MC130x

High Speed CMOS Camera

MC130x Users Manual Rev. 2.1
Camera-FirmwareV2.10-F1.30
Camera ID Nr.: MC1300, MC1301

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Table of content

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: Freisingerstr. 3
85386 Eching
Deutschland

Product: **CMOS camera MC1300**
CMOS camera MC1301

The dedicated products conform to the requirements of the Council Directives 89/336/EWG 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 50081	Electromagnetic compatibility
EN 50082	Immunity

Eching, Feb 07th. 2002

Mikrotron GmbH

Dipl.-Ing. Bernhard Mindermann
President of Mikrotron

1.6 Warranty Note

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

1.7 Remarks, Warnings

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

	**Important remark**

	**Attention, Warning**

2 Introduction

The CMOS-High Speed camera MC130x 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. With a resolution of 100 x 100 pixel, the frame rate exceeds 4850 frames/sec. The highest continuous data rate at the output can be constant with a maximum of 132 Mbyte/sec (16Bit data width at 66MHz pixel clock).

The MC130x is configured via a serial interface (MC1300 uses RS232, MC1301 uses the serial interface according to the Camera Link specification. There are six configuration parameter sets (called: profiles) available, one camera profile, four user profiles, and one factory profile that cannot be modified by the user. All profiles are stored in non volatile memory.

2.1 Top level specifications

- high resolution: 1280•1024 pixel CMOS sensor
- 256 grey levels
- up to 100 full frames/s
- 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
- low power, wide power supply range
- low temperature

2.2 Differences between the camera types

The CMOS cameras MC130x family consist of 2 cameras, the MC1300 and the MC1301. The differences between the two cameras are shown in the table below.

table 1

differences	MC1300	MC1301
digital interface	16 bit LVDS	Camera Link base configuration
serial interface	RS232 at 44p. and 9p. SUB-D connector	via MDR-26 (camera link connector)

3 Hardware

3.1 Serial interface

The communication via the serial interface is optional. The camera was programmed with predefined profiles and is fully operative. For loading new parameters or settings into the camera a serial data link is needed.

A description of the connector pinning is in chapter 9.2.

3.1.1 MC1300

A connection is accessible via a standard 9-pin **or** the 44-pin data connector.

Parameters of the RS-232 link:

table 2

Baud rate	9600 Bd
Data bits	8
Parity	n
Stop bits	1

See chapter 9.2 for pinning and wiring of the RS-232 cable.

3.1.2 MC1301

The serial interface is integrated in the Camera Link connection, which is supported by many frame grabbers. The settings for the communication are shown in table 3.

3.2 Digital video interface

The digital video interface supplies pixel data (D0...15), pixel clock (CLKOUT), line- and frame data valid signals (FDV, LDV). Start and duration of exposure time can be defined with the exposure input signal EXP.

Pixel data is 8-bit wide (256 grey levels) and two adjacent pixels are output with one pixel clock. Pixel clock is 66MHz max, all signals change after the rising edge of clock with a hold time of typical 4,5ns (3,5..6ns max). See Pixel clock for details.

Connector pinning is described in Chapter 9.2.

3.2.1 16 bit LVDS interface of MC1300

All signals are transmitted with twisted pairs at an impedance of 100Ω, conforming to RS-644 signal definition.

3.2.2 Camera Link interface of MC1301

Camera Link is a communication interface for vision applications. Up to 28 bits are serialized to 4 output signals, which are transmitted via a RS644 interface using twisted pair wiring and are terminated with 100 Ω.

3.3 Power supply

The camera needs a DC supply voltage between 8 … 35 V at a power consumption of 2,5 Watt max..

See also Connector pinning .

3.3.1 MC1300

The power is input **either** via the 6-pin circular power connector **or** via a pin from the 44-pin video data connector.

ⓘ	**Use only one power connection, otherwise there is a risk of severe damage**

3.3.2 MC1301

The power is supplied via the 6-pin circular connector.

3.4 LEDs

Two LEDs on the camera backplane show the operating condition of the MC130x.

Green LED	...	Power supply **on/off**
Yellow LED	...	**off:** Download of internal firmware in progress, no other activity is possible. **blinking:** Camera logic is configured, no other activity is possible. **on:** Camera in operation, access to internal microcontroller via serial link is possible.

3.5 Electronic „Freeze Frame“ Shutter

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

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

4 Operation

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

Camera MC130x
C-Mount Lens
Image processing system, e.g.: PC, frame grabber and Software

ⓘ	The frame grabber must be compatible with RS-644 digital signaling. Ask Mikrotron www.mikrotron.de or info@mikrotron.de for compatible frame grabbers

Additional items:

- 1 Power supply 12VDC, 0.3A min*
- 1 Camera cable
- 1 power cable*
- 1 Serial RS-232-cable*

* Not necessary if the corresponding pins on the 44-pin data connector are used.

ⓘ	To specify cables see chapter Connector pinning.

4.1 First steps

1. Switch off the image processing system
2. Connect data cable between camera and frame grabber**.
3. Connect power cable.**
4. Optional: connect serial RS-232 cable.**
5. Unscrew dust protection cover, screw in lens.

** not necessary if the corresponding pins on 44-pin. SUB-D-connector are used (only MC1300).

5 Initial setup

The MC1300 is delivered with initial parameters and therefore does not need to be configured via the serial RS-232 link. See the initial setup parameters in chapter 9.3.

5.1 Serial number and firmware revision

Serial number and firmware revision is provided in MC130x 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 Camera profile

A profile is the contents of all camera registers and therefore responsible for the cameras mode of operation.

The camera profile is the contents of all camera registers that are loaded from non-volatile memory after power up. A change of parameters by the serial link is reflected in the camera profile. See chapter 9.3 for factory setup of the camera profile.

5.3 Factory profile

The factory profile can be read but not written by the user. (see chapter 9.2).

5.4 User profiles

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

table 3

Profile-Nr.	Resolution / Pixel	Frame rate /fps
0	100 x 100	4.852
1	240 x 240	1.011
2	640 x 480	202
3	1280 x 1024	47

6 Configuration

The MC130x has 15 FPGA registers, r1..rf_h , 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 6 profiles: one camera profile, 4 user profiles and one factory profile.

Any change of a specific register through the serial interface is immediately processed and written to the camera profile. This setting is stored in a volatile part of the memory and gets lost when power goes down.

After power-up the camera profile is loaded from the non-volatile to the volatile part of the memory and is used to adjust the camera.

A load or write command exchanges data between the camera profile and one of the four user profiles.

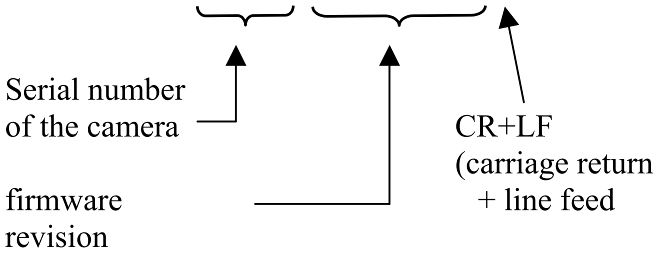
The factory profile can be read but not be written by any command.

