

# MC13xx

High Speed CMOS Camera

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MC13xx Users Manual Rev. 1.19  
Camera-Firmware: [V1.51-F2.53](#)  
Kamera ID Nr.: [MC1302 .. MC1319](#)  
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**Mikrotron GmbH**  
Landshuter Str. 20-22  
D-85716 Unterschleißheim  
Germany

Tel.: +49 89 726342 00  
Fax: +49 89 726342 99  
[info@mikrotron.de](mailto:info@mikrotron.de)  
[www.mikrotron.de](http://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  
Deutschland

Product: **camera MC1302, MC1303, MC1304, MC1305**  
**camera MC1306, MC1307, MC1308, MC1309**  
**camera MC1310, MC1311, MC1314, MC1315**  
**camera MC1316, MC1317, MC1318, MC1319**

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, June 06<sup>th</sup>. 2003

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 MC13xx is a high resolution camera with 1280•1024 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 lenses. The sensor diagonal is 1,25“ with square pixels measuring 12µm.

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 25 fps and several thousand fps depending on resolution and video data width.

With a resolution of 1280 x 1024 pixel, 500 fps (MC131x) can be output via the “full Camera Link®” parameter sets are called: profiles and stored in non volatile memory.

### 2.1 Top level specifications

- high resolution: 1.280•1.024 pixel CMOS sensor with 1300 A/D converters
- up to 1.024 gray levels
- up to 100 full frames/s for MC1302 – MC1309  
up to 500 full frames/s for MC1310 – MC1319
- arbitrary region of interest
- high sensitivity
- 12µm square pixels
- electronic “Freeze Frame” shutter
- low blooming
- programmable via serial link
- patented ImageBLITZ® image trigger (MC1310 – MC1319)
- asynchronous trigger
- download customer specific FPGA preprocessing firmware
- 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 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 mono-chrome/color or Base/Full Camera Link® interface, lens connection to C-mount or changeable lens adapter C-mount/F-mount.

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- BLITZ®	Image pre- processing supported
MC1302	8/10	M	B-2	C	100 fps	-	-
MC1303	8/10	C	B-2	C	100 fps	-	-
MC1304	8/10	M	B-2	C	100 fps	-	+
MC1305	8/10	C	B-2	C	100 fps	-	+
MC1306	8/10	M	B-2	F	100 fps	-	+
MC1307	8/10	C	B-2	F	100 fps	-	+
MC1308	8/10	M	B-2	F	100 fps	-	-
MC1309	8/10	M	B-2	F	100 fps	-	-
MC1310	8/10	M	B,F-2,8,10	C	500 fps	+	-
MC1311	8/10	C	B,F-2,8,10	C	500 fps	+	-
MC1314	8/10	M	B,F-2,8,10	C	500 fps	+	+
MC1315	8/10	C	B,F-2,8,10	C	500 fps	+	+
MC1316	8/10	M	B,F-2,8,10	F	500 fps	+	+
MC1317	8/10	C	B,F-2,8,10	F	500 fps	+	+
MC1318	8/10	M	B,F-2,8,10	F	500 fps	+	-
MC1319	8/10	C	B,F-2,8,10	F	500 fps	+	-

Table 2.3-1

+ ... supported  
- ... not supported

## 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 64 bits of data at a rate of >528 Mbytes/sec.


#### 3.1.1 Serial interface

The communication via the serial interface is incorporated in the “Base Camera Link® interface. A description of the connector pinning is in chapter [9.3](#).

### 3.2 Power supply

The camera needs a DC supply voltage between 8 ... 24 V at a power consumption of 6,0 Watt max..

See also [Connector pinning](#) .

	<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>
--	--

### 3.3 Status LED

A dual colour LED on the camera backplane shows the operating condition of the MC13xx.

LED orange...	The MC13xx is configuring the internal FPGA. No other activity is possible.
LED green...	The MC13xx is fully operational.
LED off...	If LED is off, despite the camera is powered, the FPGA configuration data is reloaded via the serial interface and stored in internal EEPROM. No other activity is possible.
LED red...	red LED that the FPGA could not be loaded because of wrong FPGA configuration data. Try to <a href="#">reload configuration</a> data.

## 4 Getting started

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

- Camera MC13xx
- C-Mount Lens
- Mikrotron Support CD
- Image processing system, e.g.: PC, frame grabber and Software



The frame grabber must have a Base- or Full Camera Link® Interface.

Additional items:

- 1 or 2 standard Camera Link® cables
- 1 Power supply 12VDC, 0.5A min
- 1 power cable



To specify cables see chapter [Connector pinning](#).

### 4.1 First steps

1. Switch off the image processing system
2. Connect Camera Link® cable between camera and frame grabber.
3. Connect power cable.
4. Unscrew dust protection cover, screw in lens.
5. Switch on the image processing system and camera power supply

## 5 Initial setup

The MC13xx 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 MC13xx 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 contents 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 one PowerUpProfile. It is loaded from 8 user profiles or 8 factory profiles or the PowerUpProfile. The camera profile is volatile and must be stored to the PowerUpProfile to be reactivated on next power up.

### 5.4 Factory profile

The factory profile can be read but not written by the user.

### 5.5 User profiles

The user can store up to eight PowerUpProfiles in non volatile memory. All load or write commands exchange data between the PowerUpProfile and one of the four user profiles.

Profil-Nr.	Video data width	resolution / pixel	Image frequency /fps
0	2x8	100 x 100	4.852
1	2x8	240 x 240	1.011
2	2x8	640 x 480	202
3	2x8	1280 x 1024	47
4	2x10	640 x 480	156
5	2x10	1280 x 1024	32
6	8x8	1280 x 1024	120
7	8x8	640 x 480	954

Table 5-1

## 6 Configuration

The MC13xx has 15 FPGA registers,  $r_1..r_{15}$ , each 10 bit wide, eight D/A registers,  $a_1..a_8$ , 8-bit wide, and one clock select register, 4 bit wide. The contents of all the above registers is called a profile. There is space in non volatile memory for 17 profiles: one 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 PowerUpProfile is loaded from the non-volatile to the volatile part of the memory.

A load or write command exchanges data between the PowerUpProfile 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  $0fh = 255$ .

### 6.1 Commands

ASCII strings are used to change camera parameters. All commands start with a colon, followed by one selection character and a value in hexadecimal notation with two or three ASCII characters.

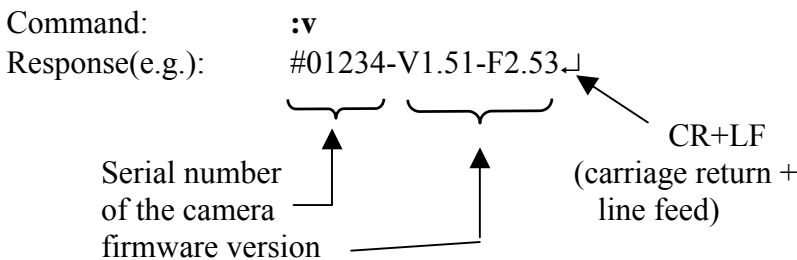
After a command has been recognized, processing is immediate, for all commands but the save type commands (:px). These need a EEPROM write time of app 1ms. An answer is provided with read type commands (:v, :w, :W) or, if the command “command acknowledge flag” is set, after processing of each command an ACK or NAK character. Processing of wrong command is stopped immediately on recognizing the error. A new command must start with a colon.

### 6.1.1 Table of commands

Syntax	Range	Answer	Description
:a<n><xx>	<n> = 1...8 <xx> = 0...ff <sub>h</sub>	--	Set one of eight analog voltages for the sensor
:A<n>	<n> = "Y", "Y", "n", "N"		En- or disable a command acknowledge or not acknowledge (ACK or NAK)
:b<n>	<n> = 0...4	--	Select baud rate: 0=9600 Bd (default setting), 1=19.2 kBd, 2=38.4 kBd, 3=56.8 kBd, 4=115.2 kBd
:c	--	--	RESET and new Initialization of the camera, new load of PowerUpProfile. Duration: some seconds
:e...	--	--	Transmit & save a new FPGA configuration
:f<n>	<n> = 0...7	--	Reload one of eight, factory defined and calibrated profiles to PowerUpProfile.
:g<n>	<n> = 0...7	--	Reload one of eight user profiles to PowerUp-Profile
:p<n>	<n> = 0...7	--	Save PowerUpProfile to one of eight user profiles, allow app. 1ms save time.
:r<n>	<n> = 1...f <sub>h</sub>	--	Write a FPGA - register
:s<n>	<n> = 0...f <sub>h</sub>	--	Select sensor and pixel clock from a table with 16 entries.
:S	6 Byte Code	--	Program sensor and pixel clock directly.
:t<n><m>	<n> = 00..7f <sub>h</sub> <m> = 00..ff <sub>h</sub>	--	Short setting of X- position in units of 10 pixel and Y-position in units of 4 lines.
:v	--	#12345- V1.10- F1.29	Read serial number (#), microcontroller - version (V...) and FPGA - version (F...).
:w	--	camera profile: 44 bytes in hex	Read actual PowerUpProfile, data output in hex
:W	--	Camera profile: 44 bytes in ASCII	Read actual PowerUpProfile, data output in ASCII

## 6.2 Read serial number and firmware revision

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



### 6.2.1 Read camera settings

The actual camera settings can be read out. The answer are the values of all camera registers.

