Industrial Contact Image Sensor

Operation manual

V 4.00

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Translation: MKi

Safety notes

Damages caused by non-observance of this manual warranty voids!
We accept no liability for consequential damage, as well as injuries and loss caused by non-observance of our safety notes

- **The Contact Image Sensor must not be used on humans or animals**
- 

  LED-lightning in visible range are classified to risk group 2 according to DIN EN 62471, meaning short termed lightemission is non-dangerous for eyes.

  Please get clarification by your laser representative!
- **Never look directly into the illumination!**
- **Only instructed personal may operate the Contact Image Sensor.**
- **The Contact Image Sensor heats up during the operation. Sufficient cooling must be ensured !**
- **Protect the pane against damage !**
- **Plug or unplug the plugs only in non-energized state !**

Content

1 What is a CIS (Contact Image Sensor)

1.1 Definition

A Contact Image Sensor (CIS) is a compact CMOS - technology based image sensor with a minimum distance to the inspected pattern likewise that in a fax machine or a document scanner. It usually consists of a reading line, a GRIN-lens and an illumination source.

1.2 CIS in general

The sensor of the CIS is at least as wide as the pattern that has to be scanned, meaning that several thousands of photosensitive points are placed side by side in a row. Every point has an assigned lens. Illumination is provided by LED-lines positioned parallel to the sensor.

As the name suggests CIS is in need of nearly direct contact to the scanning pattern.

This method of construction provides a compact construction form and energy efficient illumination in loss of a complex optic.

Due to this construction method, CIS – technology provides a low depth of field

1.3 Industrial CIS

The core construction corresponds to the reading lines of a fax machine or a document scanner.
The execution differs substantially.

Typical fax machines and scanners are usually designed for DIN A4 formate. Therefore the scan width is about 216 mm. Patterns are usually paper or papery materials. The line scanning rate of a branded scanner in the price range of 100€ is about 450 Hz for monochrome at a resolution of about 200 dpi.

A DIN A3 – scanner is priced at 4000€, but it accomplishes 200 dpi and a scanning rate of about 2800 Hz in monochrome usage.

Larger sized scanners made for patterns of about 1000 mm width accomplish a scanning rate of about 2000 Hz at a resolution of 200 dpi. This scanners are priced at 20000 € (price of 2013).

The industrial CIS can be configured for its tasks

- resolutions starting at 25 up to 2400 dpi
- scanning rates up to 250000 Hz (250kHz)
- up to 4000 mm width
- monochrome, RGB or false color illumination
- different internal and or external illumination types
- access to parameters for tuning for different patterns

Its construction is a stable metal case with an window out of glass, housing sensor-chips, optic, illumination, complex electronics and a high-speed interface for data transferring. The working distance has increased to about 10mm.

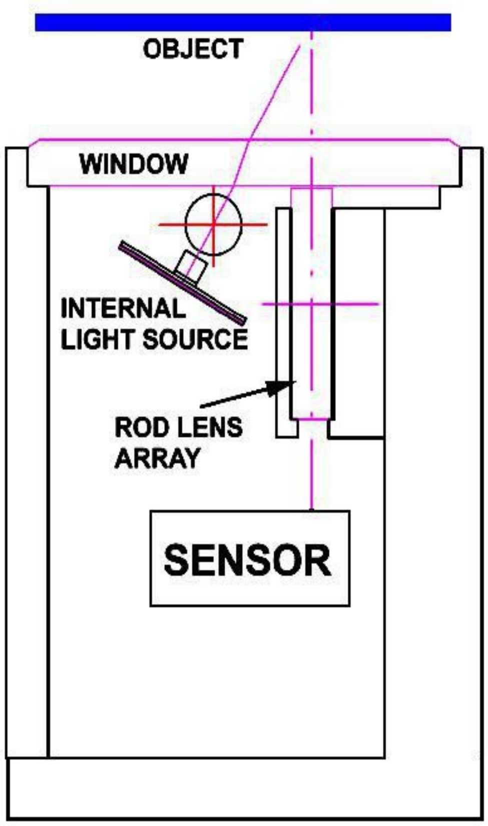
Beside standard versions we can also build special versions that satisfy customer wishes.

2 General information about Industrial Contact Image Sensor CIS

2.1 Core structure

2.1.1 CIS

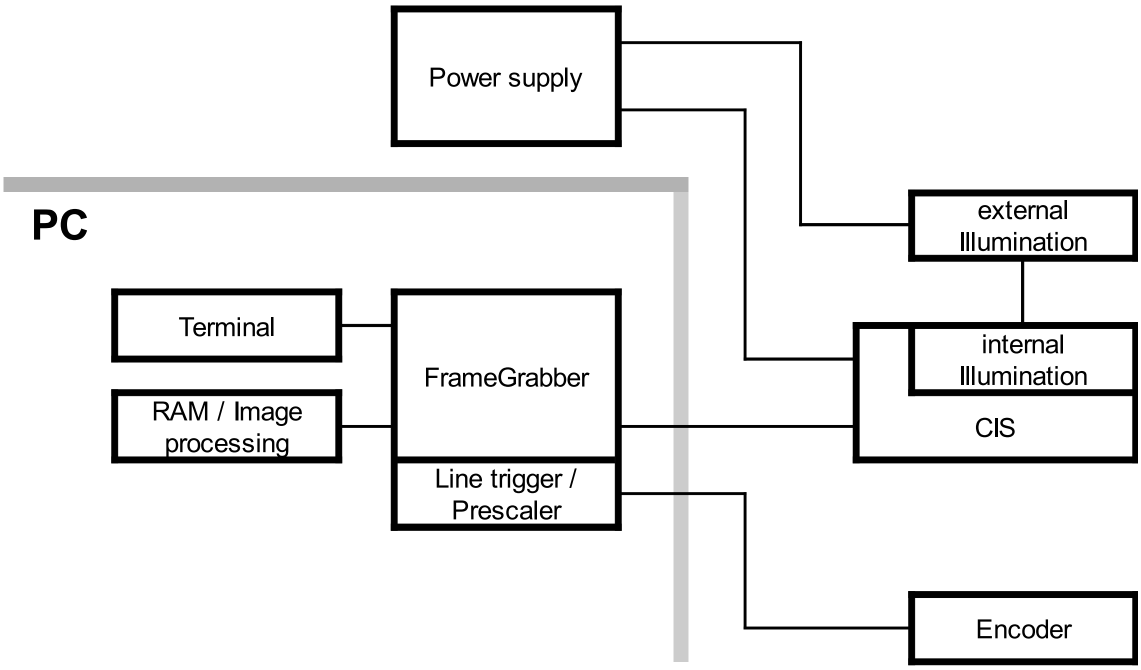
In the image 2.1.1-1 you can see core structures of a cis and how its components work together.



Img. 2.1.1-1 Core structure of a CIS

A stable aluminum case houses and protects the components. Beneath a glass pane is a GRIN-lens-array (see 2.4.1) that focuses light reflected by the object to the sensors
(see 2.2). One or multiple LED-lines and associated focus-elements out of cylinder-lenses out of glass, are also housed in that case (see 2.3.1). For some cases of use the LED-lines are housed in their own cases.

