this, the calibration values must be stored in flash memory. This can be done by clicking on the property `BadPixelCorrection_SaveToFlash` (in category `BadPixelCorrection`). Wait until the command has been finished.

Storing the calibration in permanent memory overwrites the factory calibration.

12.3 Column FPN Correction

Due to the readout structure of the image sensors there is a column-wise fixed pattern noise (FPN). The Column FPN Correction (ColCorrection) adds or subtracts a fixed value to a column. These values are obtained by a calibration process. The ColCorrection of the camera was calibrated at Photonfocus production facility.

12.3.1 Enable / Disable the Column FPN Correction

The Column FPN Correction can be enabled or disabled with the property `ColCorrection_Enable` (in category `Photonfocus/ColCorrection`). By default the correction is enabled.

12.3.2 Calibration of the Column FPN Correction

The Column FPN Correction of the camera is correctly calibrated at Photonfocus production facility. Although a new calibration is normally not required, you can recalibrate the Column FPN Correction with the following instructions:

1. Setup the camera to the mode where it will be usually used. (Exposure time, ...). The width and height should be set to its maximal value.

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

2. Start the aqcuisition of the camera.
3. Close the lens of the camera or put a cap on the lens. The calibration requires an uniform dark image. The black level offset should be set so that all pixels (except defect pixels) have values above 0.
4. Run the command `ColCorrection_CalibrateBlack` (category `ColCorrection`) by clicking on the corresponding button.

   The calibration process is waiting now for at least one image. If the camera is in triggered mode, the user must apply the corresponding trigger.

   To get the best calibration results, the camera should have achieved the working temperatur.

5. Run the command ColCorrection_Update by clicking on the corresponding button. Read the ColCorrection_Busy value which should be 0 after the calibration has finished. Repeat this step if its value is not 0. If the ColCorrection_Busy value doesn't show 0 after various tries, check if the camera receive triggers, when the triggered mode is activated.
6. Check the values of the properties ColCorrection_Overflow and ColCorrection_Underflow. Both should have the value 0 after calibration. If ColCorrection_Overflow is not 0, then decrease BlackLevel (in category AnalogControl) and re-run the procedure from step 4 on. If ColCorrection_Underflow is not 0, then increase BlackLevel (in category AnalogControl) and re-run the procedure from step 4 on.
7. The Column FPN correction is now calibrated. The calibration values are stored in the camera's RAM and these values are lost when the camera power is turned off. To store the calibration values to permanent memory see Section 12.3.3.

12.3.3 Storing the calibration in permanent memory

After running the calibration procedure (see Section 12.3.2) the calibration values are stored in RAM. When the camera is turned off, their values are lost.

To prevent this, the calibration values must be stored in flash memory. This can be done by clicking on the property ColCorrection_SaveToFlash (in category ColCorrection). Wait until the command has been finished, i.e.the property ColCorrection_Busy (category Correction / ColCorrection) is 0. ColCorrection_Busy can be updated by clicking on the property ColCorrection_Update (in category Calibration).

Storing the calibration in permanent memory overwrites the factory calibration.

12.4 Gain and Offset

There are three different gain settings on the camera:

Analog Gain Analog gain on the image sensor. Available values: x1.375, x4.0, x8.0 and x16.0. 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.

12.5 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 camera (see Section 12.5.4).

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

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

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

Some commonly used transfer curves are shown in Fig. 12.2. 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 12.5.2).

12.5.1 Gain

The 'Gain' mode performs a digital, linear amplification with clamping (see Fig. 12.3). It is configurable in the range from 1.0 to 4.0 (e.g. 1.234).

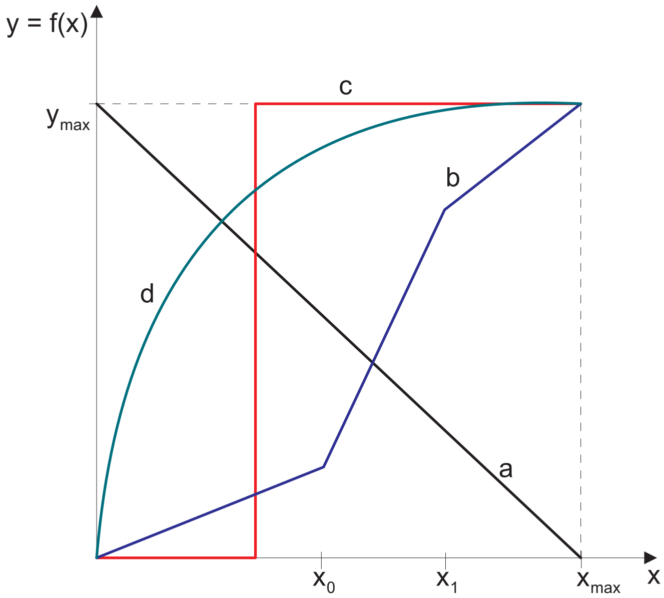

Figure 12.2: Commonly used LUT transfer curves

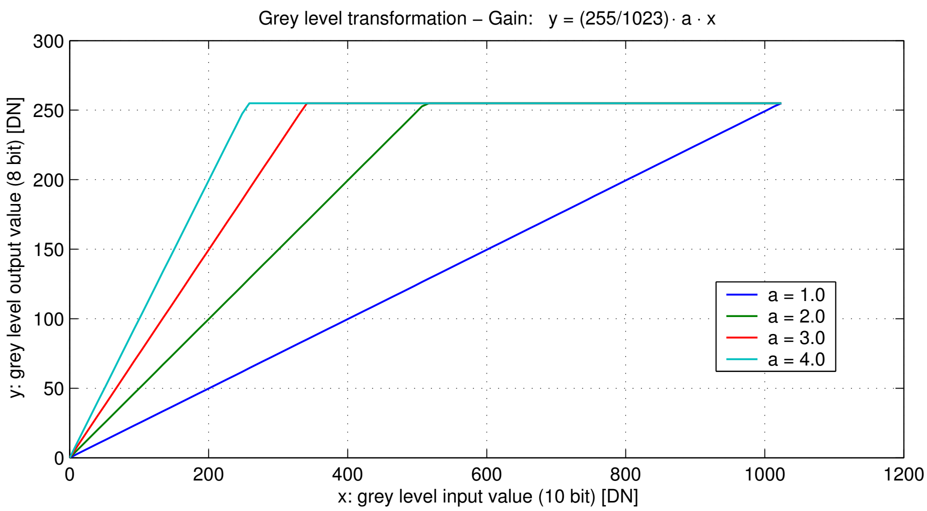

Figure 12.3: Applying a linear gain with clamping to an image

12.5.2 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. 12.4), gamma < 1.0 results in an amplification (see Fig. 12.5). Gamma correction is often used for tone mapping and better display of results on monitor screens.

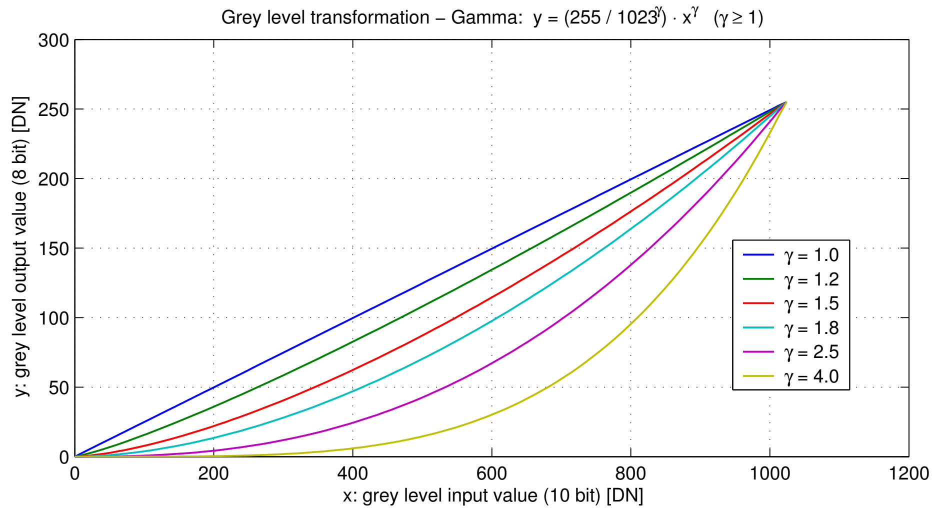

Figure 12.4: Applying gamma correction to an image (gamma > 1)

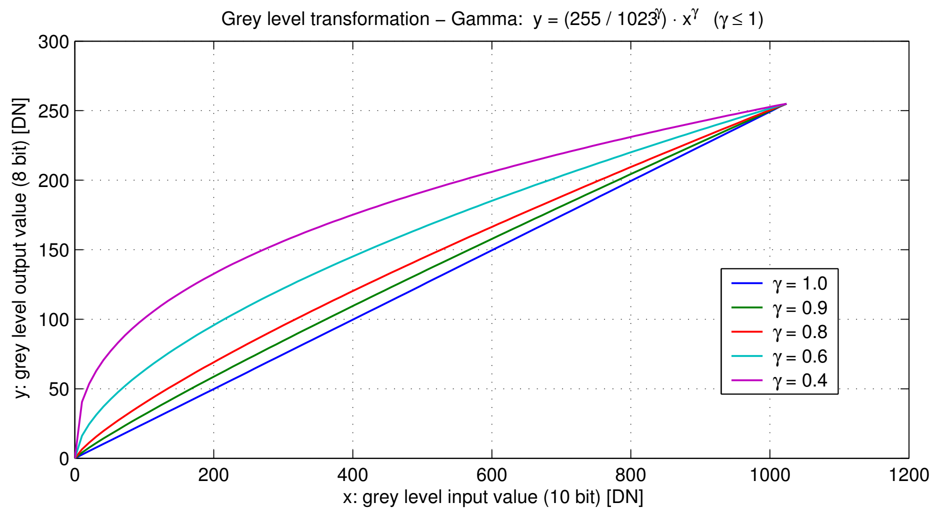

Figure 12.5: Applying gamma correction to an image (gamma < 1)

12.5.3 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 C.4.

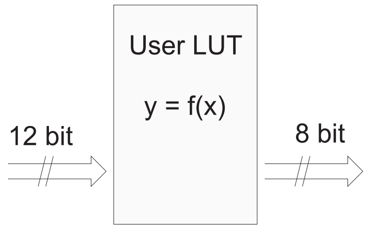

Figure 12.6: Data path through LUT

12.5.4 Region LUT and LUT Enable

Two LUTs and a Region-LUT feature are available in the camera. Both LUTs can be enabled independently (see Table 12.1). 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 12.1: 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. 12.7 and Fig. 12.8.

Fig. 12.7 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. 12.8 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.

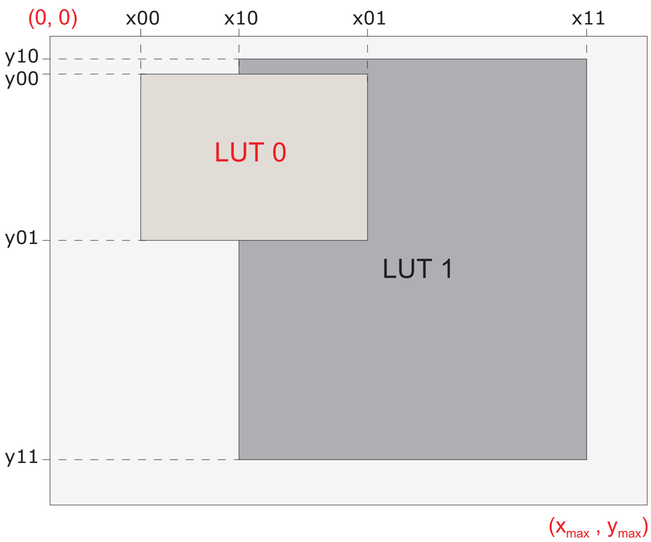

Figure 12.7: Overlapping Region-LUT example

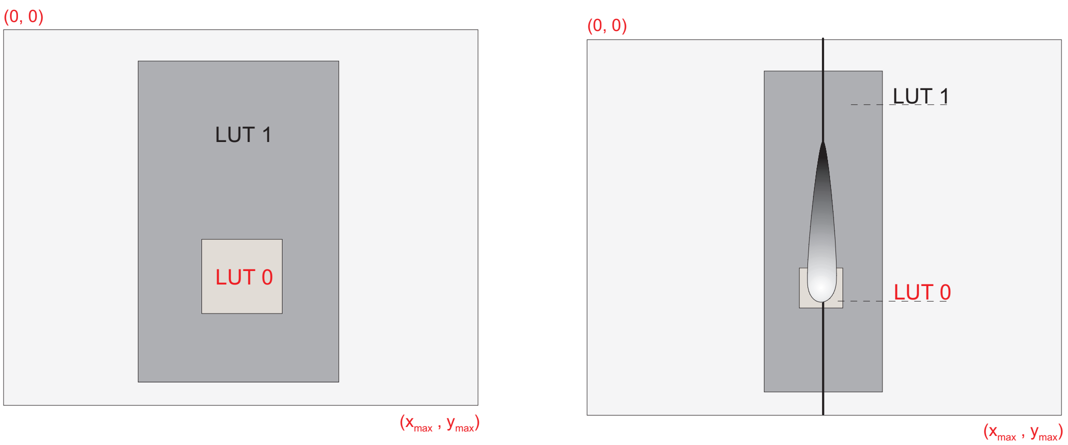

Figure 12.8: Region-LUT in keyhole inspection

Fig. 12.9 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.

