EoSens 12CXP+ Camera
Reference Guide V1.8

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CHAPTER

1

Before You Start

Please, read this chapter carefully. It provides important information on

- how to use this reference guide
- conformity and use of the product
- the warranty and non-warranty clause and how to ask for repair service
- technical support
- the EU Declaration of conformity

About This Reference Guide

This reference guide contains helpful information to install and operate the here described camera. It has been produced with care. Nevertheless, information might be erroneous or incomplete. MIKROTRON GmbH cannot be held responsible for any problems resulting from incomplete or erroneous information.

In case you detect errors or need further information, please inform us via mail:

support.mikrotron@lakesighttechnologies.com

or call +49 89 7263 4200

We highly recommend to read this reference guide carefully.

Remark: This reference guide is subject to change without notice.

Tips, Remarks, Notes and Warnings

This reference guide contains tips, remarks, notes, and warnings that are helpful and often important in order to avoid data loss or camera damage. They are emphasized as follows:

Tip: *Gives hints.*

Remark: Important information.

Note	Indicates hazards that could damage the product or result in data loss or camera damage.

WARNING!	**Indicates hazards that might result in personal injury.**

Registered Trademarks

In this reference guide the following registered trademarks are used:

1. *EoSens*®
2. GenICam®
3. Microsoft® and Windows®

In the following, these trademarks are not specially marked as registered trademarks. This in no way implies that these trademarks can be used in another context without the trade mark sign!

Conformity and Use

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 requirements 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 instructions given in this reference guide, 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 have to correct the interference at its own expense.

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

制造说明：

此设备的生产与测试依照 FCC 条例第 15 条条例，符合 A 类电子设备标准。产品提供在商用使用环境中的合理保护，以防止使用过程中可能涉及到的损害。

此设备会产生、使用并可发射出无线电波，如果未按照本手册中所述安装和使用，可能会对无线通信设备产生干扰。如本设备在居民区操作出现干扰等情况，用户需要自费处理。

备注：请注意，如未按照此使用说明操作而自行更改设备，那么您将无权使用本设备。

規制適合宣言とご使用について（米国 FCC)
この機器は、FCC 規則のパート 15 に定められたクラス A デジタル装置に関する規制要件に基づいて所定の試験が実施され、その適合が認証されています。　これらの規制要件は、商業環境において機器を使用する際、有害な干渉に対する妥当な保護を提供するために設けられています。この機器は、無線周波数エネルギーを生成かつ利用するとともに、放射することもあります。　このリファレンスガイドの指示に従って設置および使用が行われない場合は、無線通信に有害な干渉を引き起こす恐れがあります。　この機器を住宅地で利用すると有害な干渉を起こすこともあり、その場合、使用者は自己負担において適切な対策を講じる必要があります。
注意事項：　このリファレンスガイドに明示的に承認していない変更や修正を行った場合には、本製品を使用する権利が無効となることがあります

Supplements

For customers in Canada

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

Pour les utilisateurs au Canada

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

Life Support Applications

The products described in this reference guide are not designed for use in life support appliances or devices and systems where malfunction of these products can reasonably be expected to result in personal injury.

WARNING! **MIKROTRON customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify MIKROTRON for any damages resulting from such improper use or sale.**

Warranty and Non-Warranty Clause

Warranty is described in §8 of our General Terms and Conditions which can be downloaded on MIKROTRONS' web-page:

www.mikrotron.de/en/terms.html

In addition, take the following non-warranty clauses into account.

Note The camera does not contain serviceable parts. Do not open the body of the camera. If the camera has been opened, the warranty will be void.

WARNING! **The camera has to be used with a supply voltage according to the camera's specification. Connecting a lower or higher supply voltage, AC voltage, reversal polarity or using wrong pins of the power connector may damage the camera. Doing so will void warranty.**

Note Our warranty does not protect against accidental damage, loss, or acts of nature.

Note MIKROTRON cannot be held responsible for the loss of data. We recommend a backup plan.

In case of warranty, please, make a note of the camera type and its serial number (S/N).

You find all necessary information on the identification plate of the camera.

MIKROTRON

EoSens® 12CXP+

CAMMC1288
S/N 00001
CE
Made in Germany

Before sending back the camera, ask for a RMA (return merchandise authorization) number and RMA form either by:
phone: +49 - 89 - 7263 4200 or
e-mail: support.mikrotron@lakesighttechnologies.com

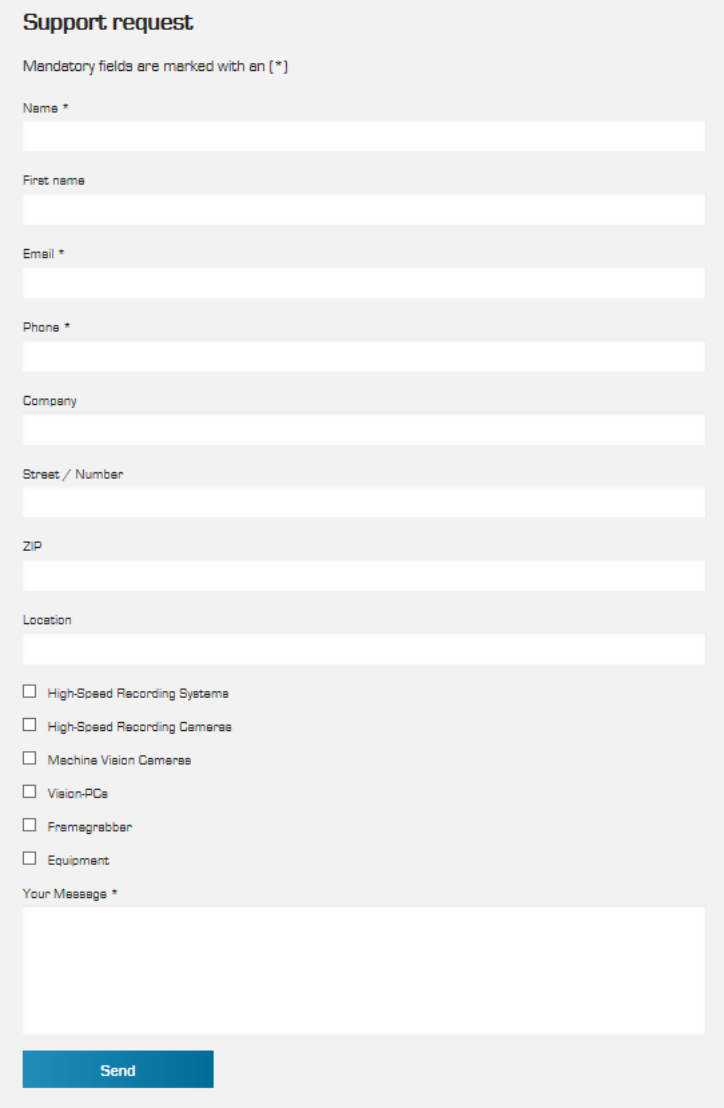
Then send the camera back to your distributor. If no distributor is available, send it back to MIKROTRON. You find the address on the last page of this reference guide.

Technical Support

In case you need technical support,

Step 1. visit
www.mikrotron.de/en/services/support.html

Step 2. Fill in the form completely



Step 3. Click [Send]

You will receive an automatic reply from our ticket system. Our field application engineer will answer your request as soon as possible.

MIKROTRON
High-Speed Vision Solutions

EU Declaration of Conformity
EU-Konformitätserklärung

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We herewith declare under our sole responsibility that the products mentioned below:
Hiermit erklären wir in alleiniger Verantwortung, dass die folgenden Produkte:

Product type: Camera
Produkt: Kamera

Models: MC1288 and MC1289
Modelle: MC1288 und MC1289

are in conformity with the following EU directives:
den folgenden EU-Richtlinien entsprechen:

Title / Titel	EU Directive
RoHS Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment RoHS-Richtlinie zur Beschränkung der Verwendung bestimmter gefährlicher Stoffe in Elektro- und Elektronikgeräten	2011/65/EU
Approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC Angleichung der Rechtsvorschriften der Mitgliedstaaten über die elektromagnetische Verträglichkeit und zur Aufhebung der Richtlinie 89/336/EWG	2014/30/EU

During conformity-testing the following standards were consulted:
Die Konformitätsvermutung wurde nach folgenden Standards überprüft:

Title / Titel	EU Standard
Information technology equipment - Immunity characteristics - Limits and methods of measurement Einrichtungen der Informationstechnik – Störfestigkeitseigenschaften - Grenzwerte und Prüfverfahren	EN55024:2011-09
Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test Elektromagnetische Verträglichkeit (EMV) - Teil 4-8: Prüf- und Messverfahren - Prüfung der Störfestigkeit gegen Magnetfelder mit energietechnischen Frequenzen	EN 61000-4-8:2009
Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement Einrichtungen der Informationstechnik – Funkstöreigenschaften - Grenzwerte und Messverfahren	EN55022:2011-12

CHAPTER

2

Introduction

This chapter informs about:

- the most important camera features and its sensor
- where the camera can be used
- what is part of the delivery
- system requirements

Overview

MIKROTRON's 12CXP+ high-speed CMOS cameras are CoaXPress Version 1.1 compliant. They come with a 12 Megapixel sensor offering a resolution of 4096 (H) x 3072 (V). Another important feature is the high photo sensitivity of @550 nm.

Configuring the camera at a resolution of 1920 x 1080 pixels and using a frame rate of up to 449 fps (8 bit) opens a fascinating field of new applications. Recordings with this high resolution are not only an advantage in industrial or high-speed applications but also when shooting a scene in high resolution documentary films or commercial clips. At a resolution of 1920 x 1080 pixels the frame rate amounts to 160 fps (@8 bit).

By defining a Region of Interest (ROI) the frame rate can be increased. The smaller the size of the ROI the higher the frame rate.

All cameras are equipped with the CoaXPress high-speed interface technology and communicate with all CoaXPress compatible frame grabbers. This technology allows transfer rates of up to 6.25 Gbit/s per connection. By using four connections, a transfer rate of 25 Gbit/s will be reached. The possible cable length depends on the cable type, quality, and the transmission speed.

The electronics of the camera is well-protected by a compact and solid full metal housing making it robust enough to comply with the requirements in heavy industrial surroundings. Shielded coaxial cables as recommended by the CoaXPress standard further improve robustness.

Camera Highlights

The most important camera features are:

- CXP connection speeds of 3.125, 5, or 6.25 Gbit/s
- power over CoaXPress of up to 13 W
- power save modes (standby, idle)
- wide power supply range from 12 to 24 V
- communication and image transfer via CoaXPress CXP6
- global shutter in µs-steps (min 1 µs)
- UV/IR filter for color cameras

Sensor Highlights

The most important features of the sensor are:

- 12 Megapixel high speed CMOS sensor
- monochrome or color (Bayer RGB filter)
- pixel size of 4.5 μm^2
- resolution of 4096 x 3072 pixels
- 8 or 10 bit pixel output
- on-chip FPN correction
- 7800 fps @reduced resolution of 128 x 32 at 6.25 Gbps
- frame rate at resolution of 1920 x 1080 pixels: 160 fps@8bit; 136fps@10 bit
- 32.6mm optical format
- sensitivity of 5.8 V lux.s @ 550 nm
- extended dynamic range of up to 59 dB
- trigger frequency of 150 kHz (one edge) and 300 kHz in AnyEdge mode

Software Highlights

CXP cameras use GenICam, which is a standardized generic programming interface. All features of the MC128x camera are described in an XML file. This electronically readable manual is supplied on the support DVD which is part of the delivery.

Apart from the few custom features, all features of the MC128x camera are compliant to the standard feature naming convention. Custom features are:

- multi-ROI
- device information
- info field
- fixed pattern noise reduction

For more information see "*Reading the XML File*" on page 4-5.

Scope of Delivery

The following components are part of delivery. Please, check whether the delivery is complete, before you start installing the camera:

- Camera MC128x as ordered
- F-Mount lens adapter
  Due to the sensor size, cameras can only be equipped with F-Mount lenses. Only lenses for industrial purpose are suitable.
- MIKROTRON's USB-Stick providing:
  - GenICam XML file
  - Manual
  - VCAM2 software and others

The firmware can be updated remotely via a special updating software.

Remark: In case you need a firmware update, see "Technical Support" on page 1-6

Optional Accessories

Lenses: Only lenses for industrial purpose are suitable. To find lenses or other accessories, visit www.mikrotron.de/en

Cables

- The four bundle cable KKRDDINDINxx/6Gx4 with DIN 1.0/2.3 connector at both ends (4x) is available in lengths of 5, 10, 15, 20, 25 and 30 meters. It is used to connect frame grabber and camera when both are equipped with DIN 1.0/2.3 connectors.