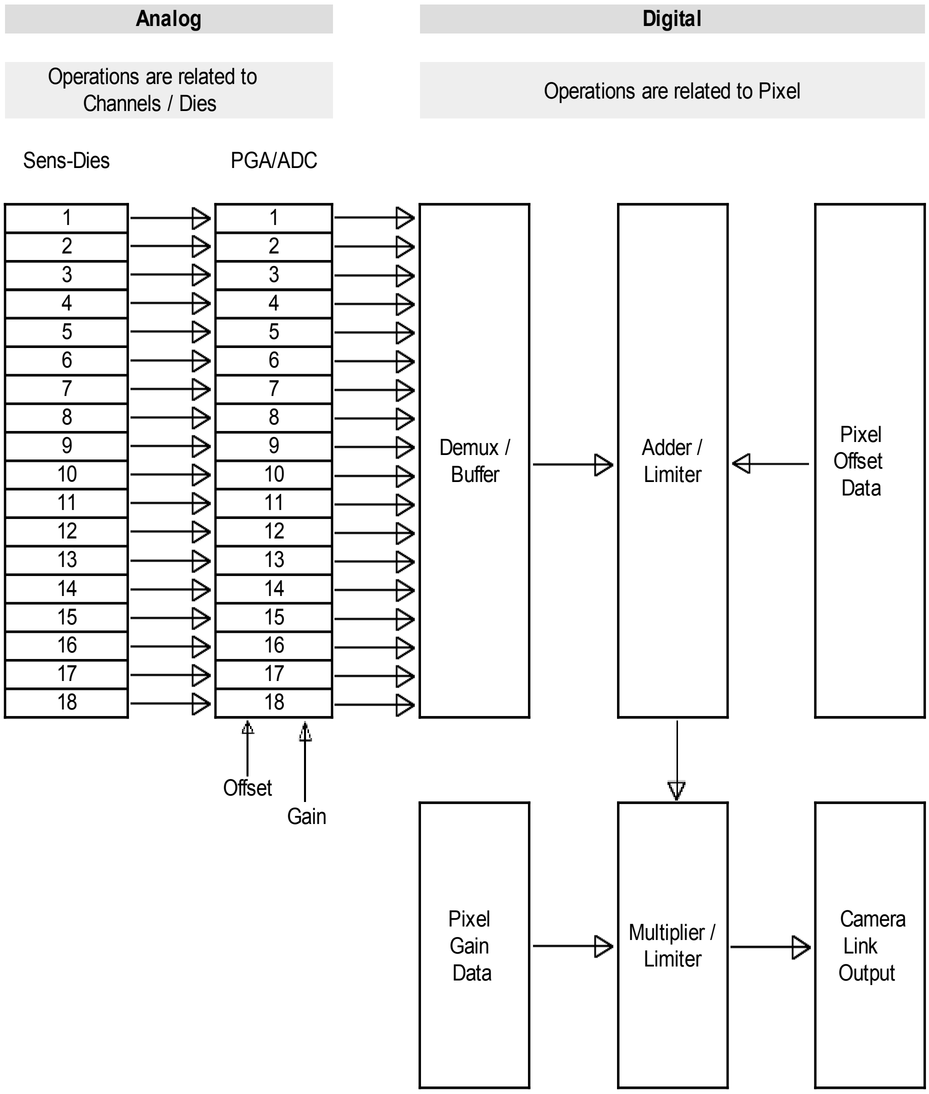
2.1.2 Image generation system



Img. 2.1.2-1 core structure of an image generation system with CIS

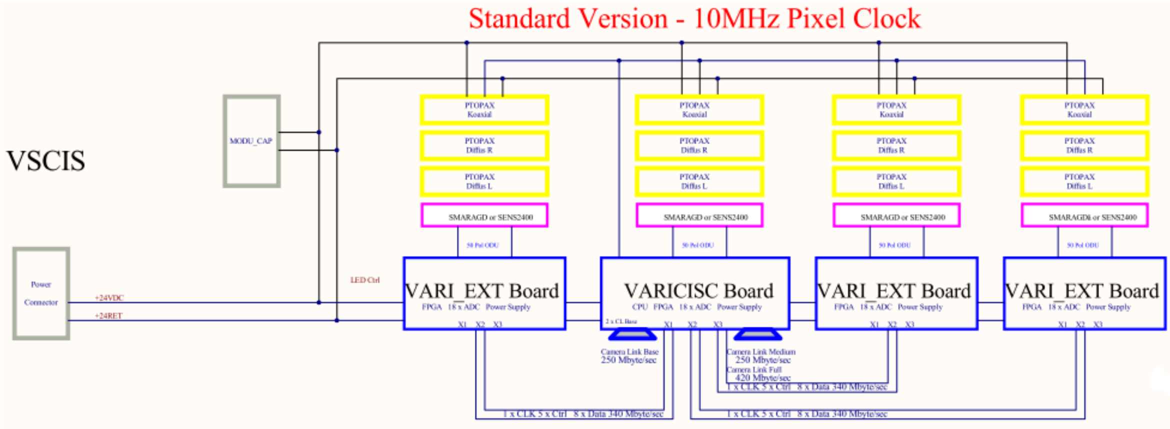
A CIS mounted in a machine is scanning a moving object line per line. An encoder triggers the creation of images. A scale of 1:1 requires quadratic pixels. The tune of the encoder is usually in a pre-scaler integrated in the frame grabber. It assembles the received images of lines to an full image and stores them in the memory of a computer. Using the frame grabber also enables a terminal application to communicate with the CIS. The power-supply takes care of the electricity supply of CIS and its illumination.

2.1.3 Wiring-diagramm of a CIS



Img. 2.1.3.-1 Signal flow of a VariCIS

The analog brightness signals of the sensor-dies are being sent to an analog-digital-converter. They affect the analog values of gain and offset. Now the brightness signals are digital and are being concluded to an digital data stream by the demultiplexer. Afterwards those signals are being edited by geo- and pixel-correction. Now the signal is a CameraLink-compliant data stream.



Img. 2.1.3.-2 Wiring diagramm of a VariCIS

The yellow elements are representing the RGB-illumination, the purple ones represent sensor-boards. A VARI-board edits and streams signals via CameraLink port.

2.2 Sensors

2.2.1 CCD and CMOS

Image sensors are based on the inner photo effect. Photons generate charges in a suitable electrical semiconductor. A pixel is one special point of an image. Image sensors can´t recognize colors, they only react on brightness.

When it comes to CCD - technology the collected charge of pixels are transported by shift registers to the pixel-line´s exit and are being amplified, after illumination finished. A pixel consists of only one photo diode. That´s why they are called passive sensors

When it comes to CMOS – technology, the collected charges of photo diodes are transferred within the pixel into voltage. By means of a reader electronics and an analog signal processor the charge is feeding the chips. That´s why they are called active sensors, because the pixel already houses the reader electronics.

Specific characteristics arise out of those different technologies. A CIS – sensor mostly houses image sensors of CMOS – technology.

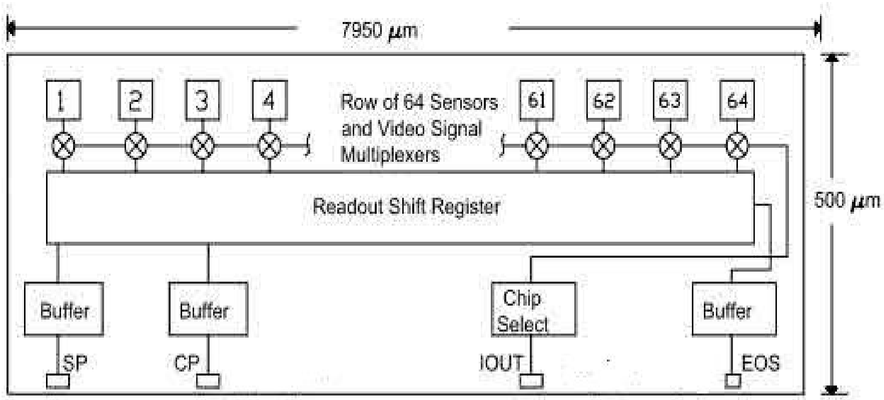
Both types of imagers convert light into electric charge and process it into electronic signals. In a CCD sensor, every pixel's charge is transferred through a very limited number of output nodes (often just one) to be converted to voltage, buffered, and sent off-chip as an analog signal. All of the pixel can be devoted to light capture, and the output's uniformity (a key factor in image quality) is high. In a CMOS sensor, each pixel has its own charge-to-voltage conversion, and the sensor often also includes amplifiers, noise-correction, and digitization circuits, so that the chip outputs digital bits. These other functions increase the design complexity and reduce the area available for light capture. With each pixel doing its own conversion, uniformity is lower. But the chip can be built to require less off-chip circuitry for basic operation.

2.2.2 Contact Image Sensor (CIS)

In contrast to image sensors of cameras in which areal sensors are built in, the CIS chip consists of a single linear line of photo diodes. That´s why the reading electronics can be arranged next to the sensor elements.

There are various structures of a CIS sensor chip. We will explain it using a 200 dpi and a 1200 dpi chip.

A block diagramm of a 200dpi chip is shown on image 2.2.2-1 (see below)

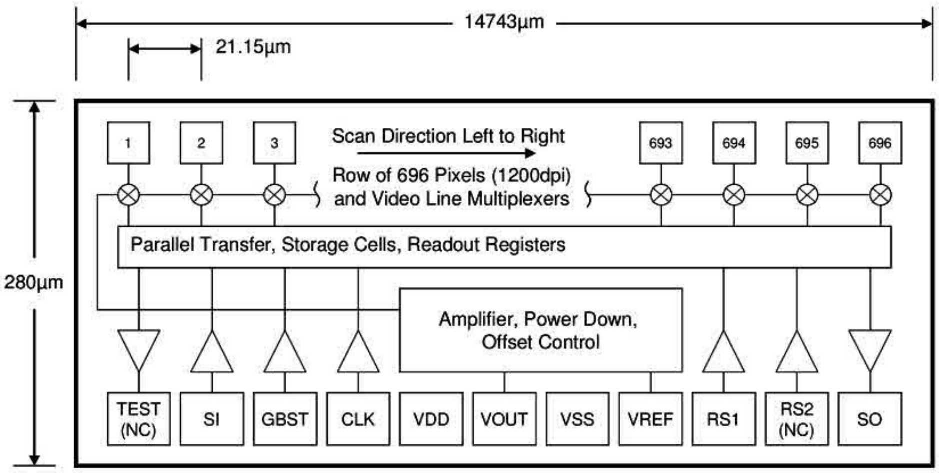


Img. 2.2.2-1 Block diagram of a 200dpi chip

An impulse SP (Start Pulse | see image) will start the reading process. The multiplexer of pixel one sends his brightness information (voltage) to the exit IOUT. The next clock-impulse at CP (see image) shifts the start impulse to the next point on the shift register. The multiplexer cuts pixel one and connects pixel two to the exit IOUT (see image). All 64 pixels will processed like this until the start pulse reaches EOS (see image) and signals the end of the reading process

During the reading process light must not enter the sensor chip. Pixel 64 would be illuminated longer than pixel 1, which was read out way earlier.