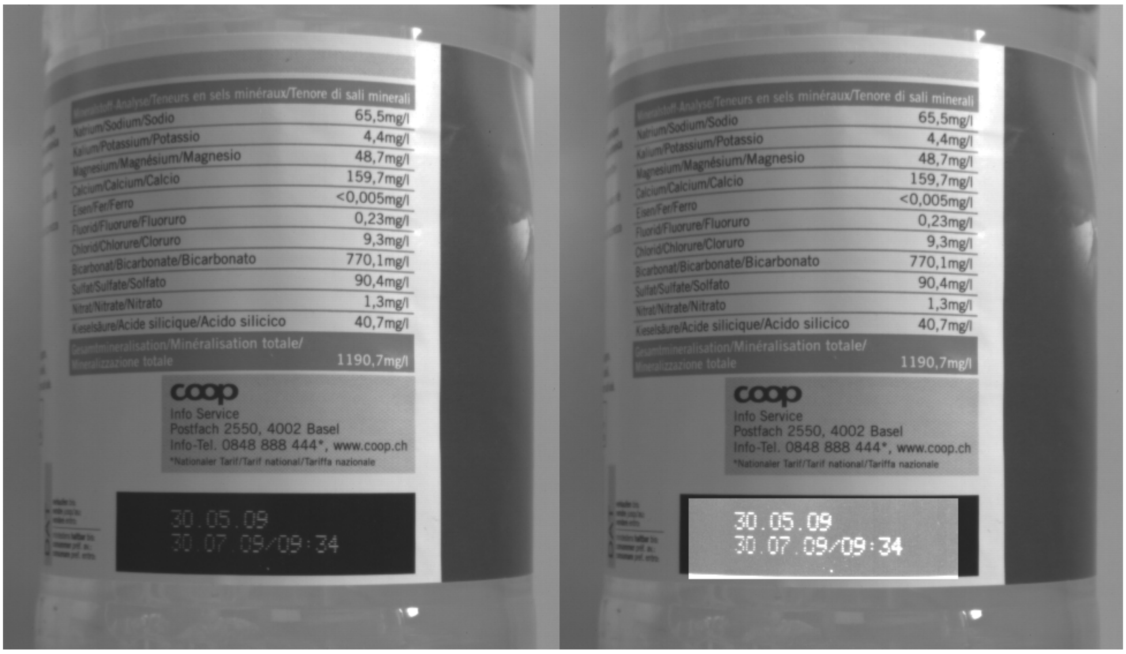

Figure 12.9: Region-LUT example with camera image; left: original image; right: gain 4 region in the are of the date print of the bottle

12.6 Binning

12.6.1 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. 12.10 shows a schematic of 2x2 binning: pixels in a 2x2 neighbourhood (displayed as pixels with the same color 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.

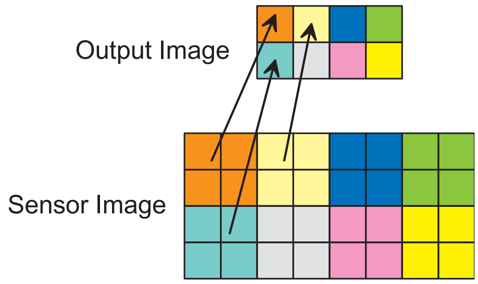

Figure 12.10: Example of 2x2 binning

12.6.2 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 12.2.

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.
BinningBitshift	Integer	Additional left bitshift after binning (overflow is ignored)
BinningSaturationMode	Enumeration	0: no saturation indication; 1: output data is saturated, if one of the pixels of the binning region is saturated; 2: LSB of output data is set ’1’ if one of the pixels of the binning region is saturated, else it is set to ’0’
Height	Integer	Height of the output image.
Width	Integer	Width of the output image.

Table 12.2: Binning parameters

Binning might increase the maximal frame rate if it is currently limited by the setting of the maximal data rate (MaxDataRateInterface).

12.7 Dual Crosshairs

Up to two crosshairs can be displayed in the live image. It inserts one or two vertical and horizontal lines into the image. The positions as well as the gray levels of the line for both crosshairs can be set individually via the camera software. The grey level is defined by a 12 bit value (0 means black, 4095 means white). This allows setting any grey level to get the maximum contrast depending on the acquired image. Figure Fig. 12.11 shows an example of two crosshairs with different grey values. One with white lines and the other with black lines.

The width of the lines can be set to one or two pixels. Two pixels increase the visibility of the crosshairs.

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

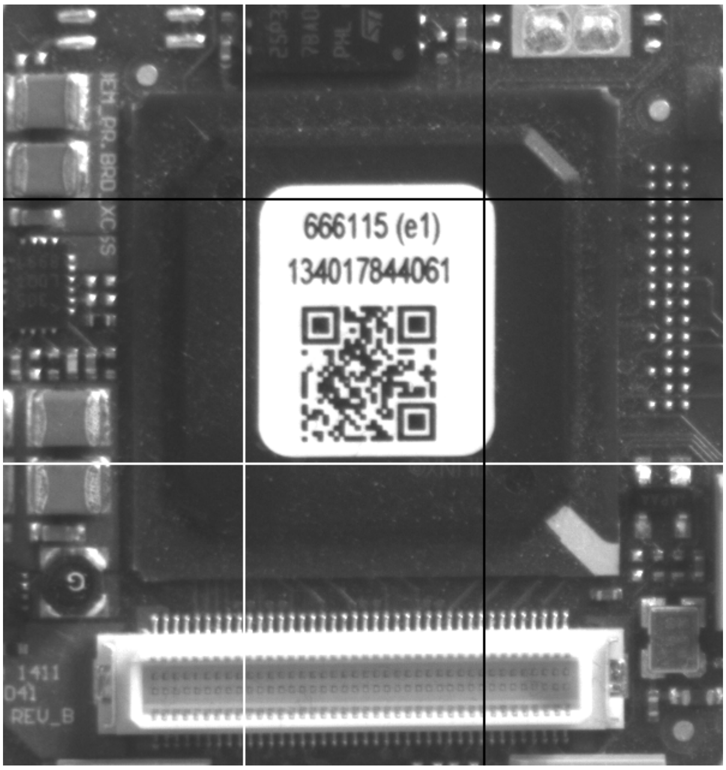

Figure 12.11: Dual Crosshairs Example with different grey values

The x- and y-positons are absolute to the sensor pixel matrix. It is independent on the image format settings (see Chapter 9 for more information about the available image format configurations).

Fig. 12.12 shows two situations of the crosshairs configuration. The same image format settings are 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 ROI region.

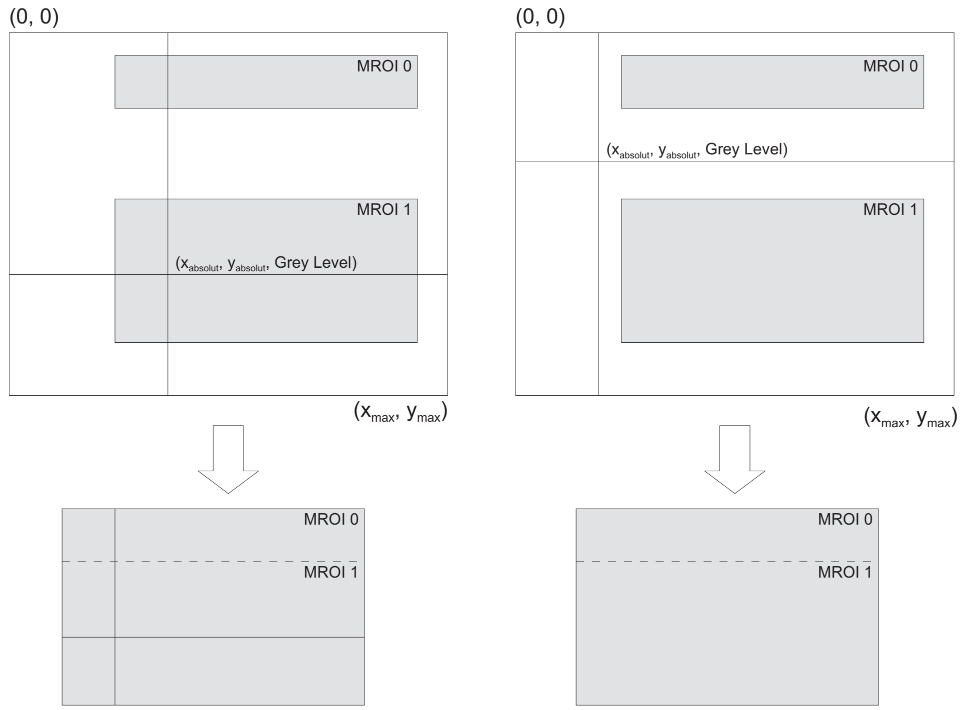

Figure 12.12: Crosshairs absolute position

12.8 Test Images

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

A test image is a useful tool to find data transmission errors or errors in the access of the image buffers by the acquisition software.

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

12.8.1 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. 12.13).

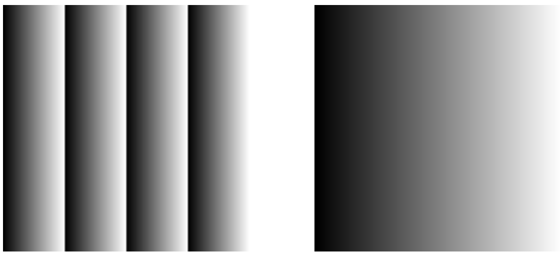

Figure 12.13: Ramp test images: 8 bit output (left), 10 bit output (right)

12.8.2 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.

12.8.3 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. The camera window can also be set to a multiple of this resolution (e.g. 2048 x 2048 or 4096 x 3072) if the camera model supports this resolution. If your image acquisition application does not provide a real-time histogram, store the image and use an image viewing tool (e.g. ImageJ) to display the histogram.

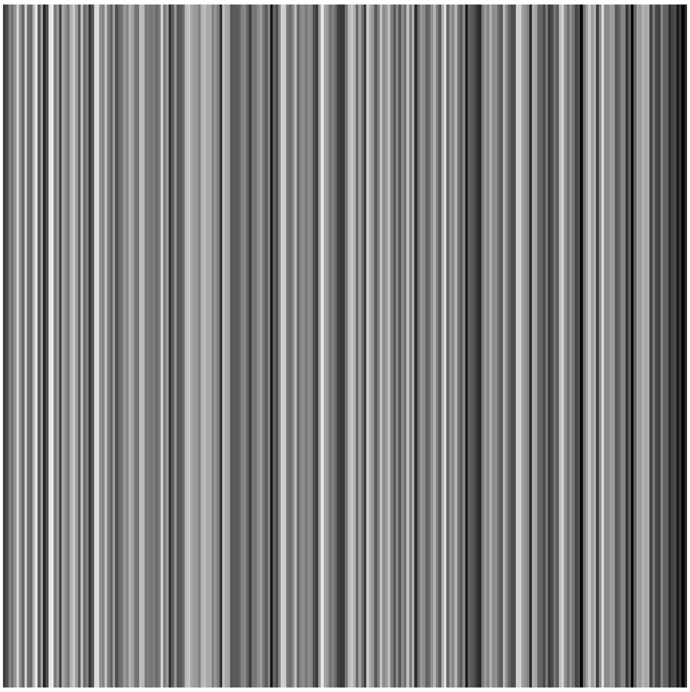

Figure 12.14: LFSR (linear feedback shift register) test image

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. 12.15). On the other hand, a non-flat histogram (Fig. 12.16) indicates problems, that may be caused either by a defective camera, by problems in the acquisition software or in the transmission path.

Figure 12.15: 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.

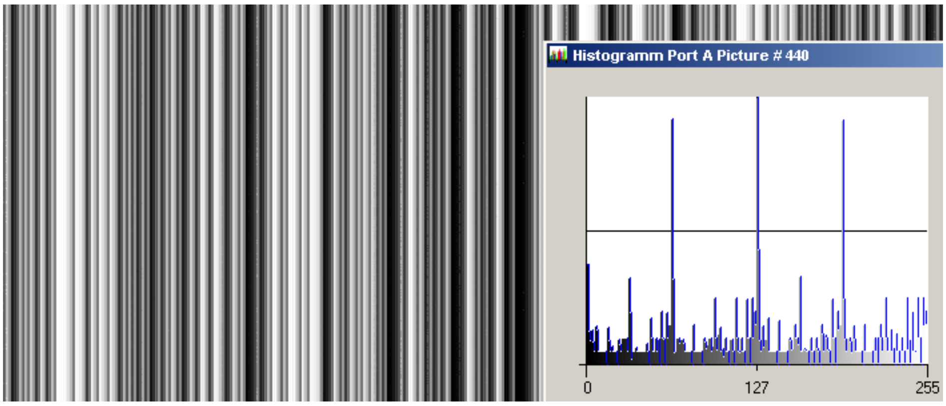

Figure 12.16: LFSR test pattern received and histogram containing transmission errors

12.9 Status Line and Image Information

There are camera properties available that give information about the acquired images, such as integration time, ROI settings or average image value. 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.

12.9.1 Image Average 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

12.9.2 Status Line Format

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. 12.17). The assignment of the parameters to the fields is listed in Table 12.3.

The status line is available in all camera modes.