Tip: The triangle on the connector indicates connection number 1.

- The cable KKRDDINBNCxx/6Gx4 with DIN 1.0/2.3 at one end and 4 BNC connectors at the other is available in lengths of 5, 10, 15, 20 or 25 meters. It is used to connect a frame grabber with BNC sockets with the camera.

Power Supply If you do not use power over CXP, you need an external power supply unit, e.g. NTCAM132x with a 12 pin Hirose plug (HR10A-10P-12S(73)) and 5 m cable.

System Requirements

In order to use the MC128x camera you need:

- an image processing system, e.g.: PC and operating system according to the requirements of the frame grabber
- a completely installed frame grabber with device driver and software
- CoaXPress cable with DIN 1.0/2.3 connector

Tip: In order to learn more about frame grabbers that were tested with MIKROTRON cameras ask for the Application Note AN0036.

Note	All cables, connectors and the frame grabber have to be CoaXPress V1.1 compliant.

CHAPTER

3

The 12CXP+ Camera

The chapter describes the camera hardware, which means:

- available camera types and its differences
- operating temperature and additional cooling
- the interfaces of the camera used to connect a frame grabber and an external power supply
- pinning of the 12 pin power connector and connecting I/O signals
- LED to verify the camera status
- correlation between transmission speed and resolution
- how to clean lens and sensor, if necessary

Overview

The 12CXP+ area scan cameras are CoaXPress V1.1 compliant and are available in monochrome or color.

Type	Data width	Mono: m Color: c	Lens Adapter	Link speed	Max. fps@4096x3072
MC1288	8/10bit	m	F-mount	CXP-6	160/136 fps
MC1288H	8/10bit	m	C-mount	CXP-6	160/136 fps
MC1289	8/10bit	c	F-mount	CXP-6	160/136 fps
MC1289H	8/10bit	c	C-mount	CXP-6	160/136 fps

Remark: When using the camera with a C-mount adapter you have to adjust the resolution. At a resolution of 1920 x 1080 pixels shadowing effects will appear because of the small lens apperture.

The sensor of the color camera is covered with a Bayer filter in order to receive the RGB information of each image pixel. In addition, color cameras are equipped with an UV/IR cut filter. These filters transmit light with a wavelength from 370 to 670 nm - which means the visible spectrum only. This is important because CMOS sensors are susceptible to UV and IR rays outside the visible spectrum. As a result the image might not be sharp. Therefore UV/IR filter improve color images.

Figure 3-2:12CXP+ camera with cooling fins (1) and F-mount adapter (2)

Operating Temperature

Despite of its high performance, the fanless 12CXP+ is very compact and works noiselessly. Supposed, the camera is mounted on mechanical parts, heat, generated during operation, will be dissipated by the cooling fins of the camera and the mechanical parts.

Note The camera's body temperature must not exceed 55°C.

In case of overheating, the communication between camera and frame grabber will be interrupted. Wait until the camera has cooled down, then switch it on.

After a restart of the software the camera can be re-initialized. Please, take appropriate cooling measures as described in the section Additional Cooling before operating the camera again.

Note The camera is not intended for use on an isolated mounting plate or in a closed housing because the temperature of the camera might rise continuously.

Additional Cooling

Tip: If the camera is e.g. mounted on a sturdy aluminum structure, not only cooling is ensured but also a stable optical path. In addition, vibrations will be minimized within the entire system.

If the ambient temperature is constantly exceeding 40°C, additional cooling is required. This can be achieved by an

- air- or water-cooling system or by
- air-conditioned housings

Interfaces of the Camera

At the rear of the camera you find one:

1) **status LED**
   in order to verify the operating status of the camera. For more information see "*Status LED*" on page 3 -10.
2) **CoaXPress DIN1.0/2.3 connector with four channels**
   which is used to connect the camera with a CoaXPress compliant frame grabber. It can supply the camera with power via power over coax (PoC). For more information see "*Connecting a Frame Grabber*" on page 3 -5.
3) **12 pin Hirose power connector**
   which is used when an external power supply (12 - 24V) and/or an external trigger is connected.
   For more information see "*Connecting an External Power Supply or I/O Signals*" on page 3 -7.

Tip: *Before connecting an external trigger, check the pinning of the Hirose connector, described on page 3-7. In addition, take the trigger settings into account. page 5-1.*

Connecting a Frame Grabber

The CoaXPress standard describes four connections for data transmission between camera and frame grabber. The transmission speed of a 12CXP+ camera can either be set to 3.125, 5 or 6.25 Gbit/s. The possible cable length depends on the cable type used, its quality, and the selected transmission speed. These values will only be reached if the signal quality meets the requirements of the CXP-1.1 specification.

CXP-Type	Transmission speed	Max. cable length RG59 style
CXP-3	3.125 Gbit/s	up to 100 m[1]
CPX-5	5 Gbit/s	up to 60 m[1]
CXP-6	6.25 Gbit/s	up to 40 m[1]
4x CXP-6	4 x 6.25 Gbit/s = 25 Gbit/s	up to 40 m[1]

1. All lines have to be of the same length.

Tip: As the maximal cable length also depends on the quality of the cables, we recommend to buy best quality e.g. CXP cables from MIKROTRON.

In order to connect a 12CXP+ camera with a frame grabber you can use any CoaXPress 1.1 compatible cable with a DIN connector. MIKROTRON offers cables with the following connectors.

- DIN ←→DIN
  (order KKRDDINDINxx/6Gx4)
- DIN ←→BNC
  (order KKRDDINBNCxx/6Gx4)

For more information see "*Optional Accessories*" on page 2 -4.

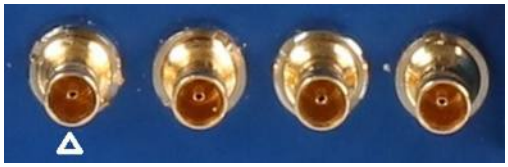
Note Please, carefully connect and release the socket with the DIN1.1/2.3 connector. Connect them precisely to avoid deformation of the connectors or other damages!

If connecting a frame grabber via DIN ←→ BNC, keep the order from left to right when connecting one, two, or four BNC connectors.

Tip: Pin 1 of the DIN connector always has to be connected.

If connecting a frame grabber via DIN ←→ DIN, take into account that the left DIN connector is the master connector number 1 (marked by a triangle). Connect it with channel one of the frame grabber (please, read the frame grabber documentation).

At the time being, the camera works with 4 lines at the link speeds 3.125, 5 or 6.25 Gbit/s.



No. of Connections	Connector combination
4	1+2+3+4 (link)

Tip: All connections are hot-pluggable.

On DIN ←→DIN cables from MIKROTRON (KKRDDINDINxx/6Gx4), pin1 is marked with a triangle on the connector housing.

The assignment of the DIN-cables KKRDDINDINxx/6Gx4 and KKRDDINBNCxx/6Gx4 connector pins is as follows:

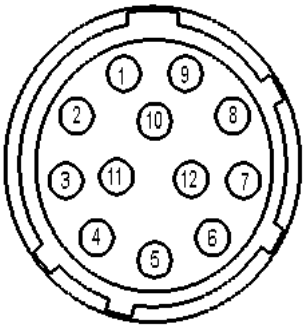
DIN connector pin	Function
1 (triangle)	TX channel 0
2	TX channel 1
3	TX channel 2
4	TX channel 3

Connecting an External Power Supply or I/O Signals

Up to 13 W are delivered when using power over CoaXPress. In case you prefer an external DC power supply, connect it with the 12 pin Hirose connector (HR10A-10R-12PB (71)) at the rear of the camera. The DC power supply has to deliver 12 - 24 V DC (min. 18 W) and has to be equipped with a HR-10A-10P-12S plug.

WARNING! **The power connector of the camera has to be connected with a DC power supply providing 12 to 24 V DC. Connecting a lower or higher supply voltage, an AC voltage, reversal polarity or using wrong pins of the power connector may damage the camera and will void warranty!**

MIKROTRON offers the power supply unit NTCAM132x including a cable. In case you assemble your own cable, pay attention to the pinning described below. The 12 pin connector provides two inputs for an external trigger and one output signal. The output signal can be controlled (see page 12-5. of the camera's Reference Guide)



Solder side

Table 3-1: Pinning of the 12 pin power connector

Pin	Signal
1 + 12	GND
2 + 11	V_{CC} (8 - 24 V)
3	IO_{GND}
4	OUT0
5	IO_{GND}
6	IN0
9	IO_{GND}
10	IN1

Remark: The I/O pins 7 and 8 are not in use.

Note The I/O standard 3.3V LVTTL applies to all output signals (OUT0 and OUT1).

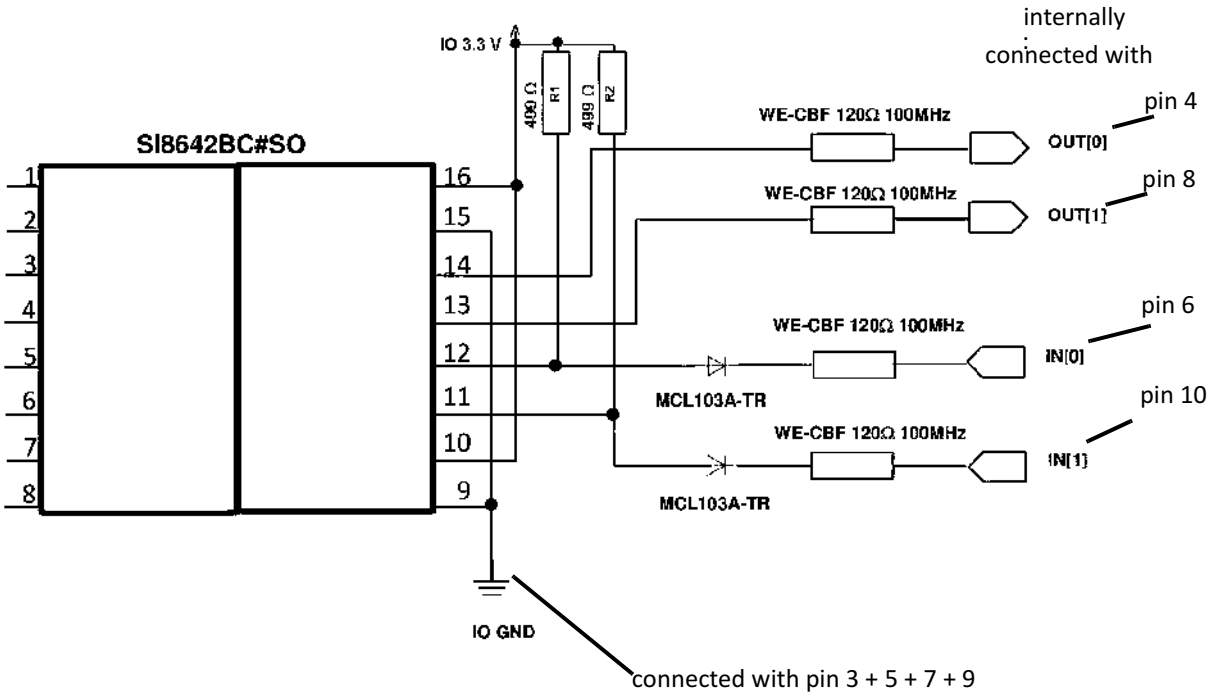
Tip: In order to invert the level of the output signal, see page 12-4.

Connecting an External Trigger

When connecting an external trigger you can for example apply a voltage of 0, 3.3, 5, 12, or 24 V or a TTL signal supplying 0 or 5 V.

Note Use IO_{GND} as reference for external trigger signals only.

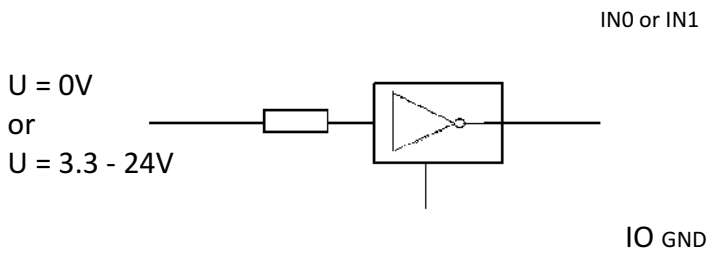
Figure 3-3:Internal circuit for IN and OUT pins and connection to Hirose



Remark: Note that the voltage of the low level has to be < 0.3 V.

