

# MC132x

High Speed CMOS GigE Vision Camera

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MC132x Users Manual Rev. 0.22

Camera-Firmware: [B2.02-V2.02-F0.71](#)

Kamera ID Nr.: [MC1324 .. MC1327](#)

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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 MC1324, MC1325, MC1326, MC1327**

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, August 04<sup>th</sup>. 2006

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 MC132x is a high resolution camera with 1280 x 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, 80 fps can be output via the Gigabit Ethernet Interface. Parameter sets are called “profiles” and stored in non volatile memory.

### 2.1 Top level specifications

- high resolution: 1.280 x 1.024 pixel CMOS sensor with 1300 A/D converters
- up to 1.024 gray levels
- up to 80 full frames/s  
up to 500 frames/s using data reduction algorithms
- arbitrary region of interest
- high sensitivity
- 12µm square pixels
- electronic “Freeze Frame” shutter
- low blooming
- programmable via serial link
- patented ImageBLITZ® image trigger
- 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<br>Type | Data<br>width<br>(bits) | Color/<br>Mono | Max BWidth  | C/F-Mount<br>lens adaption | max. frame rate@<br>1280 x 1024 | Image-<br>BLITZ® | Image pre-<br>processing<br>supported |
|------------------|-------------------------|----------------|-------------|----------------------------|---------------------------------|------------------|---------------------------------------|
| MC1324           | 8                       | M              | 110 Mbyte/s | C                          | 80 fps                          | +                | +                                     |
| MC1325           | 8                       | C              | 110 Mbyte/s | C                          | 80 fps                          | +                | +                                     |
| MC1326           | 8                       | M              | 110 Mbyte/s | F                          | 80 fps                          | +                | +                                     |
| MC1327           | 8                       | C              | 110 Mbyte/s | F                          | 80 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 GigE Vision® Interface


GigE Vision® is designed for digital cameras in machine vision applications. This interface can transfer data at a rate of 110 Mbytes/sec.

#### 3.1.1 Serial interface

### 3.2 Power supply

The camera needs a DC supply voltage between 8 ... 24 V at a power consumption of 5,0 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 MC132x.

|               |  |
|---------------|--|
| LED orange... | The MC132x is configuring the internal FPGA. No other activity is possible.  |
| LED green...  | The MC132x 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 MC132x
- C-Mount/F-Mount Lens
- Mikrotron Support CD
- Image processing system, e.g.: PC and Software



For GigE Interface the Intel MT1000 Chipset is recommended

Additional items:

- 1 GigE cable (CAT6 recommended)
- 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 GigE cable between camera and PC.
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 MC132x 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 MC132x 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. They are factory preset to the settings described in the next chapter (user profiles).

### 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<br>/Mbyte/s | resolution<br>/ pixel | Image frequency<br>/fps |
|------------|------------------------------|-----------------------|-------------------------|
| 0          | 48,5                         | 100 x 100             | 4.852                   |
| 1          | 58,2                         | 240 x 240             | 1.011                   |
| 2          | 62,1                         | 640 x 480             | 202                     |
| 3          | 61,6                         | 1280 x 1024           | 47                      |
| 4          | 48,5                         | 100 x 100             | 4.852                   |
| 5          | 58,2                         | 240 x 240             | 1.011                   |
| 6          | 62,1                         | 640 x 480             | 202                     |
| 7          | 61,6                         | 1280 x 1024           | 47                      |

Table 5-1

## 6 Configuration

The MC132x has 15 FPGA registers,  $r1..rf_n$ , each 10 bit wide, eight D/A registers,  $a1..a8$ , 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  $0ffh = 255$ .

### 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<br><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 acknowledgement or not acknowledge (ACK or NAK)                                |
| :b<n>     | <n> = 0...4  | --                                | Select baud rate:<br>0=9600 Bd (default setting),<br>1=19.2 kBd,<br>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 PowerUpProfile   |
| :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        | 6 Byte Code  | --                                | Program sensor and pixel clock directly.  |
| :t<n><m>  | <n> = 00..7f <sub>h</sub><br><m> = 00..ff <sub>h</sub> | --                                | Short setting of X- position in units of 10 pixel and Y-position in units of 4 lines.                   |
| :T        | --   | +50.5                             | Read temperature  |
| :v        | --   | #12345- V1.10-F1.29               | Read serial number (#), microcontroller - version (V...) and FPGA - version (F...).                     |
| :V        | --   | 1324000003433                     | Read identifier   |
| :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 camera information

### 6.2.1 Read serial number and firmware revision

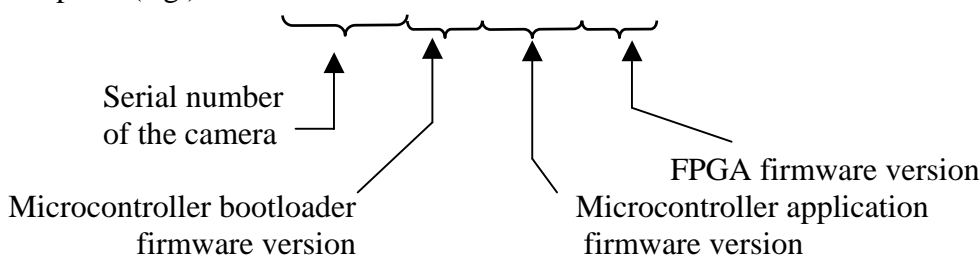
The serial number and the firmware revision can be read with the **:v** command.