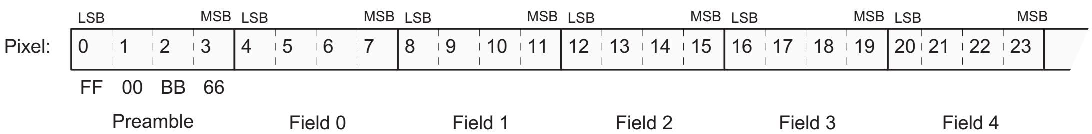

Figure 12.17: Status line parameters replace the last row of the image

Start pixel index	Parameter width [bit]	Parameter Description
0	32	Preamble: 0x66BB00FF
4	32	Counter 0 Value (see Section 5.1)
8	32	Counter 1 Value (see Section 5.1)
12	32	Counter 2 Value (see Section 5.1)
16	32	Counter 3 Value (see Section 5.1)
20	32	Timer 0 Value in units of clock cycles (see Section 5.2)
24	32	Timer 1 Value in units of clock cycles (see Section 5.2)
28	32	Timer 2 Value in units of clock cycles (see Section 5.2)
32	32	Timer 3 Value in units of clock cycles (see Section 5.2)
36	24	Integration Time in units of clock cycles
40	24	Reserved
44	32	Timer and Integration Time Clock Frequency
48	12	Image Average Value("raw" data without taking in account gain settings) (see Section 12.9.1)
52	12	Horizontal start position of ROI (OffsetX)
56	12	Image Width
60	12	Vertical start position of ROI (OffsetY).In MROI-mode this parameter is the start position of the first ROI.
64	12	Image Height
68	2	Digital Gain
72	12	Digital Offset
76	16	FineGain. This is fixed a point value in the format: 4 digits integer value, 12 digits fractional value.
80	4	Line Input Level of LineIn0, LineIn1, LineIn2 and LineIn3
84	16	Camera Type Code (see Table 12.4)
88	32	Camera Serial Number
92	32	Custom value 0: value of register StatusLineCustomValue0 that can be set by the user
96	32	Custom value 1: value of register StatusLineCustomValue1 that can be set by the user
100	32	Encoder 0 Position (see Chapter 6)

Table 12.3: Assignment of status line fields

12.9.3 Camera Type Codes

Camera Model	Camera Type Code
MV4-D1280-L01-G2	514
MV4-D1280-L01-GT	525
MV4-D1280-L01-FB	528
DR4-D1280-L01-G2	526
DR4-D1280-L01-GT	527
DR4-D1280-L01-FB	TBD
MV4-D1952-L01-G2	534
MV4-D1952-L01-GT	535
MV4-D1952-L01-FB	TBD
DR4-D1952-L01-G2	TBD
DR4-D1952-L01-GT	538
DR4-D1952-L01-FB	TBD

Table 12.4: Type codes of Photonfocus MV4 Luxima GigE camera series

12.10 Double Rate (DR cameras only)

The Photonfocus DR 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. 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.

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

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.

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 color cameras):

w_{mod} = ceil(w/64) + w/2 + oh [w = width of image in pixels]

12.11 Frame Combine

Very high frame rates that are well over 1000 fps can be achieved for small ROIs. 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 this camera. In this mode, the data of n images are bundled into one frame. In the example shown in Fig. 12.18 4 frames are combined into one frame (`FrameCombineNrFrames`=4). In this case there are 4 times less software interrupts that indicate a new frame than without FrameCombine and the CPU load is significantly reduced. Instead of receiving 4 images with 5 rows, only one image with 20 rows is received which reduces the frame rate on the computer side. Without FrameCombine, the CPU load on the computer might be too high to receive all images and images might be dropped. The value n (=`FrameCombineNrFrames`) can be set by the user. This value should be set so that the resulting frame rate is well below 1000 fps (e.g. at 100 fps). E.g. if the camera shows a maximal frame rate of 4000 (property `AcquisitionFrameRateMax`), then `FrameCombineNrFrames` could be set to 40 to have a resulting frame rate of 100 fps.

The `FrameCombineNrFrames` value should be set so that the resulting frame rate is well below 1000 fps.

12.11.1 Frame Combine Timeout

There exist possibilities to transmit the combined frame even if there is not enough data to fill it. E.g. It can be desirable to get the data immediately after an item on a conveyor belt has passed.

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.

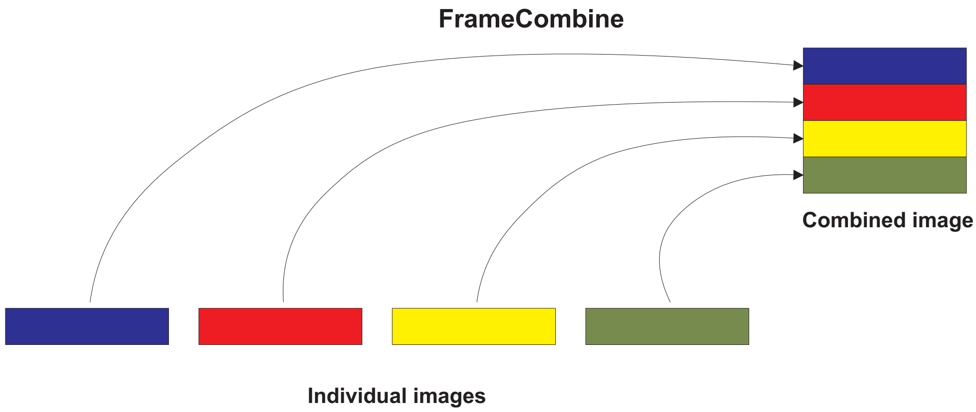

Figure 12.18: Example for FrameCombine with 4 frames

A FrameCombine_Timeout value of 0 disables the FrameCombine timeout feature.

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

When the FrameCombine is finished by a timeout, 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. An example is shown in Fig. 12.19. The timeout occured after the second frame and the two remaining frames are filled with dummy data.

When acquisition is stopped, then a pending combined frame will be discarded. To get the pending combined frame, a `FrameCombine_ForceTimeout` command must be sent prior to stopping the acquisition.

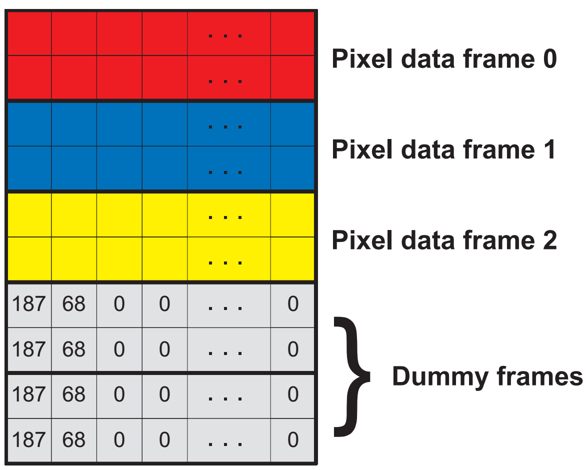

Figure 12.19: Example for timeout with dummy frames in FrameCombine with 5 frames

13

Precautions

13.1 IMPORTANT NOTICE!

READ THE INSTRUCTIONS FOR USE BEFORE OPERATING THE CAMERA

STORE THE INSTRUCTIONS FOR USE FOR FURTHER READING

The installation of the camera in the vision system should be executed by trained and instructed employees.

DANGER - Electric Shock Hazard

Unapproved power supplies may cause electric shock. Serious injury or death may occur.

- You must use camera power supplies which meet the Safety Extra Low Voltage (SELV) and Limited Power Source (LPS) requirements.
- If you use a powered hub or a powered switch in PoE or USB vision systems these devices must meet the SELV and LPS requirements.

WARNING - Fire Hazard

Unapproved power supplies may cause fire and burns.

- You must use camera power supplies which meet the Limited Power Source (LPS) requirements.
- If you use a powered hub or a powered switch in PoE or USB vision systems these devices must meet the LPS requirements.

Supply voltages outside of the specified range will cause damage. Check the supply voltage range given in this manual. Avoid reverse supply voltages.

Respect the voltage limits and the common mode rails of the camera control signals. Ensure that the output signals are not over loaded. Respect the power limitations of the outputs. Carefully design the vision system before you connect electronic devices to the camera. Use simulation tools to check your design.

Avoid compensation currents over data cables. Use appropriate ground connections and grounding materials in the installation of your vision system to ensure equal potential of all chassis earth in your system.

Incorrect plugs can damage the camera connectors. Use only the connectors specified by Photonfocus in this manual. Using plugs designed for a smaller or a larger number of pins can damage the connectors.

The cameras deliver the data to the vision system over interfaces with high bandwidth. Use only shielded data cables to avoid EMC and data transmission issues. High speed data cables are susceptible to mechanical stress. Avoid mechanical stress and bending of the cables below the minimum bending radius of the cables during installation of your vision system. For robot applications appropriate cables have to be used.

Inappropriate software code to control the cameras may cause unexpected camera behaviour.

- The code examples provided in the Photonfocus software package are included as sample code only. Inappropriate code may cause your camera to function differently than expected and may compromise your application. The Photonfocus software package is available on the Photonfocus website: www.photonfocus.com.
- To ensure that the examples will work properly in your application, you must adjust them to meet your specific needs and must carefully test them thoroughly prior to use.

Avoid dust on the sensor.

The camera is shipped with a plastic cap on the lens mount. To avoid collecting dust on the camera's IR cut filter (colour cameras) or sensor (mono and mono NIR cameras), make sure that you always put the plastic cap in place when there is no lens mounted on the camera. Follow these general rules:

- Always put the plastic cap in place when there is no lens mounted on the camera.
- Make sure that the camera is pointing down every time you remove or replace the plastic cap, a lens or a lens adapter.
- Never apply compressed air to the camera. This can easily contaminate optical components, particularly the sensor.

Cleaning of the sensor

Avoid cleaning the surface of the camera sensor or filters if possible. If you must clean it:

- Before cleaning disconnect the camera from camera power supply and I/O connectors.
- Follow the instructions given in the section "Cleaning the Sensor" in this manual.

Cleaning of the housing

To clean the surface of the camera housing:

- Before cleaning disconnect the camera from camera power supply and I/O connectors.
- Do not use aggressive solvents or thinners which can damage the surface, the serial number label and electronic parts.
- Avoid the generation of ESD during cleaning.
- Take only a small amount of detergent to clean the camera body. Keep in mind that the camera body complies to the IP40 standard.
- Make sure the detergent has evaporated after cleaning before reconnecting the camera to the power supply.

Cooling

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.

14

Hardware Interface

14.1 Absolute Maximum Ratings

Parameter	Value
Power Supply Voltage	-50 V ... +50 V
ESD Contact Discharge Power Supply	4 kV
ESD Air Discharge Power Supply	8 kV
Fast Transients/Bursts Power Supply	2 kV
Surge immunity Power Supply	1 kV
Camera Control Input Signal Voltage Single Ended	-15 V ... +30 V
Camera Control Input Signal Voltage RS422	-15 V ... +40 V
Camera Control Input Signal Voltage HTL	-15 V ... +40 V
Common Mode Range Voltage RS422	-15 V ... +20 V
Camera Control Output Signal Voltage Single Ended	0 V ... +30 V
Camera Control Output Signal Output Current Single Ended	0.5 A
Camera Control Output Signal Output Power Single Ended	0.5 W
ESD Contact Discharge Camera Control Signals	10 kV
ESD Air Discharge Camera Control Signals	7 kV
Fast Transients/Bursts Data and Camera Control Signals	1 kV
Surge immunity Data and Camera Control Signals	1 kV

Table 14.1: Absolute Maximum Ratings

14.2 Electrical Characteristics

In the following tables, VIN is the input voltage for single ended input and VID is the input voltage for differential input.

Single Ended Input Voltage	Logic Level	Fault Condition
-15V < VIN < +0.8V	Low	No Fault
+0.8V < VIN < +2.0V	Indeterminate	No Fault
+2.0V < VIN < +15V	High	No Fault
+15V < VIN < +18V	High	Indeterminate
+18V < VIN < +40V	High	High Input Fault

Table 14.2: Single-Ended TTL Mode Receiver Logic (LineIn0, LineIn1, LineIn2 & LineIn3)

Single Ended Input Voltage	Logic Level	Fault Condition
-15V < VIN < +6V	Low	No Fault
+6V < VIN < +8V	Indeterminate	No Fault
+8V < VIN < +40V	High	No Fault

Table 14.3: Single-Ended SE-HTL Low Threshold Mode Receiver Logic (LineIn0, LineIn1, LineIn2)

Single Ended Input Voltage	Logic Level	Fault Condition
-15V < VIN < +11V	Low	No Fault
+11V < VIN < +13V	Indeterminate	No Fault
+13V < VIN < +40V	High	No Fault

Table 14.4: Single-Ended SE-HTL High Threshold Mode Receiver Logic (LineIn0, LineIn1, LineIn2

Differential Input Voltage	Logic Level	Fault Condition
VID > +2V	High	No Fault
+1.2V < VID < +2V	High	Indeterminate
-0.9V $\leq$ VID $\leq$ +0.9V	Indeterminate	Low Differential Input Voltage Fault
-2V $\leq$ VID $\leq$ -1.2V	Low	Indeterminate
VID $\leq$ -2V	Low	No Fault

Table 14.5: Differential D-HTL Mode Receiver Logic (LineIn0, LineIn1, LineIn2)

Differential Input Voltage	Logic Level	Fault Condition
VID > +0.45V	High	No Fault
+0.27V < VID < +0.45V	High	Indeterminate
-0.2V $\leq$ VID $\leq$ +0.2V	Indeterminate	Low Differential Input Voltage Fault
-0.45V $\leq$ VID $\leq$ -0.27V	Low	Indeterminate
VID $\leq$ -0.45V	Low	No Fault

Table 14.6: Differential RS422 Mode Receiver Logic (LineIn0, LineIn1, LineIn2)

14.3 GigE Camera Connector

The MV4 GigE and MV4 10 GigE copper cameras are interfaced to external components via

- an X-coded M12 GigE connector to transmit configuration, image data and trigger.
- a 17-pin M12 I/O connector with 4 digital inputs 3 digital outputs and one RS485 interface.
- The camera can be powered either by PoE or by a wall adapter connected to the 17-pin M12 I/O connector.

The MV4 10 GigE fibre cameras are interfaced to external components via

- an LC connector for multimode fibre (through included SFP+ cage) 10G fibre connector to transmit configuration, image data and trigger.
- a 17-pin M12 I/O connector with 4 digital inputs 3 digital outputs and one RS485 interface.
- The camera is powered by a wall adapter connected to the 17-pin M12 I/O connector.

Fig. 14.1, Fig. 14.2 and Fig. 14.3 show the plugs and the status LED which indicates camera operation.