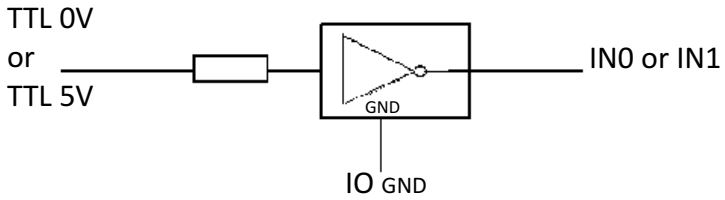
When connecting an external voltage of 0, 3.3, 5, 12, or 24V connect it via a series resistor and a transistor with IN0 or IN1 of the Hirose connector.

In case you connect 0V, the transistor blocks and the input signal of the camera will be high.



In case you connect 3.3, 5, 12, or 24V, the transistor opens and the input signal of the camera will be low.

Another possibility is to connect a TTL voltage via an inverter (I74LS01). If the TTL voltage amounts to 0, the input signal of the camera will be high.



In case you apply a TTL voltage of 5V, the input signal of the camera will be low.

The value for the series resistor has to be calculated. For more information about trigger settings, see page 5-3.

Status LED

A multi-color LED (1) indicates camera and CXP connection states according to the CXP 1.1 standard.

LED State - Operating	Indication
OFF	no power
solid orange	system is booting
slow pulse red	powered, but nothing connected (not applicable if PoCXP is used)
fast flash alternate green/orange	connection detection in progress, PoCXP active
fast flash orange	connection detection in progress, PoCXP not in use
slow flash alternate red/green	device incompatible, PoCXP active
slow flash alternate red/orange	device incompatible, PoCXP not in use
solid green	device connected but no data being transferred
slow pulse orange	device connected, waiting for event (e.g. trigger)
fast flash green	device connected, data being transferred
slow flash alternate green/orange	connection test packets being sent
red - 500 ms pulse	error during data transfer
slow flash alternate red/green/orange	compliance test mode enabled
fast flash red	system error

Resolution and Transmission Speed

The tables below show the correlation between camera resolution and the transmission speed for an 8 and 10 bit image.

Resolution		Frame rate (fps); 8 bit		
H	V	CXP-3	CXP-5	CXP-6
4096	3072	81	131	160
2048	2048	121	196	239
1920	1080	228	366	448
1280	1024	240	386	471
1024	1024	240	386	471
1024	768	317	509	623
1280	720	337	542	662
640	480	495	796	973
256	256	882	1417	1732
128	128	1590	2555	3132

Please note, that CXP-3 is not yet available in 10 bit mode.

Resolution		Frame rate (fps); 10 bit	
H	V	CXP-5	CXP-6
4096	3072	102	137
2048	2048	152	204
1920	1080	285	383
1280	1024	300	403
1024	1024	300	403
1024	768	396	532
1280	720	421	566
640	480	619	832
256	256	1102	1480
128	128	1987	2669

Cleaning Sensor and Lens

If necessary, clean the surface of the sensor and the lens with a dry and soft lens-cleaning tissue.

WARNING! **Unplug the camera before you clean any parts! Dismount the lens and the adapter but in no case open the housing when cleaning the window of the sensor.**

Note If the camera has been opened, warranty will be void.

WARNING! **If there are coarse particles on the lens or the window of the sensor, use a vacuum cleaner to remove them before cleaning. Otherwise, the lens or sensor might be scratched.**

WARNING! **Never use tools that may harm the sensor/lens.**

CHAPTER

4

First Steps

In this chapter you learn

- how to connect the camera with the image processing system
- about initial settings the camera provides when being powered-up
- basics on the configuration of the camera via GenICam

Connect Camera and Image Processing System

Before you start, make sure that all components of the camera/host chain like camera, connectors, cable and frame grabber .

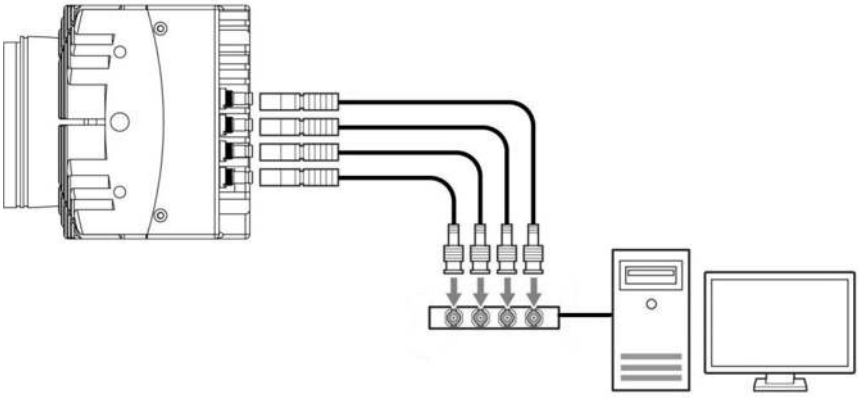
Step 1. Install the frame grabber in your image processing system (read the documentation of the frame grabber)

Step 2. Switch off the image processing system (e.g. PC)

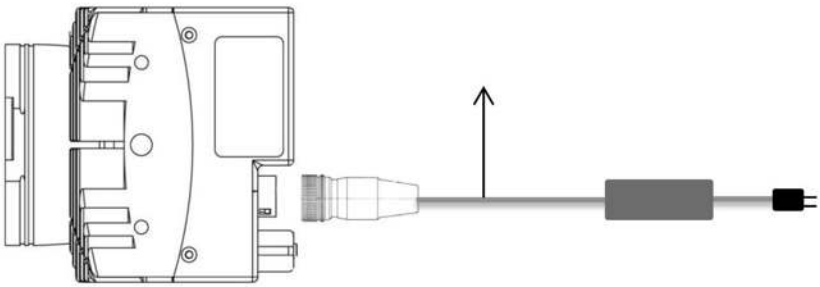
Step 3. Connect the 5W5/DIN V1.1/2.3 cable with the camera

Step 4. Connect the other end of the cable with your CoaXPress V1.1 compatible frame grabber

Tip: In order to connect the camera via SFP+ modules: For more information see "Connecting a Frame Grabber" on page 4-6.



Step 5. If an external power supply is needed, connect the power supply NTCAM132x (12 - 24 V) via the 12 pin Hirose connector with the camera



Step 6. In case you want to connect an external trigger take the pinning into account. For more information see "*Connecting an External Power Supply or I/O Signals*" on page 4-9.

Step 7. Unscrew the dust protection cover of the camera

Step 8. Mount the lens

Step 9. If an external power supply is used, connect it with the main supply

Step 10. Switch-on the image processing system

Step 11. Check the LED of the camera to verify that the camera is ready for use. For more information see "*Status LED*" on page 4-12.

Power-up Profile

If the camera is powered-up, the power-up profile which is permanently stored in the non-volatile memory of the camera, will be loaded. This profile consists of a number of camera settings like sensor resolution and frame rate. It is used to bring the camera into a defined operation mode.

Tip: The camera has NOT to be configured by the host to start operation. The power-up profile will deliver all necessary values.

Serial number and firmware version are provided in the non-volatile memory of the camera too. Use the GenICam feature DeviceSerialNumber to read the serial number and the firmware revision. Read the chapter Bootstrap Registers for more information.

If you need the serial number only, you find it on the identification plate at one side of the camera.

Configuring the Camera

All of MIKROTRON's CXP cameras are compliant to the CoaXPress specification. CoaXPress standardizes down- and uplink protocols, interfaces, cables, and connectors used by CoaXPress compliant cameras and frame grabbers.

All our CXP cameras use GenICam, which is a standardized generic programming interface. It is used to configure and control the CXP camera and supports five main features:

1. camera configuration
2. frame acquisition
3. graphical user interface (GUI)
4. transfer of camera data but also time stamps, region of interest (ROI) and histogram data
5. transfer of events like a trigger

GenICam for CXP cameras consists of four parts:

1. GenAPI
   GenAPI is the application programming interface. It is used to configure and control a camera. All features are written in an XML file. The API is available for several operating systems.
2. Standard Features Naming Convention (SFNC)
   SFNC provides standardized names and types for common device features.
3. Pixel Format Naming Convention
   PFNC is a pixel format naming convention.
4. GenTL
   The GenTL transport layer is supported by CoaXPress compliant frame grabbers and cameras. It allows to read and write into registers and to grab frames.

According to GenICam the camera uses registers for configuration. In order to change a value, e.g. the exposure time, the hexadecimal value has to be written into the camera register representing the exposure time (e.g. 0x1100).

Reading the XML File

All features of the camera are described in the GenICam XML file. Extensible Markup Language (XML) is used to describe each feature as a XML feature knot. Feature knots are displayed in a tree structure.

A knot consists of a feature knot and a register knot. The feature knot contains the description of the command whereas the register knot shows how it is implemented in the camera. For example the type of the feature (command, string, integer,...), its access mode (R/W), a descriptive name (friendly name), the corresponding register address, and a short description of the feature in plain ASCII text. Some features have min. and max. values or a default value. Each feature corresponds to a camera setting.

Example:

Feature knot

```
<Command Name="AcquisitionStart">
        <ToolTip>Starts the Acquisition of the device.</ToolTip>
        <Description>Starts the Acquisition of the device.</Description>
        <DisplayName>Acquisition Start</DisplayName>
        <Visibility>Beginner</Visibility>
        <pValue>AcquisitionStartReg</pValue>
        <CommandValue>0</CommandValue>
</Command>
```

Register knot

```
<IntReg Name="AcquisitionStartReg">
        <Address>0x8204</Address>
        <Length>4</Length>
        <AccessMode>WO</AccessMode>
        <pPort>Device</pPort>
        <Endianess>BigEndian</Endianess>
</IntReg>
```

Port knot

```
</Group>
<Port Name="Device">
<ToolTip>Port giving access to the device.</ToolTip>
</Port>
```

The port knot allows the connection to the device.

Tip: *All integer values are interpreted as 32 bit unsigned integers, if not other mentioned. All strings are NULL terminated and consist of 8 bit characters.*

The features in the XML file or your CXP camera are grouped according to their meaning. Available registers are:

- "Acquistion Control" on page 5-2
- "Bootstrap Registers" on page 7-2
- "Device Control" on page 6-1
- "Image Format Control" on page 8-1
- "Analog Control" on page 11-1
- "User Set Control" on page 9-1
- "Custom Features" on page 10-1
- "Digital I/O Control" on page 12-4
- "File Access Control" on page 13-1

The XML file is an ASCII file which is to be found on the DVD delivered with the camera. It can either be saved (compressed or uncompressed) in the camera or saved as an external file on a local computer or a remote host. The path (URL) of the file can be read from the camera using the feature XmlUrlAddress.

Use the Software delivered by the frame grabber's manufacturer to configure camera and frame grabber. In case you use a frame grabber from Active Silicon, MIKROTRON's VCAM Software which is part of the delivery too, can be used alternatively.

Please, refer to www.emva.org/standards-technology/genicam for further details on the GenICam standard.

CHAPTER

5

Acquisition Control

This chapter provides information on available settings to control image acquisition and:

- configure the trigger settings
- control exposure
- set and read the (maximal) acquisition frame rate
- select a test image

Acquistion Control

The following commands allow to make settings required for image acquisition and to control an external trigger. Settings can only be changed if image acquisition is stopped.

Name	Access	Length [Bytes]	Register Interface	Page
AcquisitionMode	R/W	4	Enumeration	5-2
AcquisitionStart	W	4	Command	5-3
AcquisitionStop	W	4	Command	5-3
TriggerSelector	R/W	4	Enumeration	5-4
TriggerMode	R/W	4	Enumeration	5-4
TriggerSource	R/W	4	Enumeration	5-5
TriggerActivation	R/W	4	Enumeration	5-6
TriggerDebouncer	R/W	4	Integer	5-7
AcquisitionBurstFrameCount	R/W	4	Integer	5-3
TriggerSoftware	WO	4	Integer	5-5
ExposureMode	R/W	4	Enumeration	5-7
ExposureTime	R/W	4	Integer	5-8
ExposureTimeMax	R	4	Integer	5-8
AcquisitionFrameRate	R/W	4	Integer	5-8
AcquisitionFrameRateMax	R	4	Integer	5-9
TestImageSelector	R/W	4	Enumeration	5-9

AcquisitionMode

This feature is used to set the device into a certain acquisition mode.

Access	read / write	
Type	enumeration	
In	**Continuous**	the camera records continuously a sequence of frames
Out	selected mode	
Remark	frame acquisition can be stopped with the feature AcquisitionStop	

AcquisitionStart

This feature enables the device to send sampled images to the host.