All values are given in hexadecimal notation, e.g.: 0xff or 0ffh = 255.

6.1 Read serial number and firmware revision

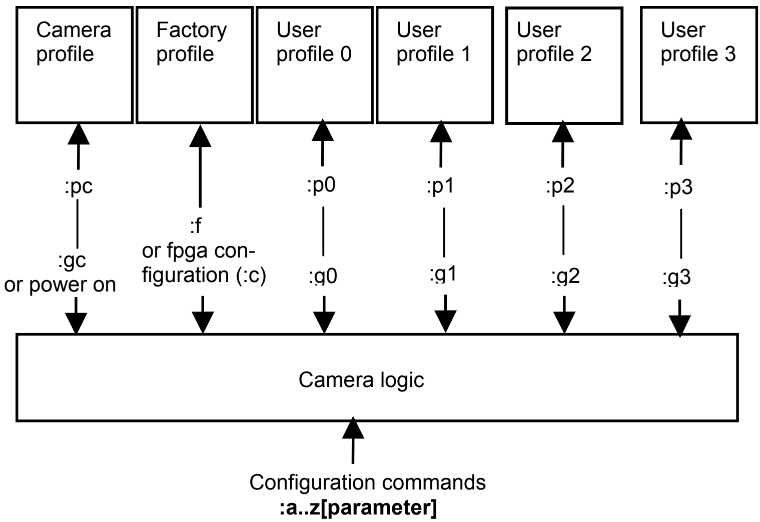
The serial number and the firmware revision can be read with the **:v** command.

Command: **:v**
Response(e.g.): #01234-V2.00-F1.20↵



6.2 Profile processing

All camera settings are loaded or stored as complete data blocks (= camera profiles). There are 6 profiles, the camera profile, the factory profile and 4 different user profiles.



6.2.1 Read camera profile

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

Command: **:w**
Response(e.g.): 6d774ac800006a1c61e88c40a1840000000003ff 000000800330000000000000000000000000000000
all values hex, e.g.: $70_{HEX} = 112_{DEC}$

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	image level control (brightness, contrast…)
Sa1 Sa2 Sa3	3 Byte synthesizer code of pixel clock
Sb1 Sb2 Sb3	3 synthesizer code of sensor clock (see chapter 6.5)
R1…R15	image control (image position, size, sync….)
R1h ...	high Byte R1
R1l ...	low Byte R1
↵ ...	CR+LF (0dh + 0ah)

6.2.2 Write user profile

The camera profile is transferred to one of the four user profiles.

Command: **:p<*n*>** <*n*> = 0 ... 3,c

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

6.2.3 Load user profile

Load one of four user profiles to the camera profile.

Command:	**:g<*n*>**	<*n*> = 0 ... 3, c

6.2.4 Load factory profile

The factory profile can be read but not changed by the user. (see also chapter Factory profile).

Command:	**:f**

6.3 Adjusting image

There are eight D/A converter to influence image quality: brightness, contrast, black up and black down. brightness, contrast and especially black up/down might be adjusted if image size and/or sensor clock changes. All eight parameters are stored in non-volatile memory within one of the six profiles.

6.3.1 Brightness

This level might be changed if image size changes.

Command:	**:a1<x_1x_0>**	<x_1x_0> : Range, typ. 55h ... 80h
Response:	none	

6.3.2 Contrast

This is the threshold for the A/D converters. Its standard value is 66h which is app. 1V. To increase the contrast the level of a2 must be lowered.

Command: **:a2<x_1x_0>** <x_1x_0> : Range,

6.3.3 Black up

Change this parameter if the dark part of the image is not dark enough.

Command: **:a5<x_1x_0>** <x_1x_0>: Range, typ. 00h ...ffh

Response: none

6.3.4 Black down

Change this parameter if the image is too dark.

Command: **:a6<x_1x_0>** <x_1x_0> : Range, typ. 00..ffh

Response: none

6.3.5 Registers a3-4, a7-8

In general these registers must not be altered.

6.4 Image size

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

- number of the first displayed line

- number of lines
- address of first displayed pixel of a line (in steps of 10)
- address of last displayed pixel of a line (in steps of 10)

6.4.1 Number of the first displayed line

Register r1 defines the first line to be displayed.

Command:	**:r1**$\boldsymbol{<x_2x_1x_0>}$
	$<x_2x_1x_0>$ ... Range 000h ...3ffh
Response:	none
Example:	:r1100
	100h = 256 (image starts at line 256)

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

6.4.2 Number of lines

Register r3 defines the number of lines to output.

Command:	**:r3**$\boldsymbol{<x_2x_1x_0>}$
	$<x_2x_1x_0>$ ... Range 000h ...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!

6.4.3 Address of the first pixel of a line

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

Command:	**:r4<$x_2x_1x_0$>**
	<$x_2x_1x_0$> ... Range 000h ...7fh
Response:	none

Calculation of the value of r4:

Value of r4 = Pixel-Nr./10

6.4.4 Address of the last pixel of a line

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

Command:	**:r5<$x_2x_1x_0$>**
	<$x_2x_1x_0$> ... Range 001h ...080h
Response:	none

Calculation of the value of r5:

Value of r5 = Pixel-Nr./10

ⓘ	The difference r5-r4 must be > 0. For the maximum difference of r5-r4 see table 10.

6.5 Clock selection

The MC130x is equipped with a 2-channel programmable clock synthesizer. One channel controls clock frequency of the sensor, the other controls the frequency of the pixel clock.

For a given data rate on the video output (pixel clock) the ratio of sensor/pixel clock defines how many pixels out of a line can be output, while maintaining the highest possible sensor clock frequency.

For an easy adjustment the speed (sensor and pixel clock) of the camera may be switched in 16 steps. To get optimized speed selection the frequency steps differ in dependence of the mode (see also chapter 9.4).

Example: Mode 2, frequency step s9
Pixel clock: 27,5 MHz
Sensor clock: 11,2 MHz

Resulting, maximal data rate at the 16 bit output:
27,5 MHz/s * 2 byte = 55,0 Mbyte/s

The clock select command **:s** selects together with the four cameramodes 48 frequency pairs for sensor and pixel clock.

Command **:s <x_0>**
<x_0> ... Range 0 ... f (hex)

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).

6.6 Camera operating modes

Control register r6 controls *camera mode*, *type of exposure* and *exposure time*.

The *camera mode* determines the maximum number of pixel of a line that can output.

Type of exposure is either synchronous or asynchronous. Synchronous means that image is output continuously. Asynchronous means that an external signal starts exposure and image output.

Ten *exposure times* can be selected for asynchronous mode.