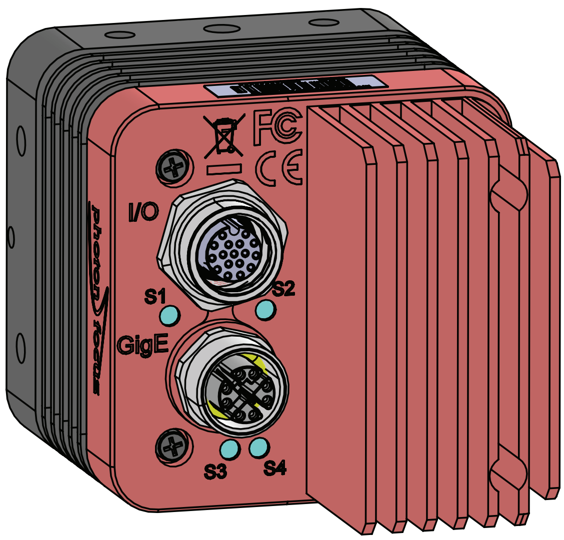

Figure 14.1: Rear view of the MV4 GigE (G2) camera

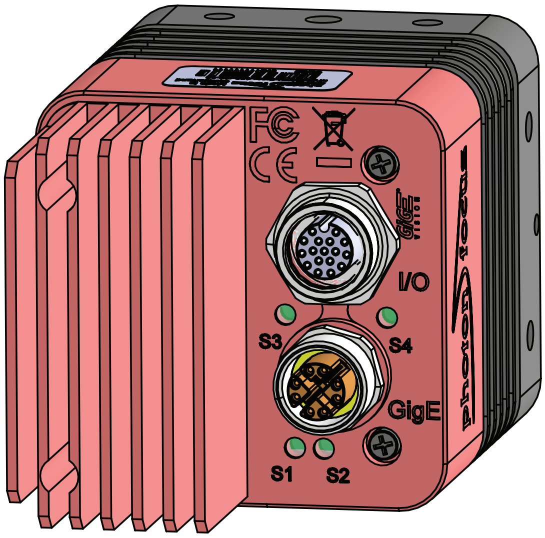

Figure 14.2: Rear view of the MV4 10 GigE (GT) camera

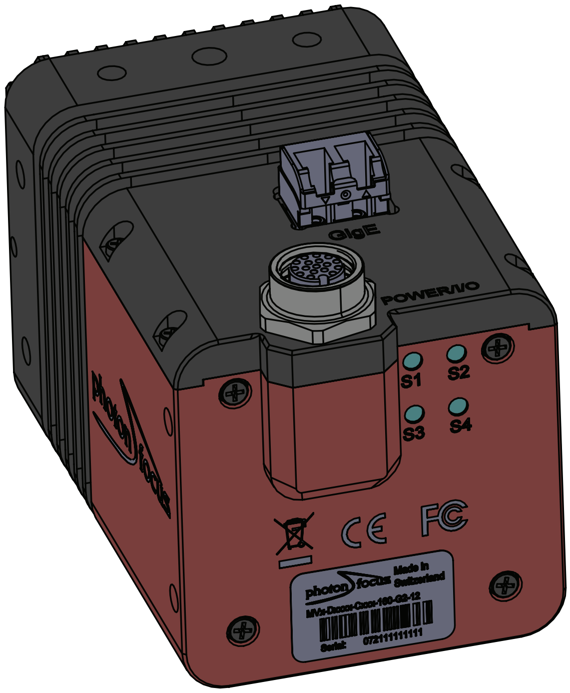

Figure 14.3: Rear view of the MV4 10 GigE fibre (FB) camera

14.4 Power Supply / Power Over Ethernet (PoE)

When the camera is powered via wall adapter it requires a single voltage input (see Table 3.4). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear power supplies provide optimum performance.

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

When using wall adapter, an input voltage of 12V has a better efficiency in the internal power supply heat generation instead of supplying 24V.

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

The GigE and 10GigE copper cameras can also be powerd over ethernet (PoE).

PoE is compliant according to IEEE 802.3bt standard Class 4: (25.5 W). Maximum working voltage according to Standard: 57V at PD side.

Suitable PoE injector can be ordered from your Photonfocus dealership.

14.5 Status Indicator (GigE cameras)

Four LEDs (S1, S2, S3 and S4) on the back of the camera give information about the current status of the GigE CMOS cameras.

Function	GigE (G2)	10 GigE Copper (GT)	10 GigE Fibre (FB)
IO Fault	S1 red	S3 red	
RS485 Activity	S1 green	S3 green	
LED0 (User Led)	S2 green	S4 green	
LED1 (User Led)	S2 orange	S4 orange	
Link Activity	S4 orange (blink)	S2 red (blink)	—
GigE Link established	S3 green (solid)	—	—
10 GigE Link established	—	S1 green (solid)	—
1, 2.5 or 5 GigE Link established	—	S1 red (solid)	—
SFP TX Fault	—	—	S1 red
SFP Fibre Loss	—	—	S2 red

Table 14.7: LED S1, S2, S3 and S4 configuration of the CMOS cameras

IO Fault Voltage fault indication (see Section 14.6.2)

RS485 Activity On: RS485 communication active; Off: RS485 communication inactive

LED0 (User Led) User configurable with LineSelector LED0 in the section DigitalIOControl. Default Configuration: It pulsates, when the camera is not grabbing images. It means, the intensity starts from dark and goes slowly to bright and slowly to dark again. 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.

LED1 (User Led) User Configurable with LineSelector LED1 in the section DigitalIOControl. Default Configuration: Indicates an active serial communication with the camera.

Link Activity On: GigE communication active; Off: GigE communication inactive

GigE Link established On: GigE Link established; Off: No Link established

10 GigE Link established On: 10GigE link established; Off: No Link established

1, 2.5 or 5 GigE Link established On: 1, 2.5 or 5GigE link established with a 10GigE camera; Off: No Link established

SFP TX Fault On: SFP TX Fault detected; Off: No SFP TX fault

SFP Fibre Loss On: Fibre Loss detected; Off: No Fibre loss

14.6 I/O Connector

14.6.1 Overview

The 17-pin M12 I/O connector contains four external line inputs, three external line outputs and one optional RS485 communication interface. All inputs and outputs are isolated.

The pinout of the I/O connector is described in Appendix A.

A suitable trigger breakout cable, as well as a breakout box, for 17-pin M12 I/O connector can be ordered from your Photonfocus dealership.

Fig. 14.4 shows the schematic of the inputs and outputs for the I/O interface.

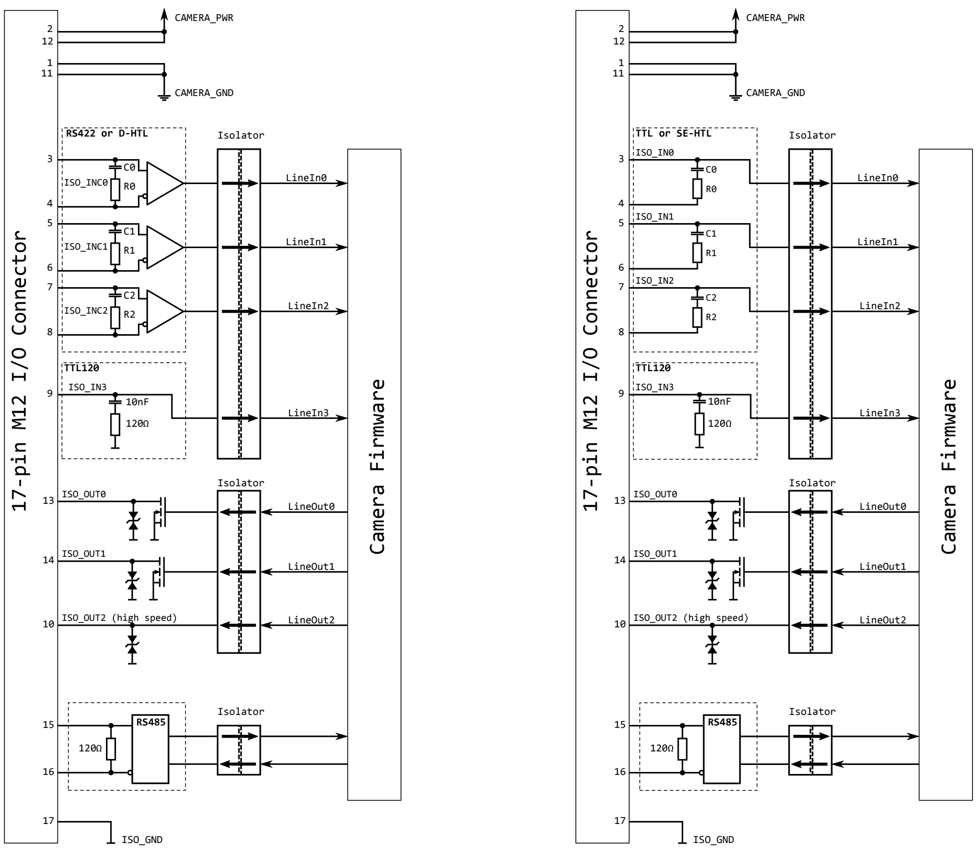

Figure 14.4: Schematic of camera inputs and outputs

The input standard of LineIn0, LineIn1 and LineIn2 is user configurable. Each of these three inputs can be configured individually. Three single ended and two differential input standards are available. The input termination and capacity is set automatically according to the input standard configuration. Table 14.8 shows the available input standards.

I/O Standard	Signalling	R0, R1 & R2	C0, C1, & C2	Threshold
TTLTerminated120	Single Ended	120 Ω	10 nF	n.a.
TTLTerminated270	Single Ended	270 Ω	100 pF	n.a.
RS422	Differential	120 Ω	10 nF	n.a.
D-HTL	Differential	270 Ω	100 pF	n.a.
SE-HTL Low Threshold [1)]	Single Ended	270 Ω	100 pF	7 V
SE-HTL High Threshold [1)]	Single Ended	270 Ω	100 pF	12 V

Table 14.8: Available input standards of LineIn0, LineIn1 and LineIn2 (Footnotes: [1)] The HTL treshold configuration is set globally to all inputs, which are configured as single ended HTL.)

Differential P and N input is available on the 17-pin I/O connector, when a differential input standard is selected.

If a single ended I/O standard is configured, only the P input is available. The N input must be tied to ISO_GND externally.

The input standard of LineIn3 is TTL and terminated with a 120 Ω resistor and can't be changed. This line can be used either as a normal camera line input or as an encoder alarm indication. If used as an encoder alarm indication it must be activated by setting the `EncoderAlarmMode` to `True`. Otherwise this configuration must be set to `False`.

The isolated RS485 input on the 17-pin I/O connector is optional. Please contact Photonfocus for activation.

14.6.2 Input Fault Detection

All inputs support a fault detection which signalises irregular conditions such as small differential signals, shorts, opens, overvoltages and undervoltages. The fault condition of each input can be read out by a software parameter. A fault condition remains active until it is acknowledged by a software command.

Additionally Led S1 signalises the fault condition on LineIn0 and LineIn1. It turns on, when a fault condition exists and turns automatically off when the input fault is resolved.

Section 14.2 lists the input range, the corresponding logic levels and fault conditions.

Unused inputs should be configured as single ended and the N-input must be tight to ISO_GND in order not to get an I/O fault condition.

If an error condition has been detected on an input and signalized by the `LineFault` parameter, it must be acknowledged by the `LineFaultAcknowledge` command in order to use or reconfigure the corresponding input again.

Parameter `LineFaultUpdate` must be performed in order to update the error state.

14.6.3 Single-ended Line Input

LineIn0, LineIn1 or LineIn2 can be configured as single-ended input (Table 14.8 lists the available standards). Fig. 14.5 shows two examples, how a single-ended configured input can be used.

The inputs must be driven by a push-pull stage or an open drain output with a pull-up resistor.

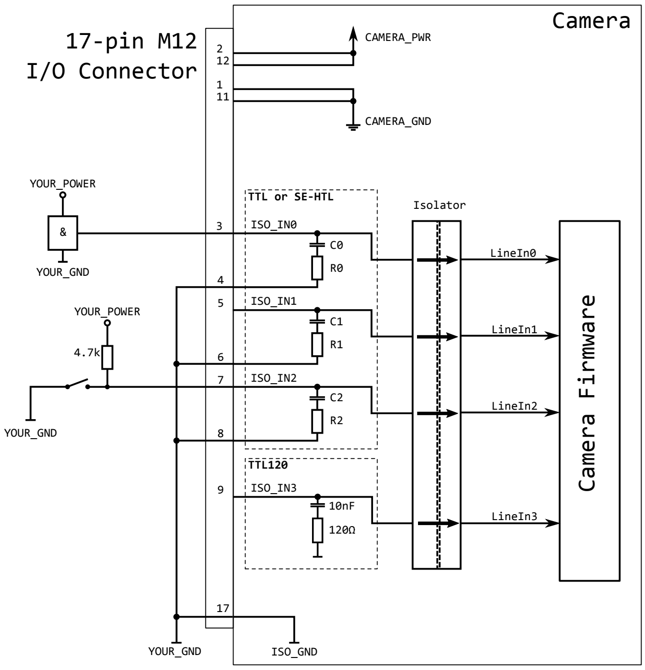

Figure 14.5: Example of input connections

14.6.4 Encoder Interface

Fig. 14.6 and Fig. 14.7 show, how differential and single ended encoder must be connected to the GigE camera's I/O interface. Encoder A and B singals must be connected to LineIn0 and LineIn1. They can be connected in either way, as long as the encoder is configured accordingly Section C.5.

If available on the encoder, the Z signal must be connected to LineIn2 and the Y/ALARM to LineIn3.

The `EncoderAlarmMode` of the encoder configuration must be set to `True` in order to use the alarm indication.

Consider the polarity of the encoders Y/ALARM signal. The LineIn3 must be inverted, when the Y/ALARM signal is low active.

The Z signal is a single pulse that occurs once every shaft encoder rotation. It can be used to reset the encoder (Section 6.4).