A block diagram of a 1200 dpi sensor chip is shown at image 2.2.2-2



Img. 2.2.2-2 Block diagram of a 1200 dpi chips

Every sensors houses 696 active pixels containing a photo diode and additional transistors, which redact the signal, repeat and memorize. This is done for every pixel at the same time. That´s why it is able to read out the values during the next illumination. A shift register shifts the cache of every pixel successively to the common exit.

In the manufacturers data sheets are no sizes of the single pixels listed, but there is the measure of the center of an pixel to the center of another pixel called spacing. For the 200dpi chip the statement is “typical 125 µm”, for 1200 dpi chips its “typical 21.15 µm”

2.2.3 Readout of image sensors

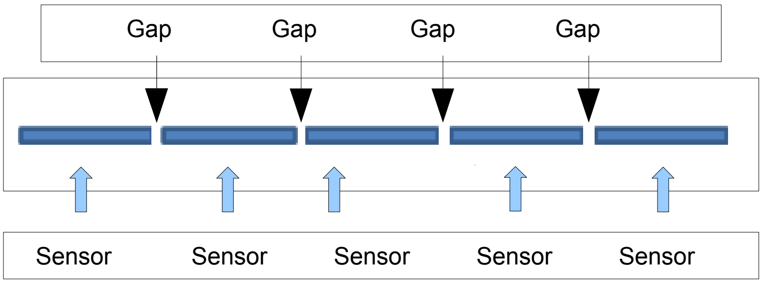
There are two possible processes for reading out an image sensor.

The “Rolling Shutter” - principle means that brightness information of the pixels are sent to the exit without any intermediate buffer. While the reading process is running, there must not be any illumination, because otherwise the pixel that are read out at last, will have a longer illumination sequence than the first ones, meaning after the illumination sequence there has to be an reading sequence. That´s why it has an direct influence to the frequency.
See 2.2.2-1 and the description to the 200dpi chip.

Using the “Global Shutter” - principle the brightness information of every pixel will be written in an intermediate buffer at the same time and afterwards, while the next illumination sequence is already running, it will be sent to the exit.
In this case the illumination sequence and the reading sequence are running parallel, but the illumination sequence has to last longer than the reading sequence.
See 2.2.232 and the description to the 1200 dpi chip.

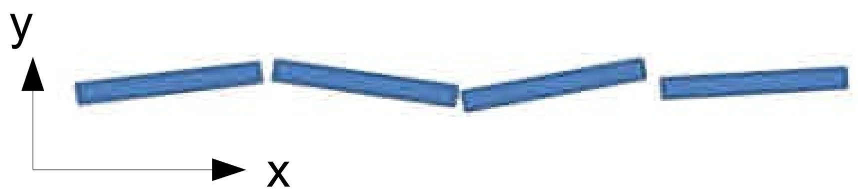
2.2.4 In-Line sensors with gap

A single line sensor chip has a width of 8mm up to 15mm. They are lined up on a sensor board. The easiest way of lining them up is in line. Thereby results a unavoidable gap between the last pixel of the first chip and the first pixel of the second. Chips cannot be mounted without any gap and aditionally a chip is larger than the outer borders of the pixels.



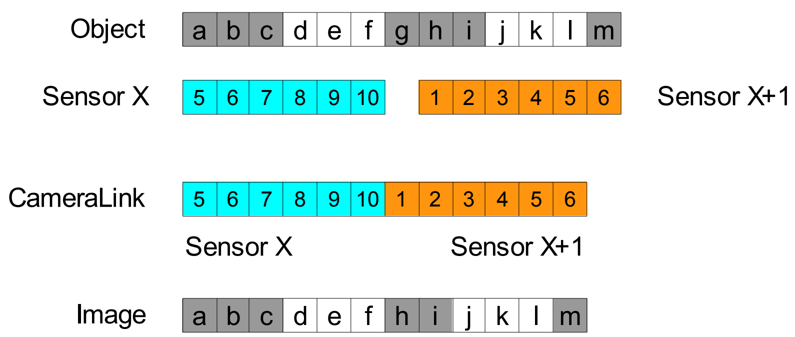
Img. 2.2.4-1 In-Line structure

In general the chip´s montage on the sensor boards are tolerance afflicted. The production tolerance not only affect the gaps inbetween those chips but also the offset of two chips mounted next to each other.



Img. 2.2.4-2   production tolerances

An unscaled representation of tolerated chip arrangement is presented in image 2.2.4-2. The gaps on the x-axis amount about 20 to 50 µm, on the y-axis the gaps amount about ± 30 µm to the ideal line.



Img. 2.2.4-3   Object and its image in a FrameGrabber

Img. 2.2.4-3 illustrates the impact of a gap. The object is being captured by sensor X using pixels 5 to 10 in the area of a to f and sensor x+1 using pixels 1 to 6 in the area of h to m. Area g got lost, because he was not captured by any of those sensors.
If an object characteristic is at least 3 pixels wide, in example Img. 2.2.4-3 about one third of the characteristics get lost.

The size of the gaps equal about the size of a pixel of a 600 dpi-Chip of typically 42,3 µm.

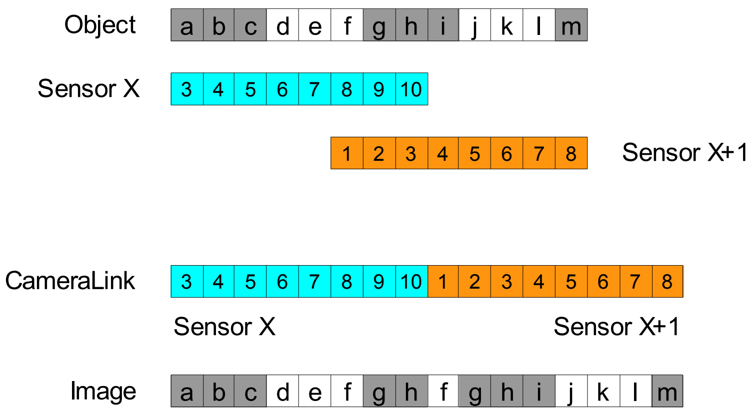
2.2.5 Zero Gap Sensors, staggered plus FIFO

To prevent gaps sensor chips can be arranged staggered or overlapped one above the other in two rows. The angular deflection (about 100 µm) of the symmetry axis of the pixel rows is chosen as a full multiple of the pixelsize

Img. 2.2.5-1 Zero Gap, staggered

By temporary buffering the files of every second sensor chip in a FIFO-Memory, the staggered line can be brought to concurrence. At an appropriate time there will be an output as one image line.
However buffering several lines presuppose, that pixel are always squares. Every movement of an object by the path length of one pixel activates one trigger-impulse (see 3.3.1)

The overlapping of the chips prevents a gap, but leads to the overlapped pixels being presented twice.



Img. 2.2.5-2 Object and its Image in a Frame Grabber

Img 2.2.5-2 presents the overlapped pixels. The object is being recorded by sensor x, using the pixel-numbers 3 to ten in the area a to h and buffered in the FIFO-MEMORY. Two trigger-impulses (=2 lines) later the object is being recordet by sensor x+1, using pixel-numbers 1 to 8 in the area of f to m. The buffered pixels of sensor x and the new pixels of sensor x+1 are now being delivered one after another to the Frame Grabber. The object area f to h exists twice, because it was recorded by both sensors

The tolerances presented in image 2.2.4-2 at the chip´s montage also occur here. The tolerance in x-direction generate an irregular overlap of the single sensors, in y-direction stags to the two ideal lines.

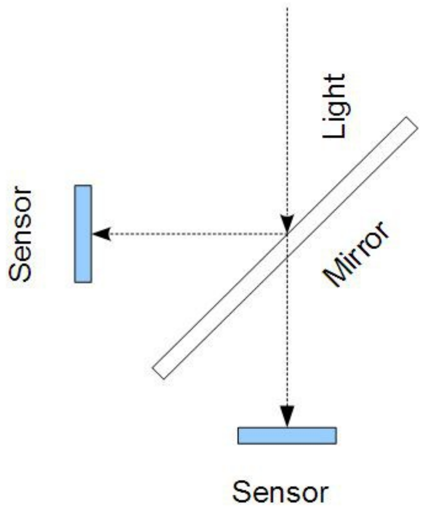
Zero Gap Sensors, staggered plus FIFO are by default installed in CIS-Sensors using 1200 dpi or 2400 dpi. Using the Line Delay -command both sensor lines can be brought to concurrence.