Command: **:w** Output as hexadecimal digits (44 Bytes)  
**:W** Output as ASCII-String

Example for **:w** (output as hex digits, 44 Databytes + CR + LF):

```
6d6448c66500650061008541898c0000
03f f03f f0000007f 0030000000000000
00000000000000000000000000000000
```

CR+LF

Example for ":W" (output as ASCII string, 91 Bytes total, 88 databytes, 1x CR preceding the databytes, 1x CR after 32 ASCII-characters and 1x CR after 64 ASCII- characters):

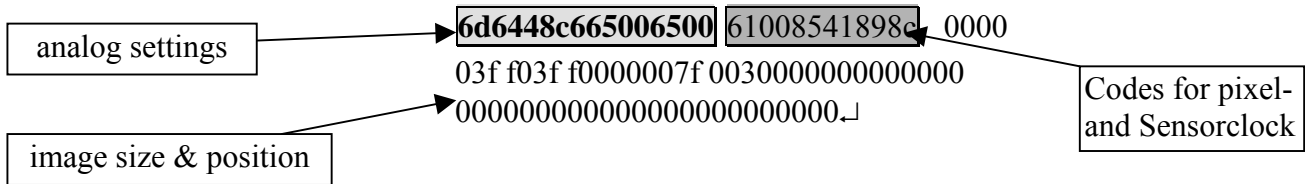
```

↓6d6448c66500650061008541898c0000↓
03f f03f f0000007f 0030000000000000↓
00000000000000000000000000000000

```

CR

Assignment of data to camera parameters:



transmitted bytes:

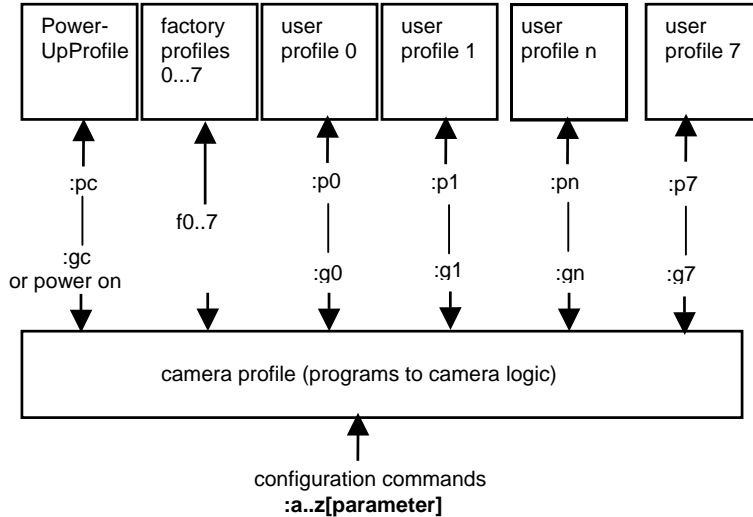
A1 A2 A3 A4 A5 A6 A7 A8 Sa1 Sa2 Sa3 Sb1 Sb2 Sb3  
R1h R1l ... R15h R15l ↵

A1...A8                    analog settings  
Sa1 Sa2 Sa3                3 Bytes frequency codes of pixelclock    (see 6.7)  
Sb1 Sb2 Sb3                3 Byte frequency codes for sensorclock    (see 6.7)  
R1...R15                   image size & position  
R1h ...                    high Byte Register1  
R1l ...                    low Byte Register1  
↵ ...                      CR+LF (0dh + 0ah)

Abb.	description	hex. Code
CR	carriage return	0d
LF	line feed	0a

### 6.3 Profile processing

All camera settings are loaded or stored as complete data blocks (= Profiles). There are 17 profiles, the Camera profile, the PowerUpProfile, eight factory profiles and eight user profiles.



#### 6.3.1 Read Camera profile

The response to the read Camera profile command `:w` is a hex string of the contents of all actual camera registers.

Command: `:w`  
 Response(e.g.): 6d774ac800006a1c6100851898c0003ff3ff  
 0000800300  
 all values hex, e.g.: 70<sub>HEX</sub> = 112<sub>DEC</sub>

Sequence of transmitted data bytes:

A1 A2 A3 A4 A5 A6 A7 A8	Sa1 Sa2 Sa3 Sb1 Sb2 Sb3	R1h R1l ... R15h R15l ↵
A1...A8	Sa1 Sa2 Sa3	R1h ...
	Sb1 Sb2 Sb3	R1l ...
		↵ ...

image level control (FPN, contrast...)  
 3 Byte synthesizer code of pixel clock  
 3 synthesizer code of sensor clock  
 (see chapter [6.7.1](#))  
 image control (image position, size, sync...)  
 high Byte R1  
 low Byte R1  
 CR+LF (0dh + 0ah)

#### 6.3.2 Write user profile

The PowerUpProfile is transferred to one of the eight user profiles.

Command: `:p<n>` `<n> = 0 ... 7,c`

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

### 6.3.3 Load user profile

Load one of eight user profiles to the PowerUpProfile.

Command: **:g<n>** <n> = 0 ... 7, c

### 6.3.4 Load factory profile

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

Command: **:f<n>** <n> = 0 ... 7

## 6.4 Video data width, Base/ Full Camera Link®


MC13xx can output video data with 2 x 8-Bit or 2 x 10-Bit via the „Base Camera Link®“ interface, or 8 x 8-Bit or 10 x 8-Bit data via the „Full Camera Link®“ interface. Use register 7 Bits 7/5 to select..

Video data width	:r7[7]	:r7[5]
2 x 8	0	0
2 x 10	0	1
8 x 8	1	0
10 x 8	1	1

Table 6.4-1

The 10 x 8 - Bit data width lowers the clock speed for a given bandwidth, and needs a compatible frame grabber. The assignment of the 10 taps to the Camera Link® ports is described in chapter: [10\\*8-Bit Assignment](#).

There are no predefined profiles for 10 x 8 Bits stored in the MC131x. Any predefined 8 x 8-Bit profile can be used as starting point. Then change :r7 [7,5] to 1 and set Pixel Clock speed as described in: [Frequencies for video data width 10\\*8 - Bit](#). This profile can then be stored as User Profile.

	<p><b>MC130x:</b> Setting of r7[7] is ignored by the camera.  <b>MC131x:</b> After a change of r7[7], change the selected frequency. See: <a href="#">Table selection of clock frequencies</a>.</p>
---	---

## 6.5 Image quality

There are three D/A converter to influence image quality: FPN, Gain, and Black up. FPN, Gain and especially Black might be adjusted if sensor clock changes. All three parameters are stored in non-volatile memory as part of the selected profile.

### 6.5.1 FPN

The **Fixed Pattern Noise** setting reduces the fixed pattern noise that is typical to CMOS sensors. This level might be changed if the sensor clock frequency is changed. For adjustment set the lens out of focus and to a medium grey level. Lower FPN until a heavy pattern appears. Then raise by a few points.

Command: **:a1<x1x0>** <x1x0> : Range, typ. 55h ... 80h  
 Response: none



### 6.5.2 Gain

This is the threshold for the A/D converters. Its standard value is 66h for app. 1V. One step is app. 10mV. To increase the gain the value of a2 must be lowered.

Command: **:a2<x<sub>1</sub>x<sub>0</sub>>** <x<sub>1</sub>x<sub>0</sub>> : Range,  
typ. 30h ... 80h

### 6.5.3 Black Level

Change Black Level if sensor clock changes. Increase this parameter until grey values in no light condition (closed lens) are close to zero.

Command: **:a5<x<sub>1</sub>x<sub>0</sub>>** <x<sub>1</sub>x<sub>0</sub>>: Range, typ. 00h ...ffh  
Response: none

## 6.6 Image size and position

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


Bit(s)	Description
r1[9..0]	Number of first line, 0..3FD <sub>h</sub>
r3[9..0]	Number of lines, 0..3FF <sub>h</sub>
r4[6..0]	Address/10 of the first pixel
r5[6..0]	Address/10 of the last pixel

Table 6.6-1

#### 6.6.1 Address of the first line

Register r1 defines the first line to be displayed.


Command: **:r1<x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>>** <x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>> ... Range 000h ...3fdh  
Response: none  
Example: :r1100  
100h = image starts at line 257

	If dual column binning is activated, r1 is doubled within the camera logic.
---	---

#### 6.6.2 Number of lines

Register r3 defines the number of lines to output.

Command: **:r3<x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>>** <x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>> ... Range 000 h ...3ffh  
Response: none  
Example: :r3200 200h = display 513 lines

	The sum of r1 and r3 must be ≤ 0x3ff/1023 or 0x1ff/511 if dual column binning is activated!
---	---

### 6.6.3 Address of the first pixel of a line

Register r4 defines the leftmost pixel. The value is the pixel address divided by ten.

Command:            :**r4**<*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*>  
                          <*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*> ... Range 000h ...7fh  
Response:            none

Calculation of the value of r4:  
Value of r4 = Pixel-Nr./10

### 6.6.4 Address of the last pixel of a line

Register r4 defines the rightmost pixel. The value is the pixeladdress divided by ten.

Command:            :**r5**<*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*>  
                          <*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*> ... Range 000h ...07fh  
Response:            none

Calculation of the value of r5:  
Value of r5 = Pixel-Nr./10



The difference r5 - r4 must be in the range:  $0 \leq r5-r4 \leq 7fh$  .

### 6.6.5 Tracking

For rapid window movement even at slow baud rates a short command is provided..

command:            :**t**<*n*>,<*m*>  
                          <*m*> = X-position in pixel/10,  
                          range 00h ...07fh  
                          <*n*> = Y-position in lines / 4,  
                          range 00h ...0ffh

Response:            none

### 6.6.6 Arbitrary shaped fields of view

Standard adjustment of the camera using the parameters [address of 1. pixel in a line](#), [address of last pixel in a line](#), [address of first line](#) and [number of lines](#) only allows to define one rectangular window . For more than one window MC13xx offers a separate function, which allows to select more fields of view with different shapes.

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.

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 ist set the next 10 pixel of line no. 1-8 are activated. Bit7 enables pixel 70..79. The next selection byte, bit0 addresses pixel 80..89.

```
command:      :r8<x2x1x0>
               <x2x1x0> ... range 000h ...03ffh
               <x1x0> ... selection byte, bits 7..0, range 00h ...0ffh
               <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
```

To set the arbitrary shaped field of view all 2048 selection bytes must be written. In each byte at least write bit (bit8) 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.

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 MC13xx using the function “Write” “File to camera”.

## 6.7 Clock selection

The MC13xx is equipped with a 2-channel programmable clock synthesizer. One channel controls clock frequency of the sensor (sensorclock,  $F_{\text{sens}}$ ), the other controls the frequency of the pixel clock (pixelclock,  $F_{\text{pix}}$ ). These independent clocks allow an always optimal ratio depending on the product of (image size • image frequency) and the data rate on the output.

Example:

The MC13xx is connected to a frame grabber with a maximum data rate of 66MBytes/s via the „Base Camera Link®“ interface using 2 x 8 bit video data.. A pixel clock of 33 MHz has to be selected.