Command:	**:r6$x_2x_1x_0$**
	<$x_2x_1x_0$> ... Range 000h ...3ffh
Response:	none

table 4

Bit(s)	Description
r6[9..8]	Camera mode
r6[7..4]	Type of exposure
r6[3..0]	Asynchronous operation

6.6.1 Camera mode and maximum line length

To maximize frame rate for a given data rate on the video output, line length is divided into four steps. Only a fraction of the full line length is then written to the FIFO of the camera with the selected sensor clock. Therefore the sensor clock can be higher than the pixel clock by a factor of 5/line length fraction. Four camera modes

0..3, corresponding to full, ½ , ¼ and 1/8 line length, can be selected from the two most significant bits of register r6.

The maximum line length is also dependent on the pixelbinning feature. Table 7 shows the relationship. As frame rate is dependent on image size which is programmable, the frame rate is given as time for one line.

$$tzz = 1/fsclk * 136 \quad [Sek]$$

t_{zz} ...Time/Line
f_{sclk}... Sensor clock frequency

table 5

Camera mode	maximum line length (Pixel)	Sensor clock (Mhz)	Time/Line (usec)
0	100	66	2.47
1	240	33	4.12
2	640	13.2	10.3
3	1280	6.6	20.6

Camera mode, max. Line length and Time/Line

> If pixelbinning is selected, the maximum line length from table 2 will be doubled. The other values don't change.

As an example it is possible to reduce line length to 100 pixel in camera mode 3, too. The time for one line is then still 20.6 µs.

6.6.2 Type of exposure

The MC130x can expose the images synchronous with or without an electronic shutter, or asynchronous with a programmable internal timer or by pulse width control of the trigger pulse. Bits 7..4 of registers r6 define exposure type: (**:r6[7..4]**).

table 6

r6 Bits	7	6	5	4
Camera stop	x	x	x	0
Synchronous	0	0	0	1
Synchronous, with electr. shutter	0	0	1	1
Asynchronous, pulse width	1	0	1	1
Asynchronous, timer	1	1	1	1

:r6[7..4] and type of exposure

6.6.3 Synchronous operation without shutter

Without electronic shutter the exposure time depends on the frame rate. As frame size can be chosen arbitrarily, the frame rate can be calculated from the time per one line (see Tab. 5).

6.6.4 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.

Exposure time t_B :

$$t_B = (r1+r3-r2)\bullet t_{ZZ}) - t_{ZZ}/2 \qquad \text{with } r2 < r1+r3$$

t_B ... exposure time in s
r1 ... value of register 1
r2 ... value of register 2
r3 ... value of register 3

t_{ZZ} ... time/line (Tab. 7)

$t_{zz} = 1/f_{sclk} * 136$ [s]

t_{zz} ... Time/line
f_{sclk}... sensor clock

Typical exposure times:

table 7

Sensor clock frequency (MHz)	r1+r3-r2 1/5.000 s	r1+r3-r2 1/10.000 s
66	81	41
33	40	20
13,2	27	14
6,6	13	7

Typical exposure times

6.6.5 Asynchronous operation, shutter control by pulse width

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

An external trigger signal (EXP input) with selectable polarity can start and stop exposure. Exposure time is then dependent on the duration of the trigger signal., or on the setting of the exposure timer. The least 4 significant bits of r6 define exposure time.

6.6.6 Asynchronous operation, shutter control by timer

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

The asynchronous exposure time is dependent on the four least significant bits of r6 and on the frequency of the sensor clock.

Range of r6[3..0]: 0 ...9

Exposure time:

$t_B = 1/f_{sclk} * 136 * 2^{(r6[3..0])}$ [s]

t_B ... exposure time in s asynchronous operation

f_{sclk}. sensor clock frequency

Example: Sensor clock = 66Mhz

r6[3..0] = 6

$t_B = (136 \bullet 2^{(6)})/66 = 0{,}131$ ms

6.7 Frame rates

Depending on camera mode and clock the frame rate is proportional to the number of lines. See table 4.

Time for one line is:

$t_{zz} = 1/f_{sclk} * 136$ [Sec]

t_{zz} ...Time/line

f_{sclk}... Sensor clock frequency

The following table shows the relationship between camera mode, line length, frame rate and sensor clock frequency.

table 8

Camera mode	0	1	2	3
Frame size with r7[5]=1 (see short vertical sync)	100x100	240x240	640x480	1280x1024
Sensor clock (MHz)	66	33	13.2	6.6
Time/line [µs]	2,47	4,12	10,3	20,6
Frames/s	4852	933	202	47

Camera modes, frame size and - rate

6.8 Firmware

6.8.1 Update Firmware

MC130x'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 (RS-232 for MC1300, serial interface of Camera Link for MC1301). Mikrotron provides configuration files (*.ibf) on request.

Example for the download procedure of configuration data files using DOS:

Camera is powered up, both LED are on, the serial RS-232 link is connected

1. Init COM1: **mode COM1: 96,n,8,1**
2. Copy *.ibf file to COM1: **copy mc0120.ibf com1: /b**

To configure the FPGA, camera must be powered down/up or the command **:c** (see 6.8.1) must be issued.

	Download of *.ibf file via serial link takes app. 1.5 min. There should be no loss of power or communication during this time!

6.8.2 Reset and configuration of the internal FPGA

The command :c executes a reset in the camera. During the following initialization the FPGA will be configured, too.

The FPGA is also configured after each power up.
Command: **:c**
Response: none

6.9 Test image

For testing of camera logic and video data transmission, sensor data can be replaced by an internal grey scale pattern with pixel values of 0..127. Use digital gain command to see pixel values of 0..255.

Command: **:r7040** r7[6]
Response: none

6.10 FDV (frame data valid) low time

Some frame grabbers need some time between images for internal activities. MC130x's internal FDV low time (Tfdvl, vertical sync inactive) is as long as the LDV low time.

If this is too short, this time can be increased to a value of app. 40µs (@typ. pixel clock) If this feature is active, some lines at the beginning of an image are not transmitted.

Command: **:r7020** r7[5]**:** short FDV low
Response: none

The table below shows the time dependencies on setting or clearing Bit 5 in register 7.

table 9

Camera mode	0	1	2	3
Pixel clock (MHz)	66	33	33	33
Time/line (output), number of pixel clocks	68	136	272	544
Missing lines at begin of image, r7[5] = 0, in pixel clocks	16	9	5	2
Vertical sync pause, r7[5] = 0, in µs	40,3	37,1	41,2	32,9
Vertical sync pause, r7[5] = 1, in pixel clocks	4	8	16	32

Duration of FDV inactive

6.11 No LDV during FDV signal is inactive

If bit 7 in register 7 is set and the signal FDV is inactive, the output of the signal LDV is suppressed.

Command: **:r7080**
Response: none

6.12 Pixelbinning

High frame rates result in short exposure times and therefore need a lot of light to get bright images. In addition the field of view gets smaller.

Pixelbinning adds the grey 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 omitted.

Command: **:r7010**
Response: none

When Pixelbinning is active, the difference between register5 and register4 must not exceed the values from table 5:

table 10

Camera mode	Difference (hex)
0	20
1	40
2	80
3	80

When selecting lines with $\mathbf{r_1}$, $\mathbf{r_2}$, or $\mathbf{r_3}$ the contents of r1 and r2 is doubled in camera logic. To address a specific line on the sensor, the values of r1 and r2 have to be divided by two.