Command:

**:v**

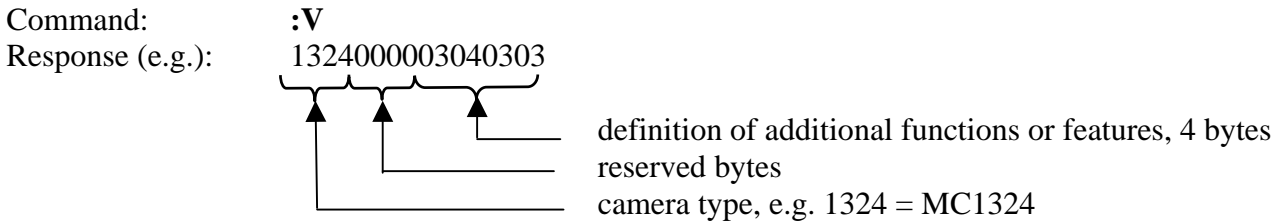
Response(e.g.):

#01234-B2.02-V2.02-F0.71



### 6.2.2 Read identifier

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



Definition of functions or features: not yet used

### 6.2.3 Read camera settings

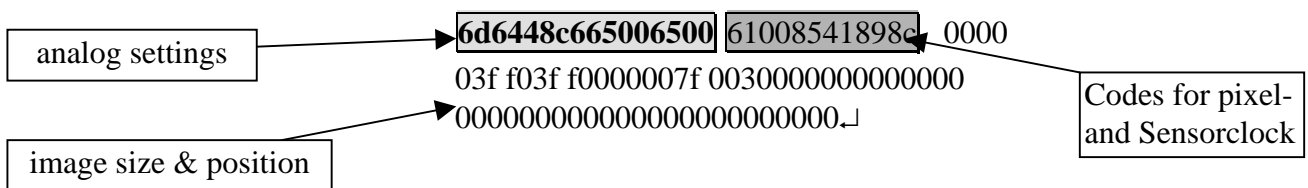
The actual camera settings can be read out. The answer are the values of all camera registers.

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        |

### 6.2.4 Reading camera temperature

To control the temperature inside , the camera disposes of an internal temperature sensor. The temperature inside the camera can be read out in steps of 0.5°. The value is delivered in ASCII characters signed.

Command: :T  
 Response(e.g.): +34.0

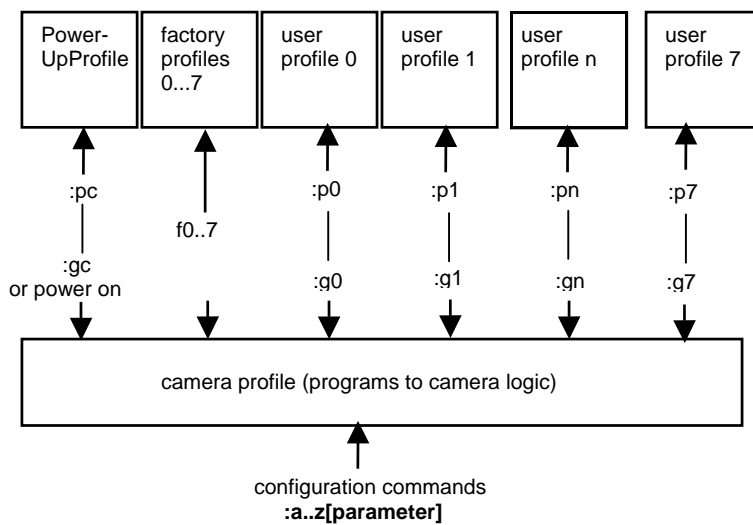
The temperature sensor is able to deliver values of -128°C to +128°C.



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

### 6.3 Profile processing


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



#### 6.3.1 Write user profile

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

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



**Issue this command only, if the PowerUpProfile was successfully tested.**

#### 6.3.2 Load user profile

Load one of eight user profiles to the PowerUpProfile.

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

### 6.3.3 Load factory profile

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

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

## 6.4 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.

### 6.4.1 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**<x<sub>1</sub>x<sub>0</sub>>                    <x<sub>1</sub>x<sub>0</sub>> : Range, typ. 55h ... 80h  
Response:                    none

### 6.4.2 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

### 6.4.3 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

## 6.5 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 6.5-1



### 6.5.1 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. |
|---|---|

### 6.5.2 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 $\leq 0x3ff/1023$ or $0x1ff/511$ if dual column binning is activated! |
|--|--|

### 6.5.3 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

### 6.5.4 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: $0 \leq r5 - r4 \leq 7fh$ . |
|---|--|

### 6.5.5 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 Clock selection

The MC132x 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 x image frequency) and the data rate on the output.

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.

### 6.6.1 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 / 2).

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


### 6.6.2 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 [9.4](#)).

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)

|   |   |
|---|---|
|  | Before selecting the data rate of the camera check the maximum data rate of the GigE Connection, which must be higher (or at least the same). |
|---|---|

### 6.6.3 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).

## 6.7 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

### 6.7.1 Type of exposure

The MC132x can expose the images synchronous or asynchronous. An external signal on CC1 can be used to synchronize MC132x cameras to each other or to an external event.

#### 6.7.1.1 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.

6.7.1.2 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 6.7-1

6.7.2 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 / (time/line • 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 6.7-2

### 6.7.3 Synchronous operation without shutter

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

### 6.7.4 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> :

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

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>zz</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 6.7-3

### 6.7.5 External synchronisation with synchronous exposure

MC132x cameras can be synchronized to an external signal that is input on the EXP (TRIG) signal. The strobe output signal of a MC132x “master camera” can be used for that purpose.

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

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](#)

### 6.7.6 Frame rate with asynchronous exposure

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

### 6.7.7 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.

### 6.7.8 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:

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

$T_B$  ... exposure time

$F_{sens}$ .. sensor clock

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

## 6.8 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 some of the firmware versions. The procedure of updating depends on the firmware package.



**Do not update more than 1 firmware at the same time.**  
**In case of updating more than 1 firmware, please start with application program, then fpga program follows.**

### 6.8.1 Update firmware microcontroller application

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 and the version cannot be read out. 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](#)”.

### 6.8.2 Update FPGA firmware

MC132x’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. 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.

See description of update procedure in chapter “[Firmware update procedure](#)”.

### 6.8.3 Firmware update procedure

Before you disable the loaded firmware please ensure that you have a adequate application firmware version to load (e.g. MC132x....A202.ibf for application firmware, MC132x...F070.ibf for fpga firmware).

- (1) Start camera and test communication, e.g. with tool press “info camera” and wait for response (serial no. and firmware)
- (2) Select in menu “Write” “Write string to camera” and write command
  - for application firmware update:               :ERASEAPP               <ENTER>
  - for fpga firmware update:                       :ERASEEPCS1           <ENTER>
 which erases the program and for application firmware will restart the camera.

|   |  |
|---|--|
|  | <b>After this command the camera may not be able to deliver any images, load/send/store register or profile data. The status led of the camera will turn to red.</b> |
|---|--|

- (3) For application firmware update only:  
 The camera now starts with the bootloader program. It is displayed during start by the status led which blink one time during power up.  
 Test communication, e.g. with MC13xx in menu “Write string to camera” and command `:v`.  
 Response (e.g.):       B2.02
- (4) Select in menu “Write” “Write file to camera” and choose application file MC132x\*.ibf) and open it. The file transfer will start immediately. If the camera recognizes a newfirmware it will switch off the status led.

|   |  |
|---|--|
|  | <b>Download of *.ibf file via serial link takes app. 1,5 - 2 min depending on the used camera. There should be no loss of power or communication during this time!</b> |
|---|--|

- (5) Wait until file transfer is finished and the status led turns on. If the upload of the file was successful, the led will turn to green, otherwise it will be red.