An optional geometry correction can calculate tolerances in y-direction and delete overlapped pixels in x-direction.

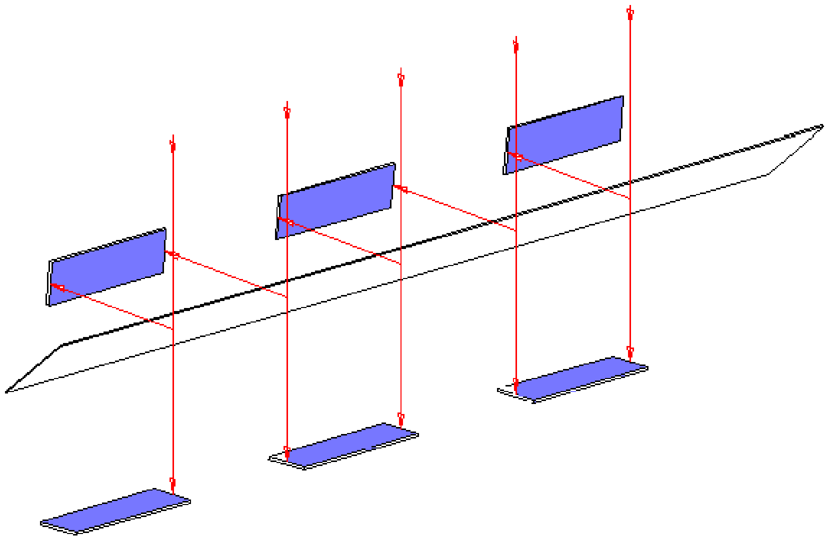
For applications, that don´t support gaps at low resolution, these Zero Gap Sensors can be binned, so that an image without gaps results.

2.2.6 Zero Gap Sensors with beam splitter

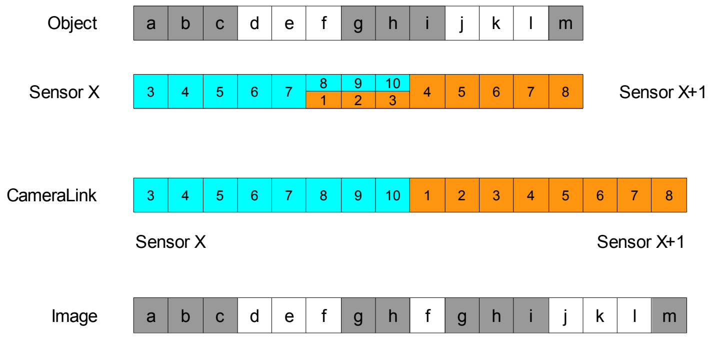
To prevent a gap between sensor-chips, they can be arranged in two different, by 90° opened layers . The sensor-chips are arrayed, that the ends overlap. A beam splitter (glass for semi translucent mirror) in the path of light reflects it on both lines at the same time. In this method, there is no need for buffering in a FIFO-MEMORY, but the overlapped pixels are still being displayed twice.



Img. 2.2.6-1 Zero Gap, with beam splitter



Img. 2.2.6-2   Perspective : Zero Gap, with beam splitter



Img. 2.2.6-3 Object and its image in a Frame Grabber

Fig. 2.2.6-3 illustrates the overlapped pixels. The object is detected by the sensor X, with the pixel numbers 3...10, in the range a...h and by sensor X+1, with the pixel numbers 1...8, in the range f...m. The pixels of sensor X and sensor X+1 are now transferred one after the other to the frame grabber. The object range f...h is available twice, since it has been detected by both sensors.

The tolerances presented in image 2.2.4-2 at the chip´s montage also occur here. The tolerance in x-direction generate an irregular overlap of the single sensors, in y-direction stags to the two ideal lines.

2.3 Illumination and its controls

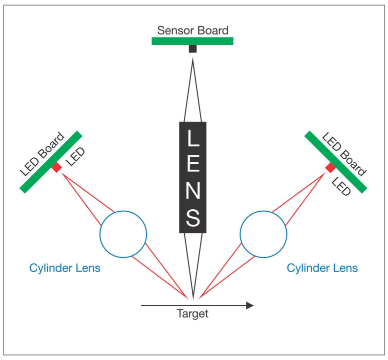
2.3.1 Illumination

LED´s are used for illumination. They are available in different colors, illumination -strength and radiation angles and can be combined to every length, can be quickly controlled and operated using 24 VDC.

Structurally identical LED´s can distinguish among each other in the emitted illumination-strength. To a certain level that´s not an issue because the camera´s pixel-correction (see 3.4) can eliminate this issue.

The LED-rows are in general positioned in the same case next to the sensor (see image 2.1.1-1). They are longer than the sensors, guaranteeing the exact same illumination at the end of an sensor as they are in the middle.

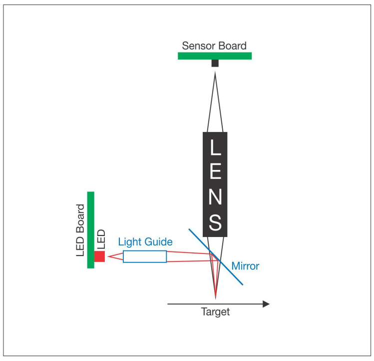
The illumination of the LED-lines can be bundled up to the working distance and focus line of the sensor by cylinder-lenses : diffuse light



Img. 2.3.1-1 diffuse light

An optical element such as a glass disc, which will be inserted into the beam path between CIS and object, relocates the illumination line away from the focus line by its refractive index. Furthermore the working distance increases by about 1/3 of the glass thickness.

The illumination can also be focused on the object by an semipermeable mirror: coaxial illumination.

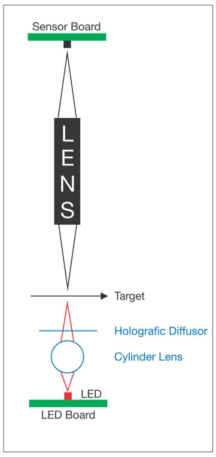


Img. 2.3.1-2 coaxial illumination

The brochure "CIS Illumination Guide" describes in detail the various lighting options, their effects and application examples.

Since image sensors usually cannot distinguish colors, the object can be illuminated with different colored light. Therefore, red, green and blue LEDs are used in the RGB-CIS.

All CIS have exposure control as standard. External lighting units have their own control cable to the CIS.



Img. 2.3.1-3 external back light

The lighting is switched on in the terminal with the command "L1 Light on/off" and switched off again with the command "L0 Light on/off".

LED-lightning in visible range are classified to risk group 2 according to DIN EN 62471, meaning short termed lightemission is non-dangerous for eyes.

Please get clarification by your laser representative!

Never look directly into the illumination!

2.3.2 Diffusor

LED's are nearly punctual light sources, that own a club-shaped emitting characteristics. Because of that a wave-like light intensity spread arises along a LED-line.

For strong reflecting objects or back light illumination this figure is reproduced by the sensors. In such cases holographic diffuser films are used, that homogenise the illumination. They own the feature to strongly stretch the round light cone of the LED´s in x-direction, but not or only weak in y-direction.

Img. 2.3.2.-1 Effect of a diffuser

In the image 2.3.2-1 a punctual light of the LED´s is shown on the right site, on the left site a holographic diffuser film provides for a homogeneous light band.

When using diffuser films an extension of the exposure time has to be counted in.

The used diffuser films own a transmission level of 88-92 %. Moreover not only the required diffusion in x-direction takes place but also to a lower part in y-direction.

Optional the diffuser films can be housed in the CIS, the diffuser is recommended in an external back light illumination.

2.3.3 Filter

For specific fields of application the illumination can be customized by a filter. Color filter, UV-filter, polarising filter, blocking filter can be integrated in the CIS.

2.3.4 Illumination control

The illumination control controls the LED´s by Pulse-Width-Modulation (PWM).
It can tune the exposure and line rate and reach a shutter.

The operator configures an suitable brightness for his operation. Therefore he can use a terminal command (see 3.1.2 serial communication) 'E<val> Set Exposure' which directly takes influence on the duration the LED´s are switched on.

Increasing the line rate, the illustration control automatically increases the apparent brightness. This is crucial, because with a shorter exposure-time of the sensor more light has to irradiate to always expose the sensor at the same level. The outgoing image brightness stays constant.

If the period duration of the line-scan frequency becomes lower than the exposure-time, the exposure control will limit the scan frequency. As a consequence the pixel becomes a more rectangular form. The line-correction does not fit exactly anymore and a color offset occurs.

In free run mode (M0) it will call attention if you create such an constellation using the 'E' or 'F' command. Running in triggered mode, this effect can easily occur.

Because the recorded object is close at a working distance of 10 mm (see 2.4.2), it screens external illumination, though you still want to prevent the CIS to be placed at unnecessary bright illumination.

Trigger impulses trigger in dependency of the mode 'M<0-4>' and Light on/off 'L<0,1>' the lines illumination.