Access	write
Type	command
In	0x00000001
Out	—
Remark	AcquisitionMode defines how frames will be acquired

AcquisitionStop

This feature stops acquiring frames after the acquisition of the current frame has been completed.

Access	write
Type	command
In	x00000001
Out	—

AcquisitionBurstFrameCount

Tip: If FrameBurstStart is selected in TriggerSelector, ExposureMode has to be set to Timed to make recording possible.

This feature defines the number of frames to be acquired after each FrameBurstStart trigger. For more information see "*TriggerSelector*" on page 4.

Access	read/write
Type	integer
In	x00000001
Out	number of frames to be acquired

TriggerSelector

This feature is used to select the type of trigger to be configured.

Access	read / write	
Type	enumeration	
In	**FrameStart**	the camera will take one picture per trigger signal
	FrameBurstStart	the camera will take as many frames as defined in AcquisitionBurstFrameCount
Out	trigger selector type	
Remark	Set AcquisitionBurstFrameCount in order to define the number of frames to be acquired when FrameBurstStart is active.	

Tip: *If FrameBurstStart is selected, ExposureMode will have to be set to Timed. Otherwise, recording will not be possible.*

TriggerMode

This feature activates or deactivates the trigger type selected by the feature TriggerSelector.

Access	read / write	
Type	enumeration	
In	**ON**	enables the selected trigger type; the camera waits for a trigger signal before acquiring a frame. The trigger signal can be a signal from the frame grabber, the 12-pin Hirose connector input, or a software trigger initiated by a software command. The trigger source has to be set in the feature TriggerSource. In trigger mode, the frame rate of the camera depends on the frequency of the trigger signals
	OFF	disables the selected trigger type; all trigger signals will be ignored. The camera is set into the current acquisition mode
Out	active mode	
Remark	If a trigger is active, ExposureMode defines whether the exposure of an image is defined by the feature ExposureTime (fixed exposure time) or by the duration of the trigger signal itself (variable exposure time). The settings in ExposureMode will only become effective if triggered mode is ON.	

TriggerSource

This feature defines the source of the trigger signal.

Access	read / write	
Type	enumeration	
In	**Line0**	CXP cameras with DIN connector offer one trigger input with two physical lines via the 12 pin Hirose connector (see page 3-7); the trigger signal can either be sent via line 0 or line 1
	Line1	CXP cameras with DIN connector offer one trigger input with two lines via the 12 pin Hirose connector; the trigger signal can either be sent via line 0 or line 1
	Software	if TriggerSoftware is set, the trigger will be generated by the software using the feature TriggerSoftware; no external (hardware) trigger signal is needed
	CXPTrigger	if CXPTrigger is set, the camera will wait for an external trigger signal from the frame grabber before acquiring another frame; exposure time for the next image is the time defined in the feature ExposureTime
Out	active source	
Remark	Only one trigger source can be active.	

TriggerSoftware

This feature generates an internal trigger.

Access	write
Type	command
In	0x00000001
Out	—
Remark	In order to generate a software trigger signal, “Software” has to be set in TriggerSource.

Tip: *When using TriggerSoftware, the exposure time of the next frame cannot be defined by TriggerWidth of the feature ExposureMode. Instead, it has to be defined by the feature ExposureTime.*

TriggerActivation

Tip: If AnyEdge is selected, a fixed exposure time (ExposureMode = Timed) has to be set.

This feature defines the activation mode for a trigger signal defined in TriggerSelector.

Access	read / write	
Type	enumeration	
In	**RisingEdge**	camera will start to acquire frames on the arrival of a CXP 'trigger rising edge' trigger packet; this activator expects a subsequent 'trigger falling edge' trigger packet to finish the trigger sequence
	Falling Edge	camera will start to acquire frames on the arrival of a CXP 'trigger falling edge' trigger packet; this activator expects a subsequent 'trigger rising edge' trigger packet to finish the trigger sequence
	Any Edge	camera will start to acquire frames on the arrival of a CXP 'trigger falling edge' as well as a 'trigger rising edge' trigger packet
Out	selected activator	
Remark	Using the activator AnyEdge doubles the maximal trigger frequency.	

TriggerDebouncer

Tip: The best way to find the appropriate value for the debounce period is to measured it with an oscilloscope.

In TriggerDebouncer the debounce period is defined. This period starts with the occurrence of a trigger edge. Within the debounce period, a new trigger signal will be ignored. Debouncing might e.g. be necessary if the trigger signal jitters.

Access	read / write	
Type	integer	
In	**min.**	0 µs
	max.	430 µs
Out	the set debounce period	
Remark	The default value amounts to 1 µs.	

ExposureMode

This feature sets the operation mode of the shutter. It defines how long a picture will be exposed if TriggerMode is activated.

Access	read / write	
Type	enumeration	
In	**Timed**	exposure time is defined in the feature ExposureTime;
	Trigger Width	width of the current trigger signal pulse is used to control the exposure time; if TriggerActivation is set to RisingEdge, it will be the time the trigger stays high; if TriggerActivation is set to Falling Edge it will last as long as the trigger stays low.
Out	set exposure mode	
Remark	ExposureMode is enabled in trigger mode only. If you choose AnyEdge in TriggerActivator, Timed has to be set. Timed also has to be set if the TriggerSelector is set to FrameBurstStart.	

ExposureTime

If the exposure mode is set to Timed or no hardware trigger is defined, this feature allows to define the duration of exposure [µs].

Access	read / write
Type	unsigned integer
In	1 … highest possible exposure time
Out	current exposure time
Remark	incremented by 1

ExposureTimeMax

Remark: This feature will soon expire. Use ExposureTime to get the highest possible exposure time.

This feature returns the highest possible exposure time for the current camera settings in [µs].

Access	read
Type	unsigned integer
In	—
Out	max. exposure time
Remark	The exposure time depends on the current frame rate settings.

AcquisitionFrameRate

Tip: *If TriggerMode = ON, AcquisitionFrameRate will be disabled.*

This feature defines the acquisition rate in [Hz] when TriggerMode is OFF.

Access	read / write
Type	unsigned integer
In	>16... highest possible frame rate
Out	AcquisitionFrameRate
Remark	incremented by 1; min. 10

AcquisitionFrameRateMax

This feature returns the highest possible frame rate in [Hz].

Access	read
Type	unsigned integer
In	—
Out	max. frame rate
Remark	The max. frame rate depends on the defined frame size, the used link speed, and the number of CoaXPress lines used for image streaming.

Remark: This feature will soon expire. Switch to AcquisitionFrameRate to get the highest possible frame rate.

TestImageSelector

This feature selects the type of test image sent by the camera.

Access	read/write	
Type	enumeration	
In	**OFF**	TestImageSelector is disabled
	GreyHorizontal Ramp	camera will send a test image that shows vertically oriented gray scale bars moving into horizontal direction on the screen
Out	current test image selection	
Remark	A connection reset sets the camera into normal operation mode.	

CHAPTER

6

Device Control

The chapter provides the only command on device control which is used to reset the camera.

Introduction

There is only one command to reset the camera.

DeviceReset

This feature resets the device into power-up state.

Access	write
Type	unsigned integer
In	0x00000001
Out	—
Remark	length of 4 Bytes

CHAPTER

7

Bootstrap CoaXPress

The chapter provides information on:

- bootstrap registers which are mainly used to deliver information about the camera in order to allow a communication between frame grabber and camera

Bootstrap Registers

CoaXPress compliant devices have to support a number of bootstrap registers. In contrast to other camera features each bootstrap register is assigned to a fixed camera address as it is defined in the CoaXPress specification.

Bootstrap registers are defined for device information and allow frame grabbers to establish and maintain the connection between host and camera in a standardized way. Usually, the connection between camera and frame grabber is running in the background.

Name	Address	Access	Length [Bytes]	Register interface	Page
Standard	0x00000000	R	4	Integer	7-3
Revision	0x00000004	R	4	Integer	7-3
XmlManifestSize	0x00000008	R	4	Integer	7-4
XmlManifestSelector	0x0000000C	R/W	4	Integer	7-4
XmlVersion	0x00000010	R	4	Integer	7-4
XmlSchemeVersion	0x00000014	R	4	Integer	7-5
XmlUrlAddress	0x00000018	R	4	Integer	7-6
Iidc2Address	0x0000001C	R	4	Integer	7-5
DeviceVendorName	0x00002000	R	32	String	7-6
DeviceModelName	0x00002020	R	32	String	7-7
DeviceManufacturerInfo	0x00002040	R	48	String	7-7
DeviceVersion	0x00002070	R	32	String	7-8
DeviceSerialNumber	0x000020B0	R	16	String	7-8
DeviceUserID	0x000020C0	R/W	16	String	7-9
WidthAddress	0x00003000	R/W	4	Integer	7-9
HeigthAddress	0x00003004	R/W	4	Integer	7-9
AcquisitionModeAddress	0x00003008	R/W	4	Integer	7-9
AcquistionStartAddress	0x0000300C	R/W	4	Integer	7-9
AcquistionStopAddress	0x00003010	R/W	4	Integer	7-9
PixelFormatAddress	0x00003014	R/W	4	Integer	7-9
DeviceTapGeometrieAddress	0x00003018	R/W	4	Integer	7-9
Image1StreamIDAddress	0x0000301C	R/W	4	Integer	7-9
ConnectionReset	0x00004000	W/(R)	4	Integer	7-10
DeviceConnectionID	0x00004004	R	4	Integer	7-10
MasterHostConnectionID	0x00004008	R/W	4	Integer	7-10
ControlPacketSizeMax	0x0000400C	R	4	Integer	7-11
StreamPacketSizeMax	0x00004010	R/W	4	Integer	7-11

Name	Address	Access	Length [Bytes]	Register Interface	Page
ConnectionConfig	0x00004014	R/W	4	Enumerate	7-12
ConnectionConfigDefault	0x00004018	R	4	Integer	7-12
TestMode	0x0000401C	R/W	4	Integer	7-13
TestErrorCountSelector	0x00004020	R/W	4	Integer	7-13
TestErrorCount	0x00004024	R/W	4	Integer	7-14
TestPacketCountTx	0x00004028	R/W	8	Integer	7-14
TestPacketCountRx	0x00004030	R/W	8	Integer	7-15
HsUpConnection	0x0000403C	R	4	Integer	7-15
Start of manufacturer specific register space	0x00006000	—	—	—	7-9

Standard

This register provides a magic number indicating that the device implements the CoaXPress standard.

Access	read
Type	unsigned integer
In	—
Out	0xC0A79AE5
Remark	The magic number is an approximation of CoaXPress.

Revision

This register provides the revision of the CoaXPress specification implemented by this device.

Access	read	
Type	unsigned integer	
In	—	
Out	bits **31 - 16** **15 - 00**	 major revision minor revision
Remark	E.g. devices compliant to revision 1.1 of the specification shall return the value 0x00010001.	

XmlManifestSize

This register returns the number of available XML manifests. At least one manifest must be available.

Access	read
Type	unsigned integer
In	—
Out	1

XmlManifestSelector

This register selects the required XML manifest registers. It holds a number between zero and XmlManifestSize – 1.

Access	read / write
Type	unsigned integer
In	0 … XmlManifestSize-1
Out	0 … XmlManifestSize-1
Remark	A connection reset sets the value to 0x00000000.

XmlVersion

This register provides the version number for the XML file given in the manifest referenced by the register XmlManifestSelector.

Access	read	
Type	unsigned integer	
In	—	
Out	bits	
	31 - 24	reserved; shall be 0
	23 - 16	SchemaMajorVersion; major version number of the XML file
	15 - 8	SchemaMinorVersion; minor version number of the XML file
	7 - 0	SchemaSubMinorVersion; sub-minor version number of the XML file

XmlSchemeVersion

This register provides the GenICam schema version for the XML file given in the manifest referenced by the register XmlManifestSelector.

Access	read	
Type	unsigned integer	
In	—	
Out	bits	
	31 - 24	reserved; shall be 0
	23 - 16	SchemaMajorVersion; major version number of the schema used by the XML file
	15 - 8	SchemaMinorVersion minor version number of the schema used by the XML file
	7 - 0	SchemaSubMinorVersion sub-minor version number of the schema used by the XML file

Iidc2Address

Tip: *This feature is currently not supported.*

This feature is meant for devices supporting the IIDC2 protocol (section 2.2 ref. 6) and will provide the starting address of the IIDC2 register space.