As the sensor outputs 10 pixel per clock a sensor clock of 6.6MHz could be chosen. Because the sensor can run up to a clock frequency of 66 MHz only 1/10 of the sensors possible speed would be used. To make use of the maximum sensor clock and maintaining the maximum data rate on the output, just 120 (1280/10 rounded to steps of 10) from the possible 1280 pixel per line can be selected.

Therefore the ratio of  $F_{\text{sens}}$  and  $F_{\text{pix}}$  depends on the selected line length:

$$F_{\text{sens}} \leq (F_{\text{pix}} \cdot 1280) / (5 \cdot \text{line length})$$

or if 100 pixel line length is chosen:

$$F_{\text{sens}} = (33 \cdot 1280) / (5 \cdot 100) = 70,4 \text{ MHz}$$

As this exceeds the maximum sensor clock frequency,  $F_{\text{sens}}$  is chosen as 66 MHz and  $F_{\text{pix}}$  as 33 MHz.

### 6.7.1 Arbitrary selection of sensor and pixel clock

Sensor and pixel clock can be set to any value, the product of: (sensor clock • line length/1280) must always be smaller (about 10%) than the quotient: (pixel clock / [video data width](#), e.g.: 2, or 8).

If [video data width](#) of 10 x 8-Bit is selected, sensor clock = pixel clock.

command     :**S** <**x**<sub>0</sub>>  
                  <**x**<sub>0</sub>> ... 6 characters, as described in chapter [Frequency selection](#)


### 6.7.2 Table selection of clock frequencies

To simplify clock selection when using video data width of 2, clocks can be selected from a table with 15 entries, each entry being optimized for four regions of line length. (see table in [9.3](#)).

Example:     240 < line length <= 640 Pixel, clock selection s9  
          pixelclock:    30,0 MHz  
          sensorclock:  11,2 MHz  
          resulting max. datarate on the 16-Bit output:  
          30,0 MHz/s \* 2 Byte = 60,0 Mbyte/sec.

This is valid for a line length between 250 and 640 pixel.

command :s <x<sub>0</sub>>  
           <x<sub>0</sub>> ... range 0 ... f (hex)

	<p>Before selecting the data rate of the camera check the maximum data rate of the frame grabber, which must be higher (or at least the same).</p>
---	--

### 6.7.3 Image Format/Speed change

There are several steps necessary for a change of image format:

- i. Disable sensor controller with :r6[4] = 0.
- ii. Set image size with (:r1, :r2, :r3, :r4, :r5).
- iii. If new sensor clock = old sensor clock:
  - 1. Do not set pixel clock nor sensor clock.
- iv. If new sensor clock > old sensor clock:
  - 1. Set new pixel clock (:S6.....), then new sensor clock (:S4.....).
- v. If new sensor clock < old sensor clock:
  - 1. Set new sensor clock (:S4.....), then new pixel clock (:S6.....).
- vi. Reenable sensor controller (:r6[4]=1).

## 6.8 Exposure control

Exposure control is selected with register r6[7..4] and register r2[9..0].

Bit(s)	Description
r6[7..4]	<a href="#">Type of exposure</a>
r2[9..0]	Exposure time

table 6-1

### 6.8.1 Type of exposure

The MC13xx can expose the images synchronous or asynchronous. An external signal on CC1 can be used to synchronize MC13xx cameras to each other or to an external event.

#### 6.8.1.1 Synchronous exposure

Synchronous exposure means that the next image is exposed, while the current image is output. This mode provides fastest frame rate while maintaining maximum exposure time as long as 1/frame rate. If an external synchronization signal is input on CC1 its frequency range can be between 30Hz and the selected free running frame rate. Use MC13xx camera configuration tool for selection.

6.8.1.2 Asynchronous exposure

With asynchronous exposure, an external signal starts exposure, and the exposed image is output immediately after the exposure ends. Exposure time is defined either by an internal timer or by the width of the external EXP (CC1) signal. The time between two consecutive EXP (CC1) edges can be indefinite. Frame rate = 1/(exposure time + image output time). Image output time equals the selected free running frame rate. Use MC13xx camera configuration tool for selection.

The following registers select exposure type:

Register Bits	:r6[7..4]	:r7[8]	:rf[0]
camera stop	xxx0	x	x
Synchronous without electronic shutter	0001	0	0
Synchronous with electronic shutter	0011	0	0
Synchronous with electronic shutter and external synchronisation signal, positive edge	0011	0	1
Synchronous with electronic shutter and external synchronisation signal, negative edge	0011	1	1
Asynchronous, pulsewidth, positive edge	1011	0	0
Asynchronous, pulsewidth, negative edge	1011	1	0
Asynchronous, timer, positive edge	1111	0	0
Asynchronous, timer, negative edge	1111	1	0

Table 6.8-1

6.8.2 Frame rate with synchronous exposure

The frame rate with synchronous exposure is direct proportional to the selected number of lines. The time for one line is:

$$T_{zz} = 1/F_{sens} \cdot 136 \quad [\text{sec}]$$

$T_{zz}$  ...time/line  
 $F_{sens}$ ... Sensorclock

Frame rate:  $= 1 / (\text{time/line} \cdot \text{number of lines} + 1)$  or:  
 $= F_{sens} / (136 \cdot (r3[9..0] + 2))$

Dependencies between image size and frame rate for typical clock frequencies are given in the following table:

image size	100x100	240x240	640x480	1280x1024
Senso rclock (MHz)	66	33	13,2	6,6
Time/line [μs]	2,06	4,12	10,3	20,6
Frames/s	4.852	1.011	202	47

Table 6.8-2

**6.8.3 Synchronous operation without shutter**

Without electronic shutter the exposure time is 1 / [frame rate](#).

**6.8.4 Synchronous operation with shutter**

In the sensor is implemented a freeze frame shutter, which allows to reduce the exposure time in steps of one line. The minimum value of the exposure time is the duration of 2 line periods, which is determined by the value of r2 (min. 001h).

Command: **:r2<x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>>**  
 <x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>> ... Range 001h ...3ffh

Response: none

Exposure time T<sub>B</sub> :

$$T_{tB} = r2 \cdot T_{ZZ} - T_{ZZ} / 2$$

T<sub>B</sub> ... exposure time in s  
 r2 ... value of register 2  
 T<sub>ZZ</sub> ... time/line  
 $T_{ZZ} = 1/F_{sens} * 136$  [s]  
 T<sub>tzz</sub> ... Time/line  
 F<sub>sens</sub>... sensor clock

Typical exposure times:

Sensor clock frequency (MHz)	Time/line (μsec)	r2 @ 1/5.000 s	r2 @ 1/10.000 s
66	2,06	97	49
33	4,12	49	24
13,2	10,3	19	10
6,6	20,6	10	5

Table 6.8-3

**6.8.5 External synchronisation with synchronous exposure**

MC13xx cameras can be synchronized to an external signal that is input on the EXP (CC1) signal. The strobe output signal of a MC13xx “master camera” can be used for that purpose. The attached frame grabber must provide the connection of an external input to the CC1 signal to the camera. The frame grabber is initialized for a MC13xx in free running mode.

See timing diagram: [Synchronous exposure with external synchronisation via CC1](#)

The cameras frame rate must be set to a frequency slightly higher than the maximum frequency of the synchronization signal. The minimum frequency should be higher than 30Hz.

Command:            **:rf<0/1>**  
                       <0> ... deselect external sync signal  
                       <1> ... select external sync signal

Response:            none

Make sure that a sync signal is present on EXP/CC1 before this command is issued or the “trigger on CC1” button is pressed on the MC13xx camera configuration tool.

The polarity of the sync signal can be selected with the [Polarity of EXP-signal](#)

### 6.8.6 Frame rate with asynchronous exposure

The frame rate with asynchronous exposure = [Frame rate with synchronous exposure](#) – (1 / exposure time).

### 6.8.7 Asynchronous exposure, shutter control by pulse width

This operating mode is selected with register 6:  
**:r6[7..4] = 0xb**

Exposure time depends on the width of the external EXP – signal.

### 6.8.8 Asynchronous exposure, shutter control by timer

This operating mode is selected with register 6:  
**:r6[7..4] = 0xf**

The asynchronous exposure time is dependent on :r2[9..0]. The exposure timer counts as many lines as are defined in register :r2[9..0].

Exposure time:

$$T_B = 1/F_{\text{sens}} * 136 * (1+r2[9..0]) \quad [\text{Sec}]$$

$T_B$  ... exposure time  
 $F_{\text{sens}}$ .. sensor clock

example:    sensor clock = 66MHz  
               value of r2[9..0] = 6  
 $T_B = 136 * 6 * 15 \text{ ns} = 12,2 \mu\text{s}$




## 6.9 Firmware

### 6.9.1 Update Firmware

MC13xx's logic is integrated into a FPGA (Field Programmable Gate Array), which's configuration is stored in an EEPROM. Upon power up or a command the FPGA is loaded with this configuration. Configuration data can be downloaded via the serial interface of Camera Link®. 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, the **:c** command can be used to reconfigure the FPGA with the internally stored configuration data.

	<p><b>Download of *.ibf file via serial link with 9600Bd takes app. 1.5-5 min depending on the used camera. There should be no loss of power or communication during this time!</b></p>
---	---

### 6.9.2 Reset and configuration of the internal FPGA

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

Command: **:c**  
Response: none

## 6.10 Horizontal pixelbinning

Pixelbinning adds the gray values of two adjacent pixels and outputs it as one pixel with double sensitivity. In X-direction only 512 pixels are needed to cover the sensors full size.

To retain aspect ratio, every second line is discarded, if this feature is not disabled by setting Bit 8 of register 6 (**:r61xx**) or [vertical pixelbinning](#) is activated.

Command: **:r7010**  
Response: none

If discarding of every other line is not disabled (**:r61xx**), the contents of **:r1** is doubled in camera logic. To address a specific line on the sensor, the value written into **:r1** has to be divided by two and **:r3** must not exceed 1ffh.

Example:  
To output 256 lines from line 128, set r1 = 63 and r3 = 255 (=0xff).