M	L	Triggerpulse	Illumination
0	0	continuous, free-run	no
0	1	continuous, free-run	yes
1,2,3,4	0	none, external	no
1,2,3,4	0	yes, external	no
1,2,3,4	1	none, external	no
1,2,3,4	1	yes, external	yes

Tab. 2.3.2-1 Trigger pulses and illumination

2.3.5 Monochrom-CIS

A Monochrome-CIS switches the illumination on and off for every line. The switching-frequency of the LED´s amount between 100 Hz and 250 kHz and equals the selected or triggered line rate. Because human eyes cannot see switching-frequencies of about 70Hz, the illumination will be percieved as constant lighting.

There is hardly any difference in what color the LED´s are. The sensor only reacts to brightness. Due to economical reasons red LED´s are standard.

The object to be recorded may need other illumination.

The trigger-impulse triggers the illumination of the line, the LED´s will be switched on with the chosen exposure-time ('E'), then the sensors will be read out into an buffer memory and are waiting for the next trigger-impulse.

Monochrome – CIS only own one illumination phase meaning that every trigger-impulse only triggers one illumination.

2.3.6 RGB-CIS

A RGB-CIS has separate LED´s for every color. In one LED-line there are red, green and blue LED´s next to each other. The exact order is R-G-B-G-... , complying to the Bayer Matrix.

A trigger-impulse causes a triple illumination of the line. The illumination in phase 0 red, in phase 1 is green and in phase 2 is blue.

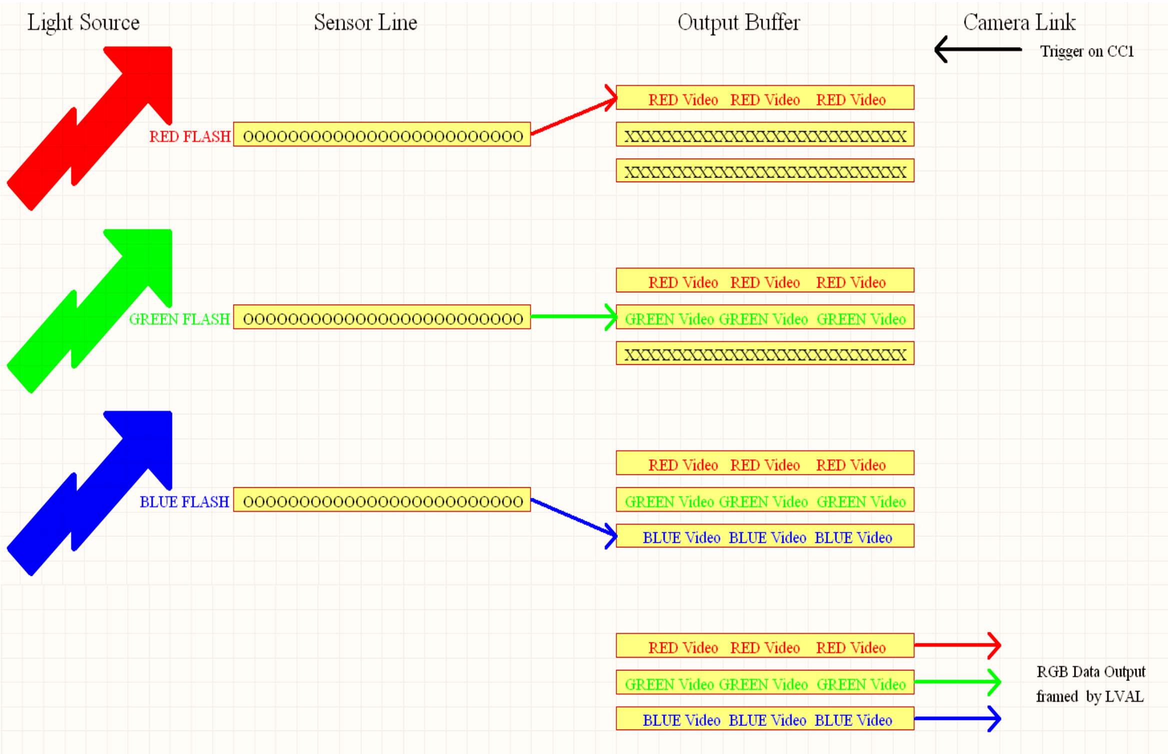
For phase 0 all red LED´s are switched on, the illumination time expires, the LED´s are switched off, the sensor is read out and the brightness-information is written in the buffer memory.

This process will be repeated for phase 1(green) and 2 (blue).

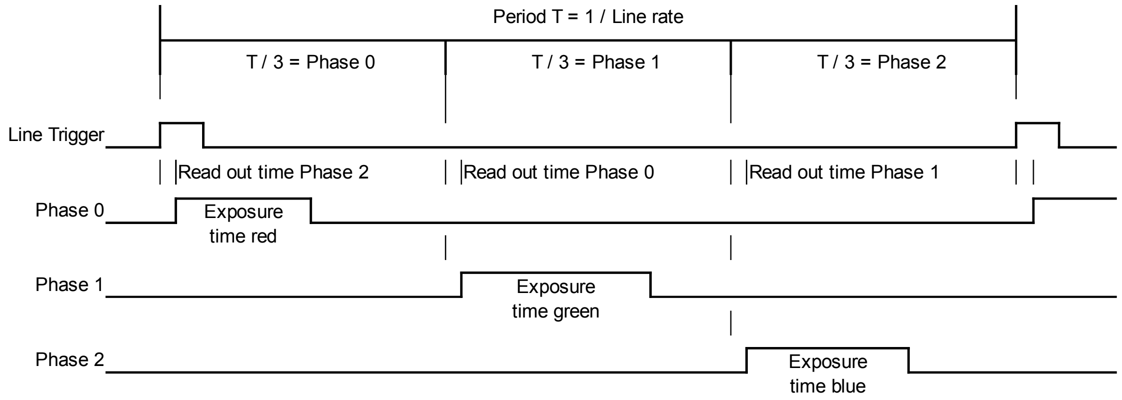
Everything was triggered by one single trigger-impulse. The buffer will be read out commonly and send to the Frame Grabber as RGB – signal.

That is why an RGB-CIS is normally slower than a Monochrome – CIS

This operation is called Multiplex Approach.



Img. 2.3.6-1 Multiplex Approach



Img. 2.3.6-2 Timing Diagram of an RGB - sequence

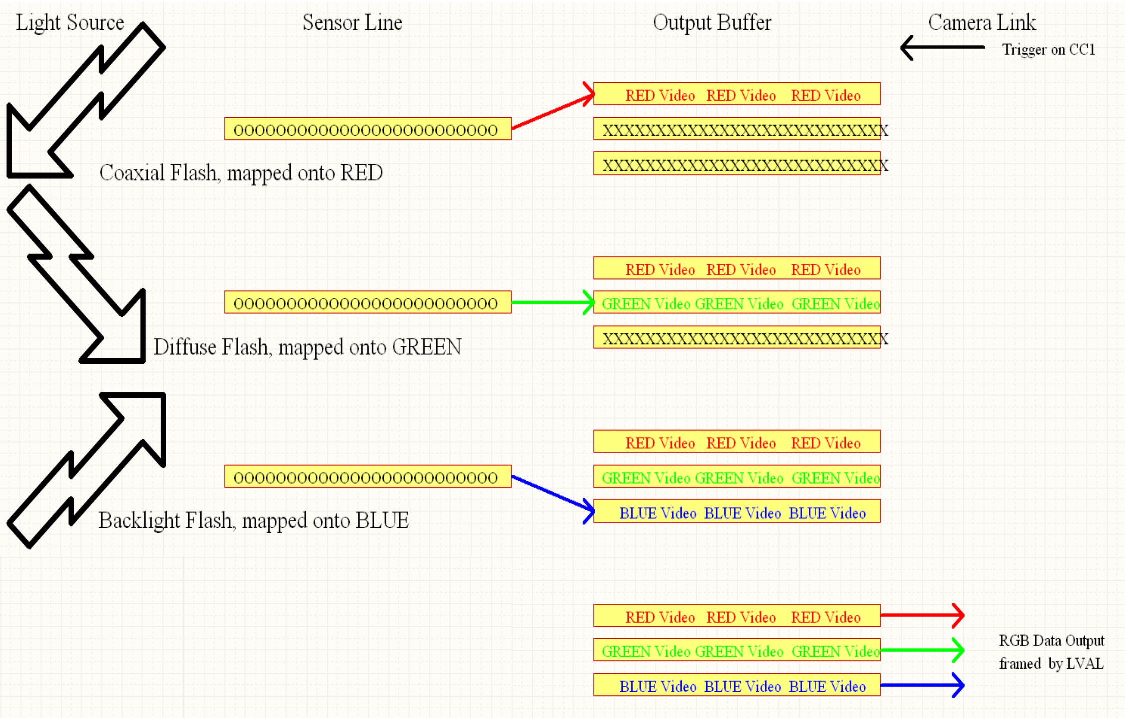
The meantime between two trigger pulses (Period T) will be equally split to the count of illumination phases.

