EoSens® CL Camera Manual

• High Speed CMOS Camera • High Sensitivity •

EoSens CL Camera Manual	Rev. 1.19
Camera-Firmware:	B2.02-V1.24-F1.17
Camera ID:	MC1360-63

Functions described in this manual may not be available with firmware versions prior than above mentioned. Information presented in this publication has been carefully checked for reliability; however, no responsibility is assumed for inaccuracies. The information contained in this document is subject to change without notice.

Mikrotron GmbH
Landshuter Str. 20-22
D-85716 Unterschleissheim
Germany

Tel.: +49 89 726342 00
Fax: +49 89 726342 99
info@mikrotron.de
www.mikrotron.de

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1 General

1.1 For customers in the U.S.A.

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 J of Part 15 of FCC Rules.

1.2 For customers in Canada

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

1.3 Pour utilisateurs au Canada

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

1.4 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. 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.

1.5 Declaration of conformity

Manufacturer: **Mikrotron GmbH**

Address: Landshuter Str. 20-22
85716 Unterschleissheim
Germany

Product: **Camera** **MC1360, MC1361, MC1362, MC1363**

The dedicated products conform to the requirements of the Council Directives 2004/108/EG for the approximation of the laws of the Member States relating to electromagnetic consistency. The following standards were consulted for the conformity testing with regard to electromagnetic consistency.

EC regulation	Description
EN 61000-6-3	Electromagnetic compatibility
EN 61000-6-1	Immunity

Unterschleissheim, October 04, 2007

Mikrotron GmbH

Dipl.-Ing. Bernhard Mindermann
President of Mikrotron

1.6 Warranty Note

Do not open the body of the camera. The warranty becomes void if the body is opened.

1.7 Remarks, Warnings

This document contains important remarks and warnings. See the corresponding symbols:

	**Important remark**

	**Attention, Warning**

2 Introduction

The CMOS high speed camera Eo*Sens* is a high resolution camera with 1280x1024 pixel. Benefits of CMOS technology are high speed, random access to pixels with free programmability and low power.

The camera uses industry-standard C-Mount or F-Mount lenses. The sensor diagonal is 22.9 mm with square pixels measuring 14 µm.

Free programmability means that the user is free to define the region of interest by size and position and the speed of data output. The frame rate can be selected between 1 fps and several thousand fps depending on resolution and video data width.

With a resolution of 1280 x 1024 pixel, 500 fps (MC1362/63) can be output via the “Full Camera Link®” Interface.

2.1 Top level specifications

- High resolution: 1280x1024 pixel CMOS sensor
- up to 1024 gray levels (10bit resolution)
- up to 110 full frames/s for MC1360/61
- up to 500 full frames/s for MC1362/63
- arbitrary region of interest
- very high sensitivity
- 14 µm square pixels
- electronic “Freeze Frame” shutter
- low blooming
- programmable via CameraLink® serial interface
- asynchronous trigger
- small, compact housing
- wide power supply range

2.2 Electronic “Freeze Frame” Shutter

Preceding exposure, the contents of all light sensitive elements is cleared. When exposure terminates, accumulated charge is transferred to an analog memory associated which each pixel. It stays there until it is read out (and discharged) by the A/D conversion cycle.

As all light sensitive elements are exposed at the same time, even fast moving objects are captured without geometric distortion.

2.3 Differences between the camera types

The CMOS cameras are available in different versions depending on the supported features monochrome/color or Base/Full Camera Link® interface.

Features Type	Data width (bits)	Color/ Mono	Base/Full Camera Link® no. of taps	C/F-Mount lens adaption	max. frame-rate @ 1280 x 1024	Image pre-processing supported
MC1360	8/10	M	B-2	C/F	110 fps	-
MC1361	8/10	C	B-2	C/F	110 fps	-
MC1362	8/10	M	B,F-2,8,10	C/F	500 fps	+
MC1363	8/10	C	B,F-2,8,10	C/F	500 fps	+

2.4 Using the camera

There are no serviceable parts inside the camera. The camera may not be opened, otherwise guarantee is lost.

Use dry, soft lens-cleaning tissue for cleaning lenses and, if necessary, the sensors window.

3 Hardware

3.1 Camera Link® interface

Camera Link® is designed for digital cameras in machine vision applications. A “Full Camera Link®” interface can transfer up to 80 bits of data at a rate of max. 680 Mbytes/sec.

3.1.1 Serial interface

The communication via the serial interface is incorporated in the Base Camera Link® interface.

3.2 Power supply

The camera needs a DC supply voltage between 8 … 24V at a power consumption of 5 Watt max.

See also chapter connector pinning.

Before applying power to the camera we strongly recommend to verify the used pins of the power connector, the polarity (+/-) of the leads and the supply voltage.

The camera may only be used with a supply voltage according to the camera specification. Connecting a lower or higher supply voltage, AC voltage, reversal polarity or using wrong pins of the power connector may damage the camera. If doing so, the warranty will expire immediately.

3.3 Status LED

A dual color LED on the camera backplane shows the operating condition of the Eo*Sens*.

LED orange...	The Eo*Sens* is configuring the internal FPGA. No other activity is possible.
LED green...	The Eo*Sens* is fully operational.
LED off...	If LED is off, despite the camera is powered, data is stored to the internal EEPROM. No other activity is possible.
LED red...	The microcontroller detected a wrong checksum or the FPGA could not be loaded because of wrong FPGA configuration data. The camera is not functional. Try to reload configuration data.
LED red blinking...	Data is loaded to microcontroller or FPGA from the PC or the camera verifies the checksum. No other activity is possible.

4 Getting started

Before starting to operate the camera, make sure that the following equipment is available:

- Camera Eo*Sens*
- C-Mount/F-Mount Lens
- Mikrotron Support CD
- Image processing system, e.g.: PC and Software

Additional items:

- 1 Camera Link® cable
- 1 Power supply 12VDC, 0.75A min
- 1 power cable

	To specify cables see chapter connector pinning.

4.1 First steps

- Switch off the image processing system
- Connect Camera Link® cable between camera and PC.
- Connect power cable.
- Unscrew dust protection cover, screw in lens.
- Switch on the image processing system and camera power supply

5 Initial setup

The Eo*Sens* camera is delivered with initial parameters and therefore does not need to be configured via the serial link.

5.1 Serial number and firmware revision

Serial number and firmware revision is provided in Eo*Sens* non volatile memory. Use **:v** command (Read serial number and firmware revision) to read serial number and firmware revision. The serial number is also marked on the type plate of the camera.

5.2 PowerUpProfile

The PowerUpProfile is the content of all camera registers to be loaded from non-volatile memory after power up.

5.3 Camera profile

The actual set of parameters is called Camera Profile. All changes of parameters by the serial link is reflected in the Camera Profile. On command the Camera Profile is saved to 8 user profiles or the PowerUpProfile. It is loaded from the PowerUpProfile, 8 user profiles or 8 factory profiles. The camera profile is volatile and must be stored to the PowerUpProfile to be reactivated on next power up.

5.4 Factory profiles

The factory profiles can be read but not written by the user. They are factory preset to the settings described below.

Profile Nr.	Video data width /Mbyte/s	resolution / pixel	Image frequency /fps	Mode	CL-Conf.	Pixelclock / MHz
0	155	640x480	405	2x10	Base	80
1	180	1280x1024	110	2x10	Base	80
2	124	640x480	405	2x8	Base	80
3	144	1280x1024	110	2x8	Base	80
4	311	640x480	811	4x10	Medium	80
5	370	1280x1024	226	4x10	Medium	80
6	490	640x480	1594	8x8	Full	80
7	570	1280x1024	430	8x8	Full	80

Profiles 4 – 7 are only available in Eo*Sens* full. (MC1362-63)

5.5 User profiles

The user can store up to eight User Profiles in non volatile memory. All load or write commands exchange data between the Camera Profile and one of the eight user profiles.

Profile Nr.	Video data width /Mbyte/s	resolution / pixel	Image frequency /fps	Mode	CL-Conf.	Pixelclock / MHz
0	155	640x480	405	2x10	Base	80
1	180	1280x1024	110	2x10	Base	80
2	124	640x480	405	2x8	Base	80
3	144	1280x1024	110	2x8	Base	80
4	311	640x480	811	4x10	Medium	80
5	370	1280x1024	226	4x10	Medium	80
6	490	640x480	1594	8x8	Full	80
7	570	1280x1024	430	8x8	Full	80

Profiles 4 – 7 are only available in Eo*Sens* full. (MC1362-63)

5.6 PowerUpProfile

The user can store one PowerUpProfile in non volatile memory.

Profile Nr.	Video data width /Mbyte/s	resolution / pixel	Image frequency /fps	Mode	CL-Conf.	Pixelclock / MHz
c	144	1280x1024	110	2x8	Base	80

6 Configuration

The content of all Eo*Sens* registers is called a profile. There is space in non volatile memory for 17 profiles: The PowerUpProfile, 8 user profiles and 8 factory profiles.

Any change of a specific register through the serial interface is immediately processed and written to the volatile part of the memory and gets lost when power goes down. A command must be used to store the actual setting in non volatile memory. After power-up the PowerUp-Profile is loaded from the non-volatile to the volatile part of the memory.

A load or write command exchanges data between the camera profile and one of the eight user profiles. The eight factory profiles can be read but not be written by any command. All values are given in hexadecimal notation, e.g.: 0xff or 0ffh = 255.

Commands:
ASCII strings are used to change camera parameters. All commands start with a colon followed by the command character. Note that the commands are case sensitive. The baudrate can not be saved. Therefore the camera always defaults to 9600 baud after power on or reset.

After a command has been recognized, processing is immediate for all commands but the save command (:p). This needs a EEPROM write time. An answer is provided with read type commands (e.g. :v, :w), or, if the command acknowledge flag is set, after processing of each command an ACK or NAK character. Processing of wrong commands is stopped immediately on recognizing the error. A new command must start with a colon.

All unknown commands will return NAK. After the colon the maximum time between the characters must not exceed 2.7 sec., else the command will terminate with NAK. This prevents the parser from hanging in the input if a command is not entered complete.

All commands return the actual value by sending '?' as parameter. Some commands then also return the actual possible value range.