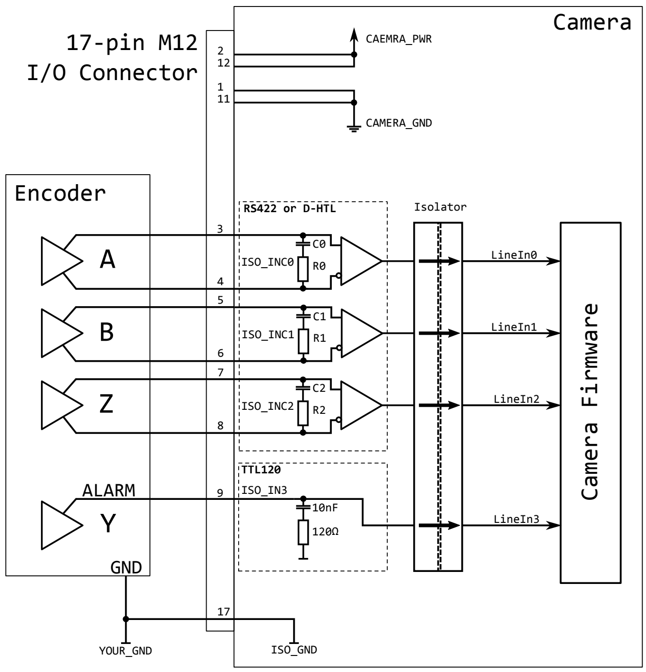

Figure 14.6: Connection of a differential encoder

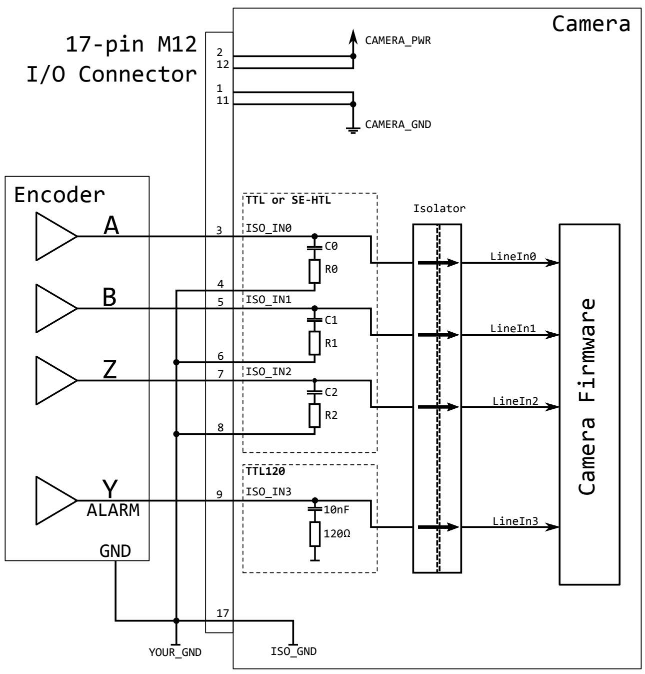

Figure 14.7: Connection of a single ended encoder

14.6.5 Single-ended Line Output

ISO_OUT0, ISO_OUT1 and ISO_OUT2 are single-ended isolated output.

Fig. 14.8 shows the connection from the ISO_OUT output to a TTL logic device.

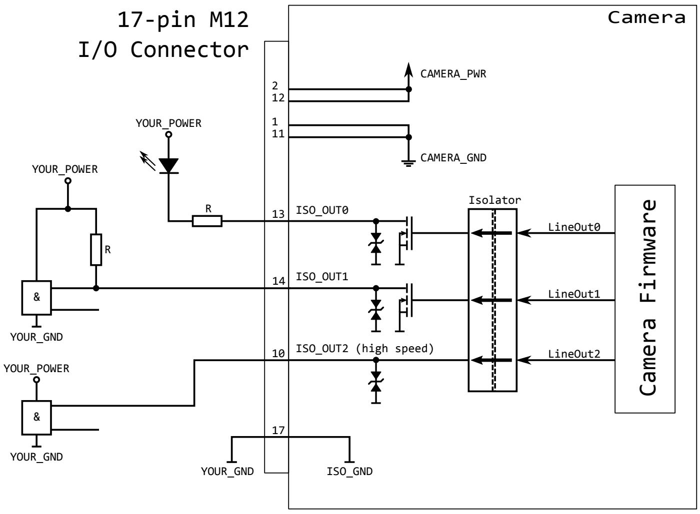

Figure 14.8: Example of output connection

Respect the limits of the opto-isolator in the connection to ISO_OUT. Maximal ratings that must not be exceeded: voltage: 30 V, current: 0.5 A, power: 0.5 W. (see also Fig. 14.9).

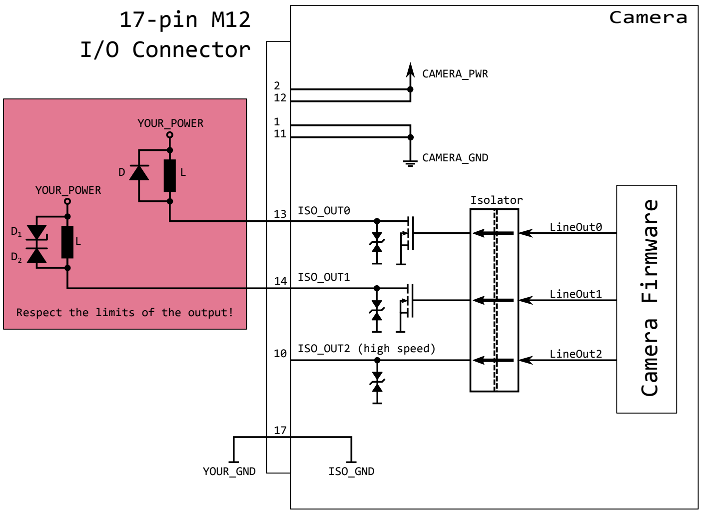

Figure 14.9: Limits of ISO_OUT output

14.6.6 Master / Slave Camera Connection

The line output of one Photonfocus GigE camera can easily be connected to a line input of another Photonfocus GigE camera as shown in Fig. 14.10. This results in a master/slave mode where the slave camera operates synchronously to the master camera.

A pull up resistor is necessary, when an open drain output (ISO_OUT0 or ISO_OUT1) is used, which is shown in the connection A in Fig. 14.10. When ISO_OUT2 is used (see connection B in Fig. 14.10), which is a high speed TTL output, it can be connected to any of the four single ended input without a pull up resistor.

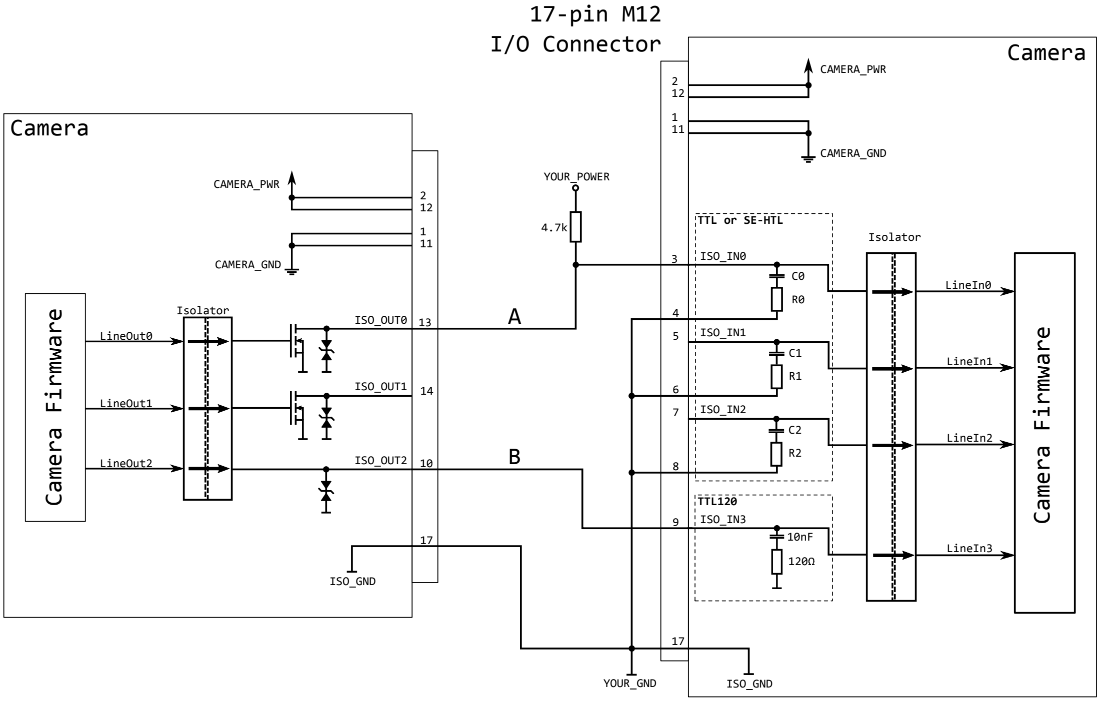

Figure 14.10: Master / slave connection of two Photonfocus GigE cameras

14.7 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) from camera power (CAMERA_GND, CAMERA_PWR)
- Using a common power supply for camera and I/O signals with star-wiring

14.7.1 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_IN, ISO_OUT) is one way to avoid ground loops. Fig. 14.11 shows a schematic of this setup. In this setup the power supplies for the camera and for ISO power must be separate devices.

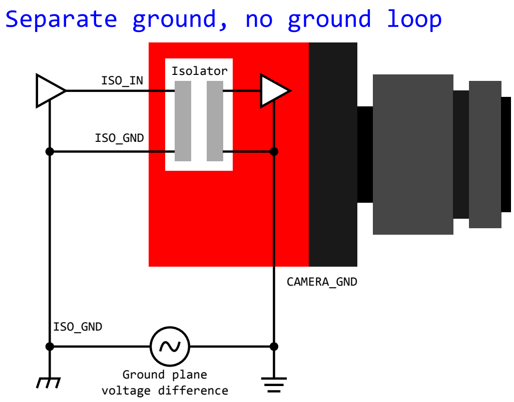

Figure 14.11: I/O wiring using separate ground

14.7.2 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. 14.12 shows a schematic of the star-wiring concept.

Fig. 14.13 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".

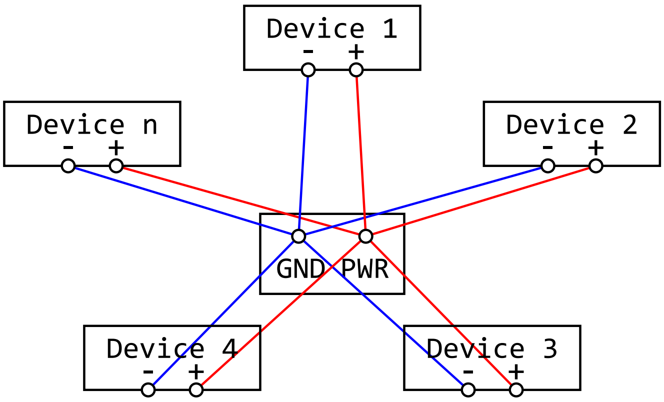

Figure 14.12: Star-wiring principle

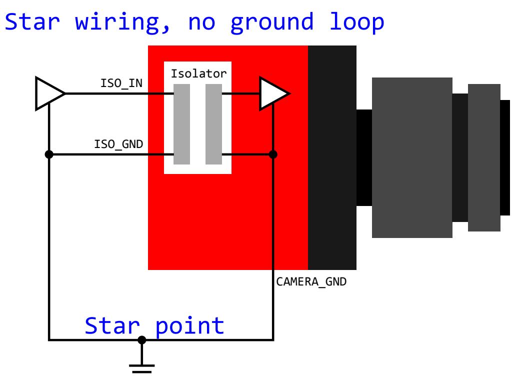

Figure 14.13: I/O wiring using star-wiring

Fig. 14.14 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.

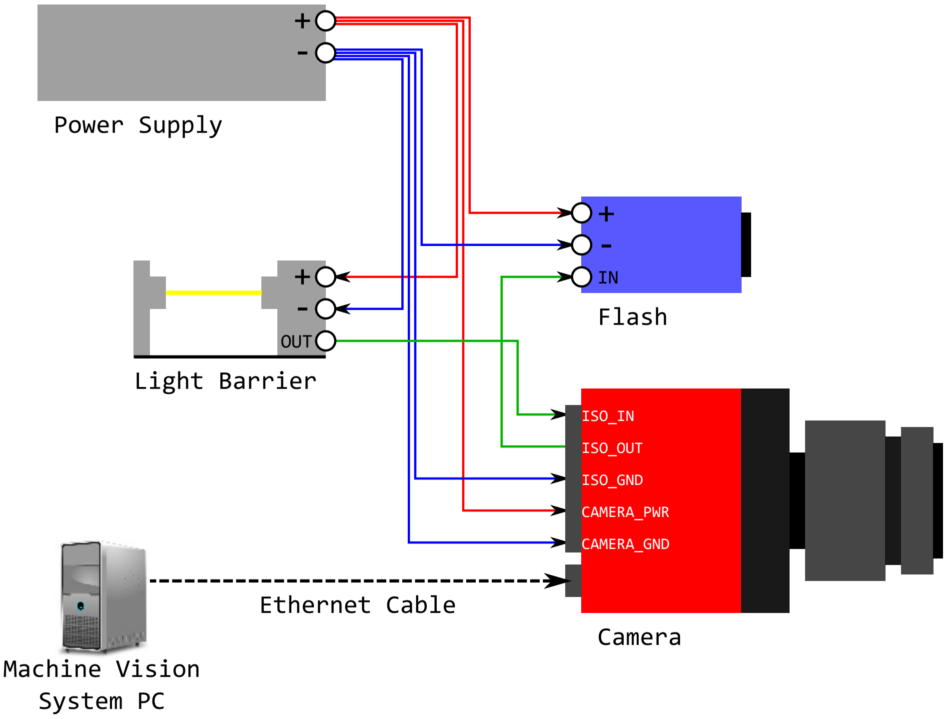

Figure 14.14: I/O wiring using star-wiring example

An example of improper wiring that causes a ground loop is shown in Fig. 14.15.