- (6) Verify version string by reading serial no. and firmware versions (command: :v). The new firmware version will be displayed as part of the version string. If the version is identical to the expected the camera is ready to use for capturing images.

#### 6.8.4 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

### 6.9 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).

### 6.10 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

### 6.11 Digital shading correction

For the best possible image quality even at the sensors clock limit, and non uniform lighting, the MC132x 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 from all lines of the following images, as long as this bit remains set.

## 6.12 Digital gain

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

## 6.13 External clock input

MC132x frequency synthesizer can use the Camera Link® used to synchronize several MC132x 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.**

## 6.14 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

## 6.15 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

## 6.16 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.

MC132x 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

## 6.17 ImageBLITZ® shutter release

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>:

### 6.17.1 ImageBLITZ® processing

When ImageBLITZ® is activated with :r7<sub>h</sub>[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<sub>h</sub>[7..0], Range: 255..0).
3. The number of exceedings (:rA<sub>h</sub>[8] = 0) or fall backs (:rA<sub>h</sub>[8] = 1), are counted, and the result is compared to a second threshold (:rB<sub>h</sub>[6..0], Range: 127..0).
4. Each time this threshold is exceeded (release condition); an “inhibit counter” (:rD<sub>h</sub>[9..0], Range 1..255) is loaded.
5. The inhibit counter” :rD<sub>h</sub>[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.

### 6.17.2 ImageBLITZ® programming

ImageBLITZ® is programmed by registers r8..rD<sub>h</sub> and activated with r7[0].



- 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  $rB_h$ .

#### 6.17.2.5 Release condition

Register  $rB_h$  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

#### 6.17.2.6 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<sub>h</sub>** <x<sub>7..0</sub>>  
 <x<sub>7..0</sub>> = 0 ..ffh, number of fulfilled,  
 sequentially trigger conditions

Response: none

### 6.17.3 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<br>8<br>9    | Exposure threshold<br>1: bright object triggers<br>0: dark object triggers<br>1: make triggerline visible |
| rB <sub>h</sub> | 6..0<br>8..7<br>9 | Number of exceedings or fall backs, release condition,<br>X – tracking correction<br>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 6.17-1


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 | Ofh                                     |

Table 6.17-2

### 6.17.4 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.

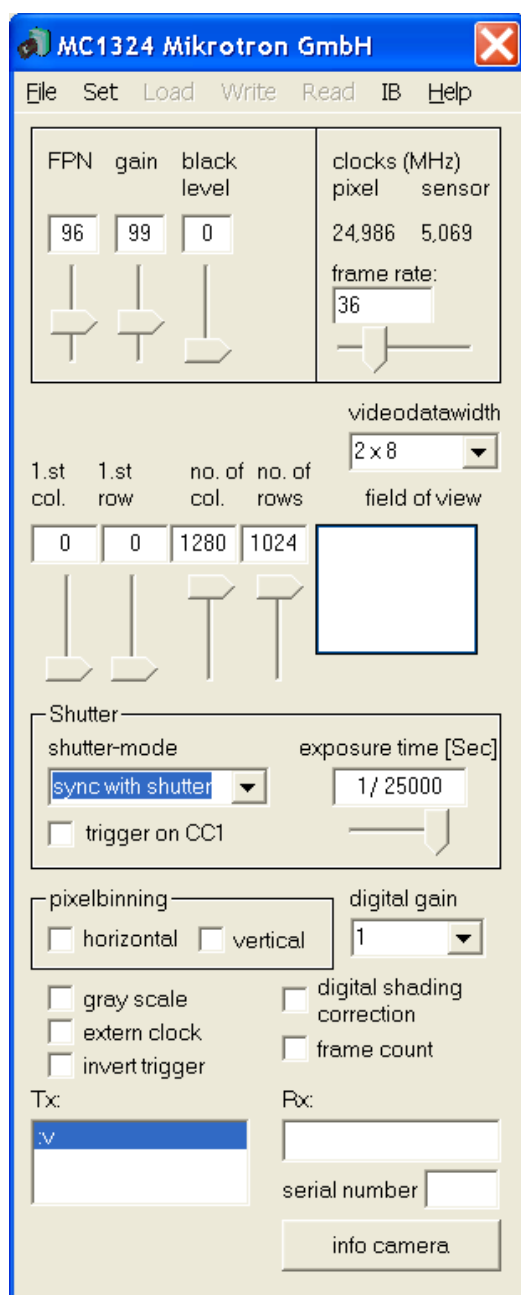
## 7 MC13xx configuration tool

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, black level:** [Adjusting image](#)