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

6.13 Digital gain

In low light conditions this feature can enhance the brightness of an image. The digital gain multiplies the grey value of every pixel by factor of 1, 2, 4 or 8. The range of the grey levels per pixel decrease (division by 2,4 or 8).

Command: **:r700x**
x = 0: Gain factor 1
x = 4: Gain factor 2
x = 8: Gain factor 4
x = C_h: Gain factor 8

6.14 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.
MC130x 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 r6[4], the camera enable bit. It is incremented by every new image.

6.15 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 MC1300 hardware checks the grey 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_h:

6.15.1 ImageBLITZ® processing

When ImageBLITZ® is activated and an active transition of the EXP input has once occurred, the following cycle is repeated:

1. MC130x Hardware checks at a repetition rate defined by the inverse of exposure time (:r6[3..0]), the intensity of a group of 10 pixel along the selected trigger window are compared against an adjustable threshold (:rA_h[7..0], Range: 255..0).

2. 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).

3. Each time this threshold is exceeded (release condition); a line counter (:rB_h[9..7], Range 0..145 in 8 steps) is loaded.

4. Once this line counter has expired, a new image is exposed and output.

5. After image is output, repeat at 1.

6.15.2 ImageBLITZ® programming

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

6.15.2.1 Number of trigger line

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

command: **:rC_h <$x_2x_1x_0$>**
<$x_2x_1x_0$> ... 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.

6.15.2.2 Nummer des linken Randes des Triggerfensters

The value of register r8 is the number of the leftmost pixel in the trigger line divided by 10.

Command: **:r8<$x_2x_1x_0$>**
<$x_2x_1x_0$> ... range 000h ...07fh
Response: none

Calculation of r8:
Value of r8 = pixel number / 10

6.15.2.3 Rightmost pixel of the trigger line

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

Command: **:r9**$<x_2x_1x_0>$
$<x_2x_1x_0>$ ... range 000h ...7fh
Response: none

Calculation of r9:

Value of r9 = pixel number / 10

ⓘ	The difference r9 – r8 must not exceed the values of table 10 (chapter 6.12).

6.15.2.4 Threshold level, superimposing trigger line

The threshold level is set by register rA_h . The pixel values along the trigger line are compared with this value.

Command: **:rA_h** $<x_2x_1x_0>$
$<x_1x_0>$ ... range 0 ..ffh
$<x_2>$ = 0: pixel grey level > threshold level, trigger line not visible
1: pixel grey level < threshold level, trigger line not visible
2: pixel grey level > threshold level, trigger line visible
3: pixel grey 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.

6.15.2.5 Release condition

Register rB_h also includes the release condition of the trigger.

The release condition is determined by the number of pixels which fulfill the trigger requirements.

Command:	**:rB_h <$x_{9..0}$>**
	<$x_{6..0}$> = 0 ..7fh, number of pixel, which fulfill the trigger requirements
Response:	none

6.15.2.6 Release limitation

The release limitation of the trigger is set in register rD_h.
It defines the number of release conditions which have to happen sequentially to fulfill the trigger requirements and expose an image.

This feature allows to select and capture only one image during a longer time where the trigger requirements are fulfilled.

Command:	**:rD_h <$x_{7..0}$>**
	<$x_{7..0}$> = 0 ..ffh, number of fulfilled, sequentially trigger conditions
Response:	none

The following table combines all adjustments of the ImageBLTZ®:

table 11

Register	Bit	Meaning
R7	0	= 1: activate ImageBLITZ®
r8	6..0	First pixel mod. 10
r9	6..0	Last pixel mod. 10
rA_h	7..0 8 9	Exposure threshold 1: bright object triggers 0: dark object triggers 1: superimpose trigger line to image
rB_h	6..0	Number of exceedings or fall backs, release condition
rC_h	9..0	Line to be checked
rD_h	7..0	exposure limitation, number of exposures without exposure condition until an image is captured

Registers r1..r7 are programmed according to image size and position and for Asynchronous operation, timer .

table 12

Register	Bit	Meaning
r1, r3..r5		Image size
r6	3..0 7..4 9..8	Async operation, timer 0fh Camera mode

6.15.3 ImageBLITZ® setup

The MC130x is configured for asynchronous operation with timer , registers r8, r9 and rC_h are loaded for the desired position of the trigger line. Register rB_h is loaded with 0, register rA_h with $201_{h,}$ so that the trigger line is visible.

ⓘ	If the image is zoomed down for display, every n_{th} line is omitted. 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_h across the object that is used for the shutter release..

Clear Bit 8 in Register rA_h if a bright objects releases the shutter, set rA_h[8] if dark objects release the shutter. While the trigger line is placed across the object, raise threshold with rA_h[7..0] until as many dashes from the trigger line disappear as are loaded in Register rB_h [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_h [9..7] with a number of exposed lines that will not met the release condition before exposing one image.

7 MC1xxx configuration tool

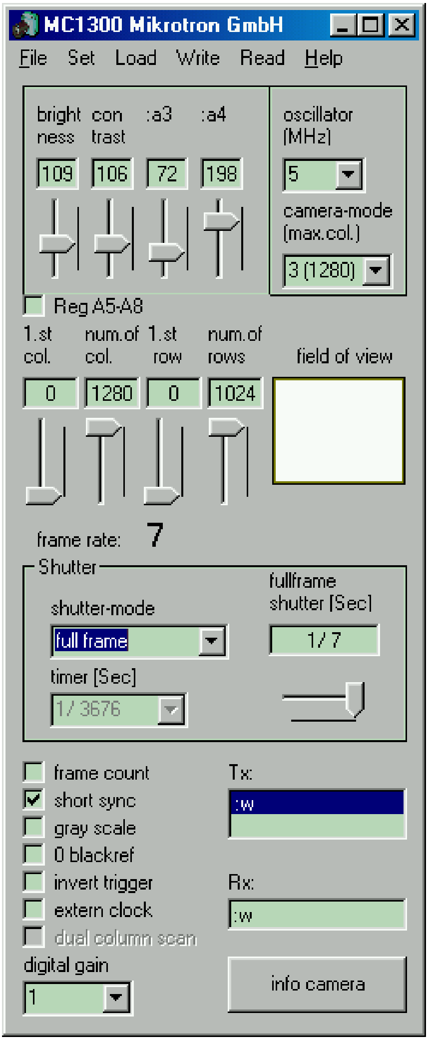
The MC1xxx configuration tool must be installed on a Windows PC. (Win9x, WinNT, Win2K, WinXP) by means of the setup software. See also www.mikrotron.de to download the latest version.

This software provides an almost self explaining user interface to modify any camera parameter. The description of the parameters follows the marked chapters in this user manual.

To connect this tool with the camera MC1300 use either a separate communication cable between COMx of the PC and the 9-pin COM camera connector (RS-232 PC cable) or a combined cable with the Rx/Tx signals fed thru the digital video cable.