## 6.11 Vertical pixelbinning

Vertical pixelbinning adds the gray values of two superimposed pixel of a column. This doubles sensitivity and vertical field of view. To retain aspect ratio, in addition [horizontal binning](#) must be activated. To activate, set bit 2 in register 6.

Command example: **:r6034**  
Response: none

## 6.12 Digital shading correction

For the best possible image quality even at the sensors clock limit, and non uniform lighting, the MC13xx can store gray levels along one line and subtract these from all lines of an image.

To setup shading correction set: `:r6[1] = 0`.

Then a uniform object should be used together with the desired lighting, exposure mode and time and lens. The lens should be closed so that the remaining light level along the center line of the image is as close to zero as possible, but not reaching zero.

Then set `:r6[1] = 1`.

The gray levels along the center line of the image are saved in volatile memory and then subtracted form all lines of the following images, as long as this bit remains set.

## 6.13 Digital gain

Digital gain selection is only possible with [video data width](#) 2 x 8-Bit or 8 x 8-Bit. Out of the 10-bits sensor data either the most significant 8 bits (gain 1), or bits 8..1 (gain 2), or the least significant 8 bits (gain 4) are selected.

Command: **:r700x**  
           x = 0: gain 1  
           x = 4: gain 2  
           x = 8: gain 4

## 6.14 External clock input

MC13xx frequency synthesizer can use the Camera Link® used to synchronize several MC13xx to one master clock.

To activate set Bit 9 of register 7.

Command example: **:r7200**  
 response: none



**If the external reference clock is different from 3.6864 MHz, the codes for the clock synthesizer have to be recalculated.**

## 6.15 Polarity of EXP-signal

The polarity of the EXP-signal can be positive- or negative active.  
 Use `:r7[8]` to select.

Negativ = `:r7[8] = 1`  
 Positiv = `:r7[8] = 0`  
 Command example: **:r7100**  
 Response: none

## 6.16 Test image

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..127. Use digital gain command to see pixel values of 0..255.

Command example: **:r7040**            r7[6]

Response:        none

## 6.17 Image counter

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.

MC13xx has a 16-Bit image counter whose count can replace the first two pixel of every image. The image counter is cleared with every low to high transition of r7[1], the camera enable bit. It is incremented by every new image.

Command example: **:r7002**            r7[1]

Response:        none

## 6.18 ImageBLITZ® shutter release, MC131x only

The ImageBLITZ® shutter release is only implemented in MC131x, not in MC130x.

ImageBLITZ can replace an external signal (e.g.: a light barrier) to release the shutter. Like a light barrier, ImageBLITZ is used to capture fast moving objects on the exact same position on the image.

Contrary to the light barrier, ImageBLITZ uses the same information as condition to release the shutter as the then exposed image.

ImageBLITZ defines one specific line or a part of the 1024 lines as trigger window. This is true even if the selected image size is less 1024 lines or outside of the selected image area.

After activation of ImageBLITZ and after issuing the EXP signal as an enable signal, the MC131x hardware checks the gray values in the trigger window at a repetition rate that is defined by the exposure time selected with bits 3..0 of r6.

If a selectable number of pixels along that trigger window exceed or fall short of a selectable threshold, one single image is exposed and output.

To adjust ImageBLITZ®, the trigger line can be superimposed to the image. Within the selected line, 10 pixel are displayed as a dotted black- and white line as long as the selected threshold is not passed.

ImageBLITZ is configured with the registers r8..rC<sub>h</sub>:

### 6.18.1 ImageBLITZ® processing

When ImageBLITZ® is activated with  $:r7_h[0] = 1$ :

1. Wait for an active edge on the EXP input.
2. The MC13xx exposes a line, that was chosen with  $:rC[9..0]$  and is called trigger line, for an exposure time defined by  $:r2[9..0]$ . It compares the intensity of a group of 10 pixel along the selected trigger line against an adjustable threshold ( $:rA_h[7..0]$ , Range: 255..0).
3. The number of exceedings ( $:rA_h[8] = 0$ ) or fall backs ( $:rA_h[8] = 1$ ), are counted, and the result is compared to a second threshold ( $:rB_h[6..0]$ , Range: 127..0).
4. Each time this threshold is exceeded (release condition); an “inhibit counter” ( $:rD_h[9..0]$ , Range 1..255) is loaded.
5. The inhibit counter”  $:rD_h[9..0]$  is counted down, each time the “release condition” was not reached. Once this “inhibit counter” has expired, a new image is exposed and output. After image is output, repeat at 1.

### 6.18.2 ImageBLITZ® programming

ImageBLITZ® is programmed by registers  $r8..rD_h$  and activated with  $r7[0]$ .


#### 6.18.2.1 Address of trigger line

The register  $rC_h$  determines the vertical position of the trigger line in the image.

command:  **$:rC_h <x_2x_1x_0>$**   
 $<x_2x_1x_0> \dots$  range 00h ...3ffh

Response: none

Example:  $:rc100$   
 $100h = 256$

	In pixelbinning mode the value of $rC$ is internally doubled. The value must not be higher than 1ffh/511.
---	---

#### 6.18.2.2 Leftmost pixel of the trigger line

The value of register  $r8 / 10$  is the number of the leftmost pixel in the trigger line.

Command:  **$:r8 <x_2x_1x_0>$**   
 $<x_2x_1x_0> \dots$  range 000h ...07fh

Response: none

Calculation of  $r8$ :

Value of  $r8 = \text{pixel number} / 10$

### 6.18.2.3 Rightmost pixel of the trigger line

The end of the trigger line is determined by the value of register r9.

Command:           **:r9**<*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*>  
                           <*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*> ... range 000h ...7fh  
 Response:           none

Calculation of r9:

$$\text{Value of r9} = \text{pixel number} / 10$$

### 6.18.2.4 Threshold level, mark trigger line

The threshold level is set by register rA<sub>h</sub>. The pixel values along the trigger line are compared with this value.

Command:           **:rA<sub>h</sub>** <*x<sub>2</sub>x<sub>1</sub>x<sub>0</sub>*>  
                           <*x<sub>1</sub>x<sub>0</sub>*> ... range 0 ..ffh  
                           <*x<sub>2</sub>*> = 0: pixel gray level > threshold level,  
   trigger line not visible  
                           1: pixel gray level < threshold level,  
   trigger line not visible  
                           2: pixel gray level > threshold level,  
   trigger line visible  
                           3: pixel gray level < threshold level,  
   trigger line visible  
 Response:           none

The trigger line is displayed as dashed, black and white line. One dash has a length of 10 pixel. The trigger line is only displayed in parts of the line where the pixel fulfill the trigger requirements.

Under normal operation conditions the trigger line will be visible only in parts. The number of dashes may be counted and used for the setting of register rB<sub>h</sub>.

### 6.18.2.5 Release condition

Register rB<sub>h</sub> contains the release condition.

The release condition is determined by the number of pixels along the triggerline that fulfill the trigger requirements.

Command:           **:rB<sub>h</sub>** <*x<sub>9..0</sub>*>  
                           <*x<sub>6..0</sub>*> = 0 ..7fh, number of pixel that match the trigger requirements  
                           <*x<sub>8..7</sub>* = 0: correction value 0 for the X - position of output window  
                           <*x<sub>8..7</sub>* = 1: correction value 4 for the X - position of output window  
                           <*x<sub>8..7</sub>* = 2: correction value 8 for the X - position of output window  
                           <*x<sub>8..7</sub>* = 3: correction value 12 for the X - position of output window  
 Response:           none

### 6.18.2.6 Release Inhibit

The Release Inhibit function is defined with  $rD_h$ . It tells ImageBLITZ how often sequentially the “release condition” must **not** be met, before an image is output.

This feature allows to trigger an object only once on the dark- to bright edge of the scene. This avoids retriggering, once the trigger condition was met and the object is still visible within the triggerline after the image has been output.

Command:  $rD_h$   $\langle x_{7..0} \rangle$   
 $\langle x_{7..0} \rangle = 0$  ..ffh, number of fulfilled,  
 sequentially trigger conditions

Response: none

### 6.18.3 ImageBLITZ® registers

Register	Bit	Description
r7	0	= 1: activate ImageBLITZ®
r8	6..0	First pixel mod. 10
r9	6..0	Last pixel mod. 10
rA <sub>h</sub>	7..0 8 9	Exposure threshold 1: bright object triggers 0: dark object triggers 1: make triggerline visible
rB <sub>h</sub>	6..0 8..7 9	Number of exceedings or fall backs, release condition, X – tracking correction X – tracking enable.
rC <sub>h</sub>	9..0	Address of triggerline
rD <sub>h</sub>	7..0	exposure limitation, number of exposures without exposure condition until an image is captured

Table 6.18-1

Registers r1..r7 are programmed according to image size and position and for [Asynchronous operation, timer](#).

Register	Bit	Description
r1, r3..r5		<a href="#">Image size and position</a>
r2	9..0	<a href="#">Async operation, timer</a>
r6	7..4	0fh

Table 6.18-2

#### 6.18.4 ImageBLITZ® setup

The MC131x is configured for [asynchronous operation with timer](#), registers r8, r9 and rC<sub>h</sub> are loaded for the desired position of the trigger line. Register rB<sub>h</sub> is loaded with 0, register rA<sub>h</sub> with 201<sub>h</sub>, so that the trigger line is visible.



If the image is zoomed down for display by an application program, every other line may be omitted and the trigger line may then disappear.

ImageBLITZ® is enabled with Register r7 Bit1=1.

Now position the trigger line with the registers r8, r9 and rC<sub>h</sub> across the object that is used for the shutter release..

Clear Bit 8 in Register rA<sub>h</sub> if a bright objects releases the shutter, set rA<sub>h</sub>[8] if dark objects release the shutter. While the trigger line is placed across the object, raise threshold with rA<sub>h</sub>[7..0] until as many dashes from the trigger line disappear as are loaded in Register rB<sub>h</sub> [6..0]. This is called the release condition.

If it is expected that the release condition is met more than once for a single object, load rB<sub>h</sub> [9..7] with a number of exposed lines that will not met the release condition before exposing one image.

