



# EoSens<sup>®</sup> 3CL CAMERA MANUAL

• HIGH SENSITIVITY • HIGH SPEED • HIGH RESOLUTION •



EoSens 3CL Camera Manual  
Camera-Firmware:  
Camera ID:

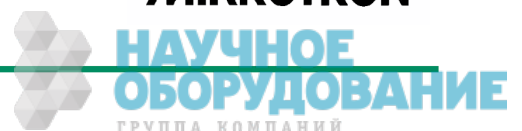
Rev. 1.01  
B2.04-V1.00-F1.00-G1.00  
MC3010-11

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.

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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 MC3010, MC3011**

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, 2009

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:



## 2 Introduction

The CMOS high speed camera EoSens 3CL is a high resolution camera with 1696x1710 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 19.27mm with square pixels measuring 8  $\mu\text{m}$ .

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 1696 x 1710 pixel, 285 fps can be output via the “Full CameraLink®” Interface.

### 2.1 Top level specifications

- 3 Megapixel high speed CMOS sensor
- 1” optical format
- High resolution: 1696x1710 pixel
- 8  $\mu\text{m}$  square pixels
- Very high sensitivity
- 256 gray levels (8 bit resolution)
- Up to 285 frames/s at full resolution
- Arbitrary region of interest
- Up to 180 000 frames/s with reduced resolution
- 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 content of all light sensitive elements is cleared. When exposure terminates, accumulated charge is transferred to an analog memory associated with 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 or color.

Features Type	Data width (bits)	Color / Mono	Full Camera Link® - no. of taps	C/F-Mount lens adaption	max. frame-rate@ 1696 x 1710	Image pre-processing supported
MC3010	8	M	8,10	C/F	285 fps	+
MC3011	8	C	8,10	C/F	285 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 CameraLink® interface

CameraLink® is designed for digital cameras in machine vision applications. The “Full Camera Link®” interface can transfer up to 850 Mbytes/sec.

#### 3.1.1 Serial interface

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

### 3.2 Power supply

The camera needs a DC supply voltage between 8 ... 24V at a power consumption of 7 Watt max.

See also 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 *EoSens*.

LED orange... The camera is configuring the internal FPGA. No other activity is possible.

LED green... The camera 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 EoSens 3CL
- C-Mount/F-Mount lens
- Mikrotron Support CD
- Image processing system, e.g.: PC and software
- 1 Power supply 12VDC, 2.5A with cables
- 2 CameraLink® cables



To specify cables see chapter connector pinning.

### 4.1 First steps

- Switch off the image processing system
- Connect CameraLink® 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 EoSens 3CL 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 EoSens 3CL 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 are 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	273	200x200	6815	10x8	Full	75
1	400	320x240	5196	10x8	Full	75
2	460	640x480	1495	8x8	Full	80
3	593	1280x1024	452	8x8	Full	80
4	630	1696x1710	217	8x8	Full	80
5	557	640x480	1810	10x8	Full	75
6	687	1280x1024	524	10x8	Full	75
7	710	1680x1710	247	10x8	Full	75

## 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	273	200x200	6815	10x8	Full	75
1	400	320x240	5196	10x8	Full	75
2	460	640x480	1495	8x8	Full	80
3	593	1280x1024	452	8x8	Full	80
4	630	1696x1710	217	8x8	Full	80
5	557	640x480	1810	10x8	Full	75
6	687	1280x1024	524	10x8	Full	75
7	710	1680x1710	247	10x8	Full	75

## 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	593	1280x1024	452	8x8	Full	80

## 6 Configuration

The content of all EoSens 3CL 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 CameraProfile 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 0xffh = 255<sub>dec</sub>.

### 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 an EEPROM write time. An answer is provided with read type commands (e.g. :v), 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.

Most of the commands can return the actual value by sending '?' as parameter. Some commands then also return the actual value range.