Access	read
Type	unsigned integer
In	—
Out	0x00000000

XmlUrlAddress

This register indicates the start of the URL string referenced by the register XmlManifestSelector.

Access	read	
Type	unsigned integer	
In	—	
Out	register address	
Remarks	Reading the returned register returns the name, register address, and the length of the GenICam XML file stored in the flash memory of the camera. The format of the address string of the following fields is:	
	Local	indicates the XML file is stored in the non-volatile memory in the device
	<Filename>	name of the XML file
	<Extension>	xml: uncompressed XML file zip: compressed ZIP file
	<Address>	address of the file in the device memory map, given in hexadecimal notation without the first to characters “0x”
	<Length>	length of the file in Bytes, given in hexadecimal without the first to characters “0x”
	Example: *“Local:Mikrotron_GmbH_MC258xS11 _Rev1_15_0.xml; 8001000;16C34?SchemaVersion=1.1.0”* indicates a GenICam XML file in the flash memory of the camera. The file can be read starting at address 8001000 and has a length of 16C34 Bytes. MIKROTRON does not support strings that reference a XML file located on the vendors homepage.	

DeviceVendorName

This register provides the name of the manufacturer of the device as a string.

Access	read
Type	string [0...32]
In	—
Out	vendor name
Remark	Example: MIKROTRON GmbH

DeviceModelName

This register provides the model name of the device as a string.

Access	read
Type	string[0...32]
In	—
Out	model name
Remark	Example: MC2586

DeviceManufacturerInfo

This register provides extended manufacturer-specific information about the device as a string.

Access	read
Type	string[0...48]
In	—
Out	manufacturer information
Remark	Example: MIKROTRON GmbH

DeviceVersion

This register provides the version of the camera hardware as a string.

Access	read		
Type	string[0...32]		
In	—		
Out	device version string including the hardware, microcontroller software and FPGA version		
Remark	The firmware version consists of the microcontroller version plus the FPGA version (V00.25.002F00.33.787). The format of the version string (byte numbers from left to right) in detail:		
	byte no.:		e.g.:
	0	hardware tag	H
	1 - 2	hardware version major number	03
	3		**.**
	4 - 5	hardware version minor number	04
	6		.
	7 - 9	hardware version sub minor number	000
	10	microcontroller tag	V
	11 - 12	mc major number	00
	13		**.**
	14 - 15	mc minor number	25
	16		.
	17 - 19	mc sub minor number	002
	20	FPGA tag	F
	21 - 22	FPGA version major number	00
	23		.
	24 - 25	FPGA version minor number	33
	26		.
	27 - 29	FPGA version sub minor number	787

DeviceSerialNumber

This register provides the serial number for the device as a NULL-terminated string.

Access	read
Type	string[0...16]
In	—
Out	serial number of the camera
Remark	Example: 000000000000157

DeviceUserID

This register provides a user-programmable identifier for the camera as a string.

Access	read/write
Type	string[0...16]
In	user ID
Out	user ID
Remark	The User ID can be freely defined by the user. It will be saved in the flash memory of the camera. As a result, it will be preserved if the camera is switched off.

Manufacturer-specific Addresses

The following registers provide the address in the manufacturer-specific register space of the use-case feature with the corresponding name. These registers have a length of 4 bit and are read-only registers.

WidthAddress	manufacturer-specific address of Width
HeightAddress	manufacturer-specific address of Height
AcquisitionModeAddress	manufacturer-specific address of AcquisitionMode
AcquisitionStartAddress	manufacturer-specific address of AcquistionStart
AcquisitionStopAddress	manufacturer-specific address of AcquistionStop
PixelFormatAddress	manufacturer-specific address of PixelFormat
DeviceTapGeometryAddress	manufacturer-specific address of DeviceTapGeometry
Image1StreamIAddress	manufacturer-specific address of Image1StreamID

Manufacturer-specific addresses allow non-GenICam applications or black-box format converters, to support the standard use-case and allow continuous acquisition and display of images.

DeviceConnectionID

This register provides the ID of the device connection via which this register is read.

Access	read
Type	unsigned integer
In	—
Out	connection ID
Remark	A connection ID of zero means that the connection is a master connection. This is a static register, but with a different value depending from which connection it is read.

ConnectionReset

Writing 0x00000001 into this register will reset the connection of the device.

Access	read / write
Type	unsigned integer
In	0x00000001
Out	0x00000000
Remark	A link reset will stop a running image acquisition. A connection reset command via the master connection (no. 0) will reset a connection and activate its discovery connection configuration within 200 ms. The camera resets the register to 0x00000000 when it has activated its discovery connection configuration. Writing by the host should be regarded as “fire and forget” without waiting for acknowledgment. In general it is not possible to read this register while it has the value 0x00000001.

MasterHostConnectionID

This register holds the host connection ID of the host connected to the device master connection.

Access	read/write
Type	unsigned integer
In	host link ID
Out	host link ID
Remark	The value 0x00000000 is reserved to indicate an unknown Host ID. All writings to device extension connection will be ignored.

ControlPacketSizeMax

This register provides the maximum control packet size the host can read from the device or write to the device. The size is defined in Bytes and will be a multiple of 4 Bytes. The defined size is that of the entire packet, not only the payload.

Access	read
Type	unsigned integer
In	—
Out	control packet size in multiples of 4 Bytes
Remark	the control packet size is at least 128 Bytes

StreamPacketSizeMax

This register holds the maximum stream packet size the host can accept. The size is defined in Bytes and will be a multiple of 4 Bytes. The defined size is that of the entire packet, not only the payload.

Access	read / write
Type	unsigned integer
In	stream packet data size in multiples of 4 Bytes
Out	stream packet data size in multiples of 4 Bytes
Remark	The device can use any packet size it wants to up to this size. A connection reset sets the value to 0x00000000.

ConnectionConfig

This register holds a valid combination of the device link speed and the number of active down connections. Writing into this register sets the connection speeds on the specified connections.

Access	read / write	
Type	enumeration	
	connection configuration example (read the electronically readable manual for further information):	
In	**CONNECTION2SPEED3125**	two connections of 3.125 Gbps per connection
	CONNECTION4SPEED3125	four connections of 3.125 Gbps per connection (default)
	CONNECTION2SPEED5000	two connections of 5.000 Gbps per connection
	CONNECTION4SPEED5000	four connections of 5.000 Gbps per connection
	CONNECTION2SPEED6250	two connections of 6.250 Gbps per connection
	CONNECTION4SPEED6250	four connections of 6.250 Gbps per connection
Out	connection configuration	

ConnectionConfigDefault

This register provides the value of the ConnectionConfig register that allows the Device to operate in default mode. This feature is used to start the camera with the default configuration that is stored in the custom profiles.

Access	read
Type	unsigned integer
In	—
Out	0x00000000
Remark	

TestMode

Writing the value 0x00000001 into this register enables a test packet transmission from the camera to the host.

Access	read / write	
Type	integer	
In	**0x00000000**	normal operation
	0x00000001	sending test packets to host
Out	same as above	
Remark	A connection reset sets the value to 0x00000000. If the value is changed from 0x00000001 to 0x00000000, the device will complete the packet of 1024 test words currently being transmitted.	

TestErrorCountSelector

This register selects the required test count [TestErrorCount] register. It holds a valid device connection ID 0 … n-1, or n for the optional high-speed up-connection.

Access	read / write
Type	unsigned integer
In	0x00000000...0x00000003
Out	0x00000000...0x00000003
Remark	A connection reset sets the value to 0x00000000.

TestErrorCount

This register provides the current connection error count for the connection referred to by the register TestErrorCountSelector.

Access	read / write
Type	unsigned integer
In	0x00000000
Out	error count
Remark	Writing 0x00000000 to this register resets the error count for the connector referred to by the register TestErrorCountSelector to zero. A connection reset sets all connection test counters to zero. The error count is the number of incorrect words that have been received in test packets.

TestPacketCountTx

This register provides the current transmitted connection test packet count for the connection referred to by the register *TestErrorCountSelector*.

Access	read / write
Type	integer
In	0x0000000000000000
Out	packet count
Remark	Writing 0x0000000000000000 into this register will reset to zero the transmitted connection packet count for the connection referred to by the register TestErrorCountSelector. A connection reset sets all connection test counters to zero.

TestPacketCountRx

This register provides the currently received connection test packet count for the connection referred to by the register TestErrorCountSelector.

Access	read / write
Type	integer
In	0x0000000000000000
Out	packet count
Remark	Writing 0x0000000000000000 to this register shall reset to zero the received connection packet count for the connection referred to by register TestErrorCountSelector. A connection reset sets all connection test counters to zero.

HsUpConnection

Tip: This feature is currently not supported.

This register indicates whether the optional high speed up-connection is supported or not.

Access	read
Type	integer
In	bits 1 - 30: reserved; shall be 0 ON = 1 OFF = 0
Out	0 if high speed up-connection is OFF 1 if high speed up-connection is ON

CHAPTER

8

Image Format Control

The chapter provides information on the image format control. You learn how to

- define the size and offset of a ROI
- read the size of the sensor
- read the max. height and width of an image
- read/write the pixel format
- read the TapGeometry
- read the streamID
- read the camera type (line or area scan)

Introduction

These commands allow to set the size of the image, the so called region of interest (ROI). A ROI - like the red field in the figure below - defines the part of an image to be scanned. It is defined by its Width, Heigth, OffsetX and OffsetY.

The commands RegionSelector and RegionMode allow to control several ROI (multi-ROI).

Name	Access	Length [Bytes]	Register Interface	Page
RegionSelector	R/W	4	Enumeration	8-3
RegionMode	R/W	4	Enumeration	8-3
RegionDestination	R/W	4	Enumeration	8-3
Width	R/W	4	Integer	8-4
Height	R/W	4	Integer	8-4
OffsetX	R/W	4	Integer	8-4
OffsetY	R/W	4	Integer	8-5
SensorWidth	R	4	Integer	8-5
SensorHeight	R	4	Integer	8-5
WidthMax	R	4	Integer	8-6
HeightMax	R	4	Integer	8-6
PixelFormat	R/W	4	Enumeration	8-6
TapGeometry	R	4	Enumeration	8-7
Image1StreamID	R	4	Integer	8-7
DeviceScanType	R	4	Enumeration	8-7

RegionSelector

This feature selects the region of interest (ROI) to be controlled.

Access	read / write
Type	enumeration
In	region0 = value0
Out	region selector
Remark	min: 1 ROI; can be incremented by 1 max: 31ROI

RegionMode

This feature allows to activate or deactivate the selected region of interest.

Access	read / write
Type	enumeration
In	**ON:** ROI activated **OFF:** ROI deactivated
Out	region mode
Remark	region 0 cannot be disabled

RegionDestination

This feature allows to select the destination of the image stream.

Access	read / write
Type	enumeration
In	stream0
Out	region destination

Width

This feature provides the image width in pixels.

Access	read / write
Type	unsigned integer
In	128 … WidthMax
Out	image width
Remark	the maximum value of this feature equals to SensorWidth; the image width has to be incremented by 64 pixels

Height

This feature provides the image height in lines.

Access	read / write
Type	unsigned integer
In	1 … HeightMax
Out	image height
Remark	the maximum value of this feature equals to SensorHeight; the image height has to be incremented by 1 line

OffsetX

Horizontal offset from the origin to the region of interest (in pixels).

Access	read / write
Type	unsigned integer
In	0 … OffsetXMax
Out	horizontal offset
Remark	the maximal offset equals to SensorWidth. The offset has to be incremented by 64 pixels.

OffsetY

Vertical offset from the origin to the region of interest (in lines).

Access	read / write
Type	unsigned integer
In	0 … OffsetYMax
Out	vertical offset
Remark	The maximal offset equals to SensorHeight. The offset has to be incremented by 1 line.

SensorWidth

Effective width of the sensor in pixels.

Access	read only
Type	unsigned integer
In	—
Out	sensor width

SensorHeight

Effective height of the sensor in pixels.

Access	read only
Type	unsigned integer
In	—
Out	sensor height

WidthMax

Maximum width of the image in pixels.

Access	read only
Type	unsigned integer
In	–
Out	maximally usable sensor width

HeightMax

Maximum height of the image in pixels.

Access	read
Type	unsigned integer
In	—
Out	maximally usable sensor height

PixelFormat

This feature returns the bit format the camera uses for acquisition. The default format is 8 bit. It can be changed to 10 bit. For color cameras, the order of the Bayer pattern can be selected.