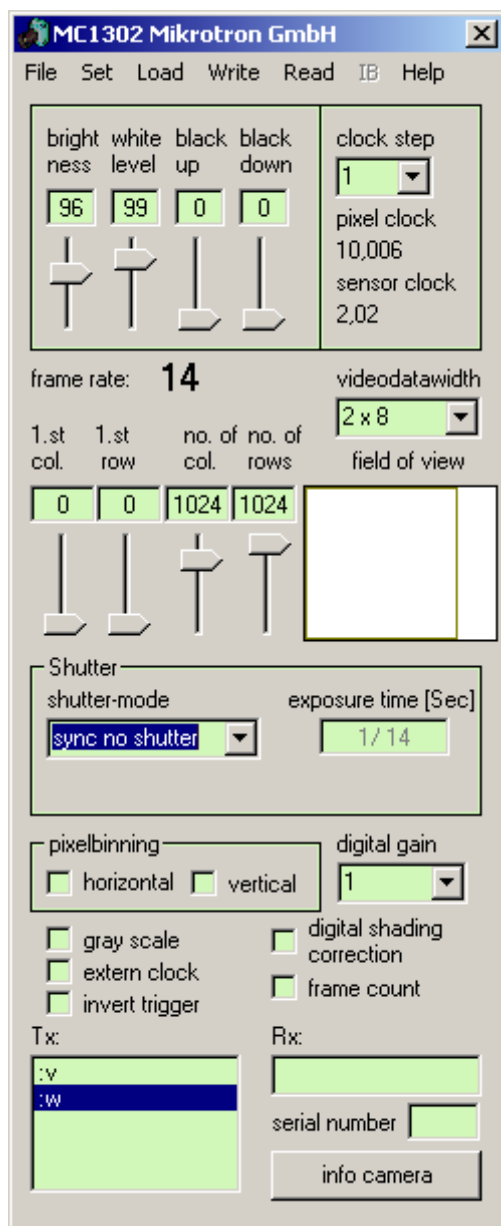
## 7 MC13xx configuration tool

The MC13xx configuration tool must be installed on a Windows PC. (Win9x, WinNT, Win2K, WinXP) 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. The description of the parameters follows the marked chapters in this user manual.

To use this tool with the camera MC13xx the serial interface is integrated in the Camera Link® interface. You do not need any other additional cable.

### 7.1 Basic Configuration



**File:** Save or read settings to or from file.

**Set:** Select com port. If Inspecta-4D and the correct cable is used, the MC13xx can be written to but not being read from.

**Load, Write, Read:** [Profile processing](#)

**FPN, Gain ...:**

[Adjusting image](#)

**Clock Step:**

[Clock selection](#)

**1.st col...num. of rows:**

[Adjusting Image](#)

**Shutter:**

[Type of exposure](#)

**Frame count** [\(6.17\)](#),

**gray scale** [\(6.16\)](#),

**invert trigger** [\(6.15\)](#),

**extern clock** [\(6.14\)](#),

**digital gain** [\(6.13\)](#)

**pixelbinning.....**[\(6.10\)](#)

**Info camera:**

[Read serial number and firmware version](#)

**Tx:**

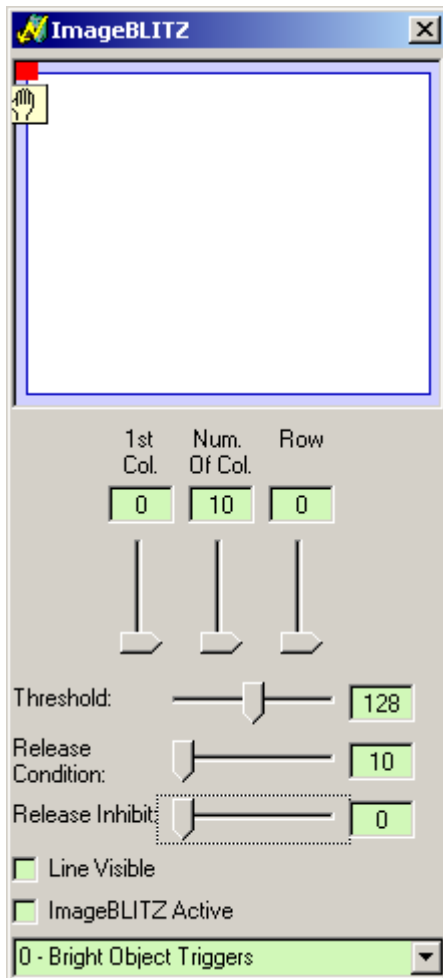
Display control strings

**Rx:**

Display response



## 7.2 ImageBLITZ® Configuration



**1<sup>st</sup> Col, Num Of Col., Row** ( Position of TriggerLine ):  
r8, r9 and rC

**Threshold:**  
rA

**Release Condition:**  
rB

**Release Inhibit:**  
rD

**Line Visible:**  
rA Bit 8

**ImageBLITZ Active:**  
r7 Bit 0

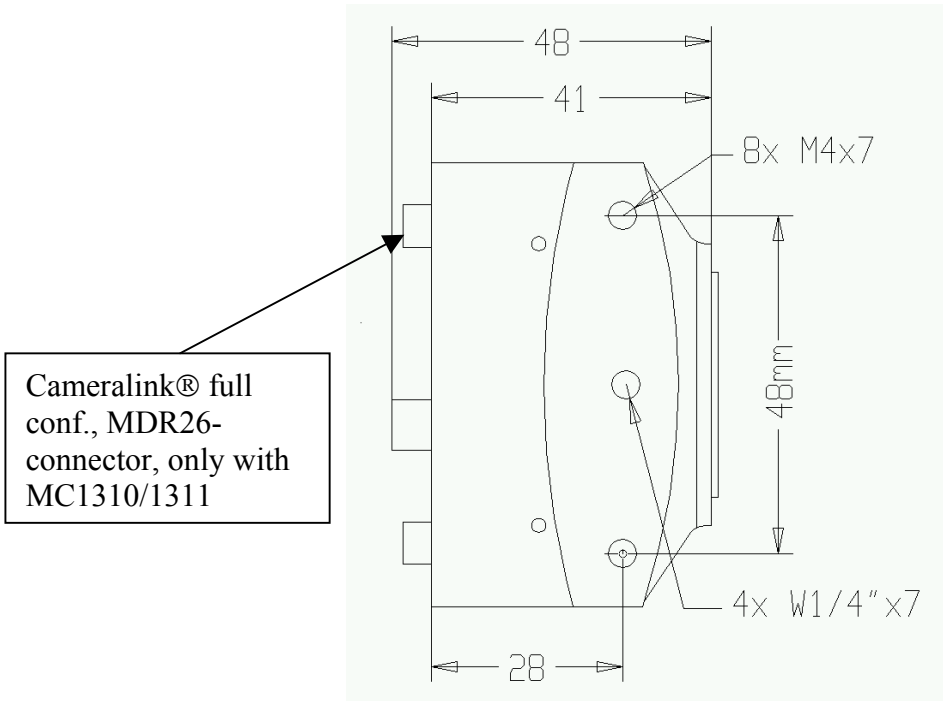
**Bright Object Triggers:**  
rA Bit 9

## 8 Mechanical dimensions

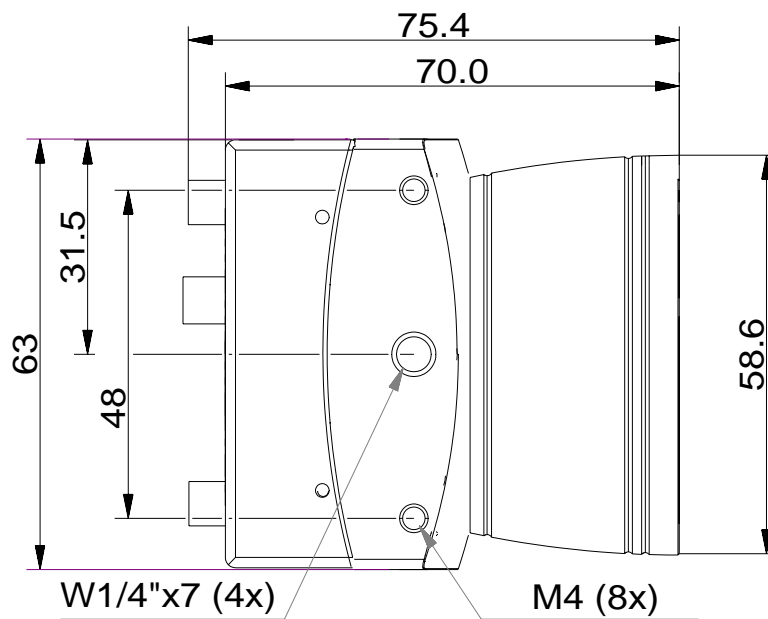
### 8.1 Camera body MC13xx

The camera body has (without lens) has very compact. To fasten the camera there are two mounting holes M4x7mm and one tripod connection on each side available.