6.1 Table of commands

Syntax	Value range	Answer	Comment	Chapter
:A<x> :A?	<x> = y,Y,n,N	-- [2] or 'y','n' [3]	command acknowledge flag yes or no	6.9.6
:b<x> :b?	<x> = 0…4	-- [2] or <x>[3]	Select baudrate 0 = 9600 (default), 1 = 19200, 2 = 38400, 3 = 57600, 4 = 115200	6.9.7
:B	--	OK or ERROR: xxxx[3]	Send last error to PC (max. 45 chars)	6.9.4
:c	--	-- [2]	Reset camera and load power up profile	6.9.5
:d<aaa><bbb><ccc><ddd> :d?	<aaa> = x-start 0…4F8$_{hex}$ <bbb> = y-start 0…3FE$_{hex}$ <ccc> = x-width 2…500$_{hex}$ <ddd> = y-height 1…400$_{hex}$	-- [2] or <aaa><bbb><ccc><ddd>[3]	Set ROI start- and endcoordinate (data area)	6.6.1
:D<xxxx> :D?	<xxxx> = 0, 400…1000h	-- [2] or <xxxx>[3]	Digital gain 400 = gain 1x, 1000 = gain 4x, 0 = gain correction off	6.5.1
:f<n>	<n> = 0…7 for EoSens full <n> = 0…3 for EoSens base	-- [2]	Load factory profile <n>	6.3.3
:g<n>	<n> = 0…7, c for EoSens full <n> = 0…3, c for EoSens base	-- [2]	Load user profile in bank <n> bank „c" = PowerUpProfile	6.3.2
:h<n> :h?	<x> = 0…2	-- [2] or <x>[3]	Shutter 0 = free run, 1 = PWC, 2 = timer	6.8.1
:H<n> :H?	<x> = 0, 1	-- [2] or <x>[3]	Set shutter pulse polarity 0 = positive edge, 1 = negative edge	6.8.1
:i<s><x> :i<s>? :i<s><xx> :i<s>?	<s> = 'n' ==> <x> = 1…3 <s> = 'd',' t' ==> <xx> = 1…63$_{hex}$	-- [2] or <x>[3] -- [2] or <xx>' '<yy>-<zz>[3]	1 = normal shutter, 2 = dual slope, 3 = triple slope set d=dual, t=triple slope in percent of shutter time get actual slope time and allowable range	6.7.3
:j<x> :j?	<x> = 0, 1	-- [2] or <x>[3]	Enable=1 or disable=0 linescan mode	6.4.3
:k<xx> :k?	<xx> = 32…C8$_{hex}$	-- [2] or or <xx>[3]	Set blacklevel; value 80h is default; increase or decrease value slightly to adjust blacklevel	6.5.2
:K<z><x> :K<z><xxx> :K<z>?	<z> = 'n' ==> <x> = 0…1 <z> = 'v' ==> <xxx> = 0…3FF$_{hex}$	-- [2] or <x>[3] or <xxx>[3]	Enable or disable threshold with :Kn1 or :Kn0 or set threshold value with :Kv<xxx>	6.9.3
:l<n><y> :l ?	<n> = 0…3 <y> = 1…f$_{hex}$	-- [2] or <ny>[3]	Select ROI move mode with external CCx input ; see command description	6.6.5
:L<z><xxx><yyy> :L<z>? :L<z><a>	<z> = 1…3 or 'n' <xxx> = x-start 0…4FE$_{hex}$ <yyy> = y-start 0…3Fe$_{hex}$ <a> = 0…3	-- [2] or <xxx><yyy>[3] or <a>[3]	Select multiple ROI's ; see command description	6.6.2
:M<x> :M?	<n> = 0…7 EoSens full <n> = 0…1, 7 EoSens base	-- [2] or <n>[3]	Set mode 0 = 2x8, 1 = 2x10, 2 = 16x1 3 = 2x8 mask, 4 = 4x10, 5 = 8x8, 6 = 10x8, 7 = 1x10	6.4.1
:n<x> :n?	<x> = 0…1	-- [2] or <x>[3]	0 = Power down + testimage 1 = normal operation	6.9.2
:N<x> :N?	<x> = 0…1	-- [2] or <x>[3]	Enable=1 or disable=0 FPN correction	6.5.3
:o<x> :o?	<x> = 0…3	-- [2] or <x>[3]	Invert readout in x- and or y-direction	6.6.6
:O<x> :O?	<x> = 1…7	-- [2] or <x>[3]	Non destructive readout 1…7 frames	6.7.4
:p<n>	<n> = 0…7, c for EoSens full <n> = 0…3, c for EoSens base	-- [2]	save actual profile in bank <n> -- takes about 2 sec. -- Bank „c" = PowerUpProfile	6.3.1
:q<xxxxxx> :q?	<xxxxxx> = 1…13880$_{hex}$	-- [2] or <xxxxxx>' '<ss>'-'<zzzzzz>[3]	Set framerate get actual framerate, and possible framerate range for actual ROI	6.7.1
:Q<x> :Q?	<x> = 0…1	-- [2] or <x>[3]	Decimation (subsampling) mode on/off	6.6.7
:R<xx> :R?	<xx>=28,2d,32,37,3c,41,46,4b,50$_{hex}$	-- [2] or <xx>[3]	Reduce pixelclock from 80MHz to 40,45,55,60,65,70 or 75 MHz	6.4.2
:SC<xxx><yyy><rrr><www> :SM<aaa><dddd> :SE :SV<n>	<xxx> = 0…500$_{hex}$; <yyy> = 0…400$_{hex}$ <rrr> = 1…300$_{hex}$; <www> = 1…400$_{hex}$ <aaa> = 0…3ff$_{hex}$; <dddd>= 0…ffff$_{hex}$ <n> = 0…1 , ?	-- [2] -- [2] -- [2] -- [2]	Shape circle create Shape mask load Shape erase Shape visible on/off	6.6.3
:t<xxxxxx> :t?	<xxxxxx> = 2…F4240$_{hex}$	-- [2] or <xxxxxxx>' '<ss>-<zzzzzz>[3]	Set shutter time in µs get actual shutter time and possible shutter time range for actual framerate	6.7.2
:T	--	(-)xx[3]	Temperature in °C	6.2.3
:u<x> :u?	<x> = 0…1	-- [2] or <x>[3]	Framecounter 0=off, 1=on	6.9.1
:v	--	Snr., Boot, App, FPGA[3]	Send snr and versions to PC	6.2.1
:V	--	Cameratype, ID[3]	Send cameratype and -ID to PC	6.2.2
:xv<aabbccddeeeeeeffffff> :xa<n>	See description	-- [2]	Automatic shutter time adjust	6.2.3

[2] if the command acknowledge flag is set the return will be ACK (0x06) or NAK (0x15).
[3] The answer is followed by a CR (0x0d) trailer.

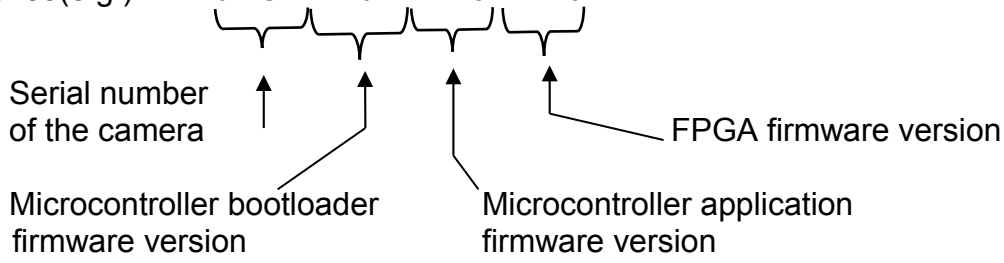
The gray printed commands are optional features

6.2 Read camera information

6.2.1 Read serial number and firmware revision, command :v

The serial number and the firmware revision can be read with the **:v** command.

Command: `:v`
Response(e.g.): `#01234-B2.02-V1.18-F1.10`

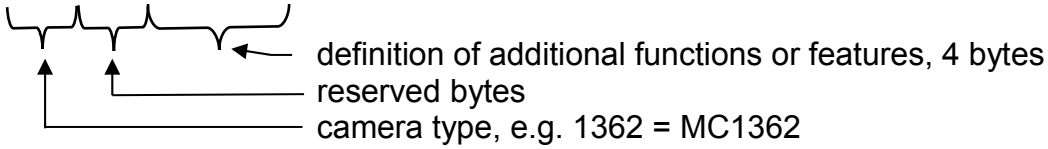


The answer is followed by a CR (0x0d) trailer.

6.2.2 Read identifier, command :V

The identifier offers information about the camera type and camera functions. It consists of 8 bytes, which are delivered as 16 ASCII characters.

Command: `:V`
Response (e.g.): `1362000003040303`



The answer is followed by a CR (0x0d) trailer.

6.2.3 Read camera temperature, command :T

To control the temperature inside , the camera disposes an internal temperature sensor. The temperature inside the camera can be read out in steps of 1°. The values are delivered in ASCII characters.

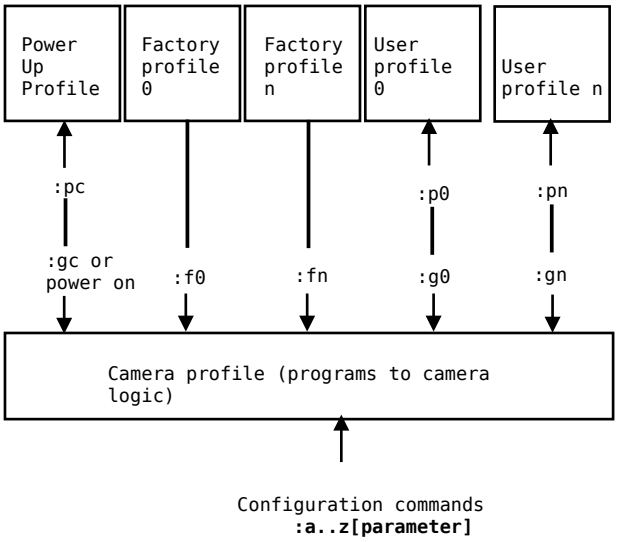
Command: `:T`
Response(e.g.): `34`

The answer is followed by a CR (0x0d) trailer.
The temperature Sensor is able to deliver values of –128°C to +128°C.

	**Take care that the temperature of the camera does not exceed the specified case temperature range.**

6.3 Profile processing

All camera settings are loaded or stored as complete data blocks (= Profiles).
Eo*Sens* full (MC1362-63) has 17 profiles consisting of 8 factory profiles, 8 user profiles and a power up profile.
Eo*Sens* base (MC1360-61) has 9 profiles consisting of 4 factory profiles, 4 user profiles and a power up profile.



6.3.1 Write user profile, command :p

The actual Profile is transferred to one of the eight user profiles or the PowerUpProfile. Profile “c“ is the PowerUpProfile.

Command: **:p<*n*>**

<*n*> = 0…7, c for Eo*Sens* full
<*n*> = 0…3, c for Eo*Sens* base

Issue this command only, if the profile was successfully tested.