Access	read/write		
Type	enumeration		
In	**Mono8**	monochrome, 8 bit/ pixel (default)	monochrome camera
	Mono10	monochrome, 10 bit/pixel packed	monochrome camera
	BayerRG8 / RG10	order of the Bayer pattern in a color image (☞ chapter Bayer Color Filter)	color camera
Out	see above		
Remark	the available pixel formats depend on the camera type connected		

TapGeometry

This feature describes the format of the image data that is transferred from the camera to the host.

Access	read	
Type	enumeration	
In	**Geometry_1X_1Y**	single pixel scanning from left to right and single line scanning from top to button
Out	see above	

Image1StreamID

This feature returns the stream ID of the primary image stream of the device.

Access	read only
Type	unsigned integer
In	—
Out	0x00000000

DeviceScanType

This feature returns the value of the camera type (area scan).

Access	read only
Type	enumeration
In	—
Out	Areascan (0x00000000)

CHAPTER

9

User Set Control

The chapter provides information on how to

- save the current camera configuration into the internal Flash memory of the camera
- load a saved configuration
- set the default configuration

Introduction

User sets can be saved into the camera's internal Flash memory. A user set can be loaded at runtime. If a user set is defined as default, it will be loaded during the start-up of the camera.

Name	Access	Length [Bytes]	Interface	Page
UserSetSelector	R/W	4	Enumeration	9-2
UserSetLoad	W	4	Command	9-2
UserSetSave	W	4	Command	9-3
UserSetDefaultSelector	R/W	4	Enumeration	9-3

UserSetSelector

This feature selects which user set (up to 3) will be loaded, saved or configured.

Access	read/write	
Type	enumeration	
In	**Default**	selects the factory settings
	UserSet1	selects the first user set
	UserSet2	selects the second user set
	UserSet3	selects the third user set
Out	active user set	
Remark	Set the UserSetSelector first to select a user set for further operations (see below).	

UserSetLoad

Loads the user set specified in UserSetSelector from the camera flash memory to the camera registers and activates it.

Access	write
Type	command
In	
Out	
Remark	If the selected User Set has not been defined previously an error message occurs. The default user set is a set of factory settings predefined by the MIKROTRON.

UserSetSave

This feature saves the user set specified in UserSetSelector into the non-volatile memory of the device.

Access	write
Type	command
In	
Out	
Remark	A previously saved user set will be overwritten. The user set “Default” is a set of factory settings and cannot be overwritten.

UserSetDefaultSelector

This feature selects the user set which will be loaded and activated after a device reset.

Access	read/write	
Type	enumeration	
In	**Default**	selects the factory setting user set
	UserSet1	selects the first user set
	UserSet2	selects the second user set
	UserSet3	selects the third user set
Out	active default user set	
Remark	The user set selector Default is preselected.	

CHAPTER

10

Custom Features

The chapter informs about

Introduction

Custom features are manufacturer specific camera functions and therefore are not defined in the standard naming convention.

Name	Access	Length [Bytes]	Interface	Page
DeviceInformationSelector	R/W	4	Enumeration	10-3
DeviceInformation	R	4	Integer	10-4
InfoFieldFrameCounterEnable	R	4	Boolean	10-5
InfoFieldTimeStampEnable	R	4	Boolean	10-6
InfoFieldRoiEnable	R	4	Boolean	10-6
FixedPatternNoiseReduction	R/W	4	Enumeration	10-7

DeviceInformationSelector

This feature selects one of the elements from the device information list

Access	read / write	
Type	enumeration	
In	**InfoSnr**	serial number of the camera (same as feature DeviceID)
	InfoType	camera type / model
	InfoSubType	camera sub type
	InfoHwRevision	camera hardware revision
	InfoFpgaVersion	camera FPGA program version
	InfoSwVersion	microcontroller software version
	InfoPwrSource	returns the source of the camera power supply (external power supply or PoC)
	InfoPwrConsumption	actual power consumption of the camera in [µA]
	InfoPwrVoltage	actual voltage of the camera power supply in [mV]
	InfoTemperature	sensor temperature degrees Celsius
Out	see row IN	
Remark	First set the selector to define the data you want to read, then read the data by reading the register DeviceInformation (see below).	

DeviceInformation

This feature returns a value of the device information list selected by feature DeviceInfoSelector.

Access	read / write	
Type	unsigned integer	
In	—	
Out	Device information values	
	InfoSnr	serial number of the camera (same as feature DeviceID); e.g.: 0x00000132
	InfoType	camera type/model; e.g.: 0x00002582 for Camera model MC2582
	InfoSubType	sub type number of the camera model; this number describes models with special features or a customized version; e.g. 0x00000001
	InfoHwRevision	describes the revision of the camera hardware bits 31-24: major revision number bits 23-16: minor revision number bits 15-00: build number e.g. 0x0103000B for revision 1.3 Build 11
	InfoFpgaVersion	version of the FPGA program of the camera: bits 31-24: major version number bits 23-16: minor version number bits 15-00: build number e.g.: 0x02050001 for Version 2.5 Build 1
	InfoSwVersion	version of the microcontroller software: bits 31-24: major version number bits 23-16: minor version number bits 15-00: 15-00 e.g.: 0x020F0011 for Version 2.15 Build 17
	InfoPwrSource	returns the source of the camera power supply value 0: external power supply value 1: power over CXP line (PoC)
	InfoPwrConsumption	returns the actual power consumption of the camera in [µA]; e.g: 0x00066580for 419200 µA = 0.4192 A
	InfoPwrVoltage	returns the actual voltage of the camera power supply in [mV]; e.g.: 0x2E4A for 11850 mV = 11.85 Volt
	InfoTemperature	returns the current camera temperature in degrees Celsius; the value returned is a signed integer; e.g.: 0x00000040 for 32 degree Celsius 0xFFFFFF2C for -2 degree Celsius
Remark	Model number, hardware revision, FPGA version, and firmware version are also included in the string of the 'DeviceVersion' Bootstrap feature.	

InfoFieldFrameCounterEnable

This feature enables/disables the Frame Counter that can be added into the info field in the image. If this option is set a frame counter will be superimposed upon each captured frame or ROI.

The frame counter occupies 4 pixels in the upper left corner of each frame starting with pixel number 0. After each activation, the counter starts with 0. When reaching the maximal value or after each acquisition start command it will restart with 0.

Access	read / write	
Type	boolean	
In	**ON**	info field is enabled (1)
	OFF	info field is disabled (0)
Out	**pixel 0**	frame counter LSB part (counter bits 7...0). The values of pixel 0 and 1 are used to build a consecutive running bit frame counter in little-endian notation. If the 24 bit counter overruns, it restarts with 0.
	pixel 1	frame counter, bits 15 … 8
	pixel 2	frame counter, bits 16 … 23
	pixel 3	ROI number – For cameras with the Multi-ROI feature the frame counter is inserted into each ROI. This starts with 1 for ROI 1. Because a set of ROIs always belongs to one frame the frame counter in each ROI is the same. For cameras without the Multi-ROI feature or if only one ROI is defined, this value is always 1.
Remark	In 10 bit mode the bits 1 … 0 in each pixel will be set to 0; guru feature	

InfoFieldTimeStampEnable

This feature enables/disables the Time Stamp filed in the image. If this feature is enabled, a 32 bit time stamp will be superimposed upon each captured frame or ROI. The frequency of the time stamp counter amounts to 25 MHz (period = 40 nanoseconds). The frame counter occupies 4 pixels in the upper left corner of each frame, starting with pixel number 4.

Access	read / write	
Type	boolean	
In	**ON**	time stamp is enabled (1)
	OFF	time stamp is disabled (0)
Out	**pixel 4**	counter bits 0...7 (LSB)
	pixel 5	counter bits 8...15
	pixel 6	counter bits 16...23
	pixel 7	counter bits 24...31 (MSB)
Remark	guru feature	

InfoFieldROIEnable

This feature enables/disables the ROI info field in the image. If this option is set, ROI info data will be superimposed upon each captured frame or ROI. The ROI info occupies 8 pixels in the upper left corner of each frame, starting with pixel number 8.

Access	read / write	
Type	boolean	
In	**ON**	ROI info field is enabled (1)
	OFF	ROI info field is disabled (0)
Out	**pixel 8**	horizontal offset, LSB, bits 0...7
	pixel 9	horizontal offset, MSB, bits 8...15
	pixel 10	width, LSB, bits 0...7
	pixel 11	width, MSB, bits 8...15
	pixel 12	vertical offset, LSB, bits 0...7
	pixel 13	vertical offset, MSB, bits 8...15
	pixel 14	height, LSB, bits 0...7
	pixel 15	height, MSB, bits 8...15
Remark	To get the value for one of the ROI parameters, multiply its MSB with 256 and add the LSB to the multiplied HSB. **Example:** ROI width = pixel 10 and 11; value of pixel 10 = 224, value of pixel 11 = 1 ROI width = 1 X 256 + 224 = 640 guru feature	

FixedPatternNoiseReduction

This feature can be used to switch the fixed pattern noise (FPN) reduction ON or OFF. Digital sensors have a noise signature, the so called Fixed Pattern Noise. This feature reduces FPN by subtracting the dark current of pixels.

Access	read/write
Type	enumeration
In	**ON:** MIKROTRON's pixel FPN reduction is activated in order to improve the quality of the image **OFF:** MIKROTRON's FPN is deactivated
Out	status (ON/OFF)

CHAPTER

11

Analog Control

The section provides information on how to control the brightness of an image by setting:

- black level
- column gain
- digital gain

Introduction

Black level defines the brightness in the darkest part of the image. Possible black level settings are values between 0 and 255. If the setting is correct, the sensor will deliver the pixel value 0 for a completely black image. If it is too high, the sensor will deliver a pixel value greater than 0 for black which means a shade of gray. If the value is too small, the sensor will deliver a pixel value of 0 for gray shades.

Gain is used to increase the brightness of an image. The available range depends on the camera connected. If you increase the gain, all pixel values of the image will be increased which means, the whole image becomes brighter. Unfortunately, noise will increase too.

Name	Access	Length [Bytes]	Interface	Page
Blacklevel	R/W	4	Integer	11-2
Digital Gain	R/W	4	Float	11-3
ColumnGain	R/W	4	Integer	11-3

BlackLevel

The black level value defines the brightness in the darkest part of an image. An optimal setting means, the pixel value 0 is delivered for a completely black image. If it is too high, it will deliver a pixel value greater than 0 (which is reserved for a shade of gray). It it is too small, it will deliver a pixel value of 0 for a shade of gray. sensor’s

Access	read/write
Type	enumeration
In	0 to 255
Out	current black level value
Remark	can be incremented by 1

ColumnGain

Column gain will be increased before the analog value is converted into a digital value. As a consequence the dynamic range will decrease and noise will increase. In case your signal is too small, use column gain before you use digital gain.

Access	read/write
Type	integer
In	min: 0
Out	max: 3
Remark	column gain can be de-/incremented by: gain0 = gain x 1 (default gain1 = gain x 1.26 gain2 = gain x 1.87 gain3 = gain x 3.17

DigitalGain

When using digital gain the all pixels values of the image will be increased. As a result, the whole image becomes brighter, the dynamic range is decreased, and noise will be increased. It is recommended to be used for 8-bit-images only.

Access	read/write
Type	float
In	min: 1 - 4
Out	max: 1 - 4
Remark	column gain can be de-/incremented in steps of 0.25

CHAPTER

12

Digital I/O Control

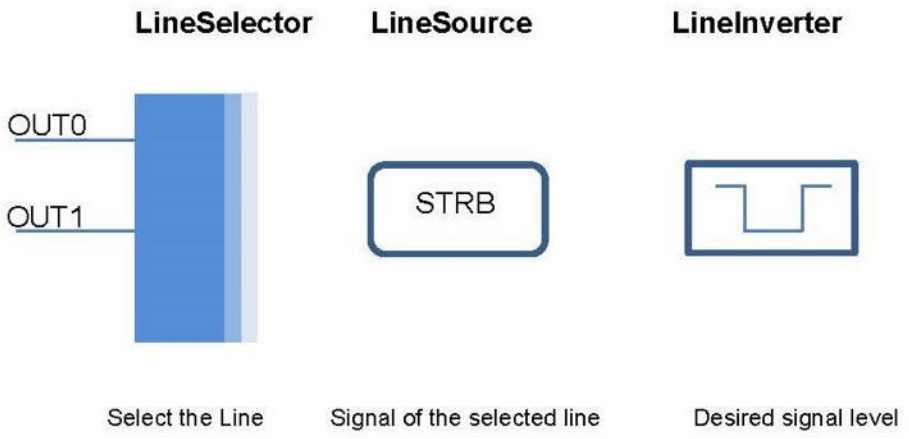
The chapter describes the features of Digital I/O Control used to

- change the signal level of a signal
- select the output OUT1 or OUT2 to output signals
- invert the output level
- send a static level of a variable to OUT1 or OUT2

Introduction

There are three features needed to control the line out signals.