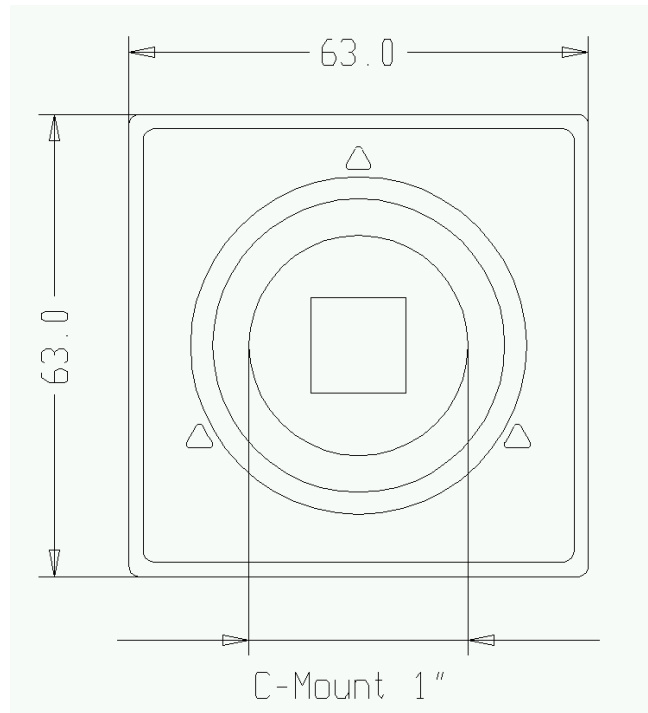
#### 8.1.1 Dimensioned drawing, side view of MC1302/03/10/11



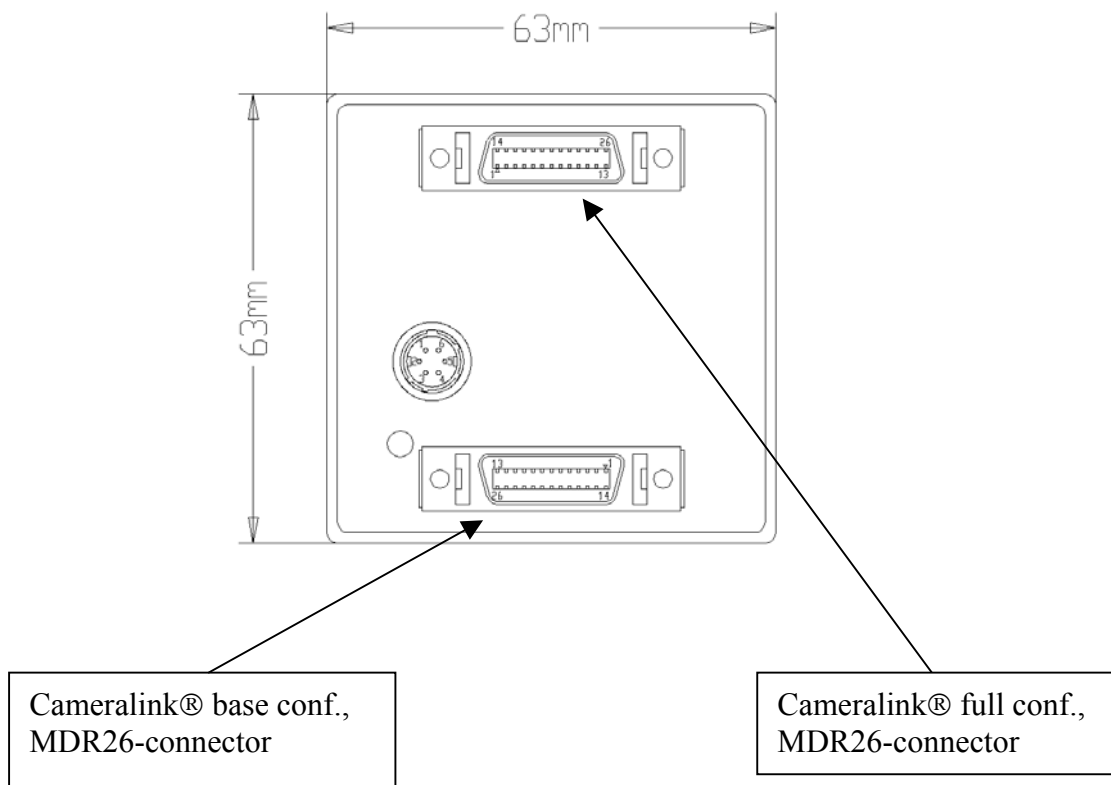
#### 8.1.2 Dimensioned drawing, side view of MC13x6 – MC13x9



**8.1.3 Dimensioned drawing, front view of MC1302/03/10/11**



**8.1.4 Dimensioned drawing, rear view of MC13xx**



## 8.2 Lens adjustment

### 8.2.1 Lens adaption

In dependence of the camera model the MC13xx camera are prepared for either C-mount or F-mount connection (see table [overview of cameras](#)).

Camera types with F-mount adaption may be converted to C-mount adaption by exchanging the lens mount flange of the camera, which is attached with 4 screws. The C-mount lens flange is not scope of delivery of the F-mount camera types and is offered separately.

### 8.2.2 Adjustable lens adapter, only for camera models with C-mount flange

For fine adjustment of the focal length a lens adapter with an adjustment range of  $\pm 1$  mm is provided. Use the three screws nearby the sensor window to fasten the lens adapter after a proper adjustment together with the chosen lens.

### 8.2.3 Lens selection for camera types with C-mount flange (see table [overview of cameras](#))

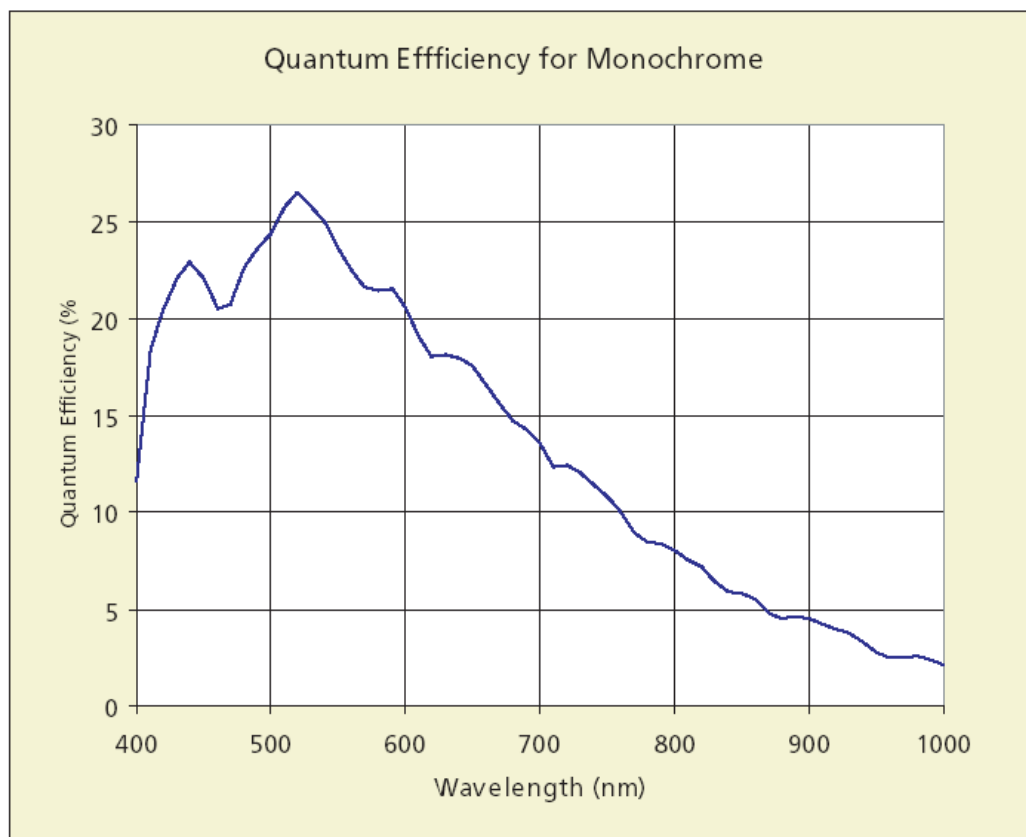
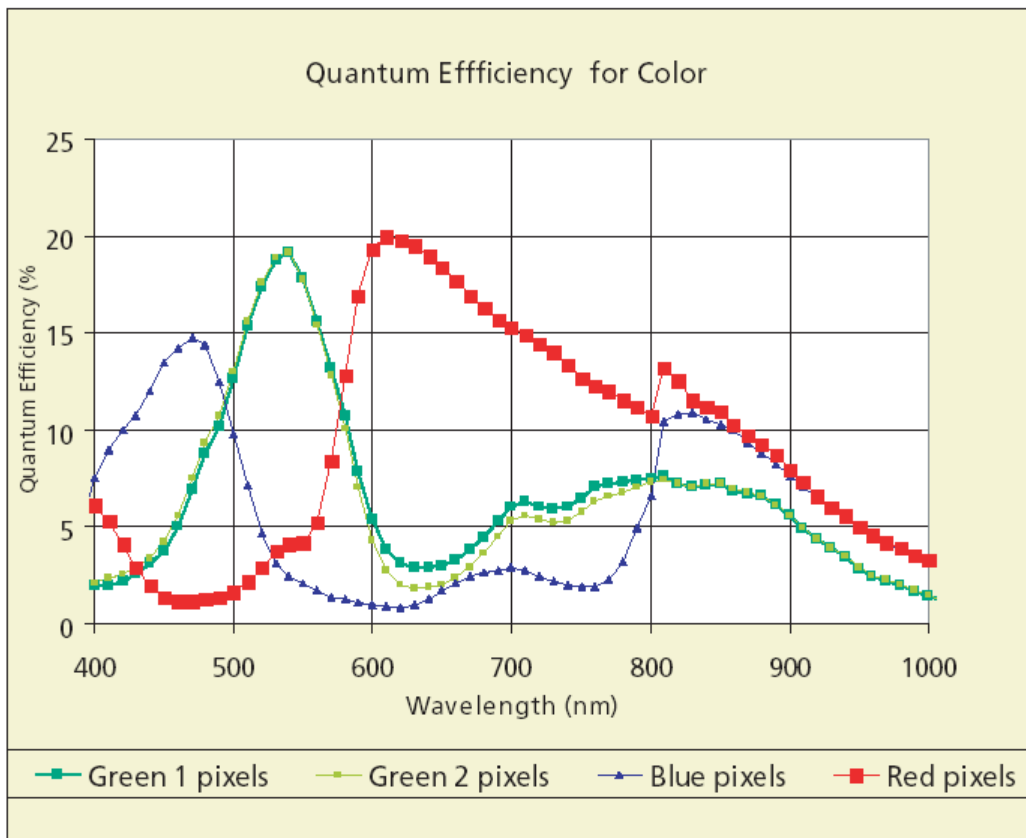
Due to the size of the sensor use C-Mount lenses with the largest possible optical diameter or an adapter for lenses like F-Mount, especially for lenses with a focal length  $< 25$ mm..