**Clocks, frame rate:** [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](#)

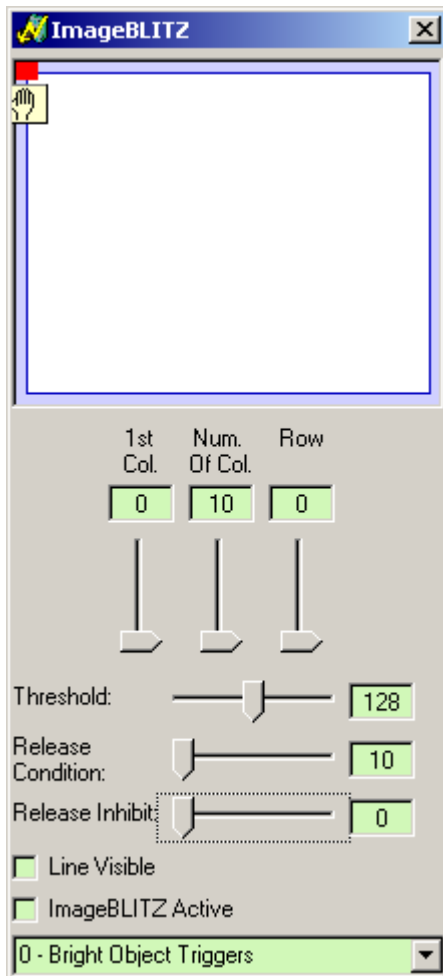
**Tx:**

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

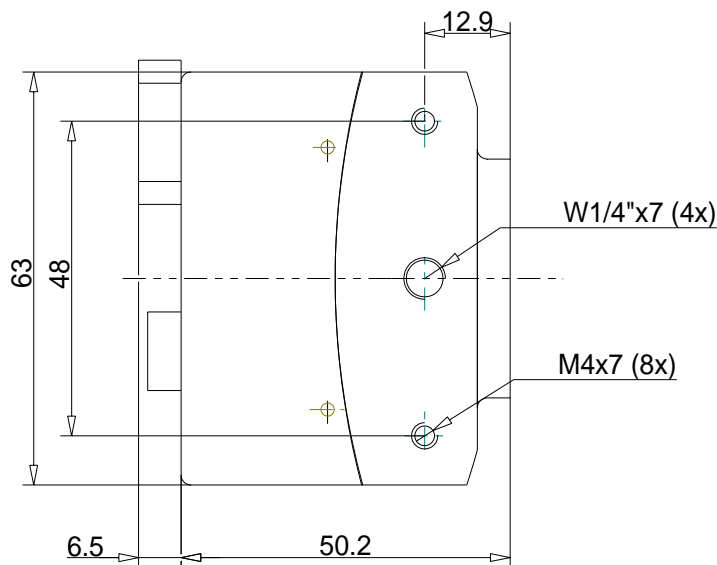
## 8 Mechanical dimensions

### 8.1 Camera body MC132x

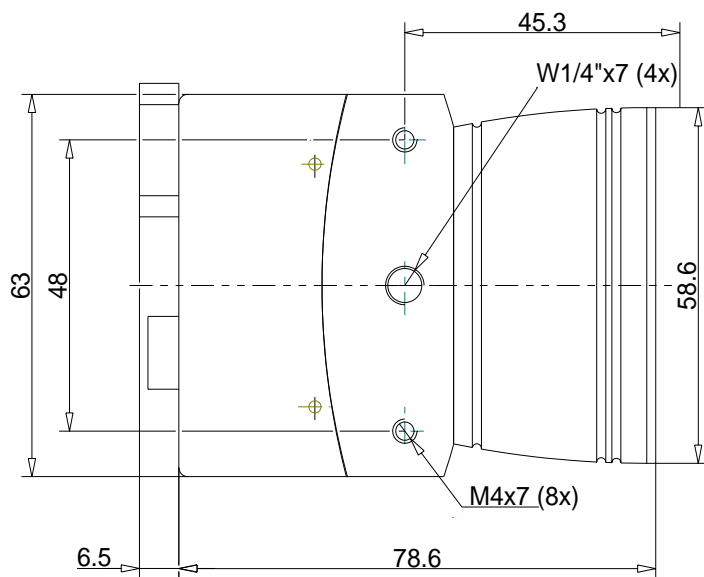
The camera body has (without lens) has very compact. To fasten the camera there are two mounting holes M4x7mm and one tripod connection on each side available.

#### 8.1.1 Dimensioned drawing, side view of MC1324/25

all dimensions in mm

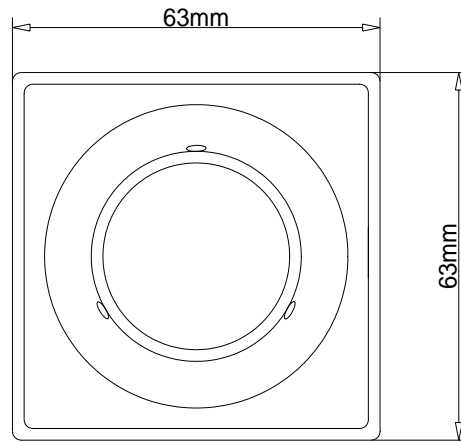


#### 8.1.2 Dimensioned drawing, side view of MC1326/27

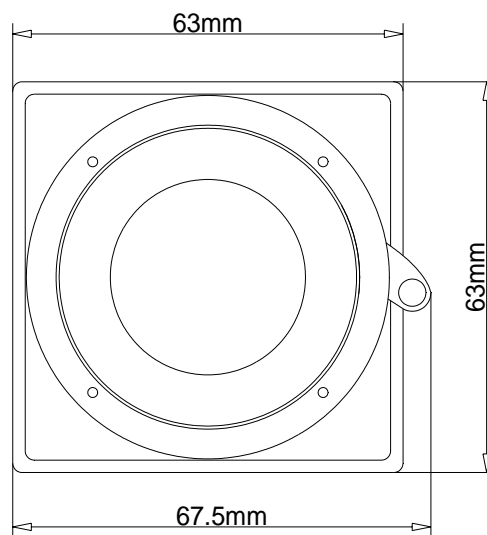




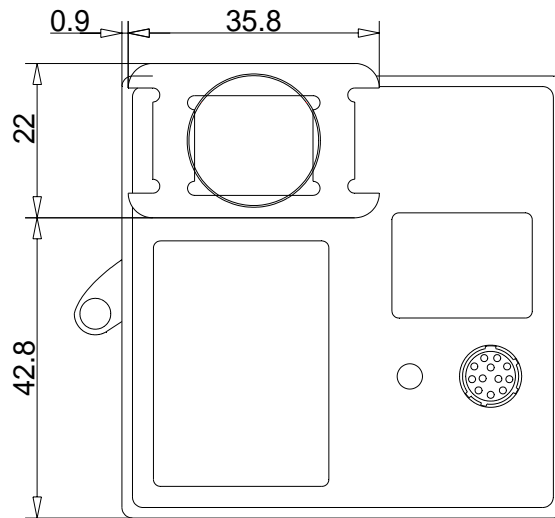
**8.1.3 Dimensioned drawing, front view of MC1324/25**



**8.1.4 Dimensioned drawing, front view of MC1326/27**



### 8.1.5 Dimensioned drawing, rear view of MC132x



## 8.2 Lens adjustment

### 8.2.1 Lens adaption

In dependence of the camera model the MC132x 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](#))