6.3.2 Load user profile, command :g

Load one of eight user profiles or the PowerUpProfile to the actual camera profile. Profile “c“ is the PowerUpProfile

Command: :g<*n*>

<*n*> = 0…7, c for Eo*Sens* full
<*n*> = 0…3, c for Eo*Sens* base

6.3.3 Load factory profile, command :f

The eight factory profiles can be read but not changed by the user.

Command: :f<*n*>

<*n*> = 0…7, c for Eo*Sens* full
<*n*> = 0…3, c for Eo*Sens* base

6.4 Output mode

6.4.1 Camera Link® output mode, command :M

Command: `:M<x>` `<x> = 0…7`
or: `:M?`

Response: `--*` `* ACK/NAK if acknowledge on`
or: `<x>` `<x> = actual value`

Description: This command selects the Camera Link® output mode. For example the mode 0 delivers 2 taps with 8 bit.

Mode	Taps x Bits	CL- config.	Pixelclock	Remark
0	2 x 8	base	80 MHz	
1	2 x 10	base	80 MHz	
2	16 x 1	base	80 MHz	optional feature, binarization
3	2 x 8	base	80 MHz	optional feature, mask mode
4	4 x 10	medium	80 MHz	only EoSens full (MC1362-63)
5	8 x 8	full	80 MHz	only EoSens full (MC1362-63)
6	10 x 8	full	75 MHz	only EoSens full (MC1362-63)
7	1 x 10	base	80 MHz	

6.4.2 Set pixelclock, command :R

Command: `:R<xx>` `<xx> = 28hex,2dhex,32hex,37hex,3chex,41hex,46hex,4bhex,50hex`
or: `:R?`

Response: `--*` `* ACK/NAK if acknowledge on`
or: `<xx>` `<xx> = actual value`

Description: This command selects the pixelclock of the cameralink interface. As default all modes work with a pixelclock of 80MHz. (Except of mode 6 with 75MHz). With this setting the full speed of the camera can be achieved. The clock can be adjusted in 5 MHz steps from 40…80MHz.

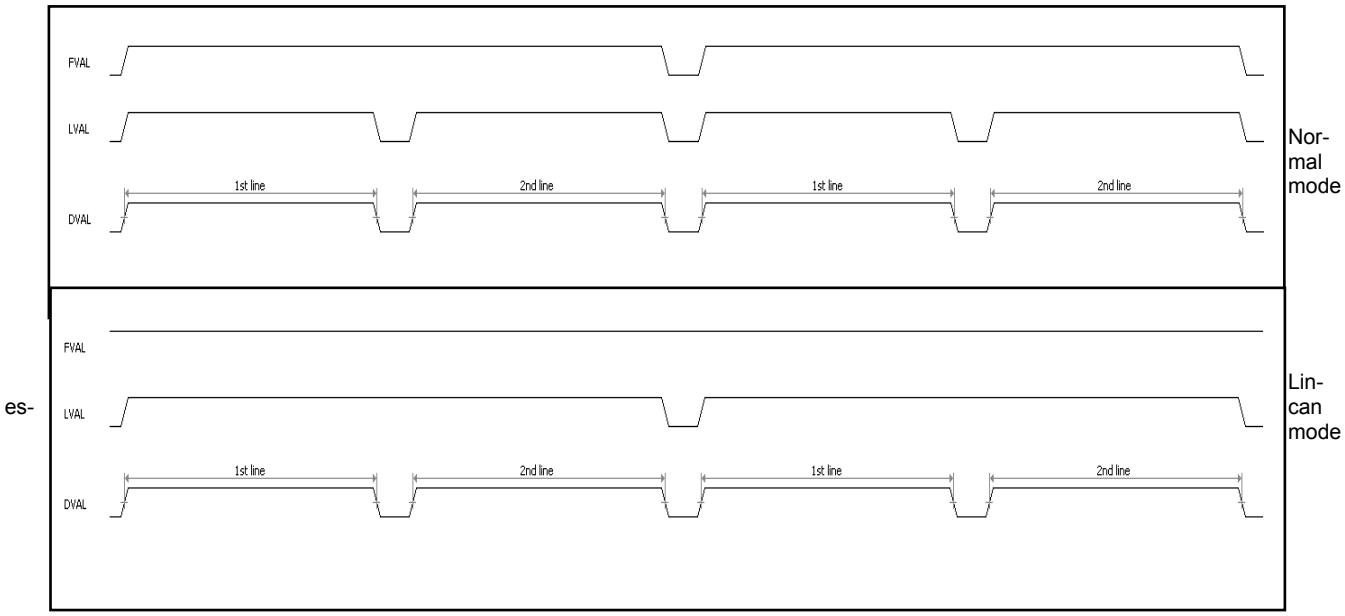
Application: Under some circumstances it is helpful to reduce the clock. This is the case if the framegrabber can't accept fast pixelclock or if a long or poor cable is used. Note that a reduced pixelclock results in a lower maximal framerate. This can be checked with the framerate command.

Note: In mode 6 the value 50_{hex} is not valid. In mode 5 values 28_{hex} and $2d_{hex}$ are not valid.

6.4.3 Linescan mode, command :j

Command:	`:j<x>`	`<x> = 0 for disable, 1 for enable`
or:	`:j?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`
or:	`<x>`	`<x> = actual value`

Description: This command enables the linescan mode. In this mode the camera behaves like a linescan camera. In detail this changes the behavior of FVAL, LVAL and DVAL signals. The following diagrams show a ROI with a height of 2 lines.



6.5 Image quality

6.5.1 Digital gain, command :D

Command:	:D<*xxxx*>	<*xxxx*> = 0400…1000$_{hex}$
or:	:D<x>	<x> = 0
or:	:D?	
Response:	--*	* ACK/NAK if acknowledge on
or:	<xxxx>	<xxxx> = actual value

Description: The digital gain can be set from 0400$_{hex}$ which is equivalent to gain 1x to 1000$_{hex}$ which is equivalent to gain 4x. Setting the gain to 0 switches off the correction completely.

Note: The digital gain controls how the 10 bit data width delivered by the image sensor are converted to the 8 bit data width of the camera link output. If a 10 bit camera link mode is used no conversion is done and therefore the digital gain has no effect.

6.5.2 Blacklevel, command :k

Command:	:k<*xx*>	<*xx*> = 32…C8$_{hex}$
or:	:k?	
Response:	--*	* ACK/NAK if acknowledge on
or:	<xx>	<xx> = actual value

Description: This command adjusts blacklevel. The value 80$_{hex}$ is the factory calibrated default. Increase or decrease this value slightly to adjust blacklevel.

6.5.3 FPN correction, command :N

Command:	:N<*x*>	<*x*> = 0 or 1
or:	:N?	
Response:	--*	* ACK/NAK if acknowledge on
or:	<x>	<x> = actual value

Description: With this command the column FPN (fixed pattern noise) correction can be activated or deactivated. At the beginning of each frame, before visible lines are read out, a fixed voltage is applied at the columns. These values are read out like real data and are stored inside the camera. When FPN correction is enabled the stored value is subtracted of each pixel. The advantage is a more homogeneous picture but with a limited dynamic.

Note: This noise is not dynamic but fixed (as the name says). That's a typical effect of a CMOS sensor. But the fixed pattern makes it easy to eliminate this noise completely. The camera does only a column correction. If an accurate pixel correction of the full frame is required this must be done by the framegrabber or in the imaging software. To do this it's best to switch off the camera's FPN correction to get the original dynamic. Then a complete image of a uniform area must be stored as a reference. This values must be subtracted for each pixel of the frame and the noise will disappear.

Camera's FPN correction OFF

and ON

6.6 Image size and position

Image size and position within the Sensor is defined by four parameters:

Block	Description		Value
<aaa>	Address of first pixel	x-start	$0…4F8_{hex\ (modulo\ 24)}$
<bbb>	Address of first line	y-start	$0…3FE_{hex}$
<ccc>	x-width	x-width	$2…500_{hex\ (modulo\ see\ table\ below)}$
<ddd>	y-height	y-height	$1…400_{hex}$

6.6.1 Setting the ROI, command :d

Setting image size and position - region of interest (ROI):

Command: `:d<aaa><bbb><ccc><ddd>` values as described above
or: `:d?`

Response: `--*` * ACK/NAK if acknowledge on
or: `aaabbbcccddd` actual value

Note: The x-start is rounded down if not modulo 24. The x-width has a modulo depending on the actual Camera Link® output mode (command :M). If the value does not fit the modulo the command will return NAK.

Mode (:M)	Taps x Bits	Modulo x-width	Remark
0	2 x 8	2	
1	2 x 10	2	
2	16 x 1	16	optional feature, binarization
3	2 x 8	*	optional feature, mask mode
4	4 x 10	4	only EoSens full (MC1362-63)
5	8 x 8	8	only EoSens full (MC1362-63)
6	10 x 8	10	only EoSens full (MC1362-63)
7	1 x 10	1	

* = only full ROI allowed

The ROI change time is 18ms including command transfer at 115kBaud. The new ROI is synchronized to the next frame so there is an additional delay of max 1 frameperiod.

For fast tracking purposes see also the ROI move mode.

6.6.2 Setting multiple ROI's, command :L

Command:	:L<z><xxx><yyy>	<z> = 1…3 window to set <xxx> = 0…4f8$_{hex}$ x-start <yyy> = 0…3fe$_{hex}$ y-start
or:	:L<z>?	show actual start of window <z>
or:	:Ln<a>	<a> = 0…3 windows to activate
or:	:Ln?	show number of active windows
Response:	--*	* ACK/NAK if acknowledge on
or:	xxxyyy	actual value
or:	a	

Description: With this command multiple ROI's are activated and controlled. Eo*Sens* allows to simultaneously choose up to four individual ROI's within the complete frame range. Thus, multiple objects can be captured independently at the same time. Normally only one window is active. This is the default of a=0. With a >=1 up to 3 additional windows can be activated. So a total of maximal 4 windows can be active. Each window can have its own start address. The size of the additional windows is the same as the main ROI.

Note: In contrast to normal mode with x-start modulo of 24 in multiple ROI mode the x-start modulo is 48 beginning with 0 or 24 depending on the main ROI. If multiple ROI's are active also the main ROI is locked to modulo 48. Start addresses not fitting this modulo will be automatically rounded by the camera and can be checked with the read command. Note also that when changing the size of the main ROI the additional ROI's will be changed automatically. So take care that these ROI's will fit into the sensor size. Also the maximum framerate will decrease if multiple windows are active.

Remark: This mode can not be combined with ROI move mode, x- or y- invert mode, decimation mode and mask mode.