To use this tool with the camera MC1301 the serial interface is integrated in the Camera Link interface. You do not need any other additional cable.

If the frame grabber Mikrotron INSPECTA-4 and the unidirectional cable is used, commands can be send to the MC130x, but not read from it.



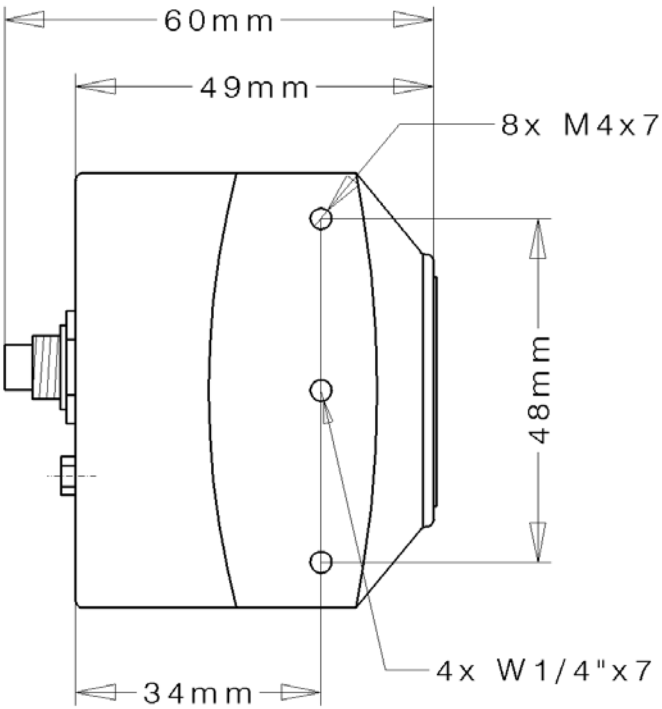
File: Save or read settings to or from file.
Set: Select com port. If Inspecta-4D and the correct cable is used, the MC1xxx can be written to but not being read from.
Load, Write, Read: Camera profiles
Brightness, contrast …:
Adjusting image
Oscillator, Camera Mode:
Clock selection, Camera operating modes
1.st col…num. of rows:
Adjusting Image
Shutter:
Type of exposure
Frame count .. digital gain:
6.9, 6.10, 6.12, 6.13, 6.14, 6.15
Info camera:
Read serial number and firmware version
Tx:
Display control strings

8 Mechanical dimensions

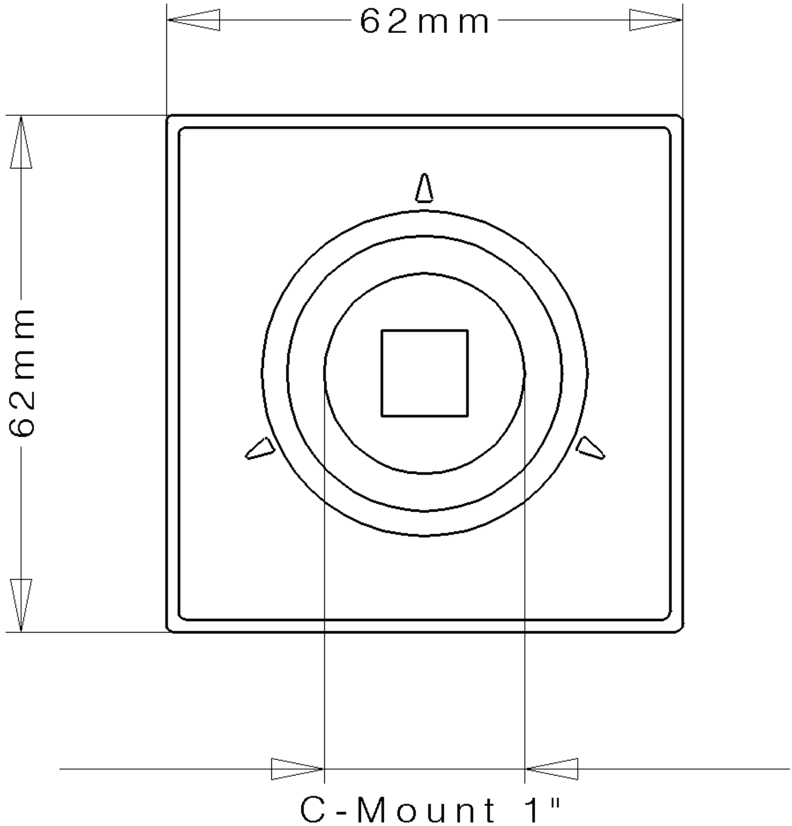
8.1 Camera body

The camera body is with its dimensions of 62 x 62 x 50 mm (without lens) very compact. To fasten the camera there are two mounting holes M4x7mm and one tripod connection on each side available.

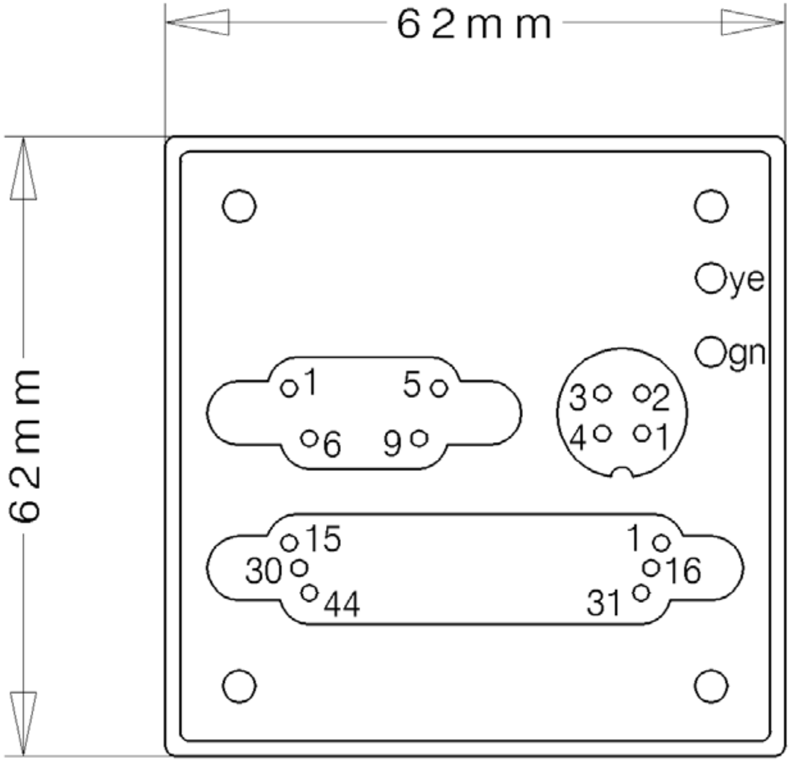
8.1.1 Dimensioned drawing, side view of MC1300