## 6.1 Table of commands

Syntax	Value range	Answer	Comment	Chapter
:A<x> :A?	<x> = y, Y, n, N	-- <sup>2</sup> or 'y', 'n' <sup>3</sup>	command acknowledge flag yes or no	<a href="#">6.9.5</a>
:b<x> :b?	<x> = 0...4	-- <sup>2</sup> or <x> <sup>3</sup>	Select baudrate 0 = 9600 (default), 1 = 19200, 2 = 38400, 3 = 57600, 4 = 115200	<a href="#">6.9.6</a>
:B	--	OK or ERROR: xxxx <sup>3</sup>	Send last error to PC (max. 45 chars)	<a href="#">6.9.3</a>
:c	--	-- <sup>2</sup>	Reset camera and load power up profile	<a href="#">6.9.4</a>
:d<aaa><bbb><ccc><ddd> :d?	<aaa> = x-start 0...600 <sub>hex</sub> <bbb> = y-start 0...6AC <sub>hex</sub> <ccc> = x-width 78...6A0 <sub>hex</sub> <ddd> = y-height 1...6AE <sub>hex</sub>	-- <sup>2</sup> or <aaa><bbb><ccc><ddd> <sup>3</sup>	Set ROI start- and endcoordinate (data area)	<a href="#">6.6.1</a>
:f<n>	<n> = 0...7	-- <sup>2</sup>	Load factory profile <n>	<a href="#">6.3.3</a>
:g<n>	<n> = 0...7, c	-- <sup>2</sup>	Load user profile in bank <n> bank „c“ = PowerUpProfile	<a href="#">6.3.2</a>
:h<n> :h?	<x> = 0...2	-- <sup>2</sup> or <x> <sup>3</sup>	Shutter 0 = free run, 1 = PWC, 2 = timer	<a href="#">6.8.1</a>
:H<n> :H?	<x> = 0, 1	-- <sup>2</sup> or <x> <sup>3</sup>	Set shutter pulse polarity 0 = pos. edge, 1 = neg. edge	<a href="#">6.8.1</a>
:i<s><x> :i<s>? :i<s><xx> :i<s>?	<s> = 'n' ==> <x> = 1...2 <s> = 'd' ==> <xx> = 1...63 <sub>hex</sub>	-- <sup>2</sup> or <x> <sup>3</sup> -- <sup>2</sup> or <xx>'<yy>.<zz> <sup>3</sup>	1 = normal shutter, 2 = dual slope set d=dual slope in percent of shutter time get actual slope time and allowable range	<a href="#">6.7.3</a>
:k<xx> :k?	<xx> = 32...C8 <sub>hex</sub>	-- <sup>2</sup> or or <xx> <sup>3</sup>	Set blacklevel; value 80h is default; increase or decrease value slightly to adjust blacklevel	<a href="#">6.5.1</a>
:M<x> :M?	<n> = 5, 6	-- <sup>2</sup> or <n> <sup>3</sup>	Set mode: 5 = 8x8, 6 = 10x8	<a href="#">6.4.1</a>
:n<x> :n?	<x> = 0...1	-- <sup>2</sup> or <x> <sup>3</sup>	0 = Power down + testimage 1 = normal operation	<a href="#">6.9.2</a>
:N :N?	<x> = 0...1	-- <sup>2</sup> or <x> <sup>3</sup>	Switch on or off FPN correction	<a href="#">6.5.2</a>
:p<n>	<n> = 0...7, c	-- <sup>2</sup>	save actual profile in bank <n> -- takes about 2 sec. -- Bank „c“ = PowerUpProfile	<a href="#">6.3.1</a>
:q<xxxxxx> :q?	<xxxxxx> = 1...2c308 <sub>hex</sub>	-- <sup>2</sup> or <xxxxxx>'<ss>'.<zzzzzz> <sup>3</sup>	Set framerate get actual framerate, and possible framerate range for actual ROI	<a href="#">6.7.1</a>
:R<xx> :R?	<xx>= 3C <sub>hex</sub> , 41 <sub>hex</sub> , 46 <sub>hex</sub> , 4D <sub>hex</sub> , 50 <sub>hex</sub> , 55 <sub>hex</sub>	-- <sup>2</sup> or <xx> <sup>3</sup>	Set pixelclock 60,65,70,75,80,85 MHz	<a href="#">6.4.2</a>
:t<xxxxxx> :t?	<xxxxxx> = 1...F4240 <sub>hex</sub>	-- <sup>2</sup> or <xxxxxx>'<ss>'.<zzzzzz> <sup>3</sup>	Set shutter time in μs get actual shutter time and possible shutter time range for actual framerate	<a href="#">6.7.2</a>
:T	--	(-)xx <sup>3</sup>	Temperature in °C	<a href="#">6.2.3</a>
:U<n>	<n> = 0...2	<xxxxxx>	Display: 0=Current in mA 1=Voltage in mV 2=Power consumption in mW all values are decimal	<a href="#">6.2.4</a>
:u<x> :u?	<x> = 0...2	-- <sup>2</sup> or <x> <sup>3</sup>	Framecounter 0=off, 1=on, 2=reset	<a href="#">6.9.1</a>
:v	--	Snr., Boot, App, FPGA <sup>3</sup>	Send snr and versions to PC	<a href="#">6.2.1</a>
:V	--	Cameratype, ID <sup>3</sup>	Send cameratype and -ID to PC	<a href="#">6.2.2</a>

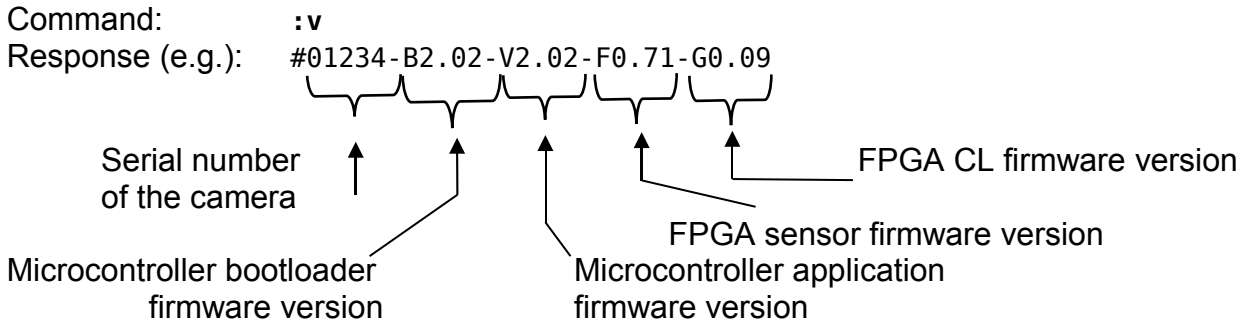
<sup>2</sup> If the command acknowledge flag is set the return will be ACK (0x06) or NAK (0x15).

<sup>3</sup> The answer is followed by a CR (0x0d) trailer.