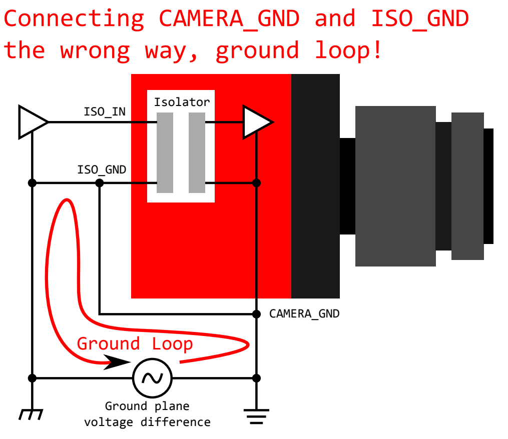

Figure 14.15: Improper I/O wiring causing a ground loop

15 Mechanical Considerations

15.1 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.

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.

15.1.1 MV4-D1280-L01 with GigE Interface

Fig. 15.1, Fig. 15.2, Fig. 15.3 and Fig. 15.4 show the mechanical drawing of the camera housing for the Photonfocus MV4-D1280-L01 GigE camera series.

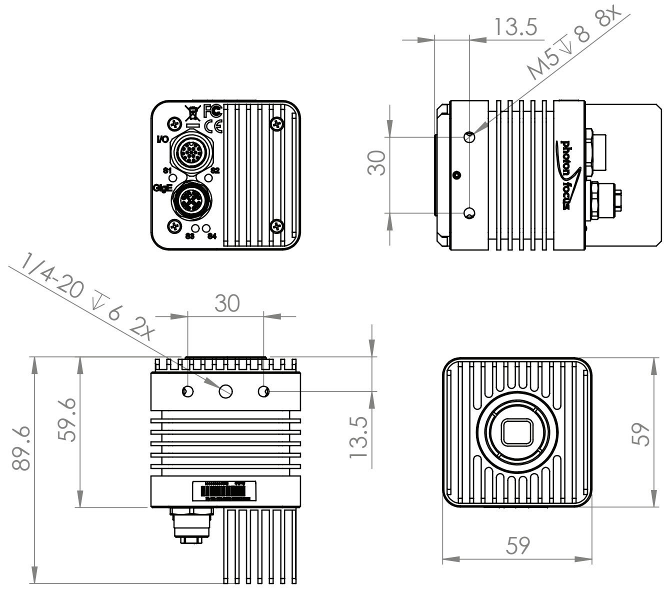

Figure 15.1: Mechanical dimensions of the Photonfocus MV4-D1280-L01 Luxima GigE cameras

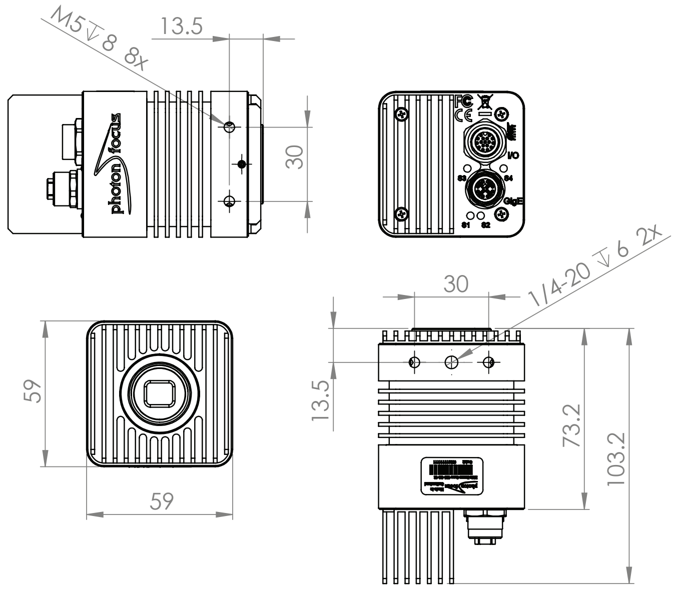

Figure 15.2: Mechanical dimensions of the Photonfocus MV4-D1280-L01 Luxima 10 GigE copper cameras

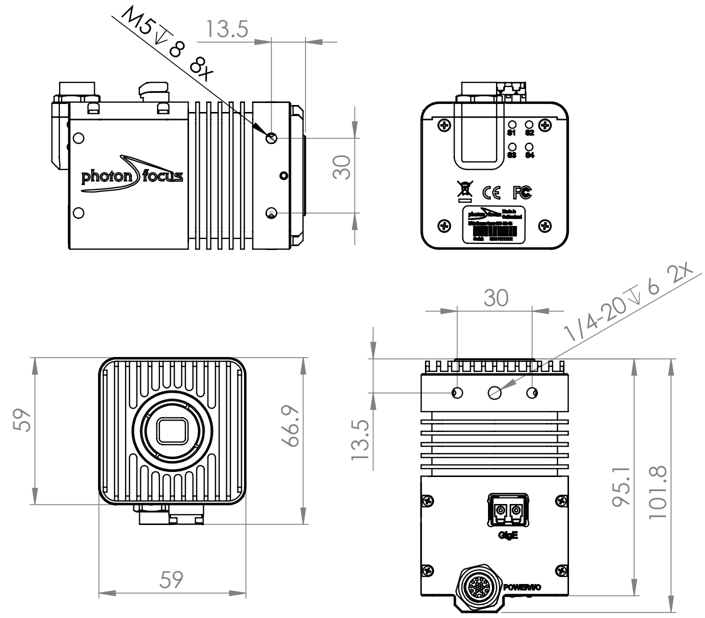

Figure 15.3: Mechanical dimensions of the Photonfocus MV4-D1280-L01 Luxima 10 GigE fibre cameras

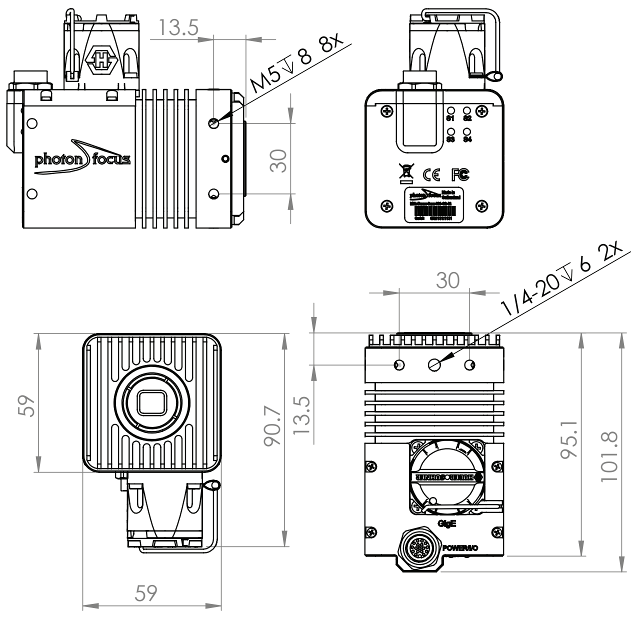

Figure 15.4: Mechanical dimensions of the Photonfocus MV4-D1280-L01 Luxima 10 GigE ruggedized fibre cameras

15.1.2 MV4-D1952-L01 with GigE Interface

Fig. 15.5, Fig. 15.6, Fig. 15.7 and Fig. 15.8 show the mechanical drawing of the camera housing for the Photonfocus MV4-D1952-L01 GigE camera series.

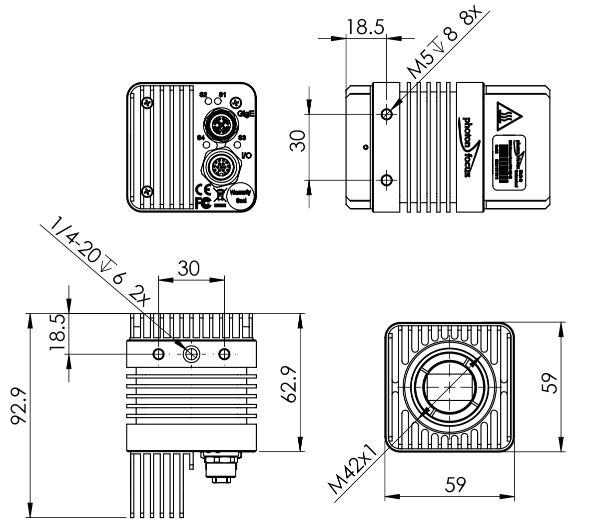

Figure 15.5: Mechanical dimensions of the Photonfocus MV4-D1952-L01 Luxima GigE cameras

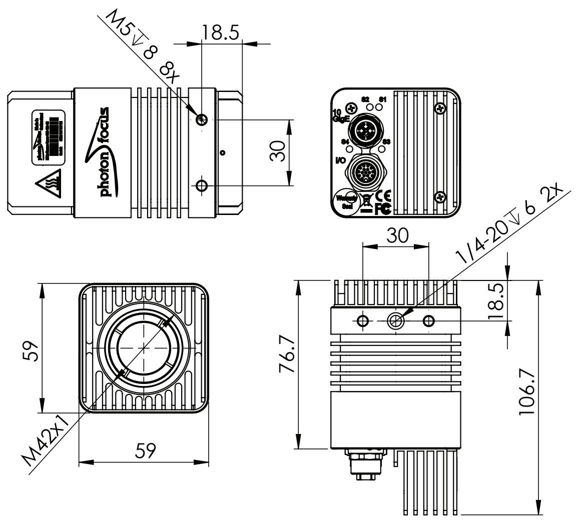

Figure 15.6: Mechanical dimensions of the Photonfocus MV4-D1952-L01 Luxima 10 GigE copper cameras

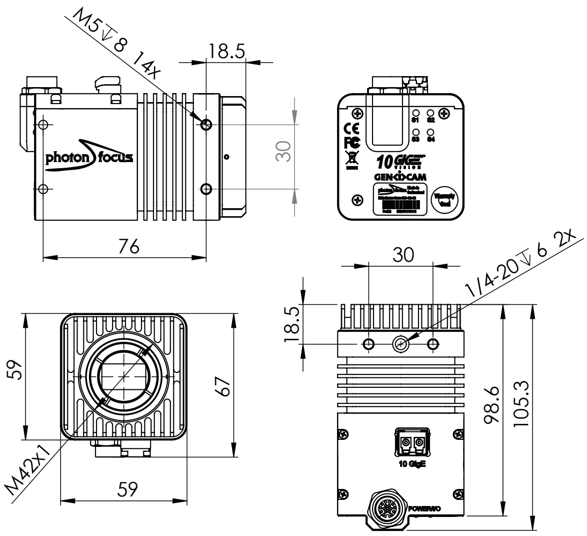

Figure 15.7: Mechanical dimensions of the Photonfocus MV4-D1952-L01 Luxima 10 GigE fibre cameras

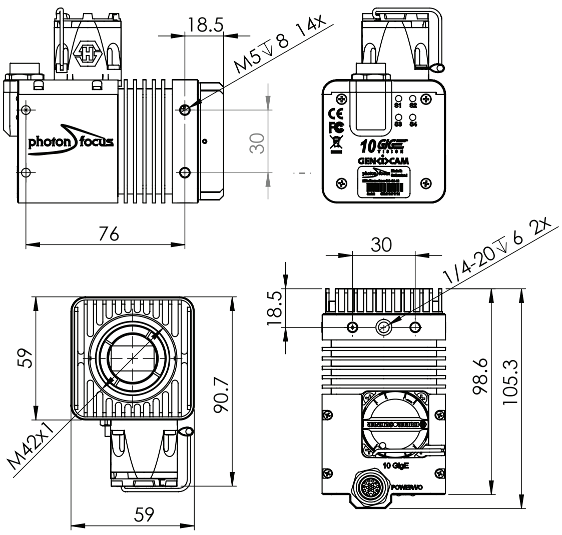

Figure 15.8: Mechanical dimensions of the Photonfocus MV4-D1952-L01 Luxima 10 GigE ruggedized fibre cameras

The MV4-D1952-L01 GigE camera series comes with an M42 lens mount. A C-mount adapter is available. Fig. 15.12 and Fig. 15.13 show the mechanical drawing of the adapter.

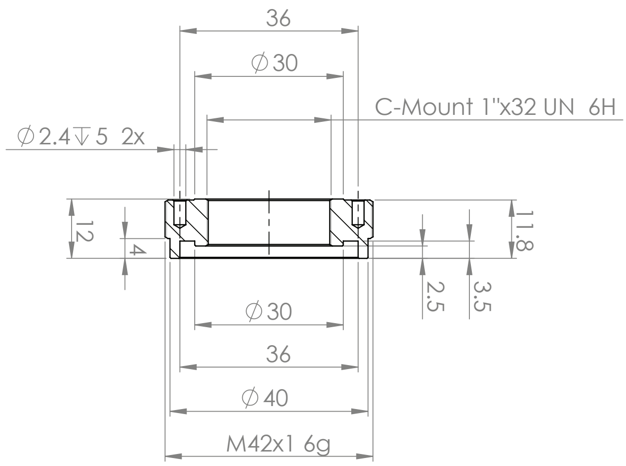

Figure 15.9: Mechanical dimensions of the MV4 C-mount M42 adapter

Figure 15.10: MV4 C-mount M42 adapter

The adapter ring can be inserted by screwing it into the M42 mount of the camera front. There are two screws on both side of the camera to lock the adapter. The back focus need to be adjusted. The procedure is shown in Section 15.2.

Figure 15.11: Position of the 2 small screws that lock C-mount-m42 adapter.ring

15.1.3 C-mount M42 Adapter

The MV4-D1952-L01 GigE camera series comes with an M42 lens mount. A C-mount adapter is available. Fig. 15.12 and Fig. 15.13 show the mechanical drawing of the adapter.