With the serial working off the single colors it inevitably comes to a slight offset of the recording. The first color channel exposes, slightly set off, an other point then the second color channel and so long, because the scanned object meanwhile minimal moved forwards. The offset is the way the object covered during the exposure and selection time of one color. Since this offset is known, this is taken into account in the buffer memories and the output is offset in such a way that no color fringes occur.

For the time offset of the single color lines faces a geometric equality. Because each line is exposed by the same sensor, a feature of the object matches exactly to the same pixel in all 3 colors.

2.3.7 False Color - CIS

According to the same schematics of an RGB-CIS, there can also be sorted to false colors. A RGB-CIS has three different types of LED-rows. Each LED-row has one color channel assigned to it. One trigger impulse actually creates three pictures, depending to the spacial position of the respective LED-rows



Img. 2.3.7-1 Example of false color assignment

In the example firstly the coax illumination is being flashed, then the defuse light and finally the external illumination. In that way the three images are assigned to the RGB-Memories and given to the Frame-Grabber as RGB-data.

There are also other configurations for an false-color-RGB-CIS.

e.g.: A monochrome CIS has one LED-row but this row is operated successively with three different exposure times. At the image evaluation the most meaningfull image is being processed.

e.g.: A RGB_CIS can query up to twelve different illumination channels on each trigger impulse. In that way for example there can be used an internal direct and external backlight RGB-illumination with different exposure times.

These technique with color- and false-color-imaging also enables us to draw specific color characteristics by simply adjusting the LED´s.

2.3.8 Mixed light, phase model

The CIS can handle up to twelve illumination-channels in up to six illumination-phases. These channels can be assigned to the phases as needed. The brightness of every illumination-channel can be adjusted.

Your display of the terminal could look like that:

*** Exposure ***

	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Phase 0:	140	0	0	140	0	0	0	0	0	0	0	0
Phase 1:	0	126	0	0	126	0	0	0	0	0	0	0
Phase 2:	0	0	136	0	0	136	0	0	0	0	0	0

Phase 0 to 2 are exposure phases.
C0 to 11 are the illumination channels:

C0...2	RGB-LED-Row 0 diffuse
C3...5	RGB-LED-Row 1 diffuse
C6...8	RGB-LED-Row coaxial
C9..11	external RGB-LED-Row

The numbers in the matrix-points represent the actual exposure-time in 100 ns counts.

In this case we have an RGB-CIS with two diffuse LED-Rows. Channel C0 and C3 are the red LED´s, C1 and C4 are the green LED´s and C2 and C5 the blue ones.

Another exampel:

*** Exposure ***

	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Phase 0:	100	0	0	100	0	0	50	0	0	0	0	0
Phase 1:	0	80	0	0	80	0	0	40	0	0	0	0
Phase 2:	0	0	85	0	0	85	0	0	45	0	0	0

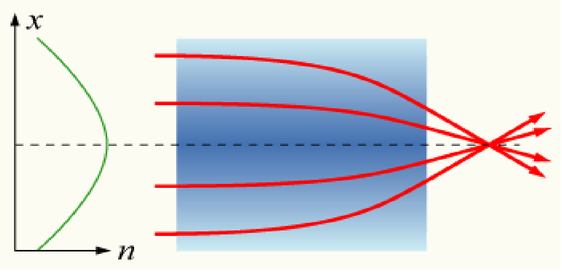
In that case a RGB-CIS with 2 diffuse LED-rows and one coaxial LED-row is present. The channels C0 and C3 are the red diffuse LED´s with the exposure-time of 10 µs, C1 and C4 are the diffuse green LED´s with 8 µs and C2 and C5 are the diffuse blue LED´s with 8,5 µs. The coaxial channels C6 red with 5 µs, C7 green with 4 µs and C8 blue with 4,5 µs illuminate at the same time with the same colored diffuse channels, so that a mixed light of diffuse and coaxial arises.

With 6 exposure phases, two independent RGB images can be captured

2.4 Optics

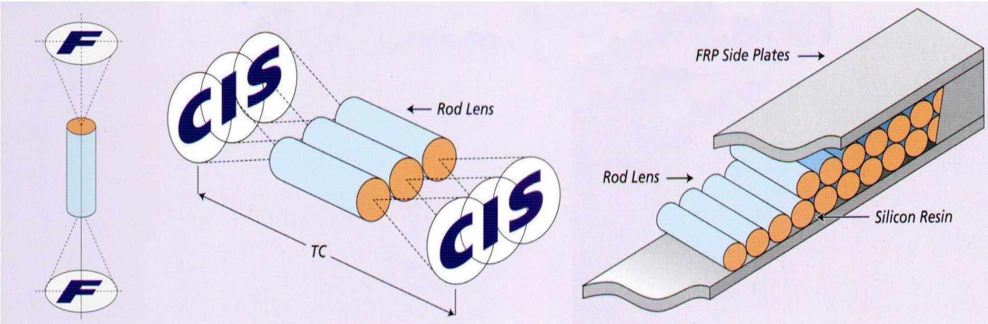
2.4.1 GRIN Lense Array

GRIN-Lenses (Graded – Index - lenses) are cylindrical segments (Rod Lens) of a graded index fibre. It has a feature that its refraction number n continuous decreases to the border. Thereby there is no total reflection of the coupled light beams on cylinder border arising, but they run sinusoidal bent through the fibre



Img. 2.4.1-1 Operation of a graded index fibre

An appropriate choice of the length of the fibre segment generates in front of the both front surfaces of the cylinder 2 identical focal lengths and working distances. An object in front of the one front surface is identically pictured as an image on the other front surface, that is an upright (non inverted) image with 1:1 scale (see Img. 2.4.1-2, left). The optical features are comparable with a biconvex spheric lens. Although the GRIN-lens owns only a diameter of 1 mm or less.



Img. 2.4.1-2 GRIN-Lense-Array

Corresponding to the size of a GRIN-lens only a small range can be pictured with one lens. For the wished picturing of an image line there are many single GRIN-lenses joined side by side in a row, whose images overlap by that. To improve the imaging features 2 rows are sticked side by side, bordered with 2 cover plates and the pictured GRIN-lens-array arises (see Img. 2.4.1-2, right). With these multiple overlapping a high homogeneity is achieved.
The – uncorrected – intensity fluctuations are about 7 % (according to vendor disclosure).

2.4.2 Working distance

In the different CIS - types GRIN-lens-arrays with a working distance of about 5...15 mm are mounted. The measure „TC“ in image 2.4.1-2 is given by:

cylinder lens length + 2 * working distance of the GRIN-lens

and is fixed set by the array type.

In the image 2.1.1-1 it is apparent out of the principal structure of a CIS, that there is a glass pane in front of the GRIN-lens-array. It mostly owns a thickness of 2 mm. Therefore the usable working distance of the CIS is decreased by these glass thickness. Simultaneously this optical element increases the working distance of the GRIN-lens-array by 1/3 of the glass thickness.

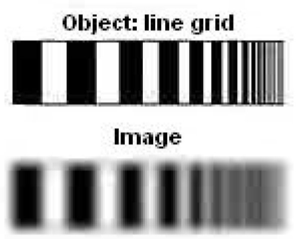
The same applies if an object has to be scanned through a glass pane. The focal line moves by 1/3 of the glass thickness and increases the working distance. Example: A 3 mm thick pane increases the distance by 1 mm.

If the CIS is equipped with a coaxial illumination (see img. 2.3.1-2), between the glass pane and the GRIN-lens-array there is placed an additional semi-permeable mirror. That one decreases the working distance by about 3 mm.

The specifications on the data sheet refer to the typical usable working distance, that is the distance between the glass pane of the CIS and the object. On the nameplate of each CIS the controlled working distance is noted.

2.4.3 Depth of field

The depth of field (DOF) is the expansion of the range before and after the image plane where the image can still be called sharp.
The definition of the depth of field results by measuring of the modulation transfer function MTF (Modulation Transfer Function). The MTF is the mathematical description of the edge contrast of the image in proportion to the edge contrast of the belonging object.