6.6.3 Setting arbitrary shaped fields of view, command :S (optional feature)

Command:	:SC<xxx><yyy><rrr><www>	<xxx> = $0…500_{hex}$; <yyy> = $0…400_{hex}$ <rrr> = $1…300_{hex}$; <www> = $1…400_{hex}$
or:	:SM<aaa><dddd>	<aaa> = $0…3ff_{hex}$; <dddd> = $0…ffff_{hex}$
or:	:SE	
or:	:SV<n>	<n> = 0…1 0 = off ; 1 = on
Response:	--*	* ACK/NAK if acknowledge on

Standard adjustment of the camera using the ROI parameters allows to define rectangular windows. For windows with different shapes the Eo*Sens* offers a feature to create arbitrary fields of view.

It can be adjusted by a selection mask consisting of 16.384 read tiles. Each tile has a size of 10(H) x 8(V). All 16.384 tiles cover the whole active sensor area with 128x128 tiles.

The camera has a built in algorithm to create a circle mask. With :SC a circle is created and all tiles that touch that circle are activated. With <xxx> and <yyy> the center of the circle is defined. The parameter <rrr> defines the radius and <www> defines the width. The circle can partially be out of the field of view. The internal calculation lasts <1 sec.

To create more arbitrary shapes the command :SM can be used. The first tile in first line is on address <aaa>=0. Tile 16 is at address <aaa>=1. The first tile in second line is at address <aaa>=8. Each address covers 16 tiles that can be switched with the data <dddd>.

For example to switch on the tile 16 and 18 in the second line use the command :SM009A000.
Address <aaa> = 0x009 covers the tiles 16..31.
Data <dddd> = 0xA000 in binary notation ‘1010000000000000’ activates the tiles 16 and 18.

The addresses can be randomly accessed and only that tiles that have to be activated must be written.

To erase all tiles use the :SE command.

For testing purposes the command :SV can be used. When in mode :M0 the activated tiles are viewed inverted in the picture but all pixels will be output.

To output only the activated tiles mode :M3 must be used.

The programmed settings are volatile and must be reprogrammed after each power up.

Remark: This mode can not be combined with ROI move mode, x- or y- invert mode, decimation mode and multiple ROI mode.

6.6.4 Setting arbitrary shaped fields of view in compatible mode, command :r (optional feature)

Command: `:r8<x2x1x0>`

`<x2x1x0>`	range 000h…03ff$_{hex}$
`<x1x0>`	selection byte, bits 7..0, range 00$_{hex}$ …0ff$_{hex}$
`<x2>`	bit 9..8 = 0 : disable arbitrary window function
`<x2>`	bit 9..8 = 1 : write 2048 selection bytes
`<x2>`	Bit 9..8 = 2 : enable arbitrary window function, disable write selection byte function

Response: `--*` * ACK/NAK if acknowledge on

Standard adjustment of the camera using the ROI parameters allows to define rectangular windows. For windows with different shapes the Eo*Sens* offers a feature to create arbitrary fields of view.

It can be adjusted by a selection mask consisting of 16.384 read tiles. Each tile has a size of 10(H) x 8(V). All 16.384 tiles cover the whole active sensor area with 128x128 tiles.

The selected tiles are summed up in 2.048 selection bytes with 8 bit and can be loaded sequentially via register r8. Each set bit in a selection byte causes the associated tile to be captured and read out.

The 1. of 2048 selection bytes addresses the leftmost, top pixel group with 10 pixel in the 1.-8. line (1. selection tile). If bit 1 is set the next 10 pixel of line no. 1-8 are activated. Bit 7 enables pixel 70..79. The next selection byte, bit 0 addresses pixel 80..89.

To set the arbitrary shaped field of view all 2048 selection bytes must be written. In each byte at least write bit (bit 8) must be set. After all 2048 selection bytes have been programmed the write function must be finished by disabling the write function (2049. command).

The whole command list should be stored into a separate configuration file (*.mcf):

byte1	byte2 …	byte n	byte n+1…	byte2048	byte2049
:r8100	:r8100 …	:r81ff	:r81ff …	:r8100	:r8200

One command is only complete, if it starts with a colon, “r8” and then 2 ASCII characters. To get a better readability of the list it is recommended to start with a new line after 16 commands (CR+LF). The single commands :r8200 and :r8000 will enable and disable the function.

When in mode :M0 the activated tiles are viewed inverted in the picture but all pixels will be output. To output only the activated pixels mode :M3 must be used.

The programmed settings of the 2048 bytes are volatile and must be programmed new after each power up. The file may be written with the camera tool using the function “Write file to camera”.

Do NOT use this command for new applications. Use the :S command instead.

6.6.5 ROI move mode with external CCx input, command :l

Command:	`:l<n><y>`	`<n> = 0…3  0=off ; 1=y ; 2=x ; 3=x+y` `<y> = 1…fh  step y-direction`
or:	`:l?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`
or:	`<ny>`	`actual value`

Description: This feature allows to move the actual ROI with the CC2…CC4 inputs of the cameralink interface. The signal can be generated by the framegrabber itself or by external signals that are input to the grabber. The stepping in x-direction is always 24 pixels, the stepping in y-direction can be selected from1-15 with the <y> parameter. Move will always be in positive direction. If the right side or the bottom of the sensor is reached no action will be on further input signals. With CC4 the position is reset to the original position; This is not necessarily the top left edge of the sensor.

Signals:
CC2 = y-increment
CC3 = x-increment
CC4 = reset to original position

Note: The input frequency can be up to 20kHz. The signals will be added between the frames. The added move signals are synchronized to the next frame. The internal process time is 500µs where no signals can be counted. This is immediately after the exposure meaning that signals input before 500µs after the falling edge of ‘strobe’ will be lost.

Example: ROI 1280x390 pixel at 287fps and 1ms exposure time. Pulses with 20kHz.

There are 3ms time to send pulses. In this time 60 pulses can be sent from frame to frame.

So the possible 634 lines will take 38ms to move and 11 frames will be exposed in this time.

Remark: This mode can not be combined with multiple ROI mode, x- or y- invert mode, decimation mode and mask mode.

6.6.6 Invert readout in x- and or y-direction, command :o

Command:	`:o<x>`	`<x> = 0…3  0=off ; 1=x ; 2=y ; 3=x+y`
or:	`:o?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`
or:	`<x>`	`actual value`

Description: This feature allows to invert the frame readout in x- and or y-direction.

Remark: This mode can not be combined with ROI move mode, multiple ROI mode, decimation mode and mask mode.

6.6.7 Decimation mode (Subsampling), command :Q

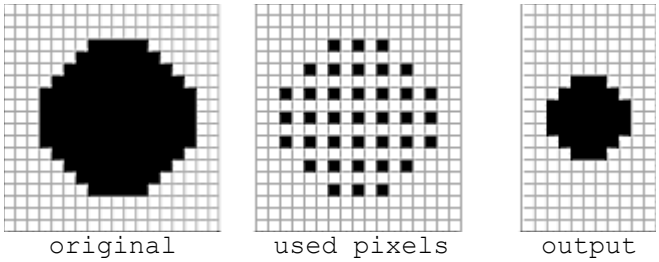
Command:	`:Q<x>`	`<x> = 0…1  0=off ; 1=on`
or:	`:Q?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`
or:	`<x>`	`actual value`

Description: With this feature enabled the sensor skips every other row and column. Therefore the maximum width is 640 pixel and the maximum height is 512 pixel. The advantage is that a lens with the same focal distance can cover the identical image size but with a higher framerate.

Note: A ROI of 640x512 covers the whole sensor area and equals the reproduction scale of 1280x1024 in normal mode. Switching on/off this mode halves/doubles the output image size.

Limitation: The ROI x-start position should be zero because else the internal FPN correction does not work correct. If a x-start position >0 is needed the internal FPN correction should be turned off. If necessary a correction must be done in the frame grabber or in software.

Remark: This mode can not be combined with ROI move mode, multiple ROI mode, x- or y- invert mode and mask mode.



6.7 Framerate and shutter

6.7.1 Setting the framerate, command :q

Command:	`:q<xxxxxx>`	`<xxxxxx> = 1…13880`$_{hex}$
or:	`:q?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`

or:	`<xxxxxx>' '<ss>'-'<zzzzzz>`	`<xxxxxx> = actual value`
		`<ss> = minimal value`
		`<zzzzzz> = maximal value`

Description: This command sets the framerate in frames per second for free run mode. The valid range depends on ROI and tap mode and can be obtained with '?' as parameter.

6.7.2 Setting the shuttertime, command :t

Command:	`:t<xxxxxx>`	`<xxxxxx> = 2…F4240`$_{hex}$
or:	`:t?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`

or:	`<xxxxxxx>' '<ss>-<zzzzzz>`	`<xxxxxx> = actual value`
		`<ss> = minimal value`
		`<zzzzzz> = maximal value`

Description: This command sets the shuttertime in microseconds for free run and sync with timer mode. Depending on the tap mode and ROI the minimal and maximal shuttertime can vary. Use the '?' parameter for the valid range. The maximal exposure time is 1/framerate.

6.7.3 Automatic shutter time control, command :x

Command: `:xv<aabbccddeeeeeeffffff>`

`<aa>`	=	$0…FF_{hex}$	Brightness
`<bb>`	=	$1…64_{hex}$	Percent of image
`<cc>`	=	$0…64_{hex}$	Hysteresis
`<dd>`	=	$0…64_{hex}$	Adjust speed
`<eeeeee>`	=	$0…FFFFFF_{hex}$	Min. shutter time
`<ffffff>`	=	$0…FFFFFF_{hex}$	Max. shutter time

or: `:xv?`

or: `:xa<n>` `<n> = 0…1 (off-on)`
or: `:xa?`

Response: `--*` `* ACK/NAK if acknowledge on`

or: `<aabbccddeeeeeeffffff>` `= actual value`
or: `<n>` `= actual value (0-1 / off-on)`

Description: This feature automatically adjusts the shuttertime depending on the object brightness. This results in a constant image brightness. To adjust the desired image brightness the pixelvalue (brightness) <aa> for <bb> percent of the image size must be set. Additional a hysteresis can be set to prevent flickering. The adjust speed can also be set. Furthermore it's possible to limit the minimum and maximum shuttertime.