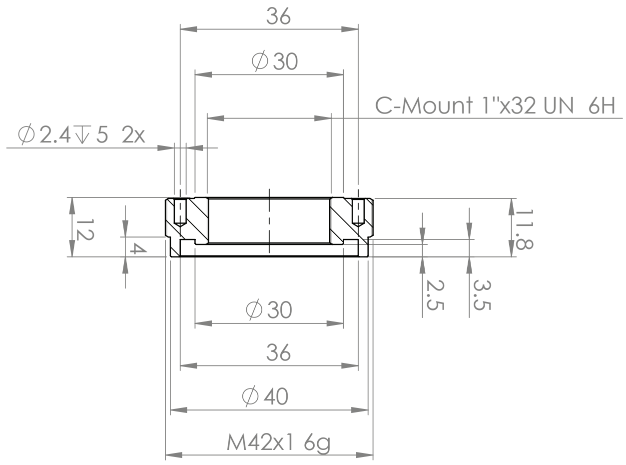

Figure 15.12: Mechanical dimensions of the MV4 C-mount M42 adapter

Figure 15.13: MV4 C-mount M42 adapter

The adapter ring can be inserted by screwing it into the M42 mount of the camera front. There are two screws on both side of the camera to lock the adapter. The back focus need to be adjusted. The procedure is shown in Section 15.2.

Figure 15.14: Position of the 2 small screws that lock C-mount-m42 adapter.ring

15.2 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 2 small screws that lock the C-mount ring with a hex-wrench of size 1.27 mm. The position of the screws is shown in Fig. 15.15. 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 15.15: Position of the 2 small screws that lock C-mount.ring

15.3 Optical Interface

15.3.1 Cleaning the Sensor

The sensor is part of the optical path and should be handled like other optical components: **with extreme care**.

Dust can obscure pixels, producing dark patches in the images captured. Dust is most visible when the illumination is collimated. Dark patches caused by dust or dirt shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

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

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

3. If further cleaning is required, use a suitable lens wiper or Q-Tip moistened with an appropriate cleaning fluid to wipe the sensor surface as described below. Examples of suitable lens cleaning materials are given in Table 15.1. Cleaning materials must be ESD-safe, lint-free and free from particles that may scratch the sensor surface.

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

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

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

Table 15.1: Recommended materials for sensor cleaning

For cleaning the sensor, Photonfocus recommends the products available from the suppliers as listed in Table 15.1.

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

16 Troubleshooting

16.1 No images can be acquired

If no images can be acquired then the cause could be one of the following:

1. Camera is not triggered: see Section 16.1.1

First proceed with the above list in numerical order. If still no images can be acquired go back to step 2. If the problem persists then write an e-mail to Photonfocus support (support@photonfocus.com).

16.1.1 No acquisition due to no triggers

Set the camera to the free-running trigger mode (see Section C.1.1).

If no images can be acquired in free-running mode then triggering is not the main cause of the acquisition problem.

If images can be acquired in free-running mode but not in your chosen trigger mode then check the trigger configuration (see Section C.1.3 and Section C.1.4), or the electrical connection of the trigger signal (see also Section 14.6).

17 Standards Compliance

17.1 Directives and General Standards

The products described in this manual in the form as delivered are in conformity with the provisions of the following European Directives:

- 2014/30/EU Electromagnetic compatibility (EMC)
- 2014/35/EU Low Voltage (LVD)
- 2011/65/EU Restriction of hazardous substances (RoHS)

Conformity to the Directives is assured through the application of the following standards:

Emission:

- EN 55032:2015/AC:2016-07: Electromagnetic compatibility of multimedia equipment - Emission requirements – Radio disturbance characteristics, Limits and methods of measurements, class A
- FCC (2010) Part 15: Limit for digital devices, class A
- EN 61000-6-4:2007/A1:2011: Generic standards – Emission standard for industrial environments

Immunity:

- EN55035:2017: Electromagnetic compatibility of multimedia equipment - Immunity requirements
- EN 61000-6-2:2017: Generic standards –Immunity standard for industrial environments
  - EN 61000-4-2:2009: Electronic discharge immunity tests
  - EN 61000-4-3:2006/A1:2008/A2:2010: Radiated, radio-frequency, electromagnetic field immunity test
  - EN 61000-4-4:2012: Electrical fast transient/burst immunity test
  - EN 61000-4-5:2014: Surge immunity test
  - EN 61000-4-6:2014: Immunity to conducted disturbances, induced by radio-frequency fields

17.2 Country-specific Information

17.2.1 For customers in the USA

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart B of Part 15 of FCC Rules.

17.2.2 For customers in Canada

This apparatus complies with the Class A limits for radio noise emissions set out in Radio Interference Regulations.

17.2.3 Pour utilisateurs au Canada

Cet appareil est conforme aux normes Classe A pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

17.3 Life support applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Photonfocus customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Photonfocus for any damages resulting from such improper use or sale.

18 Warranty

The manufacturer alone reserves the right to recognize warranty claims.

18.1 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.

18.2 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.

18.3 Breach of Warranty

To ensure that your warranty remains in force, adhere to the following rules:

1. Do not open the housing or destroy the warranty seal of the camera. Touching internal electronic components of the camera may damage the camera electronic.
2. Do not remove the camera serial number label. If the label is removed and the serial number cannot be read out from the camera registers, the product identification and the product traceability is no longer ensured.
3. Avoid mechanical stress and damage of the camera connectors and the camera housing. Secure the external connectors and cables against unusual force effects.
4. Avoid power supply voltage levels above the camera specifications and reverse voltages.
5. Avoid compensation currents over data cables. Use appropriate ground connections and grounding materials in the installation of your vision system to ensure equal potential of all chassis earth in your system.
6. Avoid electromagnetic fields strengths and electrostatic charging levels which are over the limits of the industrial standards cited in the conformity declaration of the camera.
7. Prevent the camera especially water and moisture ingress. Prevent any liquid, flammable, or metallic substances from entering the camera case.

8. Avoid cleaning the sensor with improper methods. Follow the instructions in the corresponding chapter of this manual.
9. Transport and store the camera in its original packaging only and protect the sensor and the lens mount with a camera body cap.
10. Read the manual carefully before installing and using the camera.

19 Support and Repair

This chapter describes the product support and repair.

19.1 Technical Support

First level technical support is given from the sales department of Photonfocus or your local dealer. In case your issue could not be solved in this way Photonfocus support team takes over. The Photonfocus support team is available via email: support@photonfocus.com. For an efficient handling of your case we need the following information from you:

1. Camera model name,
2. Camera serial number and
3. Detailed description of the issue.

With the camera name and serial number we can determine the exact product status in our production data base. Without these numbers we cannot provide support for your issue. Before mailing the support make sure that your description is based on the latest revision of the camera manual and driver software. The camera manual and the latest driver software can be downloaded from the Photonfocus homepage: www.photonfocus.com. Perform a factory reset to be sure that the issue is not caused by your application settings or application software.

In cases you need sales support contact the Photonfocus sales team via email: <sales@photonfocus.com>.

19.2 Repair and obtaining an RMA Number

Whenever you want to return a camera to Photonfocus contact first the Photonfocus support to be sure that the camera has to be repaired. In a repair case you will get from Photonfocus a Return Material Authorization (RMA) number. The RMA number must be stated in your delivery documents. Please send us together with the RMA a detailed description of the error.

In a warranty case we will repair the camera and return the camera to you with a repair report. In cases without warranty we determine the effort to repair the camera. Before repair we will send you an offer for the repair costs. With your acceptance the camera will be repaired and shipped back to you. The repair will be documented in a repair report.

19.3 Temporal Abandoning and Scrapping

If you want to take the camera temporally out of service close the optical interface with the camera body cap and store the camera in the camera transport package or comparable package. Best practice is to seal the camera in an anti-static plastic bag

If you scrap your vision system or machine be aware that this camera must be disposed of in compliance with the directive 2002/96/EC on waste electrical and electronic equipment (WEEE).

20

References

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

A

Pinouts

A.1 I/O Connector

The I/O plug is available from PHOENIX CONTACT connectors www.phoenixcontact.com. Fig. A.1 shows the I/O plug from the solder side. The pin assignment of the I/O 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 14.6.

Suitable I/O cables can be ordered from your Photonfocus dealership.

Connector Type	Order Nr.
P/T/S Cable M12 17-pin, PUR/PVC, 1.5m	704090.070
P/T/S Cable M12 17-pin, PUR/PVC, 3.0m	704090.071
P/T/S Cable M12 17-pin, PUR/PVC, 5.0m	704090.072

Table A.1: I/O cables with 17-pin M12

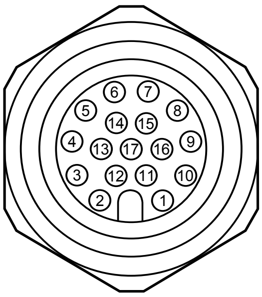

Figure A.1: Schematic of I/O connector plug

Pin	*I/O Type*	*Name*	*Description*
1	PWR	CAMERA_GND	Camera GND, 0V
2	PWR	CAMERA_PWR	Camera Power
3	I	ISO_INC0_P / ISO_IN0	Differential configuration: Isolated RS422/HTL differential input, positive polarity. Single ended configuration: Isolated TTL/HTL single ended input.
4	I	ISO_INC0_N / ISO_GND	Differential configuration: Isolated RS422/HTL differential input, negative polarity. Single ended configuration: Must be tied to ISO_GND.
5	I	ISO_INC1_P / ISO_IN1	Differential configuration: Isolated RS422/HTL differential input, positive polarity. Single ended configuration: Isolated TTL/HTL single ended input.
6	I	ISO_INC1_N / ISO_GND	Differential configuration: Isolated RS422/HTL differential input, negative polarity. Single ended configuration: Must be tied to ISO_GND.
7	I	ISO_INC2_P / ISO_IN2	Differential configuration: Isolated RS422/HTL differential input, positive polarity. Single ended configuration: Isolated TTL/HTL single ended input.
8	I	ISO_INC2_N / ISO_GND	Differential configuration: Isolated RS422/HTL differential input, negative polarity. Single ended configuration: Must be tied to ISO_GND.
9	I	ISO_IN3	Isolated TTL input
10	O	ISO_OUT2	Isolated TTL output
11	PWR	CAMERA_GND	Camera GND, 0V
12	PWR	CAMERA_PWR	Camera Power
13	O	ISO_OUT0	Isolated open drain output
14	O	ISO_OUT1	Isolated open drain output
15	IO	RS485_DATA_P	RS485 interface data positive polarity
16	IO	RS485_DATA_N	RS485 interface data negative polarity
17	PWR	ISO_GND	Isolated I/O GND

Table A.2: I/O connector plug pin assignment

A.2 GigE Connector

An X-coded M12 connector is used for the GigE interface and power supply of the camera.

Suitable GigE interface cables can be ordered from your Photonfocus dealership.

B

Camera Timing

B.1 Timed Exposure Mode Camera Timing

Fig. B.1 shows a timing example, when the camera capture frames with rising edges on the camera ISO_IN input. The external signal, which is fed into the cameras ISO_IN input is isolated by an opto-isolator. This signal is delayed by t_{iso-in} before it reaches the FPGA input "Line In". The "Line In" signal is synchronized to the FPGA clock domain and the rising edge is detected. There is a clock uncertainty because of the synchronization logic which is shown by the $t_{input-jitter}$ value. The input pulse can be delayed by the trigger delay feature (see Section 4.6.6) according to the requirement of the application. Finally the exposure time cycle starts after an offset delay $t_{exposure-offset}$.

When the application needs a strobe pulse together with the image acquisition, the internal line in pulse can also be used to start one of the timer. After the timer delay $t_{timer-delay}$ the timer duration $t_{timer-duraton}$ is started which is shown by the timer active signal (see Section 5.2). The timer active signal needs to be selected to output it on "Line Out" (see Section 7.2), which has a fix delay of $t_{lineout-offset}$. The "Line Out" is isolated by an opto-isolator from the camera electronics which leads to an additional delay of $t_{iso-out}$.

The maximum exposure offset value $t_{exposure-offset}$ is up to the read out time of one image row, when a new exposure starts during read out of the previous image. In this case, the start of the exposure is postponed to the start of the next image row read out.

Table B.1 and Table B.2 give an overview of the minimum and maximum values of the timing parameters.

Timing Parameter	Min Value	Max Value
t_{iso-in}	20 ns	165 ns
$t_{input-jitter}$	33.3 ns	44.4 ns
$t_{pulse-delay}$	0 s	0.186 s
$t_{exposure-offset}$	66.7 ns	66.7 ns [1] / (time of 1 image row 5.34 μs) [2]
$t_{exposure}$	10 μs	0.186 s
$t_{timer-delay}$	0 s	47.7 s
$t_{timer-duration}$	0 s	47.7 s
$t_{lineout-offset}$	44.4 ns	44.4 ns
$t_{iso-out}$ (ISO_OUT0 and ISO_OUT1)	150 ns	350 ns
$t_{iso-out}$ (ISO_OUT2)	15 ns	30 ns

Table B.1: LUX1310 Camera timing parameter values of the timed exposure mode (Footnotes:[1] New exposure starts after readout of previous image; [2] New exposure starts during readout of previous image)

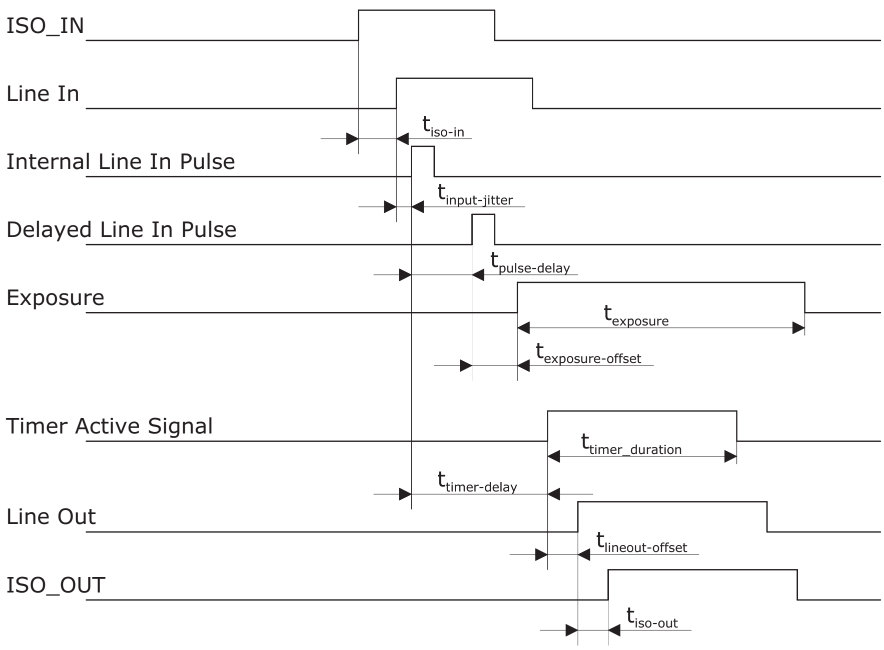

Figure B.1: Timing diagram for the timed exposure mode

Timing Parameter	Min Value	Max Value
t_{iso-in}	20 ns	165 ns
$t_{input-jitter}$	40.0 ns	53.3 ns
$t_{pulse-delay}$	0 s	0.224 s
$t_{exposure-offset}$	80.0 ns	80.0 ns [1] / (time of 1 image row 18.42 μs) [2]
$t_{exposure}$	10 μs	0.224 s
$t_{timer-delay}$	0 s	57.2 s
$t_{timer-duration}$	0 s	57.2 s
$t_{lineout-offset}$	53.3 ns	53.3 ns
$t_{iso-out}$ (ISO_OUT0 and ISO_OUT1)	150 ns	350 ns
$t_{iso-out}$ (ISO_OUT2)	15 ns	30 ns

Table B.2: LUX2100 Camera timing parameter values of the timed exposure mode (Footnotes:[1] New exposure starts after readout of previous image; [2] New exposure starts during readout of previous image)

C

Use Cases

This chapter shows some typical configurations of the camera. It gives some tips, how to acquire images and how to use the general purpose counters and timers.