## 6.2 Read camera information

### 6.2.1 Read serial number and firmware revision, command :v

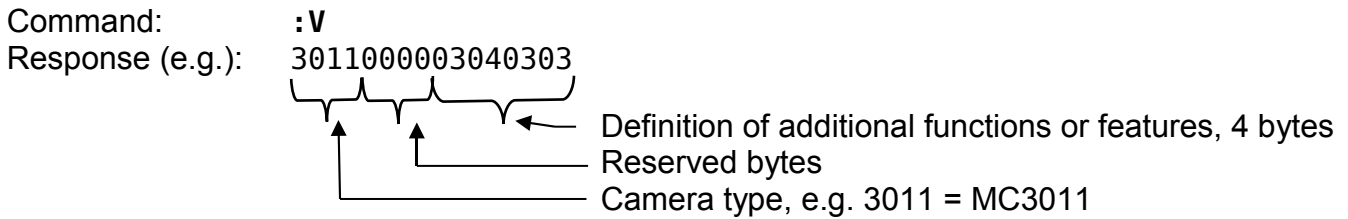
The serial number and the firmware revision can be read with the :v command.



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.



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 as decimal 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.**

#### 6.2.4 Read power information, command :U

The camera disposes an internal voltage and current sensor that can be read out. The values are delivered as decimal ASCII characters.

Command:            :U<x>                    x=0 for current in mA  
  x=1 for voltage in mV  
  x=2 for power consumption in mW

Response (e.g.):    12032                    actual supply voltage is 12.032 Volt

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

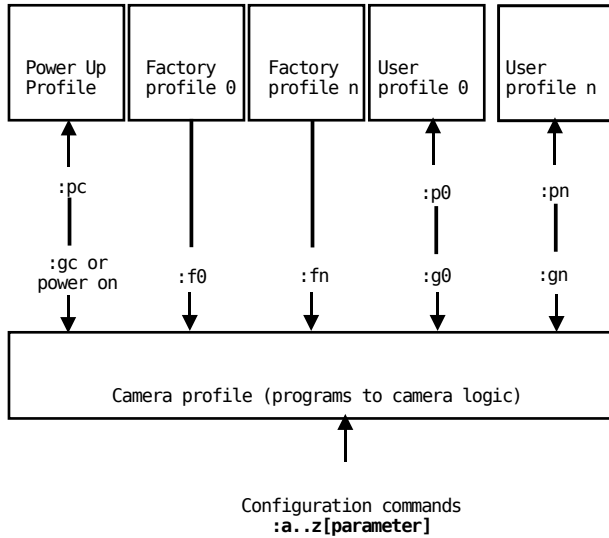


**Take care that the supply voltage does not exceed the rated specification range.**



### 6.3 Profile processing

All camera settings are loaded or stored as complete data blocks (= Profiles). There are 17 profiles. Eight factory profiles, eight 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

	<b>Issue this command only, if the profile was successfully tested.</b>
--	---

#### 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

#### 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

## 6.4 Output mode

### 6.4.1 CameraLink® output mode, command :M

Command: :M<x>                    <x> = 5, 6  
 or: :M?

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

Description: This command selects the CameraLink® output mode.

Mode	Taps x Bits	CL- config.	Pixelclock	Remark
5	8 x 8	full	80 MHz	
6	10 x 8	full	75 MHz	

### 6.4.2 Set pixelclock, command :R

Command: :R<xx>                    <xx> = 3c<sub>hex</sub>, 41<sub>hex</sub>, 46<sub>hex</sub>, 4b<sub>hex</sub>, 50<sub>hex</sub>, 55<sub>hex</sub>  
 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 CameraLink® output mode 5 works with a pixelclock of 80MHz and mode 6 with 75MHz. In general this is a good compromise between speed and reliability. The clock can be adjusted in 5 MHz steps from 60... 85MHz.

Increase pixelclock: To get a higher framerate the pixelclock must be increased. To reach the maximal possible framerate of the camera use CameraLink® output mode mode 6 and a pixelclock of 85MHz. Be sure to have a framegrabber that supports this high pixelclock. Also use cables as good and short as possible and a PC capable of processing this high datarate.

Decrease pixelclock: Under some circumstances it is helpful to reduce the pixelclock. 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.

## 6.5 Image quality

### 6.5.1 Blacklevel, command :k

Command:            :k<xx>                    <xx> = 32...C8<sub>hex</sub>  
 or:                 :k?

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

Description:        This command adjusts blacklevel. The value 80<sub>hex</sub> is the factory calibrated default. Increase or decrease this value slightly to adjust blacklevel.

### 6.5.2 FPN correction, command :N

Command:            :N<x>                    <x> = 0...1; 0 = off , 1 = on  
 or:                 :N?

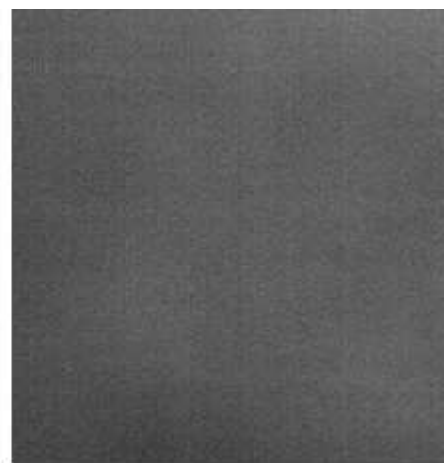
Response:           --\*                    \* ACK/NAK if acknowledge on  
 or:                 <x>                    <x> = actual value

Description:        This command switches the FPN correction on or off. With activated FPN correction the fixed pattern noise of the image sensor will be removed. Therefore a very uniform image will be output. The correction will be done in real time without any output delay.