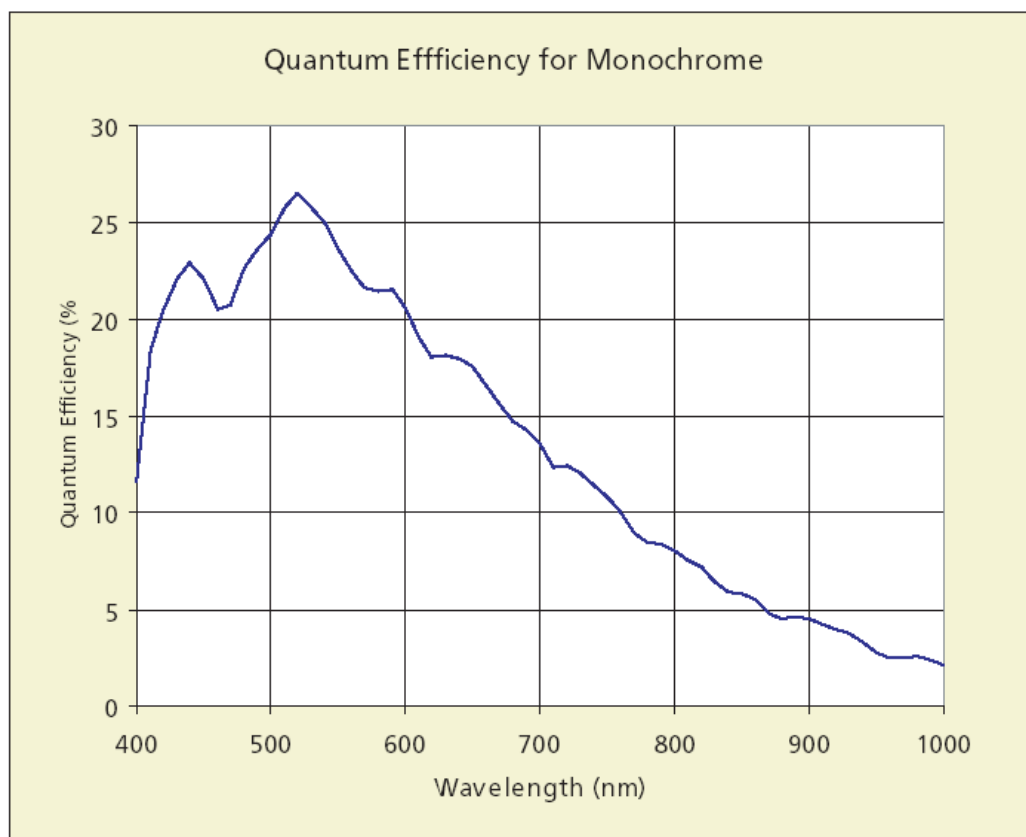
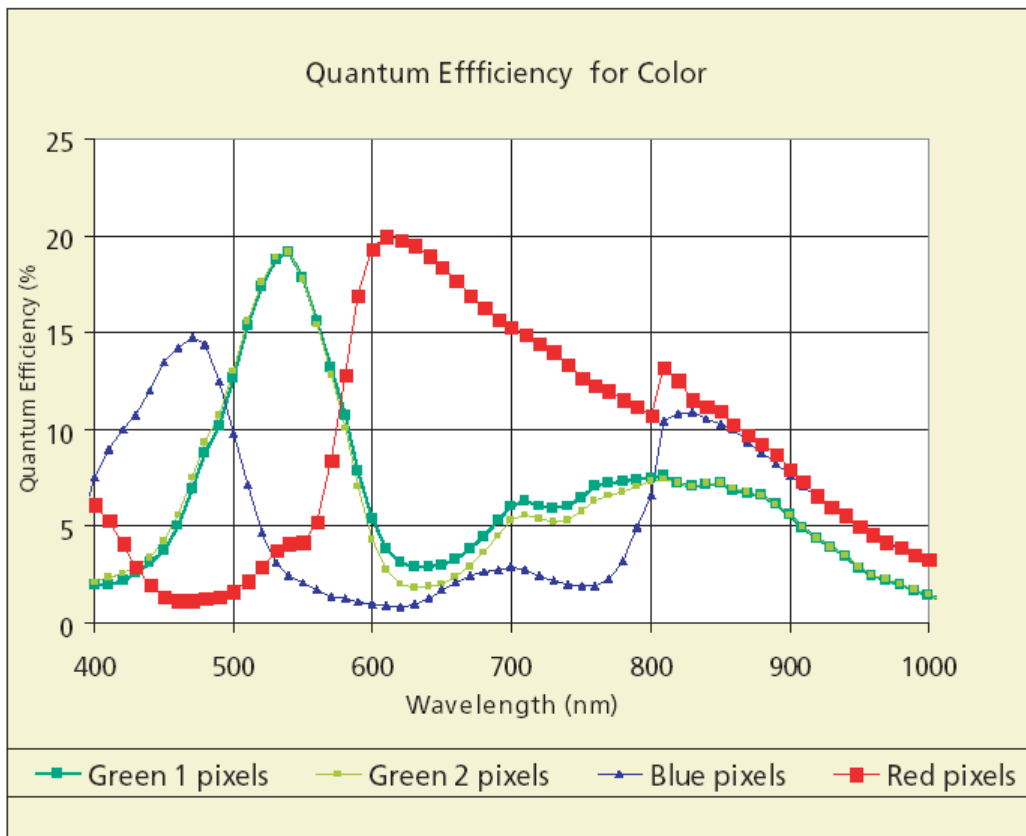
Due to the size of the sensor use C-Mount lenses with the largest possible optical diameter or an adapter for lenses like F-Mount, especially for lenses with a focal length  $< 25$ mm..