Name	Access	Length [Bytes]	Interface
LineSelector	R/W	4	Enumeration
LineSource	R/W	4	Enumeration
LineInverter	R/W	4	Enumeration



LineSelector

This feature selects the physical output line to be configured with the commands LineSource and LineInverter. Up to now, there are two output lines that can be selected: either OUT0 or OUT1.

Access	read/write
Type	enumeration
In	OUT0 OUT1
Out	selected output of the Hirose connector
Remark	expert feature

LineSource

This feature defines which signal will apply at the output selected with LineSelector.

Access	read/write
Type	enumeration
In	ExposureActive: STRB (0) UserOutput0: state of the user output bit 0 UserOutput1: state of the user output bit 1
Out	selected signal
Remark	expert feature

LineInverter

This feature controls whether the level of the output signal will be inverted or not.

Access	read/write
Type	enumeration
In	inverted = 1 not inverted = 0
Out	setting: inverted or not inverted
Remark	default is 0 (not inverted); expert feature

UserOutputSelector

This feature allows to select the variable UserOutput0 or UserOutput1. The level of the here selected variable can be defined by the feature UserOutputValue.

Access	read/write
Type	enumeration
In	UserOutput1 = 1 UserOutput0 = 0
Out	status of the variable
Remark	expert feature

UserOutputValue

This feature allows to define the output level of the variable selected by UserOutputSelector.

Access	read/write
Type	boolean
In	high = 1 low = 0
Out	status of the bit
Remark	expert feature

This static output level can be routed to a physical output with the feature LineSource.

CHAPTER

13

File Access Control

File access commands give you access on files stored in the camera flash. Up to now, only the file *defect pixel map* is available.

Introduction

Data of files stored in the camera flash can be accessed with the following commands:

Name	Address	Access	Length [Bytes]	Register interface	Page
FileSelector	0x08100000	R/W	4	Integer	13-3
FileOperationSelector	0x08100004	R/W	4	Integer	13-3
FileOperationExecute	0x08100008	W	4	Integer	13-3
FileOpenMode	0x0810000C	R/W	4	Integer	13-4
FileAccessBuffer	0x30000000	R	4	Integer	13-4
FileAccessOffset	0x08100014	R/W	4	Integer	13-4
FileAccessLength	0x08100018	R/W	4	Integer	13-5
FileOperationStatus	0x0810001C	R	4	Integer	13-5
FileOperationResult	0x08100020	R	4	Integer	13-5
FileSize	0x08102024	R	4	Integer	13-5

Procedure:

Step 1. Select the file you want to access

Step 2. Call the open command

Step 3. Execute the open command

Step 4. Define the data section that has to be loaded into the buffer (file length is available in FileSize)

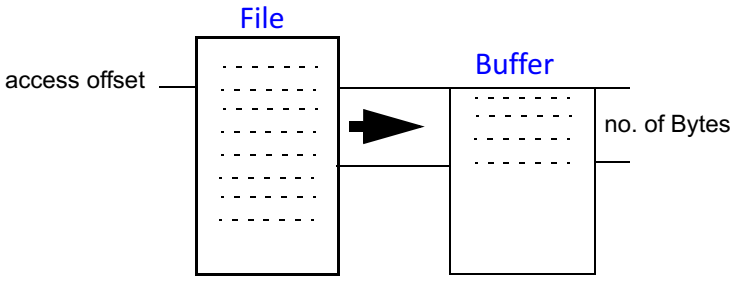
Step 5. Define the operation (write, read, delete...)

Step 6. Execute the operation

Step 7. Close the file

When reading/writing data from/into the camera, you have to define:

- where the access buffer gets mapped to the file and
- to define the length by the no. of Bytes to be read/written



Starting with the access offset the defined no. of Bytes will be written into the buffer.

FileSelector

This command allows to select one of the available files stored in the camera flash.

Access	read/write
Type	unsigned integer
In	file name: *defect pixel map*
Remark	Up to now, only the file *defect pixel map* is available. For more information see "*Camera Files*" on page E-1.

FileOperationSelector

Chose what you want to do with the selected file.

Access	read/write	
Type	unsigned integer	
In	open close read write delete	0x00000004 0x00000008 0x00000001 0x00000002 0x00000020
Remark	It depends on the file what operations are possible. The defect pixel map e.g. can be read only.	

FileOperationExecute

Executes the operation you selected by the FileOperationSelector.

Access	write only
Type	unsigned integer
In	0
Remark	Each operation has to be executed.

FileOpenMode

Defines the access mode in which the file will be opened.

Access	read/write	
Type	unsigned integer	
In	Read Write ReadWrite	0x00000001 0x00000002 0x00000010

FileAccessBuffer

Address of the access buffer Byte array.

Access	read
Type	integer
In	any existing file
Remark	The buffer size amounts to up to 0x40000 Bytes. Start address: 0x30000000 End address: 0x30040000 or max. file length

FileAccessOffset

Defines where the start of the access buffer gets mapped to the file.

Access	read / write
Type	integer
In	start address in the selected file
Remark	min.: 0 max.: file length

FileAccessLength

Define the number of Bytes to be read/written from/to the selected file.

Access	read / write
Type	integer
In	no. of Bytes to be read/written to/from the file
Remark	access length ≤ file length - access offset

FileOperationStatus

Check whether the executed operation was successful or not.

Access	read
Type	integer
Out	*success* or *failure*

FileOperationResult

Indicates the number of successfully written or read Bytes.

Access	read
Type	integer
Out	number of successfully operated Bytes

FileSize

Indicates the size of the selected file in Bytes after the file is opened.

Access	read
Type	integer
Out	file size in Bytes

APPENDIX

A

Technical Data

Sensor

Resolution	4096 x 3072
Sensor type	CMOS; monochrome or color (Bayer color filter)
Operating temperature range	-40 to +85 °C
Pixel depth	8 / 10 bit
Pixel size	4.5 µm x 4.5 µm
Pixel type	in-pixel CDS, global shutter pixel architecture
Active area	32.6mm diagonal
Light sensitivity	5.8 V/lux.s @ 550 nm
Shutter speed	from 1 µs to 0.1 s in steps of 1 µs
Internal dynamics	59 dB
Fill factor x quantum efficiency	50% @ 550 nm
Full well charge	12000 e^-

Camera

Video output	CoaXPress CXP-3, CXP-5 and CXP-6
Communication	CoaXPress with Gen<I>Cam based technology
Trigger	asynchronous shutter via CoaXPress interface, hardware trigger connected with TRIG input of the 12-pin Hirose connector, and software trigger
Power supply	12 … 24 V (min. 18 W) external power supply; power over CoaXPress of up to 13 W
Power consumption	max. (4 x 6.25 Gbps and max. resolution) 875mA@10 (5W)
Shock & vibration	70 g, 7 g_{rms} (root-mean-square acceleration)
Dimensions (H x W x D)	80 x 80 x 86 mm (F-Mount)
Case temperature range	between +5 and +50 °C
Weight	550 / 560 g without/with lens cover
Lens mount	F-mount

APPENDIX

B

Spectral Response

Monochrome and Color Version

The charts below show the sensitivity of the monochrome and color sensor with Bayer color filter on the sensor glass lid.

Color cameras are by default equipped with a UV/IR cut filter with a transmittance from 370 to 670 nm resulting in a sensitivity shown in the second chart.

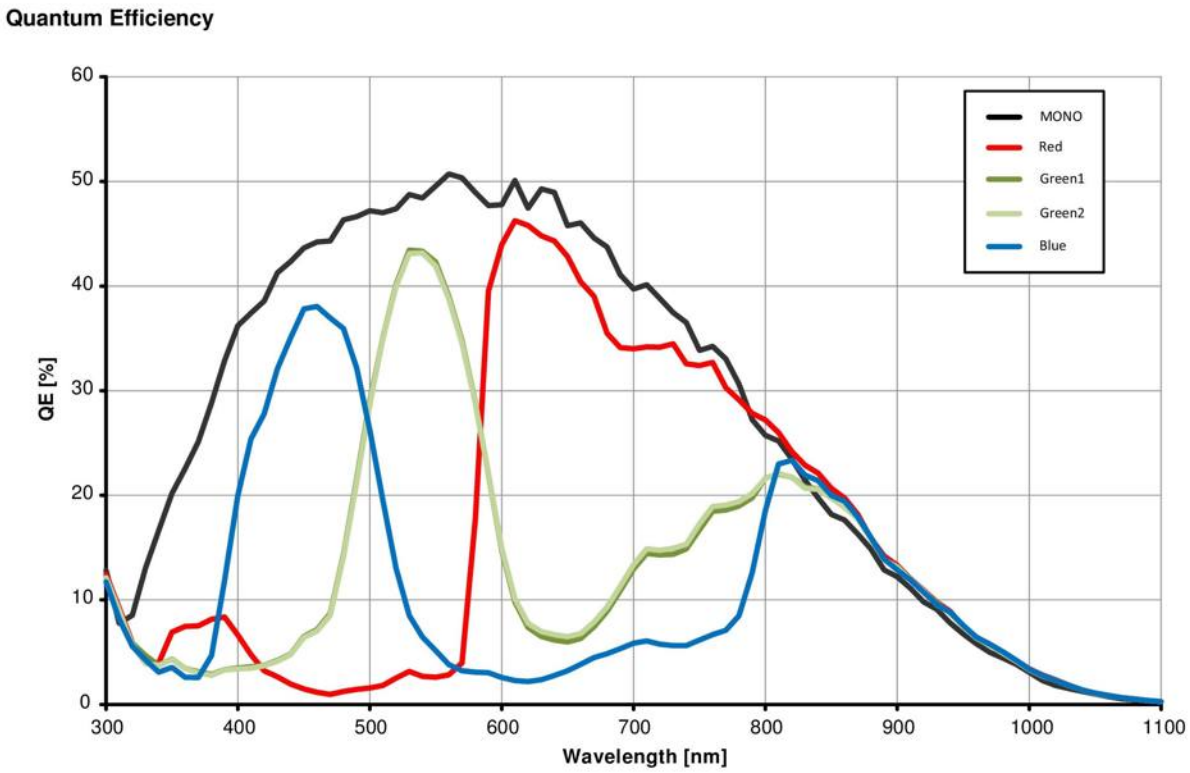


Image B-1: quantum efficiency curve for monochrome and color

On request all cameras can be delivered with or without UV/IR cut filter.