## 9 Technical Data

MC1302 – MC1319	Monochrome Bayer Filter
Number of pixel	1280 x 1024
Pixel size	12 x 12 µm
Active area	15,36 (H) x 12,29 (V) mm
Fill factor	40%
Sensitivity at 550 nm @ Vref = 1V (a2 = 66h)	1600LSB/lux-sec
Spectral response	400..800nm
Shutter	Electronic „Freeze Frame“ Shutter
Trigger	Asynchronous shutter, shutter time selectable with internal timer or by pulse width of trigger signal
Internal Dynamic	59 dB
Power supply	8 ... 24 V
Power consumption max. Thermal resistance typ.	3.5W 0.17°/W
Serial data link	RS-644 with Camera Link® 9,6 – 115 Kbd, 8 bits, 1 stop bit, no parity
Digital video MC131x	Camera Link®, Base or Full configuration
MC130x	Camera Link®, Base configuration
Case temperature	+5..50°C
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 camera type)

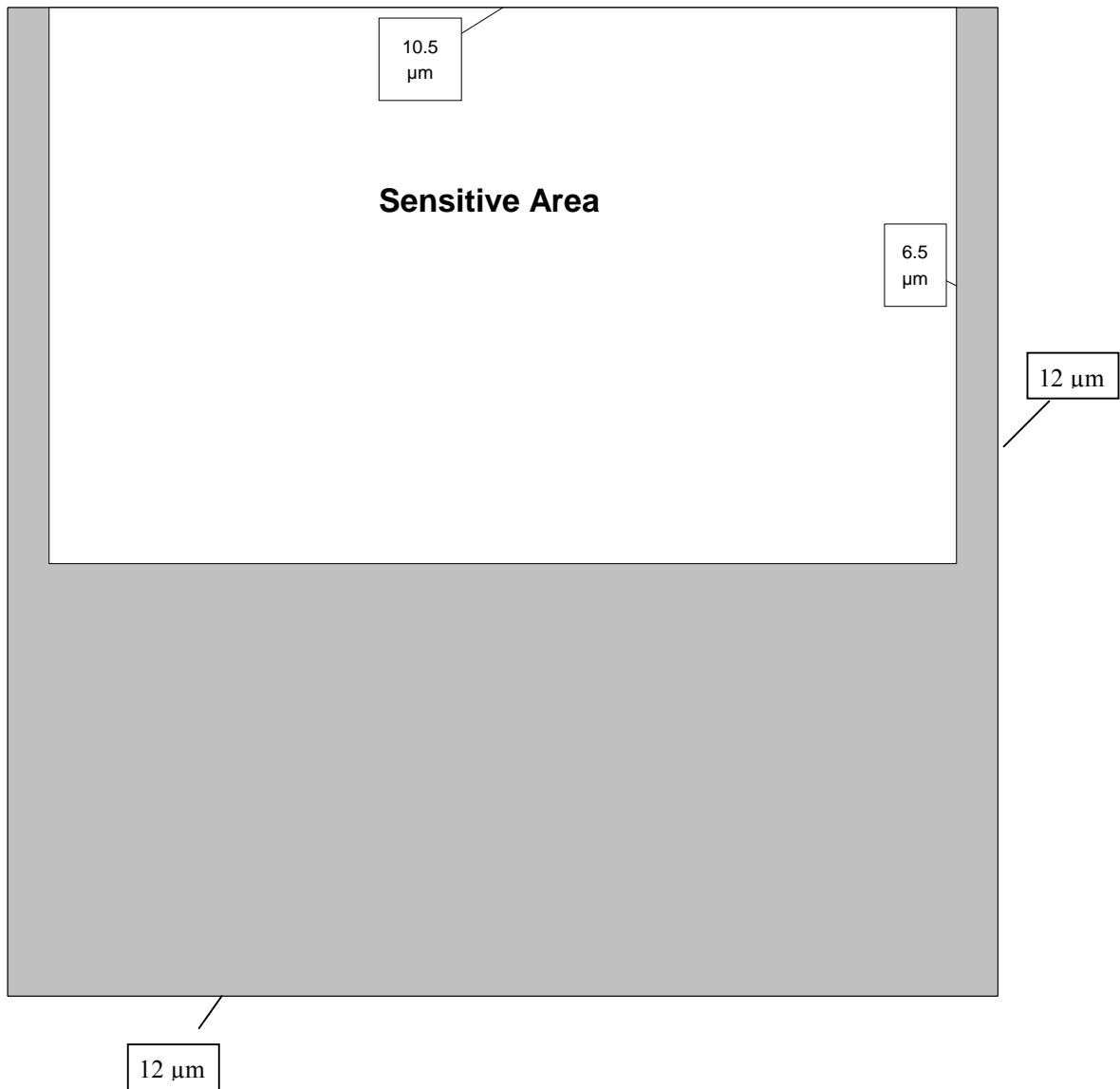
Table 8.2-1

### 9.1 Spectral response



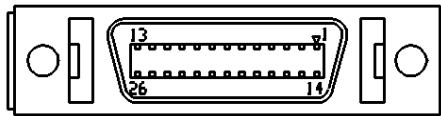
## 9.2 Sensitive area of a pixel

Pixel size: 12 x 12  $\mu\text{m}$   
 Fill factor: 40 %  
 Sensitive area: 10,5 x 6,5  $\mu\text{m}$



### 9.3 Connector pinning

#### 9.3.1 Camera Link® Connector, MDR-26



„Base Camera Link® “ Pinning:

pin	signal	pin	signal
1	GND	14	GND
2	X0-	15	X0+
3	X1-	16	X1+
4	X2-	17	X2+
5	XCLK-	18	XCLK+
6	X3-	19	X3+
7	SERTC+	20	SERTC-
8	SERTFG-	21	SERTFG+
9	CC1-	22	CC1+
10	CC2+	23	CC2-
11	CC3-	24	CC3+
12	CC4+	25	CC4-
13	GND	26	GND

Table 9.3-1

„Full Camera Link® “ Pinning:

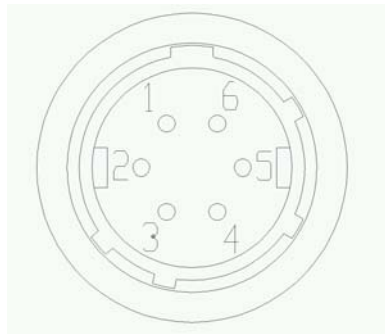
pin	signal	pin	signal
1	GND	14	GND
2	Y0-	15	Y0+
3	Y1-	16	Y1+
4	Y2-	17	Y2+
5	YCLK-	18	YCLK+
6	Y3-	19	Y3+
7	100 Ω Term.	20	100 Ω Term
8	Z0-	21	Z0+
9	Z1-	22	Z1+
10	Z2-	23	Z2+
11	ZCLK-	24	ZCLK+
12	Z3-	25	Z3+
13	GND	26	GND

Table 9.3-2

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



**9.3.2 Circular power connector, 6-pin**




pin	signal
1	VCC
2	VCC
3	STRB

pin	signal
4	DGND*
5	GND
6	GND

Table 9.3-3

\*DGND ... digital GND for signal STRB

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>
---	--

## 9.4 Camera Link® Bit Assignments

### 9.4.1 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		

Table 9.4-1

**9.4.2 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		

Table 9.4-2

**9.4.3 10\*8-Bit Assignment**

The below table shows the 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		

Table 9.4-3

## 9.5 Frequency selection

Depending on the selected line length and the datarate on the “Camera Link®” interface the frequency selection table can provide an optimal ratio of sensor /pixel clock. The pixel clock is only dependent on the selected step and not on the linelength.

The sensor clock is dependent on both the selected step, the line length and the data width. The tables show the selectable frequencies and the corresponding codes to program the synthesizer accordingly.

### 9.5.1 Frequencies for video data width 2\*8/10 - Bit, Base Camera Link®

#### 9.5.1.1 Linelength <= 100 Pixel

clock step	pixel clock in MHz	Sensorklock (MHz) for linelength <= 100 Pixel	Framerate (fps) for resolution: 100 x 100 Pixel
0	20,0	18,4	1352,9
1	20,0	24,5	1801,5
2	20,0	30,6	2250,0
3	20,0	36,9	2713,2
4	20,0	42,9	3154,4
5	21,8	49,0	3602,9
6	24,5	55,1	4051,5
7	27,2	61,2	4500,0
8	29,3	65,8	4838,2
9	30,0	67,4	4955,9
10	32,2	67,4	4955,9
11	35,3	67,4	4955,9
12	37,5	67,4	4955,9
13	42,9	67,4	4955,9
14	53,7	67,4	4955,9
15	63,3	67,4	4955,9

Table 9.5-1

9.5.1.2 Linelength <= 240 Pixel

Frequencies Step	Pixelclock (MHz)	Sensorklock (MHz) for linelength <= 240 Pixel	Framerate (fps) for resolution: 240 x 240 Pixel
0	20,0	7,1	217,5
1	20,0	9,5	291,1
2	20,0	11,9	364,6
3	20,0	14,3	438,1
4	20,0	16,7	511,6
5	21,8	19,1	585,2
6	24,5	21,4	655,6
7	27,2	23,8	729,2
8	29,3	25,6	784,3
9	30,0	26,2	802,7
10	32,2	28,6	876,2
11	35,3	31,2	955,9
12	37,5	33,4	1023,3
13	42,9	38,1	1167,3
14	53,7	47,6	1458,3
15	63,3	57,1	1749,4

Table 9.5-2

9.5.1.3 Linelength <= 640 Pixel

Frequencies Step	Pixelclock (MHz)	Sensorklock (MHz) for linelength <= 640 Pixel	Framerate (fps) for resolution: 640 x 480 Pixel
0	20,0	3,1	47,4
1	20,0	4,1	62,7
2	20,0	5,1	78,0
3	20,0	6,1	93,2
4	20,0	7,1	108,5
5	21,8	8,2	125,4
6	24,5	9,1	139,1
7	27,2	10,2	155,9
8	29,3	11,0	168,2
9	30,0	11,2	171,2
10	32,2	12,2	186,5
11	35,3	13,4	204,8
12	37,5	14,3	218,6
13	42,9	16,3	249,2
14	53,7	20,4	311,9
15	63,3	24,5	374,5