## 9 Technical Data

|   |   |
|---|---|
| MC1324 MC1326<br>MC1325 MC1327                    | Monochrome<br>Bayer Filter  |
| Number of pixel                                   | 1280 x 1024   |
| Pixel size  | 12 x 12 $\mu\text{m}$   |
| Active area                                       | 15,36 (H) x 12,29 (V) mm  |
| Fill factor                                       | 40%   |
| Sensitivity at 550 nm @ Vref<br>= 1V (a2 = 66h)   | 1600LSB/lux-sec   |
| Spectral response                                 | 400..800nm  |
| Shutter   | Electronic „Freeze Frame“ Shutter   |
| Trigger   | Asynchronous shutter, shutter time<br>selectable with internal timer or by<br>pulse width of trigger signal |
| Internal Dynamic                                  | 59 dB   |
| Power supply                                      | 8 ... 24 V  |
| Power consumption max.<br>Thermal resistance typ. | 5 W<br>0.17°/W  |
| Serial data link                                  | 9,6 – 115 Kbd, 8 bits, 1 stop bit, no<br>parity   |
| Digital video                                     | GigE Vision® Interface<br>Pleora GigE IPort Interface   |
| Case temperature                                  | +5..50°C  |
| Shock & vibration                                 | 70g, 7grms  |
| Dimensions<br>(WxHxD)                             | 63 x 64,7 x 56,27 mm  |
| Case temperature                                  | +5 ... +50° C   |
| Weight  | ca. 300 g   |
| Lens mount<br>MC1324/25<br>MC1326/27              | C-Mount<br>F-Mount  |

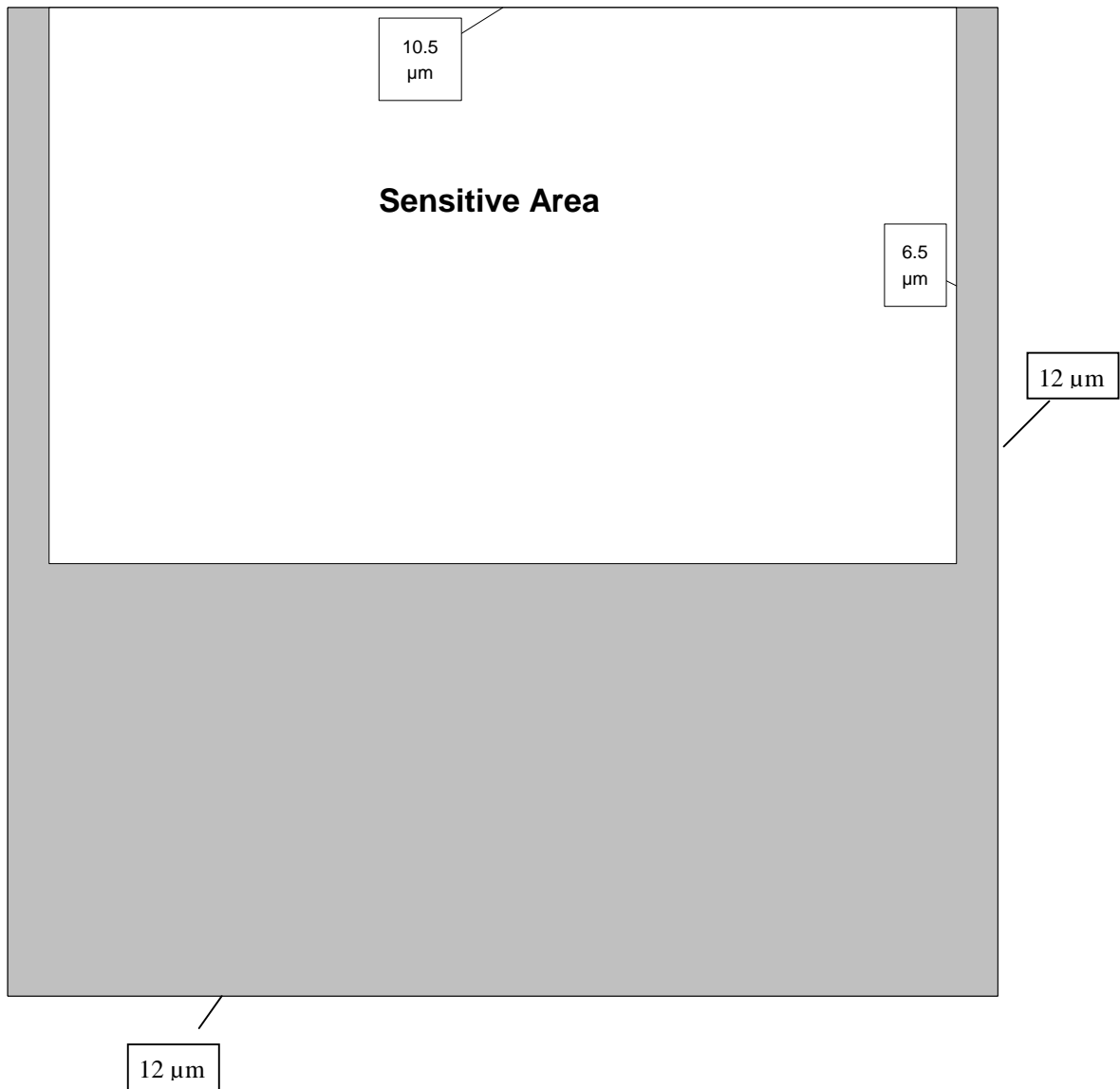
Table 8.2-1

### 9.1 Spectral response



## 9.2 Sensitive area of a pixel

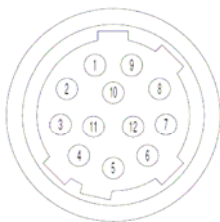
Pixel size: 12 x 12  $\mu\text{m}$   
 Fill factor: 40 %  
 Sensitive area: 10,5 x 6,5  $\mu\text{m}$



### 9.3 Connector pinning

#### 9.3.1 Gigabit Ethernet Connector

#### 9.3.2 Circular power connector, 12-pin




| pin | signal     |
|-----|------------|
| 1   | GND        |
| 2   | VCC        |
| 3   | STROBE_GND |
| 4   | STROBE     |
| 5   | TRIG_GND   |
| 6   | TRIG       |

| pin | signal |
|-----|--------|
| 7   |        |
| 8   |        |
| 9   |        |
| 10  |        |
| 11  | VCC    |
| 12  | GND    |

Table 9.3-1

Manufacturer: Hirose  
 Order no.: HR10A-10R-12P

|   |  |
|---|--|
|  | <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 Frequency selection

Depending on the selected line length and the data rate of the GigE 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 line length.

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.

### 9.4.1 Table of clock frequency codes

For free programming of the clock frequencies of pixel and sensor clock the following table can be used. All codes in the table show the code for sensor clock. The code for pixel clock is the same but starts with "6".