C.1 Acquisition

This section shows some configuration procedures of frequently used acquisition situations.

C.1.1 Camera runs in "free-running" mode

The camera needs to start acquiring images as fast as possible as soon as the command `AcquisitionStart()` has been performed. The following configuration procedure must be applied:

1. The `TriggerMode` of the `AcquisitionStart`-, `FrameStart`-, `FrameBurstStart`- and `ExposureStart`-trigger must be set to `Off`.
2. Parameter `EnAcquisitionFrameRate` must be set to `False`.
3. The required image `Width` and `Height` must be set.
4. The required `PixelFormat` must be set.
5. `AcquisitionMode` must be set to `Continuous`.
6. The software command `AcquisitionStart()` must be applied.

C.1.2 Camera runs in "constant frame rate" mode

In some application it is necessary, that the camera acquires image at a certain frame rate. This mode is similar to the "free-running" mode, however a required frame rate can be configured additionally. The following configuration procedure shows how to set the camera in the constant frame rate mode:

1. The `TriggerMode` of the `AcquisitionStart`, `FrameStart`, `FrameBurstStart`- and `ExposureStart` trigger must be set to `Off`.
2. Parameter `EnAcquisitionFrameRate` must be set to `True`.
3. Either the `AcquisitionFrameTime` or `AcquisitionFrameRate` must be set accordingly.
4. The required image `Width` and `Height` must be set.
5. The required `PixelFormat` must be set.
6. `AcquisitionMode` must be set to `Continuous`
7. The software command `AcquisitionStart()` must be applied.

C.1.3 Camera runs in triggered mode

The camera can be triggered by a software or hardware signal. In this mode, a frame is started on every generated trigger signal. The following configuration procedure shows how to set the camera in triggered mode:

1. The TriggerMode of FrameStart trigger must be set to On. The AcquisitionStart, FrameBurstStart and the ExposureStart must be set to Off.
2. The TriggerSource of the FrameStart trigger must be set to the corresponding source. For instances to Line0.
3. Since the source is set to Line0, the TriggerActivation must be set accordingly: RisingEdge, FallingEdge or AnyEdge.
4. TriggerDelay and TriggerDivider of the FrameStart trigger must be set accordingly.
5. The required image Width and Height must be set.
6. The required PixelFormat must be set.
7. AcquisitionMode must be set to Continuous.
8. The software command AcquisitionStart() must be applied.

After these configurations, the camera is waiting for the corresponding signal edge of the selected trigger source, in this case Line0.

It might be necessary to adjust the polarity of the Line0 input signal. This can be done by the parameter LineInvert in the section DigitalIOControl.

If the camera must be triggered by a software signal, there are two ways, how this can be done:

- Set the TriggerSource of the FrameStart trigger to Software. A frame is started, when the TriggerSoftware() command of the FrameStart trigger is applied.
- Set the TriggerSource of the FrameStart trigger to one of the eight software signals; for instances SoftwareSignal0. A frame is started, when the command TriggerSignalPulse() in the section SoftwareSignalControl is applied (SoftwareSignalSelector must be set to SoftwareSignal0).

C.1.4 Camera runs in burst triggered mode

If a certain number of images must be acquired on a single trigger input event, the cameras frame burst start trigger feature can be used. The following configuration procedure shows how to set the camera in burst triggered mode:

1. The TriggerMode of FrameBurstStart trigger must be set to On. The AcquisitionStart, FrameStart and the ExposureStart trigger must be set to Off.
2. The TriggerSource of the FrameBurstStart trigger must be set to the corresponding source. For instances to Line0.
3. Since the source is set to Line0, the TriggerActivation must be set accordingly: RisingEdge, FallingEdge or AnyEdge.
4. TriggerDelay and TriggerDivider of the FrameBurstStart trigger must be set accordingly.
5. The number of frame within a burst must be set by parameter AcquisitionBurstFrameCount parameter.
6. Set the parameter EnAcquisitionFrameRate to False if the frames within a burst must be acquired as fast as possible.
7. If the frames within a burst must be acquired with a certain speed, set the parameter EnAcquisitionFrameRate to True and configure either AcquisitionFrameTime or AcquisitionFrameRate accordingly.
8. The required image Width and Height must be set.

9. The required PixelFormat must be set.
10. AcquisitionMode must be set to Continuous.
11. The software command AcquisitionStart() must be applied.

It might be necessary to adjust the polarity of the Line0 input signal. This can be done by the parameter LineInvert in the section DigitalIOControl.

C.1.5 Trigger controlled exposure mode

The exposure time can be controlled by an externally applied trigger signal on LineIn input. The following configuration procedure shows how to set the camera in the trigger controlled exposure mode:

1. Parameter ExposureMode must be set to TriggerControlled.
2. The TriggerMode of ExposureStart and ExposureEnd trigger must be set to On. The AcquisitionStart, FrameStart and FrameBurstStart trigger must be set to Off.
3. The TriggerSource of the ExposureStart trigger must be set to Line0.
4. The TriggerActivation of the ExposureStart trigger must be set to RisingEdge.
5. The TriggerSource of the ExposureEnd trigger must be set to Line0.
6. The TriggerActivation of the ExposureEnd trigger must be set to FallingEdge.
7. TriggerDelay and TriggerDivider of the ExposureStart and ExposureEnd trigger must be set accordingly.
8. The required image Width and Height must be set.
9. The required PixelFormat must be set.
10. AcquisitionMode must be set to Continuous.
11. The software command AcquisitionStart() must be applied.

C.2 Timer

There are four general purpose timers available. The following sections show some use cases, how the timers can be used.

C.2.1 Strobe Signal Output

The timer can be used to generate a pulse with a certain width on the LineOut output together with every exposure cycle in order to control an external light. The following procedure shows, how to configure one of the timer for this purposes:

1. Select one of the four available timers by setting of the TimerSelector to Timer0, Timer1, Timer2 or Timer3.
2. Select the timer trigger source. Set TimerTriggerSource to ExposureStart.
3. Parameter TimerTriggerActivation can be ignored. This configuration is only necessary, when Line0 input is selected as a trigger source.
4. Configure the necessary TimerDuration value and the TimerDelay value.

At this stage, the configured timer generates a pulse of a certain width and after a certain delay every time, when a new exposure cycle starts, which is indicated by the internally available TimerActive status. This signal must be connected to the camera LineOut output, which can be done in the DigitalIOControl section:

1. Set the LineSelector to LineOut0.
2. Set the LineSource of this output to the corresponding timer acitve signal: Timer0Active, Timer1Active, Timer2Active or Timer3Active.
3. Set the polarity of this output accordingly with the parameter LineInverter.

C.3 Counter

There are four general purpose counters available, which can be used to count any events in the camera. The following sections show some use cases, how the counters can be used. There are some examples of simple counter configurations as well as some more sophisticated settings.

C.3.1 Counter Reset

A counter needs to be reset in order to be activated after configuration. This can be done by the software reset command CounterReset or by an external reset source, which can be selected by the parameter CounterResetSource of the corresponding counter. Furthermore for each counter there is an automatically counter reset at acquisition start feature available: CounterAcquisitionStartReset. If it is set to True, the corresponding counter is reset when an acquisition start command is applied. Depending on the application, it might be necessary, that the current counter value must not be reset at acquisition start. In this case the parameter CounterAcquisitionStartReset must be set to False for the corresponding counter and the user must execute the parameter CounterReset manually for a first counter start.

C.3.2 Image Counter

Any of the four available counters can be used as an image counter. The following configuration procedure must be applied:

1. Select one of the four available counters by setting of the CounterSelector to Counter0, Counter1, Counter2 or Counter3.
2. Select the corresponding counter event source by the parameter CounterEventSource. Any signal source, which is generated with every frame, can be select. For instances FrameStart or ExposureStart can be selected.
3. Parameter TimerTriggerActivation can be ignored. This configuration is only necessary, when Line0 input is selected as a trigger source.
4. All other counter parameter must be left in default state (Both the CounterResetSource and CounterTriggerSource must be set to Off)
5. The counter needs to be reset (see C.3.1).

C.3.3 Real Time Counter

Any of the four available counters can be used as a real time counter. The following configuration procedure must be applied:

1. Select one of the four available counters by setting of the CounterSelector to Counter0, Counter1, Counter2 or Counter3.
2. Set the parameter CounterEventSource to TimeStampTick.
3. Parameter TimerTriggerActivation can be ignored. This configuration is only necessary, when Line0 input is selected as a trigger source.

4. Configure the time stamp tick value CounterTimeStampTickValue. For instances a value of 1 μs generates an event every 1 μs.
5. All other counter parameter must be left in default state (Both the CounterResetSource and CounterTriggerSource must be set to Off)
6. The counter needs to be reset (see C.3.1).

C.3.4 Missed Trigger Counter

For monitoring purposes it might be necessary to detect an overtriggering condition. It means, that not all applied triggers can be processed by the camera. This can be done by setting up of a missed trigger counter. Any of the four available counters can be used as a missed trigger counter. The following configuration procedure must be applied:

1. Select one of the four available counters by setting of the CounterSelector to Counter0, Counter1, Counter2 or Counter3.
2. Set the corresponding CounterEventSource to MissedAcqStartTrigger, MissedFrameStartTrigger, MissedFrameBurstStartTrigger, MissedExposureStartTrigger or MissedTrigger.
3. Parameter TimerTriggerActivation can be ignored. This configuration is only necessary, when Line0 input is selected as a trigger source.
4. All other counter parameter must be left in default state (Both the CounterResetSource and CounterTriggerSource must be set to Off)
5. The counter needs to be reset (see C.3.1).

C.4 Look-Up Table (LUT)

C.4.1 Overview

The LUT is described in detail in Section 12.5.

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

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

C.4.2 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 C.4.4.
5. Turn on LUT by setting LUTEnable to True.

C.4.3 Region LUT

The Region LUT feature is described in Section 12.5.4. 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 C.4.4.
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.

C.4.4 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 C.4.2 or Section C.4.3.

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.

C.4.5 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 C.4.2 and Section C.4.3.
2. Set LUTAutoMode (in category LUTControl) to the desired value.
3. If the LUTAutoMode requires additional settings (e.g. Gain LUTAutoMode), then it can be set with LUTAutoValue.

C.5 Encoder

This section shows the configuration procedure of an encoder. Fig. 14.6 and Fig. 14.7 show, how an encoder needs to be connected to the camera.

C.5.1 Configuration of the encoder AB signals

The A and B signal of the encoder need to be connected to LineIn0 and LineIn1. It can be connected in either way.

1. Configure the `LineFormat` of `LineIn0` and `LineIn1` according to the encoder output standard.
2. Configure `EncoderSourceA` and `EncoderSourceB` of the `EncoderControl` respectively. One must be `LineIn0` and the other `LineIn1` or vice versa, depending how the encoder is connected to the camera.
3. Configure `EncoderMode`, `EncoderDivider` and `EncoderOutputMode` accordingly.

C.5.2 Configuration of the encoder Z signal

If used, the encoder Z signal must be connected to LineIn2. The Z signal can be used to reset the encoder

1. Configure the `LineFormat` of `LineIn2` according to the encoder output standard.
2. If the Z signal is used to reset the encoder, the `EncoderResetSource` must be set to `LineIn2`.

C.5.3 Configuration of the encoder ALARM signal

If used, the encoder ALARM signal must be connected to LineIn3. The IO standard of this input is `TTLTerminated120` and can't be changed.

1. The LineIn3 must be inverted by setting the `LineInverter` to `True`, when the ALARM signal is low active.
2. Set the `EncoderAlarmMode` to `True`.
3. The parameter `EncoderAlarmUpdate` needs to be performed in order to get current value of `EncoderAlarmStatus`.
4. When an alarm has occured the parameter `EncoderAlarmAcknowledge` will acknowledge the pending alarm.

D

Document Revision History

Revision	Date	Changes
1.0	September 2019	First Version
1.1	January 2020	Updated information about Multislope Mode, Camera model MV4-D1952-L01 added
1.2	Mai 2020	Updated information about minimum exposure time; frame rate of MV4-D1280-L01-GT/FB slightly modifed
1.3	April 2021	Drawings of MV4-D1952-L01 camera models added. Wrong image sensor resolution corrected