Note:                Fixed pattern noise is a typical effect of CMOS sensors. But because it's a fixed pattern it is possible to eliminate the noise completely. Each EoSens 3CL camera possesses a factory calibrated reference image of the fixed pattern that will be applied to each output frame. Therefore EoSens 3CL can remove the noise very effective.



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...600 <sub>hex</sub> (modulo 64)
<bbb>	Address of first line	(y-start)	0...6AC <sub>hex</sub>
<ccc>	x-width	(x-width)	78...6A0 <sub>hex</sub> (modulo see table below)
<ddd>	y-height	(y-height)	1...6AE <sub>hex</sub> (mono camera) 2...6AE <sub>hex</sub> (color camera)

### 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 64. The x-width modulo is dependent on the actual CameraLink<sup>®</sup> output mode (command :M). If the value does not fit the modulo, the command will return NAK.

Note 2: With color cameras y-start and y-height must be an even value because of the bayer pattern. Entered odd values will be rounded down.

Mode (:M)	Taps x Bits	Modulo x-width	Remark
5	8 x 8	8	
6	10 x 8	10	

The ROI change time is 7ms including command transfer at 115kBaud. The new ROI is synchronized to the next frame so there is an additional delay of max 1 frameperiod.



### 6.7.3 Setting the slopes for dynamic range adjustment, command :i

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

                      <s> = 'n'    ==>   <x>    = 1..2            Number of slopes  
                       <s> = 'd'    ==>   <xx> = 1..63h<sub>hex</sub>   Dual 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 1 selectable step, 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, EoSens 3CL 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. 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



dual slope activated

## 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 EoSens 3CL can expose the images in free run mode or with an external signal on CC1. The external modes are used to synchronize EoSens 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...181000 fps and the exposure time can be set from 1 $\mu$ s to 1s.

### 6.8.3 Pulswidth 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. An internal timer defines exposure time. 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...2; 0 = off, 1 = on, 2 = reset  
                   or:                    :u?

Response:           --\*                    \* ACK/NAK if acknowledge on  
                   or:                    <x>

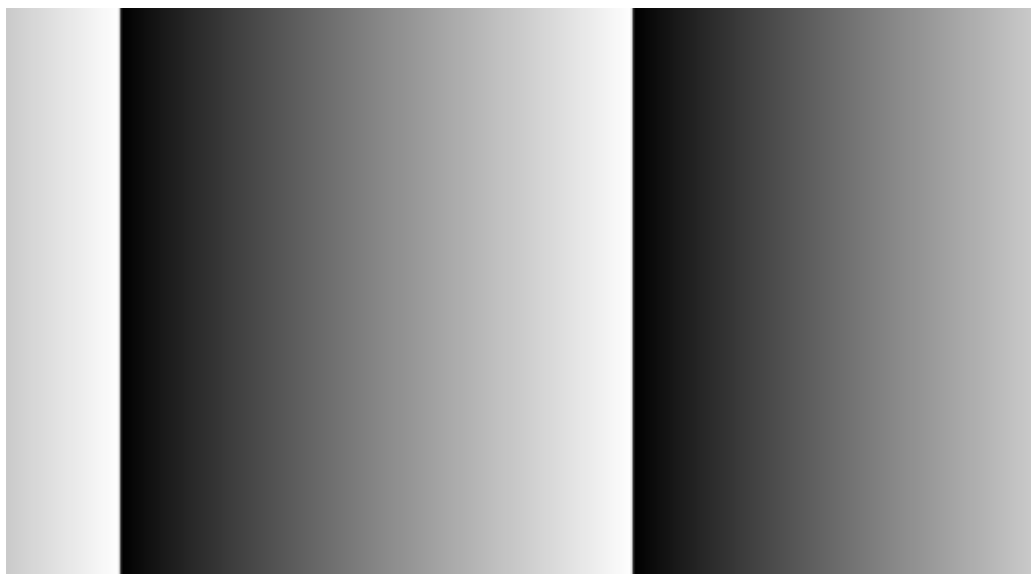
Description: If a sequence of frames is to be recorded for long time at a high frame rate, it can be useful to mark the images for later identification or check for completeness. EoSens 3CL has a 32-Bit image counter whose count can replace the first four pixel of every image. It is incremented by every new image. With x=2 the counter is reset (and not displayed) and will stay at 0 until the command is sent again with another valid value.

### 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 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 Get last error, command :B

Command: :B

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

Description: This command reads the actual status of the camera. It can be used to check the status after power up or to get the reason why a command returned NAK.

### 6.9.4 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.

### 6.9.5 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.

Note: After reset or power up the camera always defaults to acknowledge on.