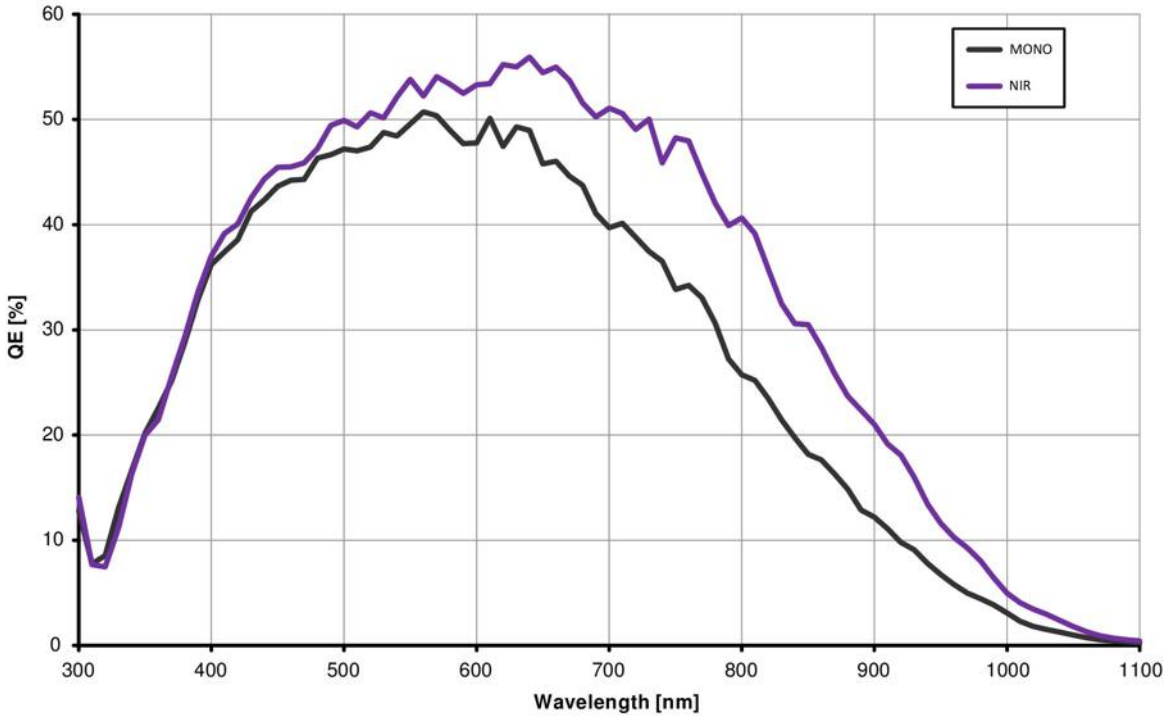


Image B-2: quantum efficiency curve for standard and NIR monochrome

APPENDIX

C

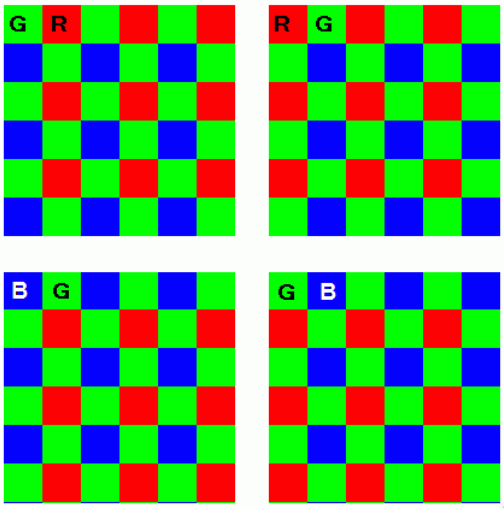
Bayer Pattern

Color Filter Array

The sensor glass lid of MIKROTRON's Eo*Sens* color cameras is covered with a Bayer color filter. In order to get the color information, the imaging software has to decode the information of each pixel into RGB by using the values of its neighbor pixels.

Depending on the sensor type, the color pattern can differ. The entry in the feature PixelFormat in the XML file shows what pattern applies to the sensor you use.

BayerRG10 for example stands for a 10 bit pattern that starts with a red pixel followed by a green one. BayerGB8 stands for an 8 bit pattern that starts with a green pixel followed by a blue one. The figure below shows the four possible Bayer patterns:



Example for BayerRG

In a BayerRGB color pattern pixel (0;0) has a red filter situated in the upper left corner in the first line. Green1 pixels are located in the red-green row, green2 pixels are located in a green-blue row.

Each red, green and blue filter element covers exactly one pixel on the sensor. A matrix of 2 x 2 filter elements builds a filter element matrix.

Conclusions

Because of the size and the order of a filter matrix element three facts can be concluded:

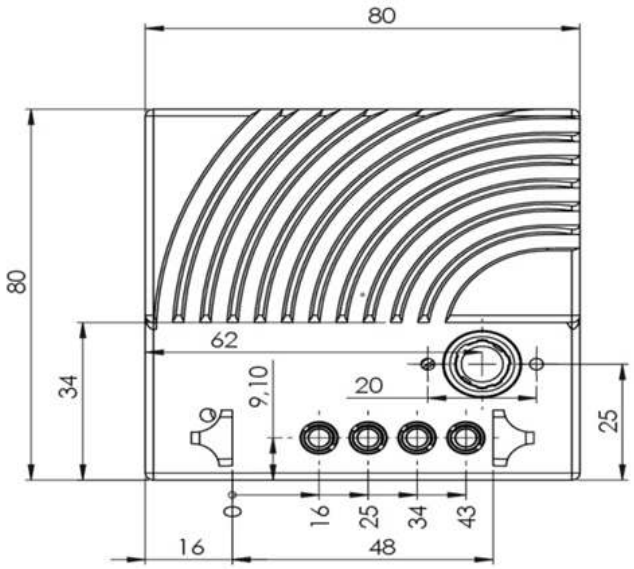
1. Any (sub) region of a Bayer pattern coded image has always to start with the same color on the top left (0;0) pixel position of the region.
2. A Bayer pattern image has to have an even number of pixels and an even number of lines.
3. Changing the image size can only be done by steps of 2 in the horizontal **and** vertical direction.

APPENDIX

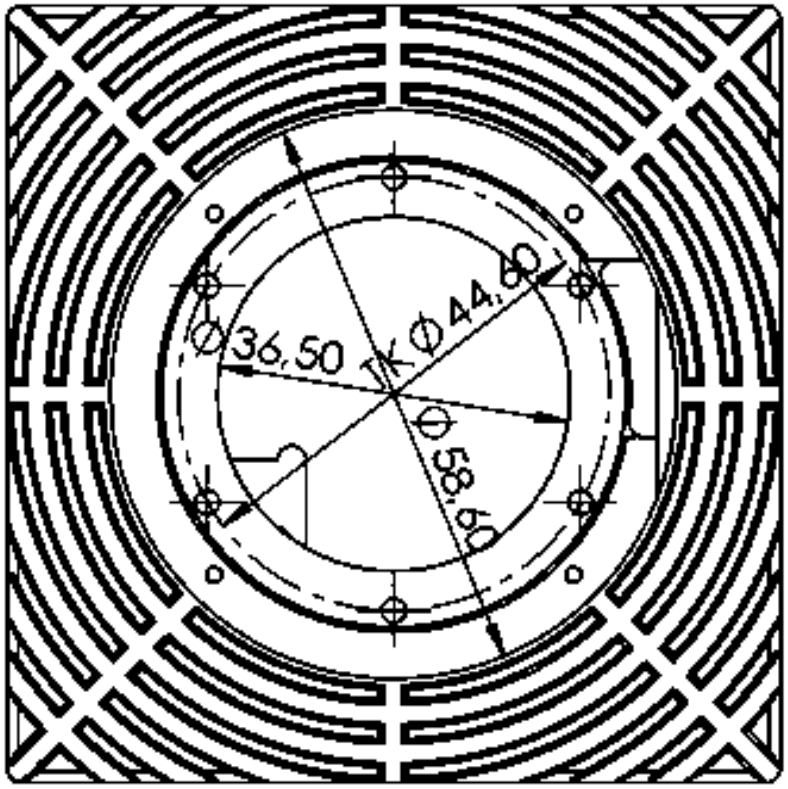
D

Camera Dimensions

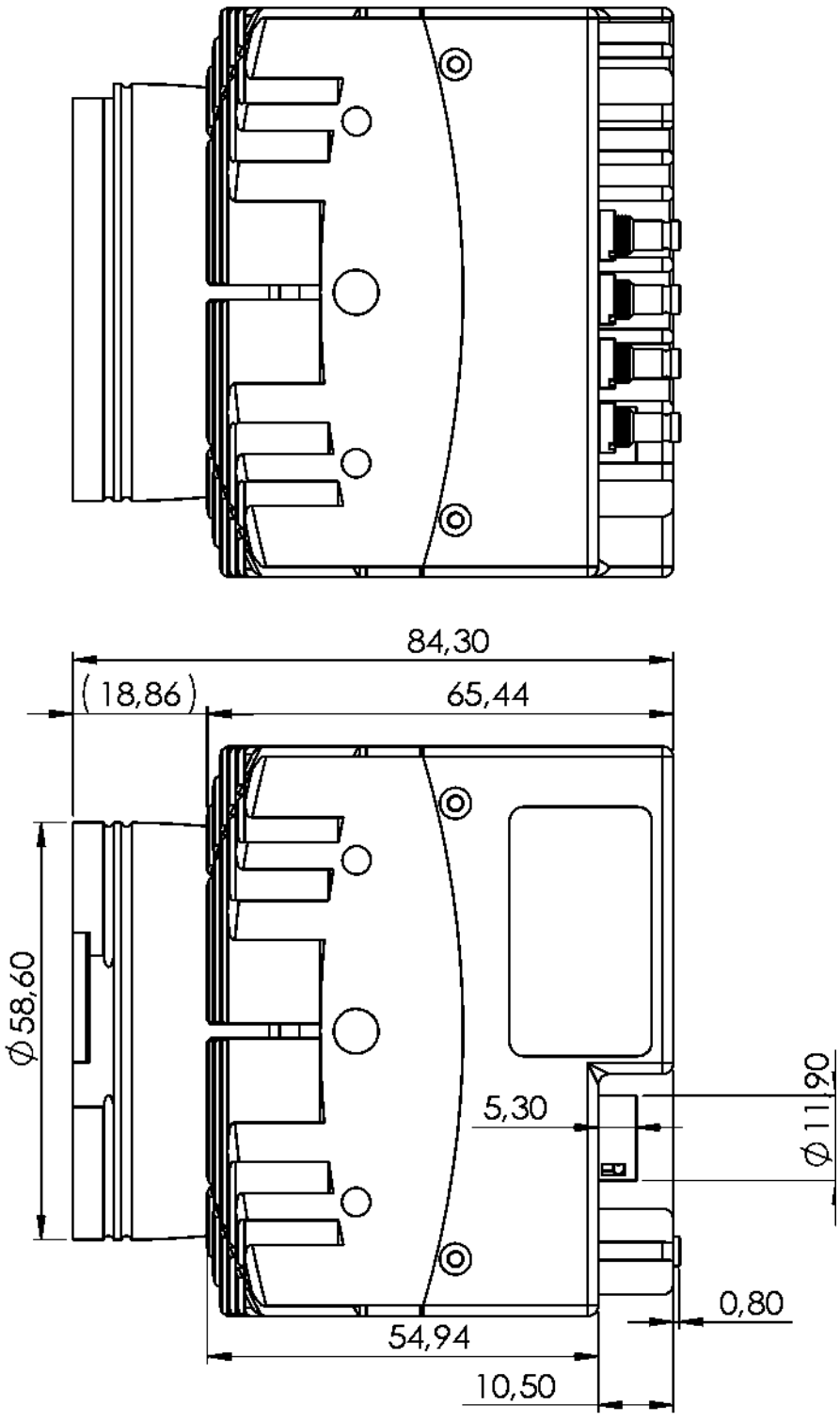
Rear View



Front View



Side View



APPENDIX

E

Camera Files

Up to know, there is one camera file available:

- Defect Pixel Map

Defect Pixel Map

Pixels in an image that are not performing as expected are called defect pixels. Mikrotron provides a defect pixel map file in order to analyze pixels of a frame.

The defect pixel map can be read with the commands described in the chapter "File Access Control" on page 13-1.

Remark: Defect pixel maps can be read only.

There are three different defect pixel types:

- white pixels (hex value 0)
  pixels that are too bright
- black pixels (hex value 1)
  pixels that are too dark
- bad pixels (hex value 3)
  pixels with a difference of +/- 40 grey levels compared to the surrounding pixels

The defect pixel map lists in hexadecimal numbers:

- pixel type
- number of defect pixels of this type
- x-position of each defect pixel
- y-position of each defect pixel

Note Take into account that the hexadecimal numbers have to be read from right to left in packages of two digits (little endian). For example: 13 6D has to be read 6D 13.

Reading a Pixel Map

The first line starts always with the pixel type 0 (white). The second line indicates the x and y position of the detected defect pixel.

The first two Bytes: 00 00 indicate the pixel type. In this case zero (white).

```
00 00 01 00
6E 13 2C 10
```

The second two Bytes: 00 01 indicate the number of defect pixels of type 0. In this case there is one defect white pixel.

```
00 00 01 00
6E 13 2C 10
```

The x position of this defect white pixel is: **13 6E** (decimal: 4974).

The y position of this defect white pixel is: **10 2C** (decimal: 11280).

Example of a Pixel Map

A complete defect pixel map could look like this:

```
00 00 00 00
01 00 02 00
BA 01 00 00
A6 04 00 00
02 00 04 00
26 06 A5 05
C0 06 FE 05
10 07 3A 03
F8 08 A1 06
```

The first line shows that there is no defect white pixel (0). In this case there will not follow an x or y position.

```
00 00 00 00
```

The second line indicates two defect black pixels (`01 00 02 00`). Their positions are given in the next two lines:

	x position	y postion
`BA 01 00 00`	01 BA	00 00
`A6 04 00 00`	04 A6	00 00

The fifth line indicates four bad pixels (`02 00 04 00`).
Their positions are given in the next four lines:

	x position	y postion
`26 06 A5 05`	06 26	05 A5
`C0 06 FE 05`	06 C0	05 FE
`10 07 3A 03`	07 10	03 3A
`F8 08 A1 06`	08 F8	06 A1

Manual Revision

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