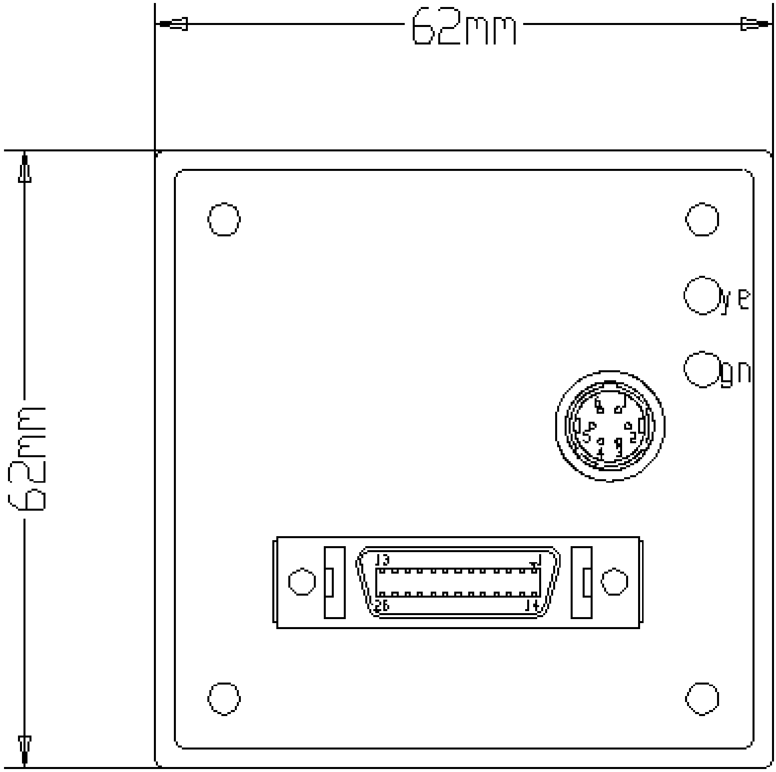
8.1.2 Dimensioned drawing, front view of MC130x



8.1.3 Dimensioned drawing, rear view of MC1300



8.1.4 Dimensioned drawing, rear view of MC1301



8.2 Lens adjustment

8.2.1 Adjustable lens adapter

For fine adjustment of the focal length a lens adapter with an adjustment range of ± 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.

8.2.2 Lens selection

Due to the size of the imager use C-mount lenses with an optical diameter of min. 1” or adapter for larger lenses like F-Mount..

9 Technical Data

table 13

Sensor	monochrome
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)	1000LSB/lux-sec
Spectral response	400..800nm
Shutter	Electronic „Freeze Frame“ Shutter
Trigger	Asynchronous shutter, shutter time selectable with internal timer in 10 steps or by pulse width of trigger signal
Internal Dynamic	59 dB
Power supply	8 ... 35 V
Power consumption	2,5W
Serial data link of MC1300 of MC1301 configuration of serial link (MC130x)	 RS-232 RS-644 of Camera Link interface 9600 Bd, 8 bits, 1 stop bit, no parity, no handshake
Digital video of MC1300 of MC1301	 16-Bit LVDS, Clock, LDV, FDV, EXP Camera Link, Base configuration
Lens mount	C-mount, 1“
Dimensions (WxHxD in mm)	62 x 62 x 50
Temperature range	+5 ... +50° C
Weight	ca. 300 g

9.1 Spectral response

table 14

Wavelength (nm)	Quantum efficiency (%)
389.9	12.12
399.9	14.12
409.9	15.46
419.9	17.97
430.0	19.03
440.0	19.82
450.0	20.81
460.0	21.41
469.9	22.50
479.9	22.75
489.9	22.73
499.9	23.44
509.9	23.23
520.0	21.88
530.0	21.01
540.0	21.77
550.0	20.88
560.0	19.55
570.0	17.21
579.9	18.49
589.8	17.49
599.9	16.39
609.9	15.93
619.9	15.01
629.9	14.92
639.9	13.98
649.9	14.16
659.9	11.55
669.9	11.85
679.9	12.51
689.9	11.11
699.9	11.17
709.9	8.80
719.9	9.82
729.9	8.82
739.9	7.67

Wavelength (nm)	Quantum efficiency (%)
749.9	8.90
759.8	8.24
769.8	7.74
779.8	7.48
789.8	5.93
799.8	5.50
809.7	5.97
819.7	5.27
829.7	4.92
839.7	5.03
849.7	4.38
859.7	3.69
869.7	3.81
879.7	3.77
889.7	2.96
899.7	2.37
909.7	2.42
919.7	2.44
929.7	1.97
939.7	1.60
949.7	1.52
959.7	1.62
969.7	1.36
979.7	1.03
989.7	0.81
999.7	0.79
1009.7	0.77
1019.7	0.66
1029.7	0.45
1039.6	0.34
1049.6	0.25
1059.6	0.23
1069.6	0.16
1079.6	0.13
1089.6	0.08
1099.6	0.05

9.2 Connector pinning

9.2.1 Video connector, D-Sub 44-pins, used in MC1300

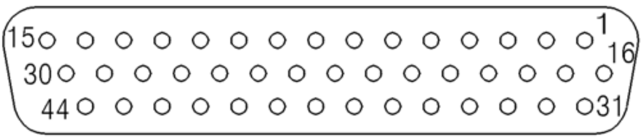


table 15

pin	signal	pin	signal	pin	signal
1	D0+	16	D0-	31	D15+
2	D1+	17	D1-	32	D15-
3	D2+	18	D2-	33	LDV+
4	D3+	19	D3-	34	LDV-
5	D4+	20	D4-	35	CLKOUT+
6	D5+	21	D5-	36	CLKOUT-
7	D6+	22	D6-	37	EXP+
8	D7+	23	D7-	38	EXP-
9	D8+	24	D8-	39	FDV+
10	D9+	25	D9-	40	FDV-
11	D10+	26	D10-	41	TXD
12	D11+	27	D11-	42	VCC
13	D12+	28	D12-	43	RXD
14	D13+	29	D13-	44	GND
15	D14+	30	D14-		

9.2.2 Camera Link connector, MDR-26, used in MC1301

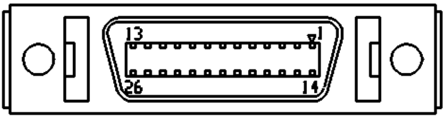


table 16

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

Manufacturer: 3M
Order-no. 10226-6212VC

9.2.3 RS-232 connector, D-Sub 9-pins, used in MC1300

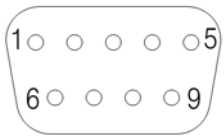
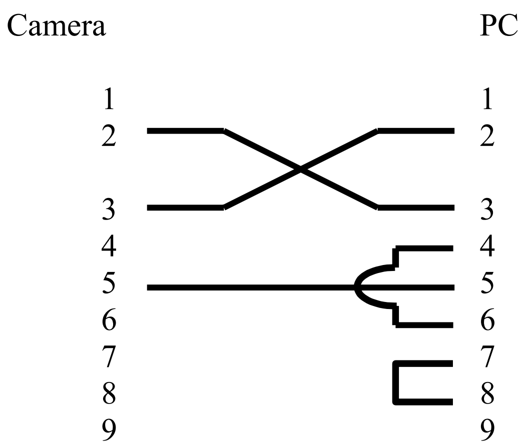


table 17

pin	signal		pin	signal
1	CLKIN+		6	CLKIN-
2	RxD		7	n.c.
3	TxD		8	n.c.
4	n.a.		9	n.c.
5	GND		n.c. ... not connected	