### 6.9.6 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.

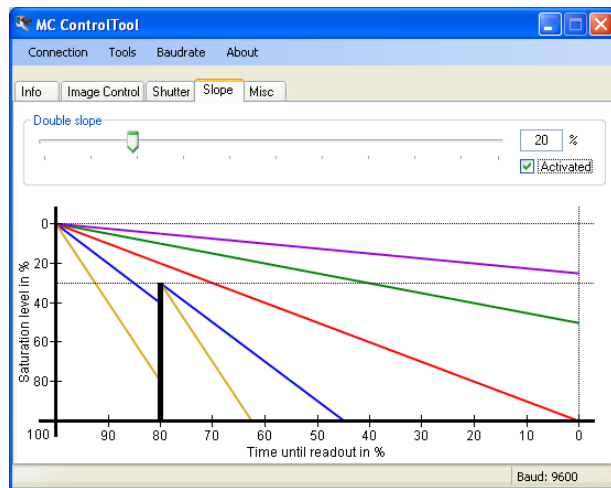
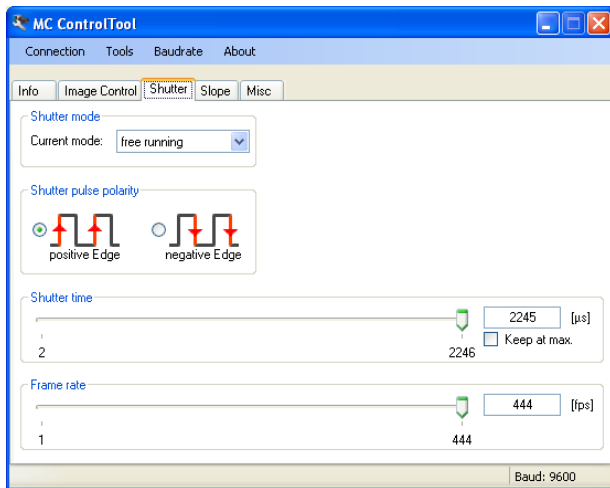
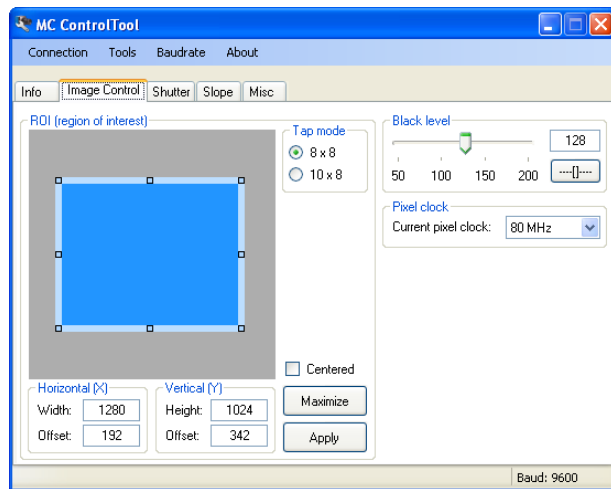
Note: After a reset or a power up the camera always defaults to a baudrate of 9600 Baud.

# 7 EoSens 3CL configuration tool

The EoSens configuration tool must be installed on a Windows PC by means of the setup software. See also [www.mikrotron.de](http://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 two FPGA's (**F**ield **P**rogrammable **G**ate **A**rray), which's configuration is stored in EEPROM's. Upon power up or reset the FPGA's are 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 EoSens 3CL firmware consists of 3 files. Mikrotron always provides these files as one package. Be sure to always update all 3 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.

You need the following files:

- $\mu$ Controller..... MC301xM718Axxx.ibf
- Sensor FPGA..... MC301xM713Fxxx.ibf
- CameraLink FPGA... MC301xM718Gxxx.ibf

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



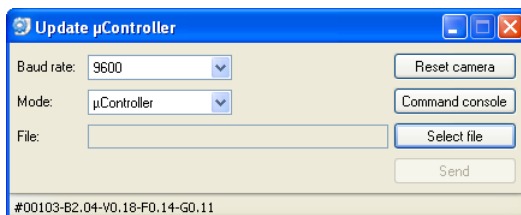
**Once started YOU CANNOT UNDO THIS COMMAND.**

**Also note that your saved power up and user profiles will be overwritten with standard profiles.**

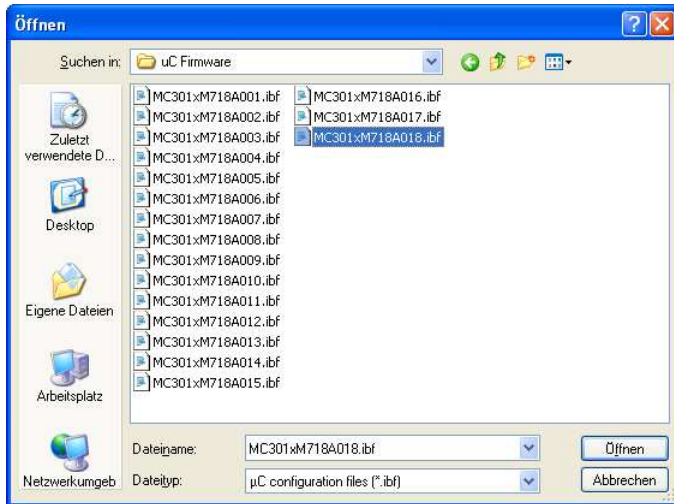
- Start camera control tool and select “EoSens 3CL” camera. Wait until the info screen displays serial no. and firmware version.
- Select in menu “Tools” - “Update camera”:



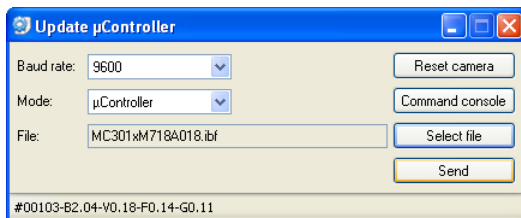
- In the drop down menu „Mode“ select the desired device to update:



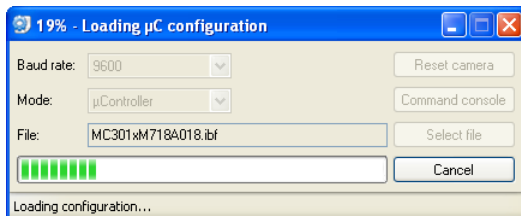
- Click “Select file” and choose the appropriate file (see above):



- 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.