Table 9.5-3

9.5.1.4 Linelength <= 1280 Pixel

Step \ Frequencies	Pixelclock (MHz)	Sensorklock (MHz) for linelength <= 1280 Pixel	Framerate (fps) for resolution: 1280 x 1024 Pixel
0	20,0	1,5	10,8
1	20,0	2,0	14,3
2	20,0	2,5	17,9
3	20,0	3,0	21,5
4	20,0	3,5	25,1
5	21,8	4,0	28,7
6	24,5	4,5	32,3
7	27,2	5,1	36,6
8	29,3	5,4	38,7
9	30,0	5,6	40,2
10	32,2	6,1	43,8
11	35,3	6,6	47,3
12	37,5	7,1	50,9
13	42,9	8,1	58,1
14	53,7	10,1	72,5
15	63,3	12,1	86,8

Table 9.5-4

Tolerance: ± 5 %





**9.5.2 Frequencies for video data width 8\*8 - Bit, Full Camera Link®**

clock step \ pixel clock in MHz	Pixelclock program code	sensor clock in MHz	Sensorclock program code	Frame rate fps
0	:S612505	15,0	:S41dd0d	108
1	:S60c902	18,7	:S40e904	134
2	:S61f08e	22,5	:S40e903	161
3	:S612086	26,5	:S41c08e	188
4	:S60c883	30,0	:S41dc8d	215
5	:S61d088	33,7	:S41d08b	242
6	:S60c882	37,5	:S40e884	269
7	:S61e40f	41,2	:S41e089	296
8	:S61f00e	45,0	:S40e883	323
9	:S610806	48,7	:S40fc83	350
10	:S60f805	52,5	:S41d80f	376
11	:S61e80b	54,4	:S40e006	390
12	:S61f80b	56,2	:S40e806	403
13	:S611405	58,2	:S411007	417
14	:S60c803	60,0	:S41dc0d	430
15	:S607801	62,3	:S412407	447

Table 9.5-6

**9.5.3 Frequencies for video data width 10\*8 – Bit**

Use the arbitrary frequency selection command:

command :S <x<sub>0</sub>>

<x<sub>0</sub>> 6 characters, programcode in the following table

clock step \ pixel clock in MHz	Pixelclock program code	sensor clock in MHz	Sensorclock program code	Frame rate fps
0	:S612505	15,0	:S41dd0d	108
1	:S60c902	18,7	:S40e904	134
2	:S61f08e	22,5	:S40e903	161
3	:S612086	26,2	:S41d88f	188
4	:S60c883	30,0	:S41dc8d	215
5	:S61d088	33,7	:S41d08b	242
6	:S60c882	37,5	:S40e884	269
7	:S61e40f	41,2	:S41e089	296
8	:S61f00e	45,0	:S40e883	323
9	:S610806	48,7	:S40d087	350
10	:S60f805	52,5	:S41d80f	376
11	:S61e80b	54,4	:S40e006	390
12	:S61f80b	56,2	:S40e806	403
13	:S611405	58,2	:S405411	417
14	:S60c803	60,0	:S41dc0d	430
15	:S607801	62,3	:S412407	447

Table 9.5-7

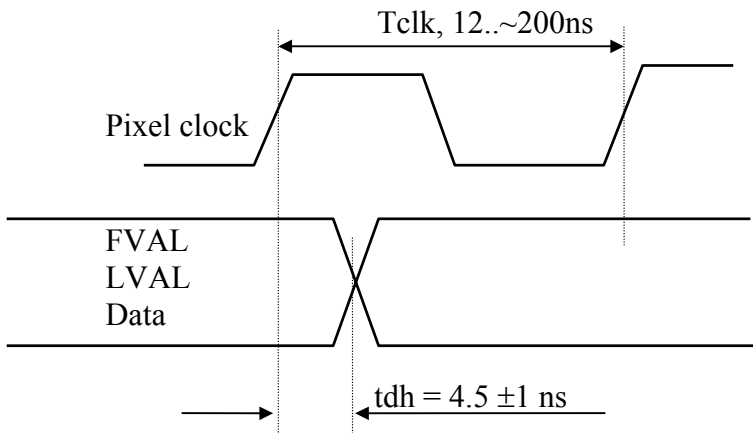
## 9.6 Programming sequence, factory profile f3

Example: resolution: 1.280 x 1.024 pixel  
frame rate: 48 fps  
pixel clock: 35,3 MHz sensor clock: 6,65 MHz  
shutter: full frame , exposure time: 21 ms

Strings: :a16d  
:a277  
:a34a  
:a4c8  
:a5xx xx... may be any value 00h ... ffh  
:a600  
:a76a  
:a81c  
:r6000  
:r1000  
:r23ff  
:r33ff  
:r4000  
:r507f  
:r7000  
:r6030  
:r8000  
:r9000  
:ra000  
:rb000  
:rc000  
:rd000  
:re000  
:rf000  
:sb

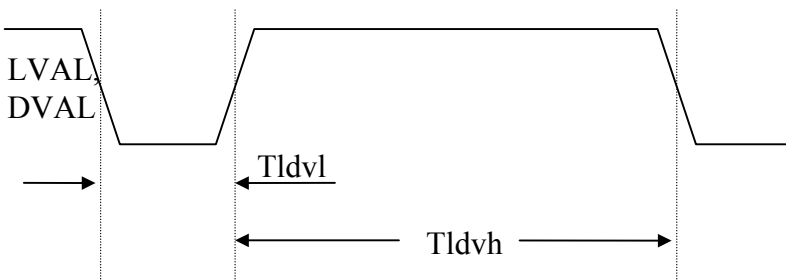
## 9.7 Timing

### 9.7.1 Pixel clock



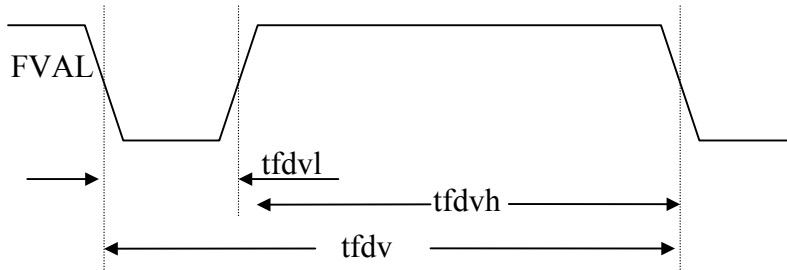
The above illustration shows hold time of video data, LVAL and FVAL signal to rising edge of pixel clock.

### 9.7.2 Line Valid (LVAL, DVAL)



LVAL and DVAL are connected internally in the camera. The timing for the LVAL / DVAL signal shown in multiples of the pixel clock depend on the ratio of sensor/pixel clock, on selected line length, and on video data width.  $T_{ldvh}$  is always the same for a specific setting of the above parameters,  $T_{ldvl}$  may vary by one clock from line to line. The LVAL / DVAL signal is also output while FVAL is inactive.

**9.7.3 Frame Valid (FVAL)**



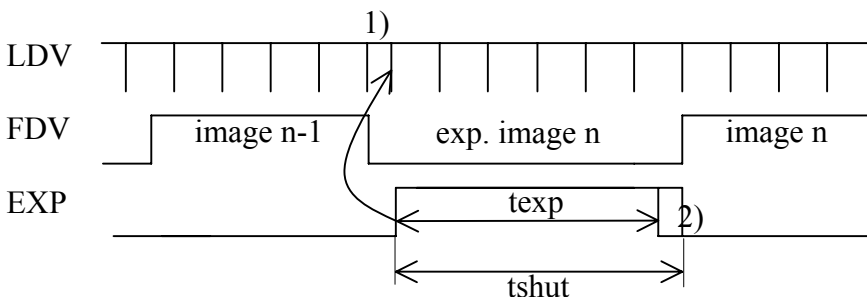
The rising edge of FVAL marks that line, that is programmed in Register r1.

$t_{fdvh}$  is equal to the value programmed in Register r3 multiplied with [time/line](#).  $t_{fdvl}$  in [synchronous mode](#) is equal to one [time/line](#).

**9.7.4 Exposure Signal EXP, to be input on CC1**

The EXP signal (Camera Link™ CC1 signal) is positive active if register 7, Bit 8 = 0, negativ active if register 7, Bit 8 = 1. EXP Signal may not be asserted while the previous image is output (FDV active)

The sensors exposure starts and the [strobe output](#) activates ( $t_{exp}$ , (1) three sensor clocks after the active edge of the EXP signal ( $t_{shut}$ ), and ends up to 135 sensor clocks after deactivation (2).

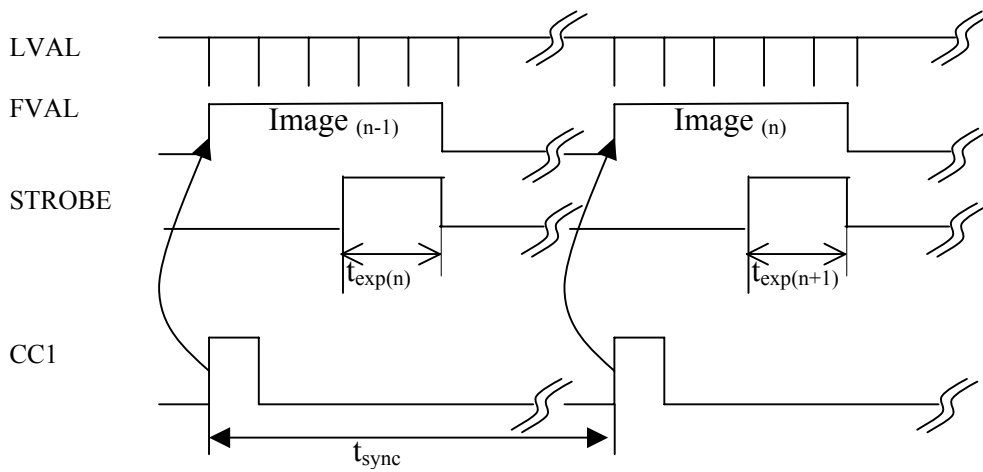


1) The active edge of the EXP signal clears the horizontal counter.

2) End of exposure time is synchronised with the internal horizontal counter.

EXP is also used as enable signal for ImageBLITZ shutter release.

**9.7.5 Synchronous exposure with external synchronisation via CC1**



$t_{exp}$ : Exposure time selectable with register [:r2](#)

$t_{sync}$ : The synchronisation frequency must be smaller than the framerate to which the MC13xx is set and greater 30Hz.