9.2.4 RS-232 ↔ PC cable



9.2.5 Circular connector 6-pole, used in MC1301

table 18

pin	signal
1	VCC
2	VCC
3	STRB

pin	signal
4	DGND*
5	GND
6	GND

*DGND ... digital GND for signal STRB

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

9.3 Camera profiles, factory settings

9.3.1 Profile 0: 100 x 100, 4.852 fps, camera mode 0

:a1	:a2	:a3	:a4	:a5	:a6	:a7	:a8	:s	:r1	:r2	:r3
*	*	48	c6	*	00	65	1a	9	1ce	1ce	063

:r4	:r5	:r6	:r7	:r8	:r9	:ra	:rb	:rc	:rd	:re	:rf
03b	045	030	020	000	000	000	000	000	000	000	000

9.3.2 Profile 1: 240 x 240, 1.011 fps, camera mode 1

:a1	:a2	:a3	:a4	:a5	:a6	:a7	:a8	:s	:r1	:r2	:r3
*	*	48	c6	*	00	65	1a	b	188	188	0ef

:r4	:r5	:r6	:r7	:r8	:r9	:ra	:rb	:rc	:rd	:re	:rf
034	04c	130	020	000	000	000	000	000	000	000	000

9.3.3 Profile 2: 640 x 480, 202 fps, camera mode 2

:a1	:a2	:a3	:a4	:a5	:a6	:a7	:a8	:s	:r1	:r2	:r3
*	*	48	c6	*	00	65	1a	b	110	110	1df

:r4	:r5	:r6	:r7	:r8	:r9	:ra	:rb	:rc	:rd	:re	:rf
020	060	230	020	000	000	000	000	000	000	000	000

9.3.4 Profile 3: 1.280 x 1.024, 47 fps, camera mode 3

:a1	:a2	:a3	:a4	:a5	:a6	:a7	:a8	:s	:r1	:r2	:r3
*	*	48	c6	*	00	65	1a	b	000	000	3ff

:r4	:r5	:r6	:r7	:r8	:r9	:ra	:rb	:rc	:rd	:re	:rf
000	080	330	020	000	000	000	000	000	000	000	000

9.3.5 Default-Profile: 1.280 x 1.024, 47 fps, camera mode 3

:a1	:a2	:a3	:a4	:a5	:a6	:a7	:a8	:s	:r1	:r2	:r3
6d	77	48	c6	00	00	65	1a	B	000	000	3ff

:r4	:r5	:r6	:r7	:r8	:r9	:ra	:rb	:rc	:rd	:re	:rf
000	080	330	020	000	000	000	000	000	000	000	000

9.3.6 Camera profile: 1.280 x 1.024, 47 fps

:a1	:a2	:a3	:a4	:a5	:a6	:a7	:a8	:s	:r1	:r2	:r3
6d	77	48	c6	00	00	65	1a	B	000	000	3ff

:r4	:r5	:r6	:r7	:r8	:r9	:ra	:rb	:rc	:rd	:re	:rf
000	080	330	020	000	000	000	000	000	000	000	000

* these values can change.

Read profiles (see: Read camera profile):
When reading a camera profile with the **:w** command, some return values differ from the input values. While clock frequencies are selected via the **:s** command from a table within the microcontroller, the return value are two actual hexadecimal codes used to program the cameras synthesizer. See: Code for Clock Synthesizer.

Profile 0
xxyy48c6zz00651a61788b40f4051ce1ce06303b045030020000000
000000000000000000
Profile 1
xxyy48c6zz00651a61e88c407c821881880ef03404c130020000000
000000000000000000
Profile 2
xxyy48c6zz00651a61e88c40c1051101101df0200602300200000000
000000000000000000
Profile 3
xxyy48c6zz00651a61e88c41898c0000003ff000080330020000000
000000000000000000
Default profile
6d7748c60000651a61e88c41898c0000003ff000080330020000000
000000000000000000
Camera profile
6d7748c60000651a61e88c41898c0000003ff000080330020000000
000000000000000000

Values xx, yy and zz replace the actual x, y and number of columns/lines values.

9.4 Camera clock, frequency selection

The MC130x operates with two clocks: the sensor and the pixel clock. The sensor clock runs the sensor and thus defines the cameras data rate. The pixel clock is responsable for the data rate on the LVDS output. The ratio of both frequencies differ according to selected camera mode. See: Camera mode and maximum line length. All frequencies are selected from an internal table with 4 x 16 entries. These are 4 camera modes x 16 select codes, 0..f_h , command **:s<x_0>,** see chapter 6.5
The pixel clock is only dependant on the select code **<x_0>** , the sensor clock is dependant on the camera mode and select code.

Example: Camera mode 3, selection 4:
Sensor clock = 3 MHz
Pixel clock = 15 MHz

Table 19 shows the selectable frequencies, table 20 shows the programming codes that will be returned as a result from the **:w** command.

table 19

step in hex	pixel clock in MHz	sensor clock of mode 0 in MHz	sensor clock of mode 1 in MHz	sensor clock of mode 2 in MHz	sensor clock of mode 3 in MHz
0	7,5	18,4	7,1	3,1	1,5
1	10,0	24,5	9,5	4,1	2,0
2	12,5	30,6	11,9	5,1	2,5
3	15,0	36,9	14,3	6,1	3,0
4	17,5	42,9	16,7	7,1	3,5
5	20,0	49,0	19,1	8,2	4,0
6	22,5	55,1	21,4	9,1	4,5
7	25,0	61,2	23,8	10,2	5,1
8	26,9	65,8	25,6	11,0	5,4
9	27,5	67,4	26,2	11,2	5,6
a	30,0	see step 9*	28,6	12,2	6,1
b	33,0	see step 9*	31,2	13,4	6,6
c	35,0	see step 9*	33,4	14,3	7,1
d	40,0	see step 9*	38,1	16,3	8,1
e	50,0	see step 9*	47,6	20,4	10,1
f	60,0	see step 9*	57,1	24,5	12,1

* The maximal allowed sensor clock is reached in mode 0 at step 9. All steps above step 9 (in mode 0) are automatically set back to step 9.