- Repeat these steps for sensor FPGA and CameraLink FPGA by choosing the „Mode“ in the drop down menu.
- After all modules have been updated verify the versions in “EoSens” 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.

- 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:



Connect to the camera and the tool will automatically start with the "Update  $\mu$ Controller" 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.





- Possible error:** One of the FPGA programs were not loaded successful. The camera confirms this with 3x red blink after power up. The 'Info' tab of the control tool shows 'F0.00' or 'G0.00'. In this case just repeat the 'Update FPGA firmware' procedure.



## 9 Technical Data

### 9.1 Overview

MC3010 MC3011	Monochrome Bayer Filter
Number of pixel	1696 x 1710
Pixel size	8 x 8 $\mu\text{m}$
Active area	13.57 (H) x 13.68 (V) mm
Fill factor	36%
Sensitivity	1270 $\text{V}\cdot\text{m}^2/\text{W}\cdot\text{s}$ at 600 nm with microlens
Full well charge	27000 $e^-$
QE x FF	37% at 680 nm with microlens
Shutter	Electronic „Freeze Frame“ Shutter
Trigger	Asynchronous shutter, shutter time selectable with internal timer or by pulse width of trigger signal
Power supply	8...24 V
Power consumption max. Thermal resistance typ.	7 W 0.17°/W
Serial data link	RS-644 with CameraLink® 9.6...115 kBd, 8 bits, 1 stop bit, no parity
Digital video MC3010-11	CameraLink®, Full configuration
Shock & vibration	70g, 7grms
Dimensions (WxHxD)	63 x 63 x 49 mm without lens adapter
Case temperature	+5...+50 °C
Weight	250g without lens adapter
Lens mount	C-/F-mount (depending on adapter)

## 9.2 Sensor defect specifications

Parameter	Description	Limit
Bright Pixels	Number of bright pixels allowed in the full window size of 1696x1710. A bright pixel is defined as a pixel that has a 25% higher response than the median response of the dark image.	Up to a maximum of 25 bright pixels allowed. The bright pixel defects are stored in a global defect map.
Mid Defect Pixel	Number of mid pixels defects allowed in the full window size of 1696x1710. A mid defect pixel is defined as a pixel that has a +/-25% response from the median response of the gray image.	The mid pixel defects are stored in a global defect map.
Dark Defects	Number of dark defects allowed in the full window size of 1696x1710. A dark defect pixel is defined as a pixel that has a 25% response lower than the median response of the saturated image.	The dark defects are stored in a global defect map.
Total Defects	The total number of defect count from the global defect map.	Less than 50 total defect pixels allowed in the full active window.
Defective Column	Number of bad columns in the full window size of 1696x1710 derived from a half scale image. A bad column is defined as a column that has a response of more than 5% deviation from the median of the surrounding 20 columns.	Zero defective columns allowed
Defective Row	Number of bad rows in the full window size of 1696x1710 derived from a half scale image. A bad row is defined as a row that has a response of more than 5% deviation from the median of the surrounding 20 rows.	Zero defective rows allowed
Cluster	Number of clusters allowed in the full window size of 1696x1710. A cluster is defined as a group of pixels greater than 4 neighboring defect pixels (top, bottom or side; not diagonal). Clusters that exceed a maximum of 4 defect pixels are not allowed.	Zero clusters allowed

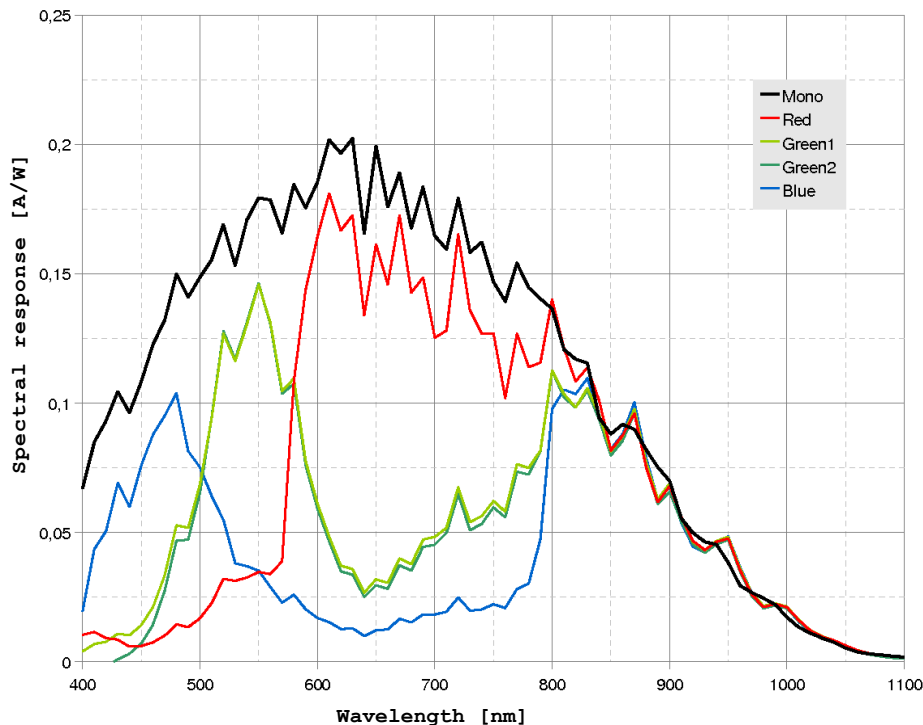
### Test Conditions:

All calculations are performed on the full pixel array of the chip.  
The illumination source is a RGB light source and F number=5.4  
Integration time for all types of images: 7.8 msec.