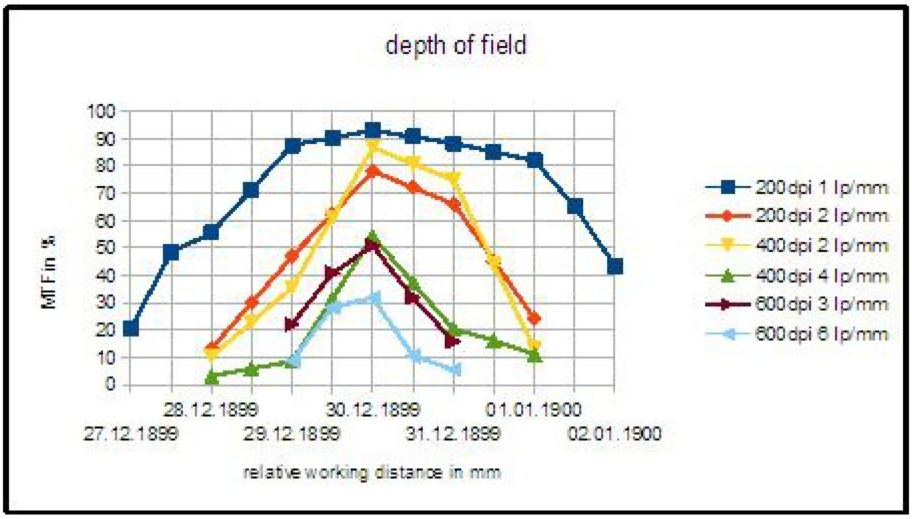
Img. 2.4.3-1 edge contrasts object - image

The MTF is defined by:

MTF = [white (object) – black (object)] / [white (ref) – black (ref)]

(object) line grid: 1 line pair / mm for 8 Pixel of the sensor
(ref) white or black wide object range

In the formula the single grey levels are to set.



Img. 2.4.3-2 field of depth curves

The range before and behind of the working distance where the MTF is better than 20% is defined as depth of field and stated in mm.

In the following table there are shown the depth of field ranges for a working distance of 10 mm depending to sensor resolution.

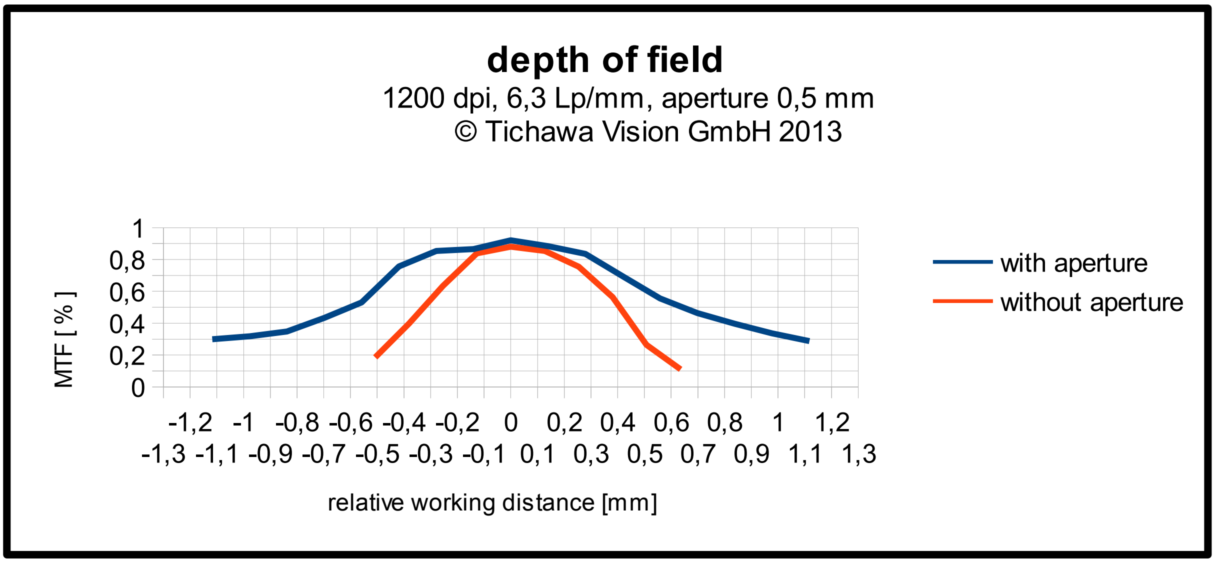
dpi	Depth of field [mm]
25	+ 16 / -10
50	± 8
75	± 6
100	± 4
150	± 3
200	± 2
300	± 1,5
400	± 1
600	± 1,0
1200	± 0,5
2400	± 0,25

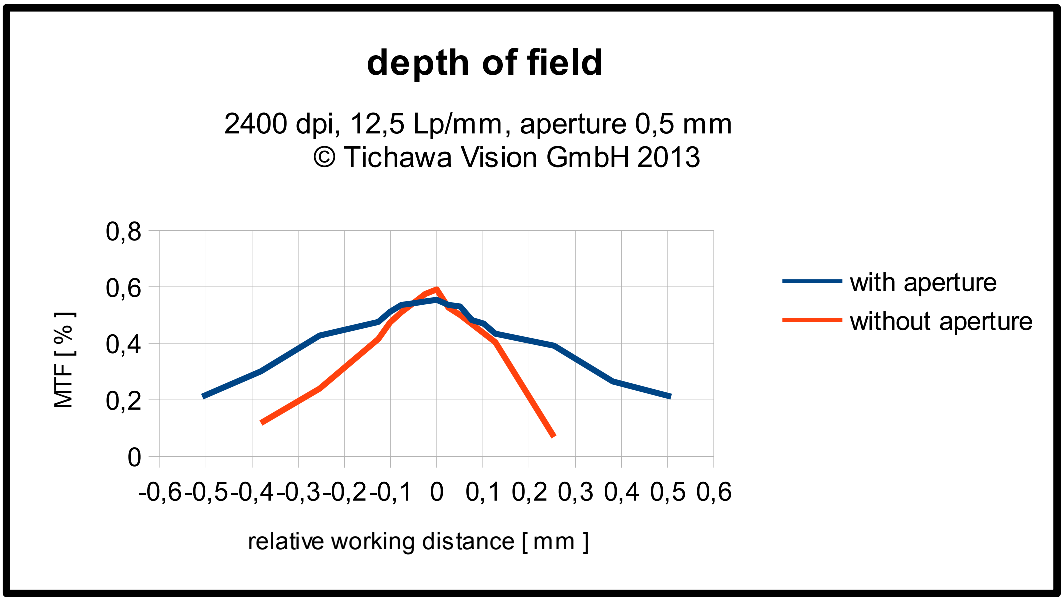
Tab. 2.4.3-1 depth of field ranges

2.4.4 Aperture

To improve the depth of field for higher resolutions of 1200dpi and 2400dpi a aperture film can be precisely put on the GRIN-lens. With that indeed the exposure time is extended with the factor 3...4, but the MTF curve runs lower. For lower resolution no noticeable improvement can be reached.

The diameter of the used GRIN-lens is about 1 mm, the single aperture – about 0,5 mm.





Img. 2.4.4-1 Depth of field curves with 0,5 mm aperture

The depth of field ranges are doubled by the aperture.

2.5 Image Transfer

2.5.1 Camera Link

2.5.1.1 Camera Link Standard

The first version of the Camera Link was published in the year 2000. Camera Link is based on the Channel Link Protocol of National Semiconductor.
Camera Link (CL) is an interface of the industrial image processing for fast image transfer with real time. The maximum pixel frequency is 85 MHz. Several parallel streams, called taps, allow a high data rate.

Camera Link is given in five variants:

- Lite (maximal 10 Bit pro tact)
- Base (maximal 24 Bit pro tact) – e.g.: 255 MB/s with 3 taps à 8 Bit
- Medium (maximal 48 Bit pro tact)
- Full (maximal 64 Bit pro tact) – e.g.: 680 MB/s with 8 taps
- Full 80 bit (maximal 80 Bit pro tact) 850 MB/s bei 10 taps

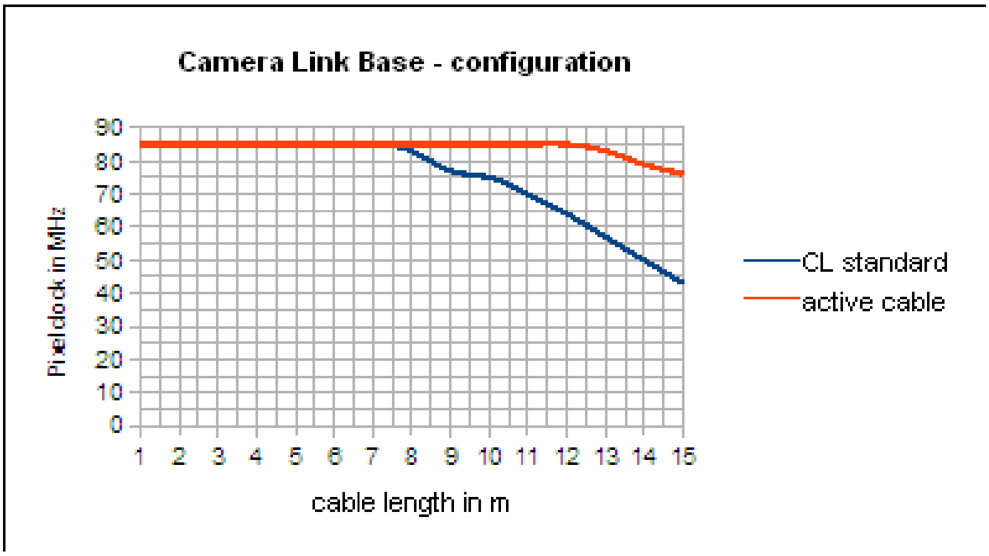
There can be transferred as well monochrome as color images.