Example: For a typical scenery a brightness of 170 for 50 percent of the image is a good value. To use this setting with 20 percent hysteresis, 95 percent of the possible adjust speed and without shutter time limitation use `:xvaa32145f000000ffffff`

6.7.4 Setting the slopes for dynamic range adjustment, command :i

Command: `:i<s><x>`
or: `:i<s><xx>`
or: `:i<s>?`

`<s> = 'n'`	`==>`	`<x> = 1…3`	`(Number of slopes)`
`<s> = 'd',' t'`	`==>`	`<xx> = 1…63h`$_{hex}$	`('d'ual or 't'riple slope in percent)`

Response: `--*` `* ACK/NAK if acknowledge on`
or: `<x>` `(Number of Slopes)`
or: `<xx>' '<yy>-<zz>` `<xx> = actual value`
`<yy> = minimal value`
`<zz> = maximal value`

Description: This command sets the multiple slope function for dynamic range adjustment. Through 2 selectable steps, the camera's dynamic range adjustment option allows to approach the CMOS sensor's linear range into a dynamic range corresponding to the non-linear human eye. Consequently, Eo*Sens* provides definite image details even in case of extreme dark-light contrasts, which means an invaluable benefit exceptionally in image processing. With 'n'=1 the multiple slopes are deactivated and the frame will be exposed with the whole shuttertime. With activated slopes the bright pixels will be reset after <xx>percent of the shuttertime. The dual value must be smaller than triple. Depending on the mode, ROI and shuttertime the first slope can eventually not start at 1 percent. The valid range can be read out with the '?' argument. Only if valid values are set the function can be activated. See also 'last error' command.

multiple slope off

triple slope activated

6.7.5 Non destructive readout for multiple pixel exposure, command :O

Command:	`:O<x>`	`<x> = 1…7`
or:	`:O?`	
Response:	`--*`	`* ACK/NAK if acknowledge on`
or:	`<x>`	`actual value`

Description: This command controls the non destructive readout mode. If desired, pixel exposure can be accumulated up to 7 times, resulting in increasing image exposures. The optimally exposed image can be selected for further processing. At indefinite lighting conditions, as in 24 hour outdoor applications, Eo*Sens* becomes the high speed camera that spots everything. With x=1 after every frame the pixels are reset (normal operation). With x>1 all pixels will be read out multiple times (max. 7) after they are reset. So for low light the last samples are useful and for high light levels the first samples are useful.

Note: Only the first image is exposed with the selected shutter time. The following images will be exposed with the frametime (1/framerate). This is because once the shutter opens it will remain open until all of the maximum 7 images are taken.

6.8 Exposure control

Exposure control is selected with commands :h, :H and :t

Command	Description
:h	Select exposure mode
:H	Trigger edge select
:t	Set exposure time

6.8.1 Type of exposure, commands :h, :H and :t

The Eo*Sens* can expose the images in free run mode or with an external signal on CC1. The external modes are used to synchronize Eo*Sens* cameras to each other or to an external event. See also the timing diagrams in the technical data section of this manual.

The following commands select exposure type:

Mode description	Mode	Edge	Shuttertime
Free run with electronic shutter	:h0	--	:t<xxxxxx>
Pulsewidth, positive edge	:h1	:H0	Pulsewidth
Pulsewidth, negative edge	:h1	:H1	Pulsewidth
External sync with internal timer, positive edge	:h2	:H0	:t<xxxxxx>
External sync with internal timer, negative edge	:h2	:H1	:t<xxxxxx>

6.8.2 Free run with electronic shutter

In free run mode the framerate and shuttertime can be selected with camera settings. Depending on tap mode and ROI the framerate can be set from 1…120000 fps and the exposure time can be set from 2µs to 1s.

6.8.3 Pulsewidth mode

In this mode an external signal starts exposure and the exposed image is output immediately after the exposure ends. Exposure time is defined by the width of the external EXP (CC1) signal. The exposure of the next image can be started while the last image is transferred or at a later time.

6.8.4 External sync with internal timer

In this mode an external signal starts exposure and the exposed image is output immediately after the exposure ends. Exposure time is defined by an internal timer. The exposure of the next image can be started while the last image is transferred or at a later time.

6.9 Other

6.9.1 In frame counter, command :u

Command:	`:u<x>`	`<x> = 0…1`	`0 = off`
or:	`:u?`		`1 = on`
Response:	`--*`	`* ACK/NAK if acknowledge on`	
or:	`<x>`		

Description: If a sequence of frames is to be recorded for long time at a high framerate, it can be useful to mark the images for later identification or check for completeness. Eo*Sens* has a 32-Bit image counter whose count can replace the first four pixel of every image. It is incremented by every new image

6.9.2 Test image, command :n

Command:	`:n<x>`	`<x> = 0…1`	`0 = power down + test image`
or:	`:n?`		`1 = normal operation`
Response:	`--*`	`* ACK/NAK if acknowledge on`	
or:	`<x>`		

Description: For testing of camera logic and video data transmission, sensor data can be replaced by an internal gray scale pattern with pixel values of 0..255. With x=0 the camera sends a grayscale that is slowly rolling from right to left. This mode can also be used to save power consumption because the image sensor will be set to standby mode.

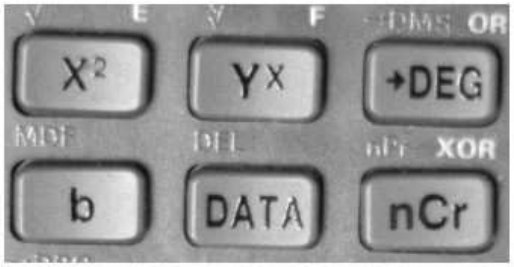
6.9.3 Setting threshold mode, command :K (optional feature)

Command: `:K<s><x>`
or: `:K<s><xxx>`
or: `:K<s>?`

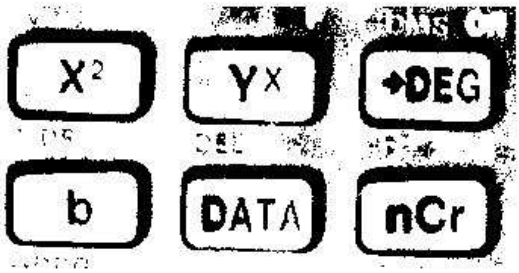
`<s> = 'n'` ==> `<x> = 0…1` threshold off or on
`<s> = 'v'` ==> `<xxx> = 0…3ff`$_{hex}$ threshold value

Response: `--*` * ACK/NAK if acknowledge on
or: `<x>` threshold off or on
or: `<xxx>` actual threshold value

Description: With this command the threshold mode can be activated. All pixels above the threshold level in the image will be output as white while all pixels below will be output as black. The threshold relates to the 10 bit sensor data. This feature is especially useful with the mode 2 (16 tap x 1 bit)



threshold off



threshold on

6.9.4 Get last error, command :B

Command: `:B`

Response: `'OK' or 'ERROR: xx message'`

Description: With this command the camera status after power up or the last command can be read out. If a command returns NAK maybe the reason can be found.

6.9.5 Reset and configuration of the internal FPGA, command :c

Command: `:c`

Response: `--*` `* ACK/NAK if acknowledge on`

Description: The command **:c** executes a reset in the camera. The FPGA will be re configured and all internal registers reloaded with the last saved PowerUpProfile. The FPGA is also configured after each power up.

6.9.6 Command acknowledge flag, command :A

Command: `:A<x>` `<x> = 'y' or 'Y' for ON`
or: `:A?` `'n' or 'N' for OFF`

Response: `--*` `* ACK/NAK if acknowledge on`
or: `<x>` `'y' or 'n'`

Description: This command switches on or off the command acknowledge. If set to on every write command returns an ACK (0x06) if the command was processed successful or NAK (0x15) if the command failed to execute.

6.9.7 Setting the baudrate, command :b

Command: `:b<n>` `<n> = 0 -> 9600 Baud (default)`
or: `:b?` `1 -> 19200 Baud`
`2 -> 38400 Baud`
`3 -> 57600 Baud`
`4 -> 19200 Baud`

Response: `--*` `* ACK/NAK if acknowledge on`
or: `<n>` `actual baudrate`

Description: The command :b sets the baudrate for the camera control communication.

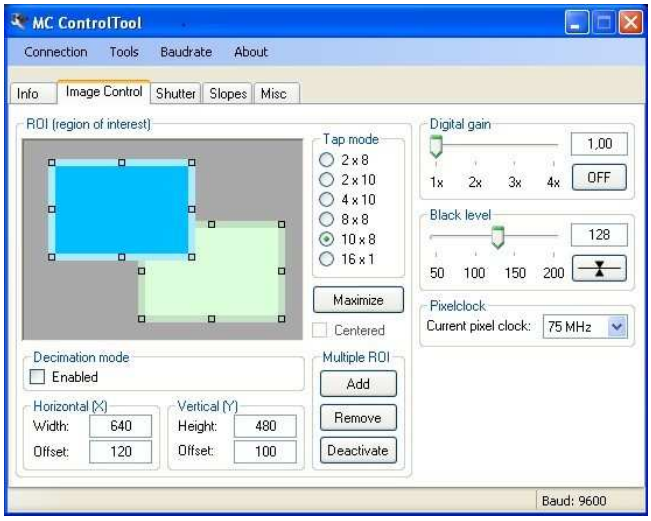
Note: After a reset or a power up the camera always defaults to a baudrate of 9600 Baud.

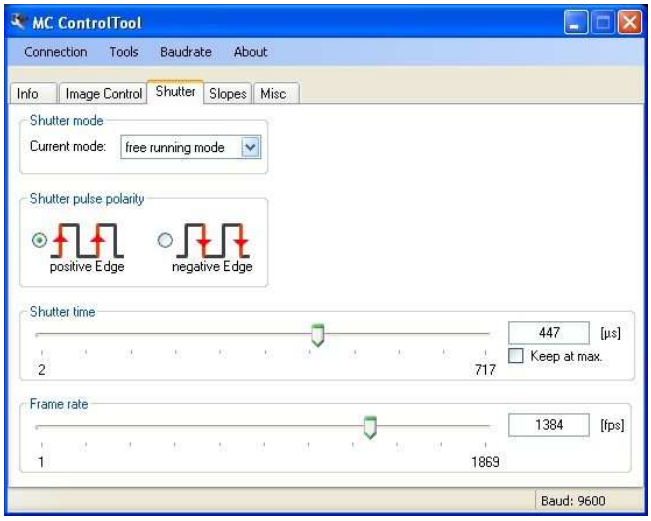
7 MC ControlTool

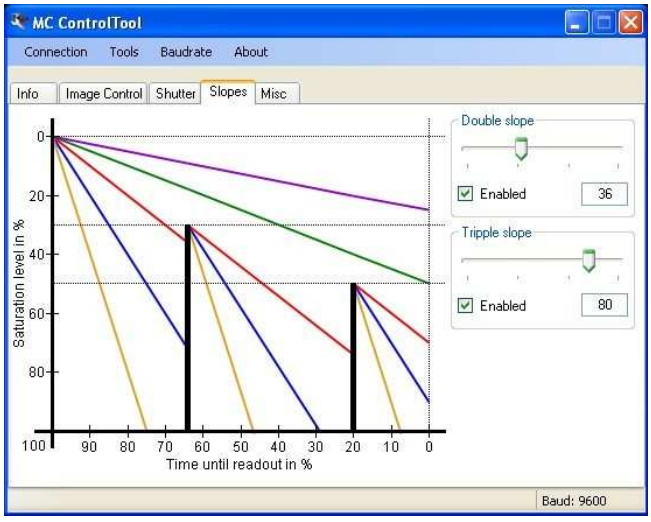
The Eo*Sens* configuration tool must be installed on a Windows PC by means of the setup software. See also www.mikrotron.de to download the latest version.