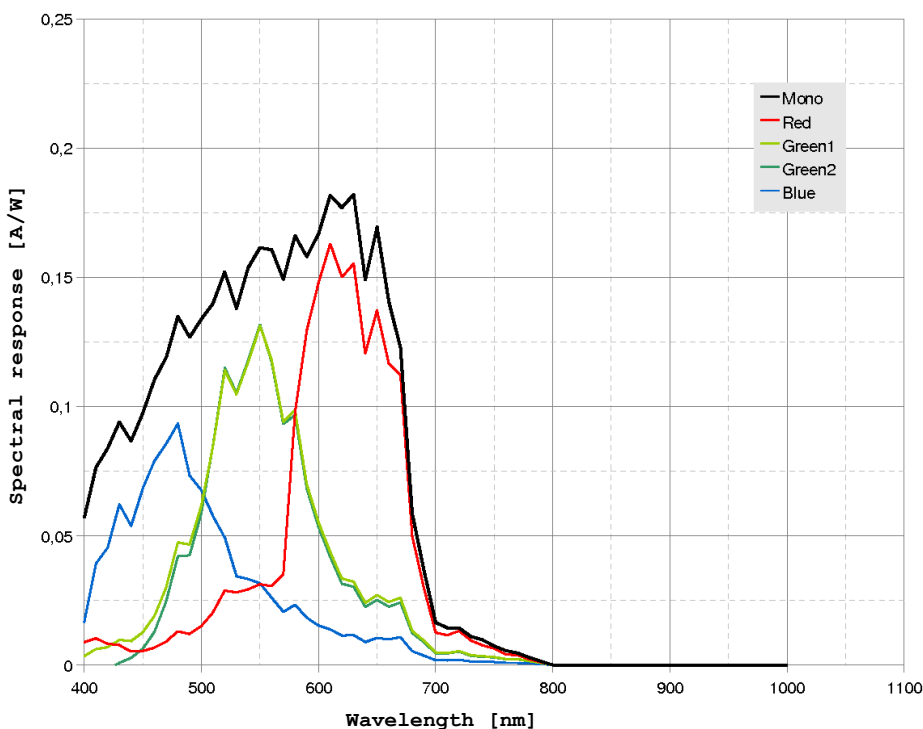
### 9.3 Spectral response

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.

Sensitivity of camera without UV/IR cut filter (standard monochrome version)

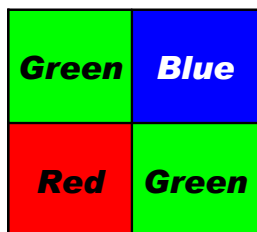


Sensitivity of camera with UV/IR cut filter (standard color version)



## 9.4 Bayer pattern filter

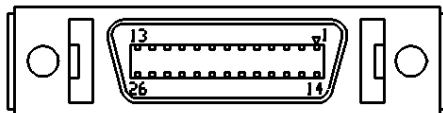
The EoSens color camera has a bayer pattern filter on the sensor glass lid. To get the color information the imaging software must decode the information. The pattern beginning from first row, first column is:



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.

## 9.5 Connector pinning

### 9.5.1 CameraLink® connector, MDR-26



„Base CameraLink®“ 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

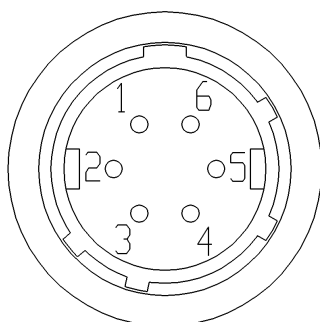
„Full CameraLink®“ pinning:

pin	signal
1	GND
2	Y0-
3	Y1-
4	Y2-
5	YCLK-
6	Y3-
7	100Ω 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	100Ω 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 STROBE\_OUT

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

	<p>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.</p> <p>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.</p>
---	--

## 9.6 CameraLink® bit assignments

### 9.6.1 Full CameraLink® 8\*8-bit assignment

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

Plug 1, CameraLink® X			Plug 2, CameraLink® Y			Plug 2, CameraLink® 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		



### 9.6.2 10\*8-bit assignment

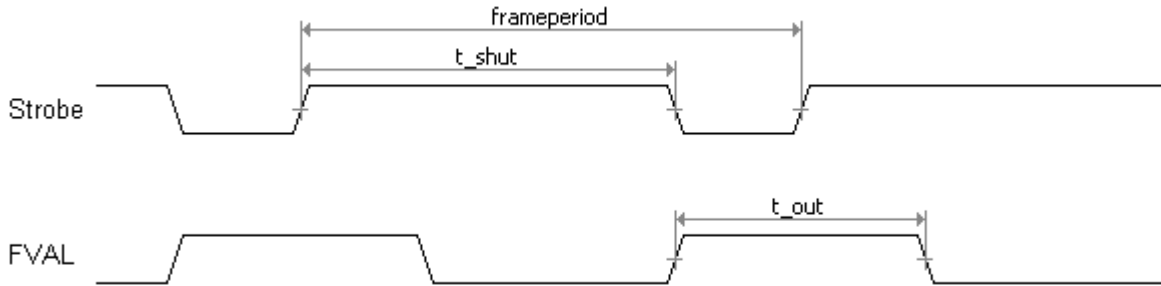
The table below shows the assignment of 10 adjacent pixels, 8-Bit each. This assignment is compatible to Basler's A504 camera.