Tolerance: ± 5 %

9.4.1 Code of the clock synthesizer

Each frequency pair corresponds to two hexadecimal codes that are used to program the synthesizer. These are also obtained on a read camera profile (:w) command.

table 20

step in hex	pixel clock in MHz	sensor clock of mode 0 in MHz	sensor clock of mode 1 in MHz	sensor clock of mode 2 in MHz	sensor clock of mode 3 in MHz
0	61dd8d	406d01	407182	416a85	416705
1	612585	416905	407181	40ee05	41be8b
2	61dd87	414088	41f988	41de09	407a81
3	61dd0d	406c81	407102	416a05	416685
4	608d02	41f489	41f10c	407182	405201
5	612505	416885	407101	40ed85	413207
6	60e903	41f00f	416906	41f98b	410a05
7	61dd07	414008	41f908	41dd89	407a01
8	611888	41e80c	41e890	41d188	40e203
9	61788b	40f405	40f487	411984	41da08
a	61dc8d	see step 9*	407082	416985	416605
b	61e88c	see step 9*	407c82	40c105	41898c
c	608c82	see step 9*	41f08c	407102	405181
d	612485	see step 9*	407081	40ed05	413187
e	61dc87	see step 9*	41f888	41dd09	41d589
f	61dc0d	see step 9*	407002	416905	416585

There is a 3-byte code for each frequency. The code for the sensor clock is set to sb1…3 of a returned camera profile (command :w). The code of the pixel frequency corresponds to sa1…3.

Example: return of frequency codes

On command :w following answer was returned:

6d774ac800006a1c**61e88c41898c**0000003ff000080**330**02000000000000000 0000000000↵

61e88c...	Sa1...3, pixel clock (see code of table 20) 61e88c = step b, equivalent to 33,0 MHz
41898c...	Sb1...3, sensor clock according to table 20, mode 3 41898c= stepb, equivalent to 6,6 MHz
330...	Reg. 6 (see chapter 6.6) : -> Mode 3

9.5 Programming sequence, factory profile

Example: Mode 3, full frame shutter, 1280 x 1024, 14 fps

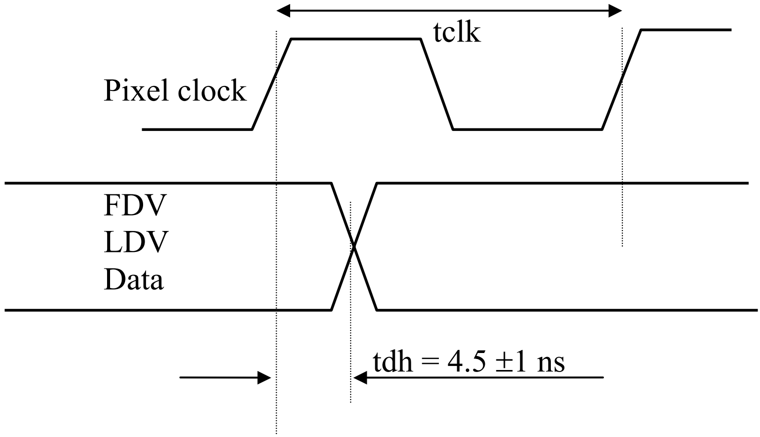
Strings:

```
:r6300
:a16d
:a277
:a34a
:a4c8
:a500
:a600
:a76a
:a81c
:r1000
:r2000
:r33ff
:r4000
:r5080
:r7020
:r8000
:r9000
:ra000
:rb000
:rc000
:rd000
:re000
:rf000
:sb
...................
:r6330
```

The dotted line before the last command is used as a delay (character “.”, about 20 ms at 9600 Bd), which is need for correct command transfer. The delay time must be at least 15 ms.

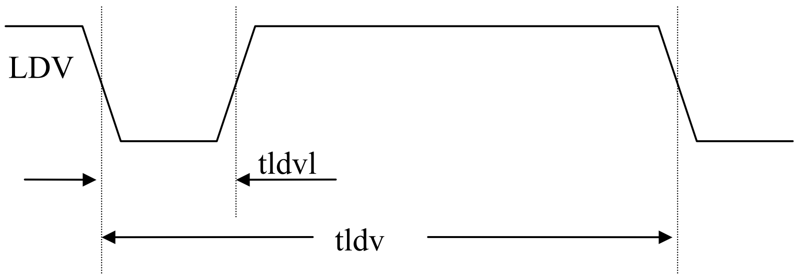
9.6 Timing

9.6.1 Pixel clock



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

9.6.2 Line Data Valid (LDV)



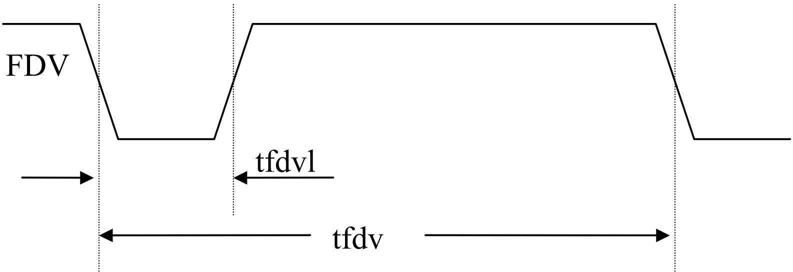
The timing for the LDV signal is shown in multiples of the pixelclock dependent on camera mode and shutter.

table 21

Camera modes	0	1	2	3
tldvl in pixel clocks	4	8	16	32
tldv in pixel clocks	68	136	272	544

LDV signal is also active while FDV is inactive. (FDV = LOW)

9.6.3 Frame Data Valid (FDV)



The rising edge of FDV marks that line, that is programmed in Register r1, reduced by the number of lines from table 18 depending on the setting of Bit 5 in Register 7.

Tfdv is equal to the value programmed in Register r3 multiplied with time/line from table 5, chapter 6.6.1.

table 22

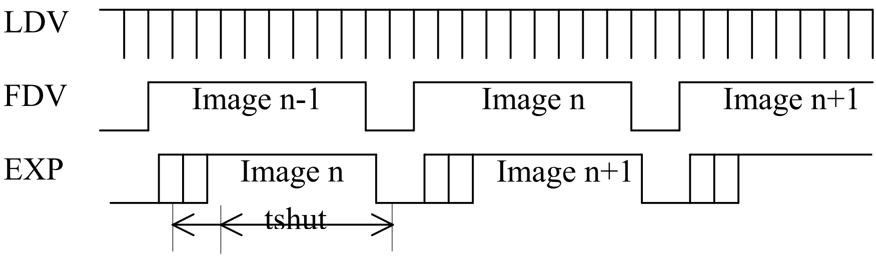
Camera mode	0	1	2	3
Tfdvl in number of LDV with Register 7 Bit 5 =0	16	9	5	2
Tfdvl in pixel clocks with Register 7 Bit 5 =1	4	8	16	32

9.6.4 Exposure Signal (EXP)

The EXP signal is positiv active if register 7, Bit 8 = 0, negativ active if register 7, Bit 8 = 1.

The EXP signal is synchronized with an internal line signal, and effective exposure starts and stops up to 136 sensor clocks after assertion/deassertion of the EXP signal.

The effective exposure time tshut is synchronised with an internal line signal.



EXP Signal can be asserted even while the previous image is output (FDV active), provided that exposure time set by the width of the EXP signal or by timer is longer than the FDV active time.

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