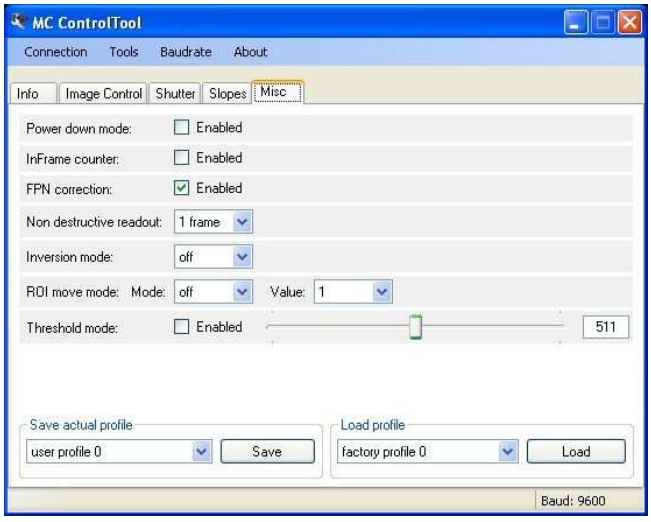
This software provides an almost self explaining user interface to modify any camera parameter.

Since the serial interface is integrated in the CameraLink® interface you do not need any other additional cable.









8 Firmware

The camera possesses programmable devices, which are working with some firmware packages. New cameras were programmed with all needed firmware packages and will not need any update.

For customized firmware or additional features the camera offers the possibility to update the firmware. The procedure of updating depends on the firmware package.

8.1 Microcontroller firmware

The microcontroller works with 2 programs, the bootloader and the application program.

The bootloader is the basic program of the microcontroller, which ensures some basic functions (e.g. communication, loading application program) and cannot be changed or updated. In standard use of the camera it will never work in the bootloader program. It's only used for updating the application program.

The application program is the active microcontroller program in the camera, which supports communication, data handling and FPGA program updates.

See description of update procedure in chapter "Firmware update procedure".

8.2 FPGA firmware

The camera logic is integrated into a FPGA's (**F**ield **P**rogrammable **G**ate **A**rray), which's configuration is stored in an EEPROM. Upon power up or reset the FPGA is loaded with this configuration. Configuration data can be downloaded via the serial interface. Mikrotron may provide configuration files (*.ibf) on request. After download of configuration data, this data is permanently stored in EEPROM and the FPGA is configured with the new data. Besides a power cycle or the **:c** command can be used to reconfigure the FPGA with the internally stored configuration data.

See description of update procedure in chapter "Firmware update procedure".

8.3 Firmware update procedure

The Eo*Sens* firmware consists of two files. Mikrotron always provides these files as one package. Be sure to always update all two firmwares. Do not mix firmwares of different packages. Before you begin please ensure that you have the adequate application firmwares to load. The files may be packed in a .zip file and you have to unzip them first.

For Eo*Sens* CL you need the following files:

- µController..... `MC1362M622Axxx.ibf`
- FPGA..... `MC136xM651Fxxx.ibf`

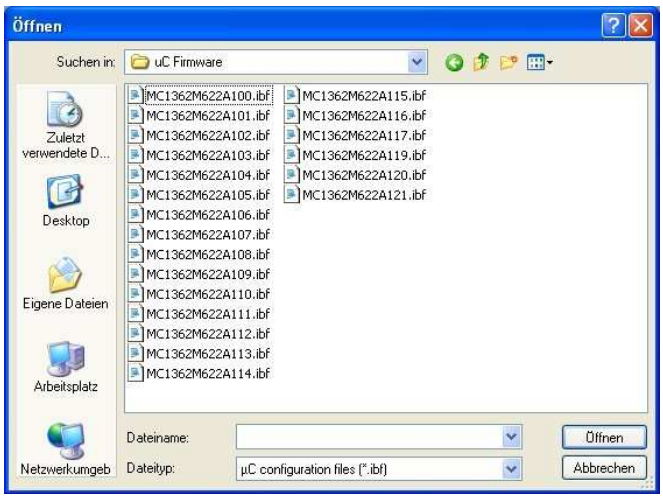
The last ‘xxx’ represents the version number. For example ‘116’ is version number ‘1.16’.

	Once started YOU CANNOT UNDO THIS COMMAND. Also note that your saved power up and user profiles will be overwritten with standard profiles.

- Start camera control tool and select “Eo*Sens*” camera. Wait until the info screen displays serial no. and firmware version.
- Select in menu “Tools” - “Update camera”:

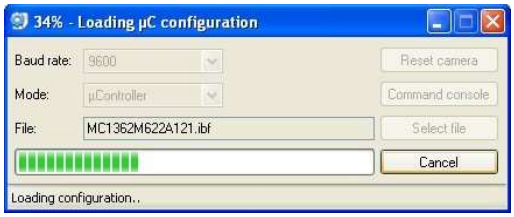
- In the drop down menu „Mode“ select the desired device to update:

- Click “Select file” and choose the appropriate file (see above):



- Click “Send” and the file transfer will start immediately:

- While loading the camera LED will blink red:



Upload of *.ibf files via serial link takes several minutes depending on the used baudrate. There should be no loss of power or communication during this time! Also no other activity should be made on the PC while doing the upload.

- Wait until file transfer has finished and the camera status LED stays on. If the upload was successful, the LED will turn to green, otherwise it will be red.

- If the update was successful you can proceed with the next firmware. Otherwise check the troubleshooting in the next chapter. Repate these steps for sensor FPGA by choosing the „Mode“ in the drop down menu.

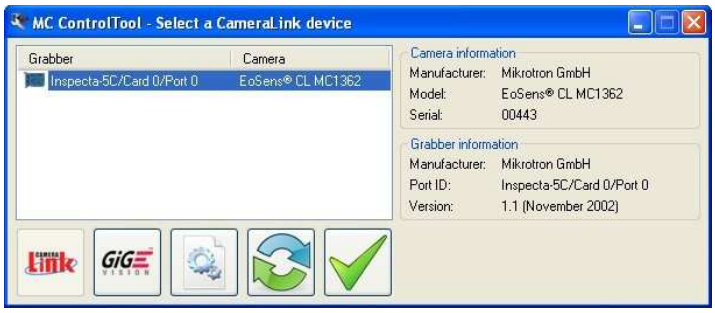
- After all modules have been updated verify the versions in “Eo*Sens*” info screen. The new firmware version will be displayed. If the version is identical to the expected the camera is ready to use for capturing images.

8.4 Firmware update troubleshooting

If the update procedure was not successful the camera should be powered off and on and the control tool should be restarted. There are two possible errors. When repeating the update the baudrate should be left at 9600.

1. Possible error: The microcontroller was not loaded successful and the camera has only it's bootloader active. The camera confirms this with 1x red blink after power up. In the camera connect window *'Bootloader'* will appear instead of the camera name:

Solution: Connect to the camera and the tool will automatically start with the "Update µController" dialog. Start the microcontroller update as described above. After successful update close the dialog and the tool will restart with the connect dialog showing the camera.



2. Possible error: The FPGA program was not loaded successful. The camera confirms this with 3x red blink after power up. The *'Info'* tab of the control tool shows 'F0.00'.

Solution: In this case just repeat the *'Update FPGA firmware'* procedure.

9 Technical Data

9.1 Overview

MC1360 / 62 MC1361 / 63	Monochrome Bayer Filter
Number of pixel	1280 x 1024
Pixel size	14 x 14 µm
Active area	17.92 (H) x 14.34 (V) mm
Fill factor	40%
Response	25 V/lux.s @ 550nm
Spectral response	400…720nm monochrome 400…670nm color
Dark Current (@ 21 °C)	200mV/s
Dynamic range	Up to 90 dB with multiple slope
Pixel saturation level	30000e¯
QE x FF	35% at 550 nm
Shutter	Electronic „Freeze Frame“ Shutter
Trigger	Asynchronous shutter, shutter time select-able with internal timer or by pulse width of trigger signal
Framerate and shutter timebase accuracy	+/- 50ppm
Power supply	8…24 V
Power consumption max. Thermal resistance typ.	5 W 0.17°/W
Serial data link	RS-644 with Camera Link® 9,6…115 kBd, 8 bits, 1 stop bit, no parity
Digital video MC1362-63 MC1360-61	 Camera Link®, Base or Full configuration Camera Link®, Base configuration
Shock & vibration	70g, 7grms
Dimensions (WxHxD)	63 x 63 x 47 mm
Case temperature	+5…+50° C
Weight	ca. 300 g
Lens mount	C-/F-mount (depending on adapter)