Plug 1, CameraLink® X			Plug 2, CameraLink® Y			Plug 2, CameraLink® 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

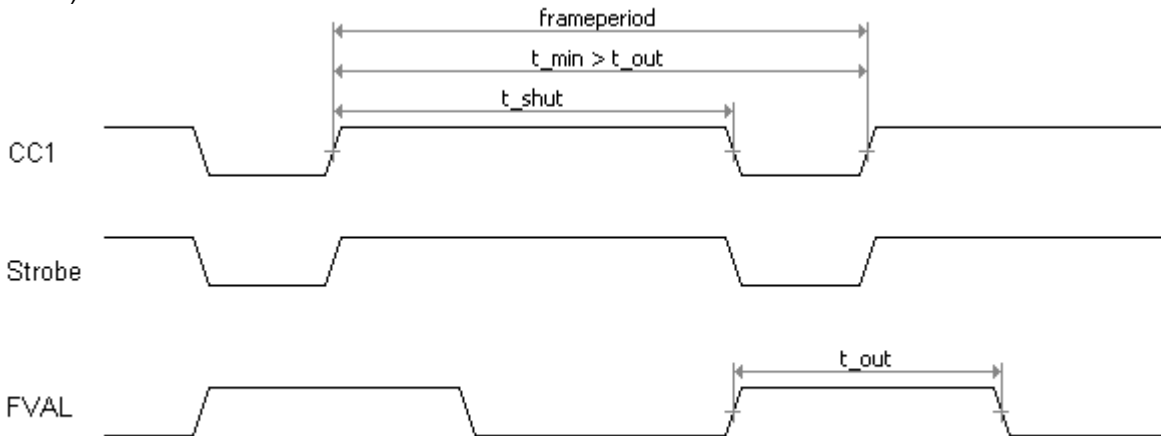
### 9.7.1 Free run with electronic shutter

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



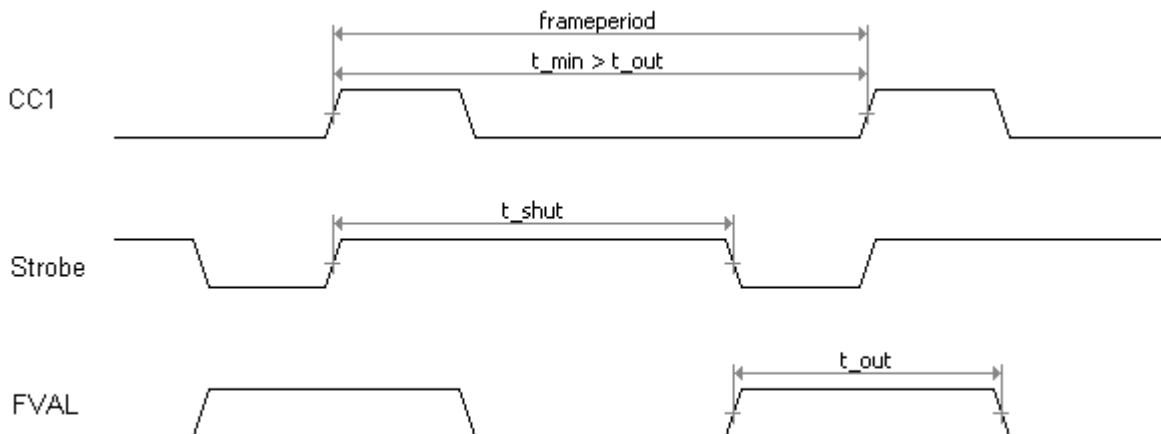
### 9.7.2 Pulswidth mode

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).



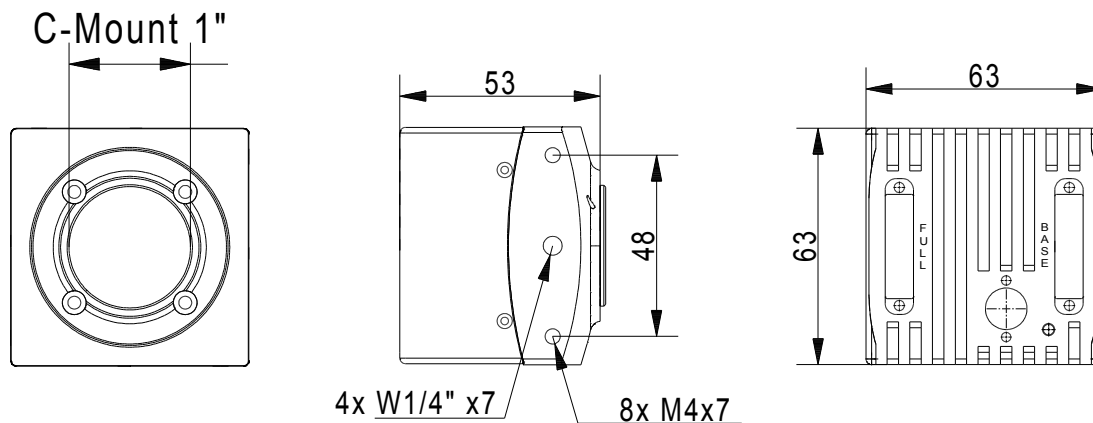
### 9.7.3 External sync with internal timer

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



## 9.8 Mechanical dimensions

### 9.8.1 EoSens 3CL with C-Mount



### 9.8.2 EoSens 3CL with F-Mount