Example: Adjustment 1 MHz  
Command for sensor clock: :S41bb0b  
Command for pixel clock: :S61bb0b



Pixel and sensor clock must be adjusted in dependence of the used camera mode as described in chapter frequency selection. Undefined settings may lead to functional faults or can damage the camera.

| Frequency / MHz |        | Code   | Frequency / MHz |        | Code   | Frequency / MHz |        | Code   |
|-----------------|--------|--------|-----------------|--------|--------|-----------------|--------|--------|
| Wanted          | Real   |        | Wanted          | Real   |        | Wanted          | Real   |        |
| 1.0             | 1.001  | 41bb0b | 24.5            | 24.488 | 416905 | 48.0            | 47.923 | 409081 |
| 1.5             | 1.497  | 409301 | 25.0            | 24.986 | 41dd07 | 48.5            | 48.538 | 413084 |
| 2.0             | 2.002  | 41ba8b | 25.5            | 25.498 | 41408a | 49.0            | 48.976 | 416885 |
| 2.5             | 2.501  | 412685 | 26.0            | 26.010 | 41f090 | 49.5            | 49.503 | 416c85 |
| 3.0             | 2.995  | 409281 | 26.5            | 26.496 | 41c08e | 50.0            | 49.971 | 41dc87 |
| 3.5             | 3.502  | 408e03 | 27.0            | 27.034 | 404c81 | 50.5            | 50.475 | 41580b |
| 4.0             | 4.005  | 41ba0b | 27.5            | 27.506 | 41788b | 51.0            | 50.995 | 41400a |
| 4.5             | 4.501  | 41f20b | 28.0            | 28.017 | 408c83 | 51.5            | 51.610 | 404801 |
| 5.0             | 5.003  | 412605 | 28.5            | 28.508 | 41c48d | 52.0            | 52.019 | 41f010 |
| 5.5             | 5.483  | 41d208 | 29.0            | 29.000 | 41cc8d | 52.5            | 52.477 | 41d80f |
| 6.0             | 5.990  | 409201 | 29.5            | 29.491 | 405481 | 53.0            | 52.992 | 41c00e |
| 6.5             | 6.502  | 41f190 | 30.0            | 29.983 | 41dc8d | 53.5            | 53.453 | 406802 |
| 7.0             | 7.004  | 408d83 | 30.5            | 30.497 | 416089 | 54.0            | 54.067 | 404c01 |
| 7.5             | 7.495  | 41dd8d | 31.0            | 31.027 | 41888a | 54.5            | 54.445 | 41740b |
| 8.0             | 8.010  | 41b98b | 31.5            | 31.502 | 416c89 | 55.0            | 55.012 | 41780b |
| 8.5             | 8.499  | 414187 | 32.0            | 32.043 | 41b88b | 55.5            | 55.513 | 41f40f |
| 9.0             | 9.003  | 41f18b | 32.5            | 32.507 | 417889 | 56.0            | 56.033 | 408c03 |
| 9.5             | 9.492  | 419188 | 33.0            | 32.914 | 41e88c | 56.5            | 56.525 | 405001 |
| 10.0            | 10.006 | 412585 | 33.5            | 33.513 | 418489 | 57.0            | 57.016 | 41c40d |
| 10.5            | 10.506 | 40d983 | 34.0            | 33.997 | 414087 | 57.5            | 57.508 | 409003 |
| 11.0            | 10.967 | 41d188 | 34.5            | 34.518 | 419089 | 58.0            | 57.999 | 41cc0d |
| 11.5            | 11.520 | 40bd82 | 35.0            | 35.021 | 408c82 | 58.5            | 58.491 | 41d00d |
| 12.0            | 11.981 | 409181 | 35.5            | 35.482 | 412886 | 59.0            | 58.982 | 405401 |
| 12.5            | 12.493 | 41dd87 | 36.0            | 36.013 | 41f08b | 59.5            | 59.509 | 41b80c |
| 13.0            | 13.005 | 41f110 | 36.5            | 36.495 | 418088 | 60.0            | 59.965 | 41dc0d |
| 13.5            | 13.517 | 404d01 | 37.0            | 36.864 | 406c81 | 60.5            | 60.457 | 409803 |
| 14.0            | 14.008 | 408d03 | 37.5            | 37.478 | 40e884 | 61.0            | 60.993 | 416009 |
| 14.5            | 14.500 | 41cd0d | 38.0            | 37.970 | 419088 | 61.5            | 61.440 | 405801 |
| 15.0            | 14.991 | 41dd0d | 38.5            | 38.502 | 416c87 | 62.0            | 62.054 | 41880a |
| 15.5            | 15.514 | 41890a | 39.0            | 39.014 | 41f08a | 62.5            | 62.423 | 41f00d |
| 16.0            | 16.022 | 41b90b | 39.5            | 39.497 | 412085 | 63.0            | 63.004 | 416c09 |
| 16.5            | 16.457 | 41e90c | 40.0            | 40.024 | 412485 | 63.5            | 63.520 | 41b40b |
| 17.0            | 16.998 | 414107 | 40.5            | 40.550 | 407881 | 64.0            | 64.087 | 41b80b |
| 17.5            | 17.510 | 408d02 | 41.0            | 41.011 | 415886 | 64.5            | 64.512 | 408002 |
| 18.0            | 18.007 | 41f10b | 41.5            | 41.472 | 40a882 | 65.0            | 65.015 | 417809 |
| 18.5            | 18.432 | 406d01 | 42.0            | 42.025 | 40d883 | 65.5            | 65.536 | 413407 |
| 19.0            | 18.985 | 419108 | 42.5            | 42.561 | 41f089 | 66.0            | 65.829 | 41e80c |
| 19.5            | 19.507 | 41f10a | 43.0            | 43.008 | 408081 | 66.5            | 66.355 | 406001 |
| 20.0            | 20.012 | 412505 | 43.5            | 43.500 | 40e083 | 67.0            | 67.025 | 418409 |
| 20.5            | 20.506 | 415906 | 44.0            | 43.868 | 41d088 | 67.5            | 67.489 | 41d00b |
| 21.0            | 21.012 | 40d903 | 44.5            | 44.605 | 41d888 | 68.0            | 67.994 | 414007 |
| 21.5            | 21.504 | 408101 | 45.0            | 44.974 | 40e883 | 68.5            | 68.462 | 40f805 |
| 22.0            | 21.934 | 41d108 | 45.5            | 45.466 | 408881 | 69.0            | 69.036 | 419009 |
| 22.5            | 22.487 | 40e903 | 46.0            | 46.080 | 40bc82 | 69.5            | 69.515 | 40fc05 |
| 23.0            | 23.040 | 40bd02 | 46.5            | 46.541 | 418886 | 70.0            | 70.042 | 408c02 |
| 23.5            | 23.501 | 40c102 | 47.0            | 47.002 | 40c082 |                 |        |        |
| 24.0            | 23.962 | 409101 | 47.5            | 47.514 | 41c487 |                 |        |        |