9.2 Sensor defect specifications

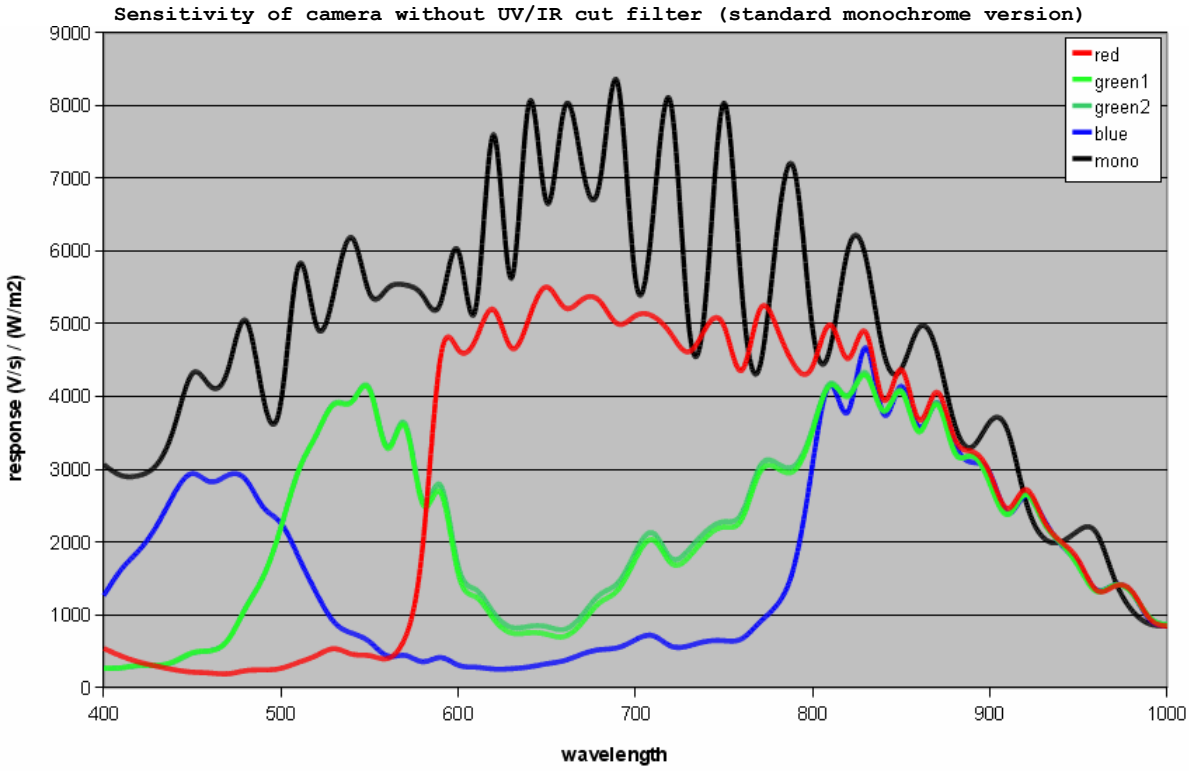
Parameter	Description	Limit
BrightPix	Amount of bright pixels (response higher then half scale) in a dark image. Dark image must first be FPN corrected.	< 10
DarkMeanOutput	Average value of a dark image (10-bit scale).	0 < x < 235
50%MeanOutput	Average value of a half scale image (10-bit scale).	390 < x < 547
FPN	Fixed pattern noise of a dark image should be smaller than 3.1% of the signal swing	< 3.1%
TotDefects	Amount of defect pixels in a half scale image. A defect pixel is defined as a pixel that has a response that is 20% off the median response of all pixels. The half scale image must be FPN corrected.	< 20
BadColumnOutput	Amount of bad columns in a half scale image. A bad column is defined as a column that has a response that is 10% off the median of the surrounding 40 columns. The half scale image needs to be FPN corrected.	0
BadRow	Amount of bad rows in a half scale image. A bad row is defined as a row that has a response that is 10% off the median of the surrounding 40 rows. The half scale image needs to be FPN corrected.	0
Cluster	Amount of clusters allowed See note 1.	0
Coverglass Dig/Scratch	Uniform illumination. Test sensor for defective pixels. Defects on cover glass will generate defect pixels. No defect pixels may be visible.	0

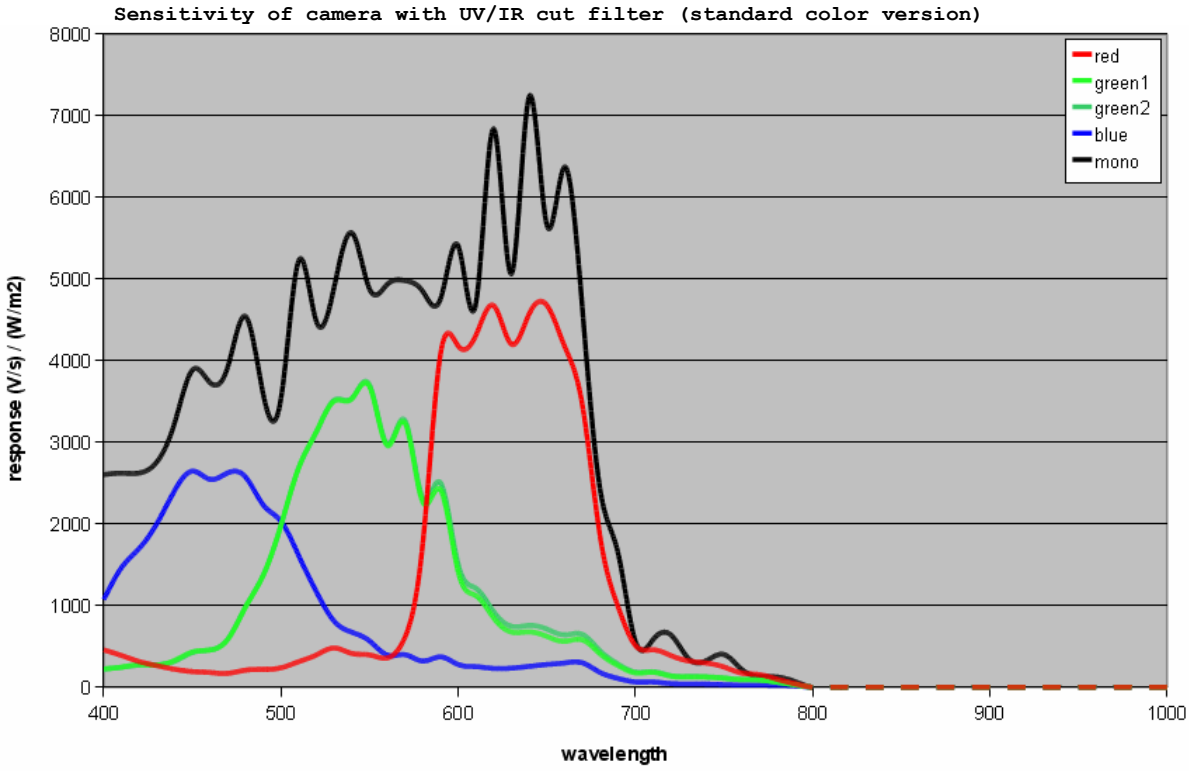
Measurement conditions:
1. Illumination source: High brightness led light source (white) Using a pinhole to imitate the lens setup in the application. F=5.4
2. Temperature is 25ºC (logged during the test program) and 30 ºC on wafer. Dark current limit is set at 30 ºC
3. Definition of operation conditions: Nominal clock frequency is 310 MHz. Unity Gain Power supplies as specified in the datasheet (recommended operation conditions) Integr. times:Dark image short IT: 4µs, Dark image long IT: 1s, Other images: 2ms

Note 1: A cluster is defined as a group of minimal 2 and maximum 4 neighboring defect pixels (top, bottom or side; not diagonal). Clusters that exceed the maximum of 4 defect pixels are not allowed at all.

9.3 Spectral response

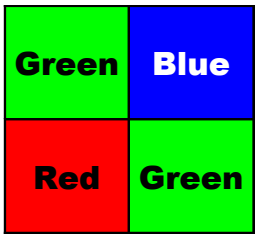
The charts below show the sensitivity of the monochrome and the color sensor with a bayer pattern filter on the sensor glass lid. The color camera is by default equipped with a UV/IR cut filter with a transmittance of 370-670nm resulting in a sensitivity shown in the second chart. By request all types of cameras can be delivered with or without UV/IR cut filter.





9.4 Bayer pattern filter

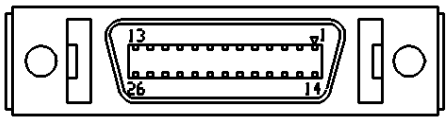
The Eo*Sens* color camera has a bayer pattern filter on the sensor glass lid. To get the color information the imaging software must decode the information. The pattern beginning from first row, first column is:



Because the pattern must always start at the same field with a color camera only even height and even offset-y is possible. The camera will automatically round down if odd values are entered. Also mind if using the invert readout function the pattern must be inverted too.

9.5 Connector pinning

9.5.1 Camera Link® connector, MDR-26



„Base Camera Link®“ pinning:

pin	signal
1	GND
2	X0-
3	X1-
4	X2-
5	XCLK-
6	X3-
7	SERTC+
8	SERTFG-
9	CC1-
10	CC2+
11	CC3-
12	CC4+
13	GND

pin	signal
14	GND
15	X0+
16	X1+
17	X2+
18	XCLK+
19	X3+
20	SERTC-
21	SERTFG+
22	CC1+
23	CC2-
24	CC3+
25	CC4-
26	GND

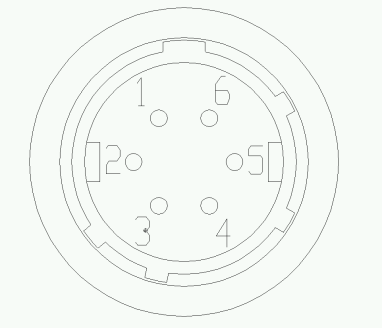
„Full Camera Link®“ pinning:

pin	signal
1	GND
2	Y0-
3	Y1-
4	Y2-
5	YCLK-
6	Y3-
7	100 Ω Term.
8	Z0-
9	Z1-
10	Z2-
11	ZCLK-
12	Z3-
13	GND

pin	signal
14	GND
15	Y0+
16	Y1+
17	Y2+
18	YCLK+
19	Y3+
20	100 Ω Term
21	Z0+
22	Z1+
23	Z2+
24	ZCLK+
25	Z3+
26	GND

Manufacturer: 3M
Order-Nr.: 10226-6212VC

9.5.2 Circular power connector, 6-pin



Pin	Signal	Voltage level
1	VCC	8 - 24V DC
2	VCC	8 - 24V DC
3	STROBE_OUT	LVTTL 3.3V
4	DGND*	
5	GND	
6	GND	

*DGND ... digital GND for signal STRB

Manufacturer: Hirose
Order no.: HR10A-7P-6S

Before applying power to the camera we strongly recommend to verify the used pins of the power connector, the polarity (+/-) of the leads and the supply voltage.

The camera may only be used with a supply voltage according to the camera specification. Connecting a lower or higher supply voltage, AC voltage, reversal polarity or using wrong pins of the power connector may damage the camera. If doing so, the warranty will expire immediately.

9.6 Camera Link® bit Assignments

9.6.1 Base Camera Link® 2*8/10 - bit Assignment

The following table shows the bit assignment of two adjacent pixel, eight or ten bits each. All unused bits are set to logical LOW level, the SPARE outputs are set to logical HIGH level.

Plug 1, Camera Link® X, 2*8-bit			Plug 1, Camera Link® X, 2*10-bit		
Port	Tx	Signal	Port	Tx	Signal
A0	0	D0	A0	0	D0
A1	1	D1	A1	1	D1
A2	2	D2	A2	2	D2
A3	3	D3	A3	3	D3
A4	4	D4	A4	4	D4
A5	6	D5	A5	6	D5
A6	27	D6	A6	27	D6
A7	5	D7 (msb)	A7	5	D7
B0	7	D8	A8	7	D8
B1	8	D9	A9	8	D9 (msb)
B2	9	D10	LOW	9	LOW
B3	12	D11	LOW	12	LOW
B4	13	D12	B8	13	D18
B5	14	D13	B9	14	D19 (msb)
B6	10	D14	LOW	10	LOW
B7	11	D15 (msb)	LOW	11	LOW
LOW	15	LOW	B0	15	D10
LOW	18	LOW	B1	18	D11
LOW	19	LOW	B2	19	D12
LOW	20	LOW	B3	20	D13
LOW	21	LOW	B4	21	D14
LOW	22	LOW	B5	22	D15
LOW	16	LOW	B6	16	D16
LOW	17	LOW	B7	17	D17
LVAL	24	LVAL	LVAL	24	LVAL
FVAL	25	FVAL	FVAL	25	FVAL
DVAL	26	DVAL	DVAL	26	DVAL
SPARE	23	HIGH	SPARE	23	HIGH
TxClk			TxClk		

9.6.2 Full Camera Link® 8*8-bit Assignment

The following table shows the bit assignment of eight adjacent pixel. All unused bits are set to logical LOW level, the SPARE outputs are set to logical HIGH level.

Plug 1, Camera Link® X			Plug 2, Camera Link® Y			Plug 2, Camera Link® Z		
Port	Tx	Signal	Port	Tx	Signal	Port	Tx	Signal
A0	0	D0	D0	0	D24	G0	0	D48
A1	1	D1	D1	1	D25	G1	1	D49
A2	2	D2	D2	2	D26	G2	2	D50
A3	3	D3	D3	3	D27	G3	3	D51
A4	4	D4	D4	4	D28	G4	4	D52
A5	6	D5	D5	6	D29	G5	6	D53
A6	27	D6	D6	27	D30	G6	27	D54
A7	5	D7 (msb)	D7	5	D31 (msb)	G7	5	D55 (msb)
B0	7	D8	E0	7	D32	H0	7	D56
B1	8	D9	E1	8	D33	H1	8	D57
B2	9	D10	E2	9	D34	H2	9	D58
B3	12	D11	E3	12	D35	H3	12	D59
B4	13	D12	E4	13	D36	H4	13	D60
B5	14	D13	E5	14	D37	H5	14	D61
B6	10	D14	E6	10	D38	H6	10	D62
B7	11	D15 (msb)	E7	11	D39 (msb)	H7	11	D63 (msb)
C0	15	D16	F0	15	D40	LOW	15	LOW
C1	18	D17	F1	18	D41	LOW	18	LOW
C2	19	D18	F2	19	D42	LOW	19	LOW
C3	20	D19	F3	20	D43	LOW	20	LOW
C4	21	D20	F4	21	D44	LOW	21	LOW
C5	22	D21	F5	22	D45	LOW	22	LOW
C6	16	D22	F6	16	D46	LOW	16	LOW
C7	17	D23 (msb)	F7	17	D47 (msb)	LOW	17	LOW
LVAL	24	LVAL	LVAL	24	LVAL	LVAL	24	LVAL
FVAL	25	FVAL	FVAL	25	FVAL	FVAL	25	FVAL
DVAL	26	DVAL	DVAL	26	DVAL	DVAL	26	DVAL
SPARE	23	HIGH	SPARE	23	HIGH	SPARE	23	HIGH
TxClk			TxClk			TxClk		

9.6.3 10*8-bit assignment

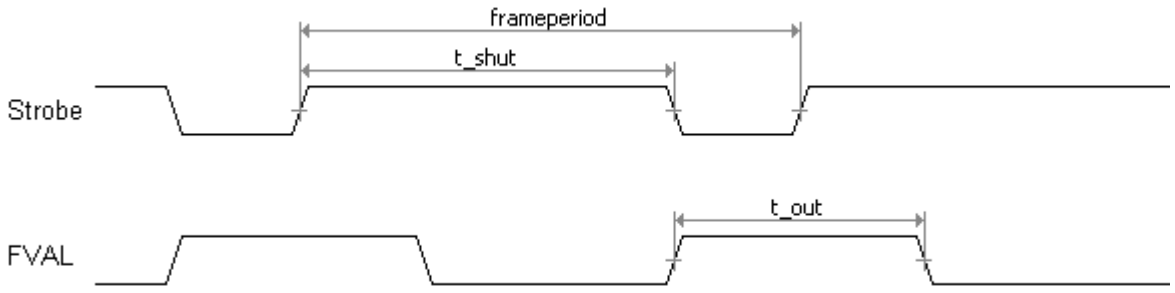
The below table shows the assignment of 10 adjacent pixel, 8-Bit each. This assignment is compatible to Baslers A504 camera.

Plug 1, Camera Link® X			Plug 2, Camera Link® Y			Plug 2, Camera Link® Z		
Port	Tx	Signal	Port	Tx	Signal	Port	Tx	Signal
A1	0	D0_0	D3	0	D3_2	G6	0	D6_5
A2	1	D0_1	D4	1	D3_3	G7	1	D6_6
A3	2	D0_2	D5	2	D3_4	G8	2	D6_7 (msb)
A4	3	D0_3	D6	3	D3_5	H1	3	D7_0
A5	4	D0_4	D7	4	D3_6	H2	4	D7_1
A6	5	D0_5	D8	5	D3_7 (msb)	H3	5	D7_2
A7	6	D0_6	E1	6	D4_0	H4	6	D7_3
A8	7	D0_7 (msb)	E2	7	D4_1	H5	7	D7_4
B1	8	D1_0	E3	8	D4_2	H6	8	D7_5
B2	9	D1_1	E4	9	D4_3	H7	9	D7_6
B3	10	D1_2	E5	10	D4_4	H8	10	D7_7 (msb)
B4	11	D1_3	E6	11	D4_5	I1	11	D8_0
B5	12	D1_4	E7	12	D4_6	I2	12	D8_1
B6	13	D1_5	E8	13	D4_7 (msb)	I3	13	D8_2
B7	14	D1_6	F1	14	D5_0	I4	14	D8_3
B8	15	D1_7 (msb)	F2	15	D5_1	I5	15	D8_4
C1	16	D2_0	F3	16	D5_2	I6	16	D8_5
C2	17	D2_1	F4	17	D5_3	I7	17	D8_6
C3	18	D2_2	F5	18	D5_4	I8	18	D8_7 (msb)
C4	19	D2_3	F6	19	D5_5	J1	19	D9_0
C5	20	D2_4	F7	20	D5_6	J2	20	D9_1
C6	21	D2_5	F8	21	D5_7 (msb)	J3	21	D9_2
C7	22	D2_6	G1	22	D6_0	J4	22	D9_3
C8	23	D2_7 (msb)	G2	23	D6_1	J5	23	D9_4
LVAL	24	LVAL	G3	24	D6_2	J6	24	D9_5
FVAL	25	FVAL	G4	25	D6_3	J7	25	D9_6
D1	26	D3_0	G5	26	D6_4	J8	26	D9_7 (msb)
D2	27	D3_1	LVAL	27	LVAL	LVAL	27	LVAL
TxClk			TxClk			TxClk		

9.7 Timing diagrams

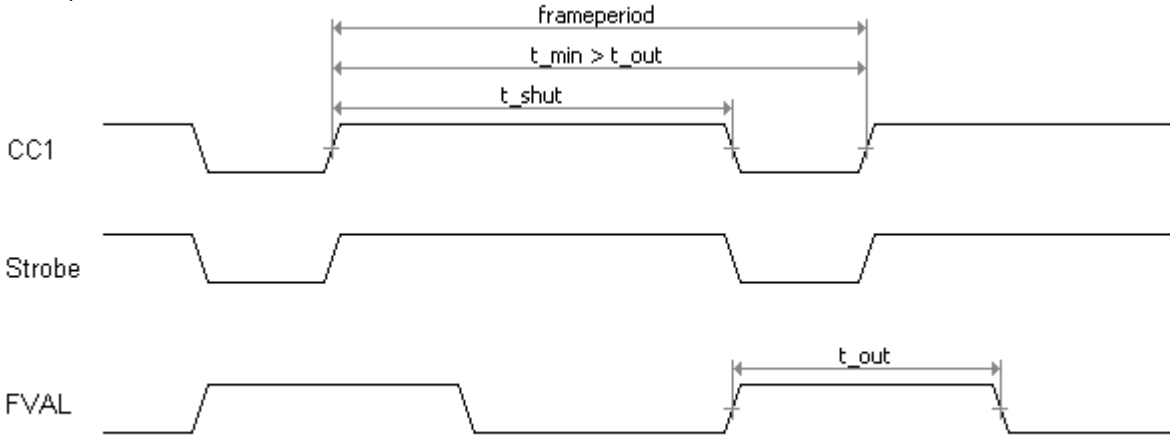
9.7.1 Free run with electronic shutter

In this mode framerate and exposure time is controlled by the camera. At the strobe output (in power connector) there is a high signal while the camera exposes a picture.



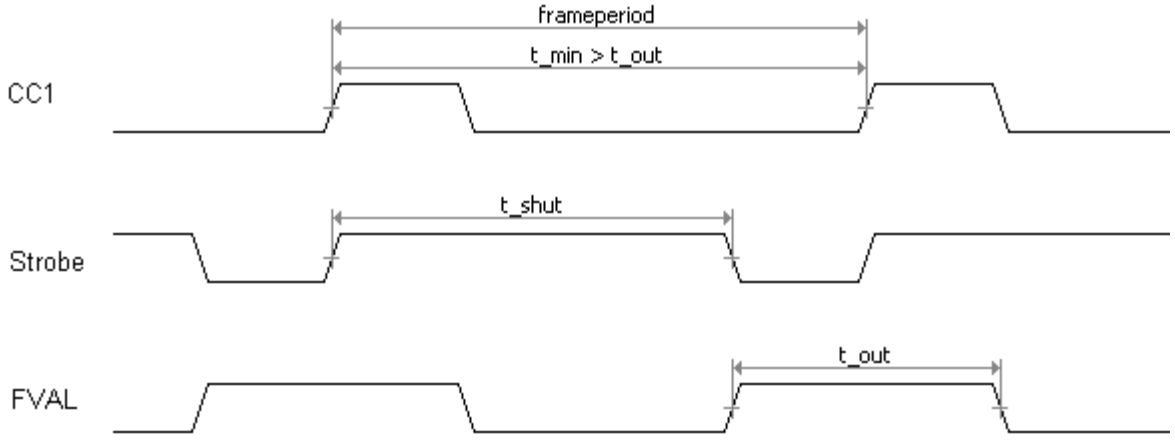
9.7.2 Pulsewidth mode

In this mode framerate and exposure time is controlled by the framegrabber with the CC1 (CameraLink) camera input. The time t_min (that defines the framerate) must not be smaller than t_out (which is the output time for one frame).



9.7.3 External sync with internal timer

In this mode the framerate is controlled by the framegrabber while the exposure time is controlled by the camera.



9.8 Mechanical dimensions