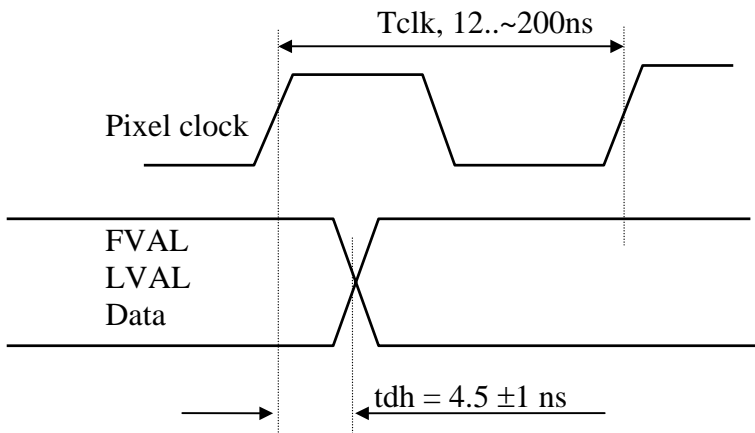
## 9.5 Programming sequence, factory profile f3

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

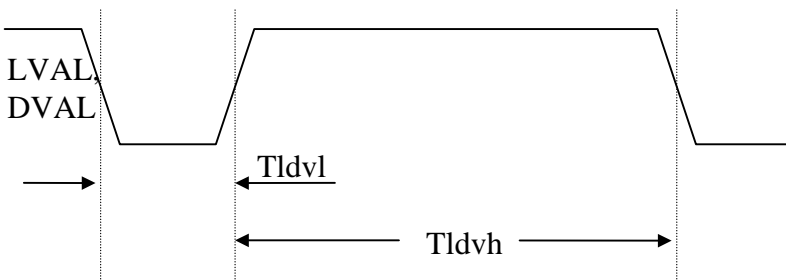
## 9.6 Timing

### 9.6.1 Pixel clock



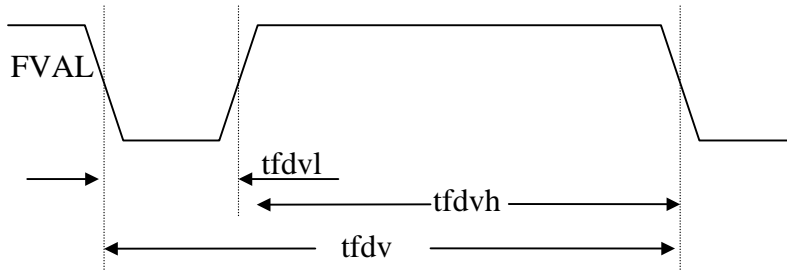
The above illustration shows hold time of video data, LVAL and FVAL signal to rising edge of pixel clock.

### 9.6.2 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.

**9.6.3 Frame Valid (FVAL)**



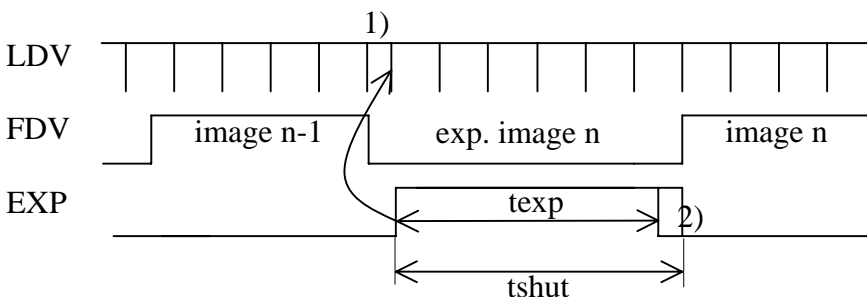
The rising edge of FVAL marks that line, that is programmed in Register r1.

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

**9.6.4 Exposure Signal EXP, to be input on TRIG**

The EXP 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).

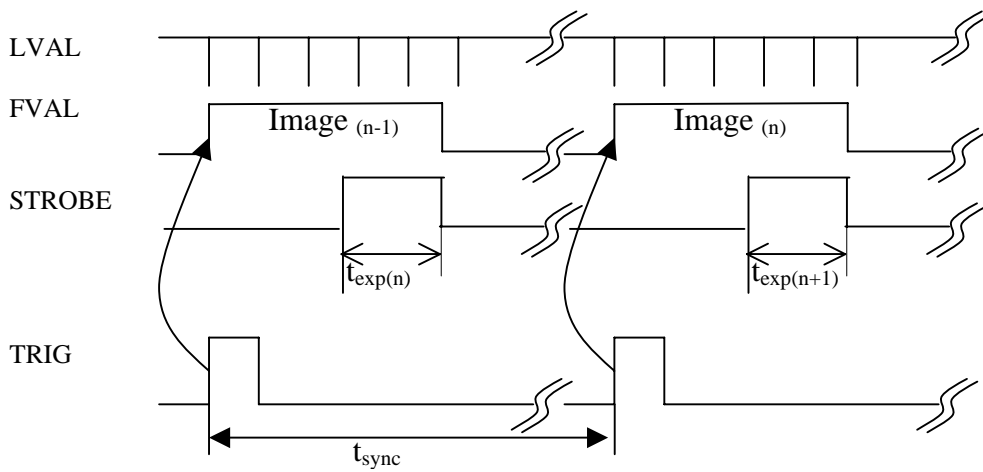


1) The active edge of the EXP signal clears the horizontal counter.

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

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

### 9.6.5 Synchronous exposure with external synchronisation via TRIG



$t_{exp}$ : 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.