The Lite configuration is irrelevant for the CIS.
In the base configuration 1 Camera Link cable is required, for medium, full and full 80 bit configuration 2 cables. The CIS generally uses the base configuration. If the data rate becomes too high for a CL connection, a second CL connection is added and the configuration Medium or Full 80 bit is selected.
The full configuration does not matter, as 2 x RGB can also be transmitted in medium.
The first CL port is defined as master and is the only one to transmit the image enabel, camera control and communication signals (see also 2.5.1.3).

A CL-camera is connected by a CL-cable to the PC, that has to be equipped with a CL-FrameGrabber.

2.5.1.2 Camera Link Kabel

The maximum cable length depends on the pixel clock and the used cable type:



Img. 2.5.1.2-1 cable-length and pixel-clock

Camera Link-cable are available in several standard lengths and specifications. For in the TiVi-CIS standard used 85 MHz pixel clock the standard cable of 5 m should not be exceeded for the sake of safety.

For special CIS versions, lengths of up to 15 m can be bridged in conjunction with selected CL cables.

Active cables own an integrated signal adjusting and pre-amplification, that allows a cable length of about 15 m.

On some CIS-models it´s possible to change the pixel-clock to 60, 40 or 25 MHz. This enables us to use longer cables, but therefore we reduce the data rate of the transfer.

Another possibility to increase the length of the cable is the use of a repeater (see 2.5.1.5)

Img. 2.5.1.2-2 Camera-Link cable with 2 MDR-26-plugs

As the plug is defined a MDR-26-plug or a 26-pole SDR-plug of 3M. The plugs are available with different cable outlets, e.g. straight, collateral, graded.
Connectors with retaining screws have to be used.
As standard the TiVi-CIS are equipped with MDR-connectors.

The smaller SDR-26 connectors are used by some frame grabbers. This must be taken into account when procuring cables.

Starting with the Camera Link Version 1.2 additionally there is defined a Power over Camera Link (PoCL) interface.
Consequently with specific PoCL-cable a power supply of a camera can be realized.
It can transfer maximum 333 mA for 12 VDC.
It can not be used for the TiVi-CIS because of the supply voltage of 24 VDC and the higher electricity demand for the integrated illumination
.

Attention: PoCL-cables are not compatible to a standard-CL-cable

2.5.1.3 Camera Link Signals

The Camera Link-Standard defines the Camera signals:

Video Data = Image Data

Image Enable signals

Those Signals describe the state of the transferred pixels

Signal-Name	Acronym	CIS-level	Description
Frame Valid	FVAL	constant high (1)	not needed for line cameras
Line Valid	LVAL	high (1)	for valid pixel of the line
Data Valid	DVAL	constant high (1)	only for very slow line rates active
Spare	Spare		reserve

Tab. 2.6.1-1 Pixel Qualifier Signal

In the CIS only the Line Valid Signal is active.

Camera Control Signals

4 Camera Control Signals, CC1...CC4, for an pair of LVDS-cable-pairs each (Low Voltage Different Signaling) are freely configurable.

CC1 is intended for the external trigger signal of the camera and is also used in the CIS.
CC2....CC4 are not used.

Serial communication

For the communication between PC and camera there are available two LVDS – Interface-Standard (Low Voltage Different Signalling) line pares. The serial interface owns the features:

9600 Baud
no handshake
no parity
1 start bit
1 stop bit

By using a terminal program the communication with the camera is possible.

Any terminal program can be used. On the web-site of Tichawa Vision there is also a terminal program available for download: TiViCISIF

2.5.1.4 Camera Link Frame-Grabber

The CIS is an special form of an line-camera, which has to be supported by the Frame-Grabber.

The CIS in the Camera-Link version, operates on an pixel-clock of 85 MHz using the default configuration. That enables us to transfer data up to 255MB/s

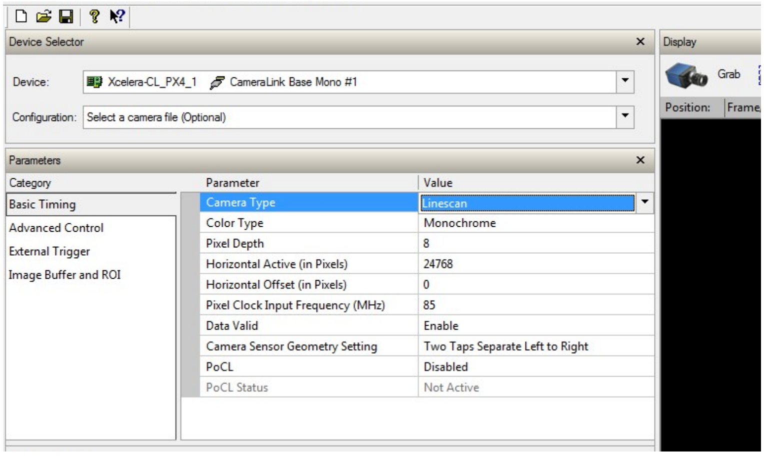
By default the serial communication uses the RS-232 – interface and the trigger-impulse use the CC1-signal of the camera-link connector.

Both signals are transfered over the FrameGrabber and the Camera Link cable to the CIS.
The trigger signals can usually be adjusted to the CIS with pre-scaler and/or multiplier.
The terminal program for serial communication is integrated to the FrameGraber over a COM-interface or a DLL or the FrameGrabber provides an own input mask.

The CIS data sheets show the number of Camera Link connectors and the number of ports per connector.

For each Camera Link connection an own FrameGrabber or a Grabber with several connections is needed.

For the transferring of the RGB-signals all ports of Base-connection are used.
For the transferring of the monochrome signals with higher data rates the signals are split over several ports and rightly restrung together in the FrameGrabber. When for example on the data sheet 2 ports are given, in the FrameGrabber 2 taps will be set left to right.



Img. 2.5.1.4-1 Example using an Dalsa Frame-Grabber

Camera Sensor Geometry Setting –Two Taps Separate Left to Right

Other criteria for choosing is the maximum number of pixels of the CIS and the data-rate to work on.

2.5.1.5 Camera Link Repeater

The Camera Link cable are limited to about 5 m with the pixel clock of 85 MHz. With the repeater Tichawa Vision offers a doubling of the reachable cable length. The repeater is located in a separate housing and is included between 2 Camera Link cables.

It owns a Camera Link receiver- and a Camera Link transmitter component. The repeater receives the already weakened signal, transforms it to a RGB-signal, supplies with it the transmitter component and gives over the refreshed Camera Link signal to the next cable. Camera Link transmitter components can only run a certain cable length. Is these length exceeded the video signal can be weakened that far, that an undisturbed receiving in the FrameGrabber is no longer possible.

The repeater needs a 5 VDC, 200 mA power supply, that can be provided via USB from the receiving computer.

2.5.2 GigE Vision

GigE Vision is a in the middle 2006 established interface-standard for the industrial image processing. It allows the connection of industrial cameras over networks by using of the Gigabit-Ethernet-Standard.
The features of the GigE Vision Standard:

- High data rates – up to 100 MB/s (based on Gigabit-Ethernet)
- Cable lengths up to 100 meter without amplifying
- Low Cost CAT5e or CAT6 cable
- Multiple offers on specific cables, e.g. chain compatible, robot compatible,...
- Based on existing Ethernet Standards and existing hard- and software
- Several cameras on one host

The standard, that fathered about 50 firms, shell provide an exchanging of hardware products basing on the protocol UDP/IP and the GenICam interface enable vendor independent software for any GigE Vision cameras.

The plugs are available with different cable outlets, e.g. straight, lateral, graded, with horizontal or vertical contacts.
There have to be used plugs with retaining screws.

The CIS, in GigE Version, equipped with a Pleora IP Engine, operates as standard with a pixel frequency of 40 MHz.
The recommended cable length is 30 m for a CAT5e cable.
The communication runs over the Ethernet cable, whereas for the triggering an own cable to the CIS is needed.

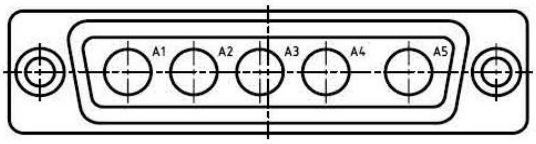
As standard the MaxiCIS is deliverable in GigE-version. In these CIS there is enough space to accommodate the Pleora IP-Engine.

2.6 Power supply

2.6.1 Power plug

WARNING: It is crucial to only apply the right operating voltage. False or reversed voltage can damage the CIS

The plug connection of the power-supply is the TiVi-Type 03974.



Img. 2.6.1-1 Drawing of the Power Connector

PIN	Signal	Wire-Nr
A1	+ 24 V	1
A2	+ 24 V (LED)	2
A3	not used	5
A4	GND (LED)	3
A5	GND	4

Tab. 2.6.1-1 Pin assignment power plug connection

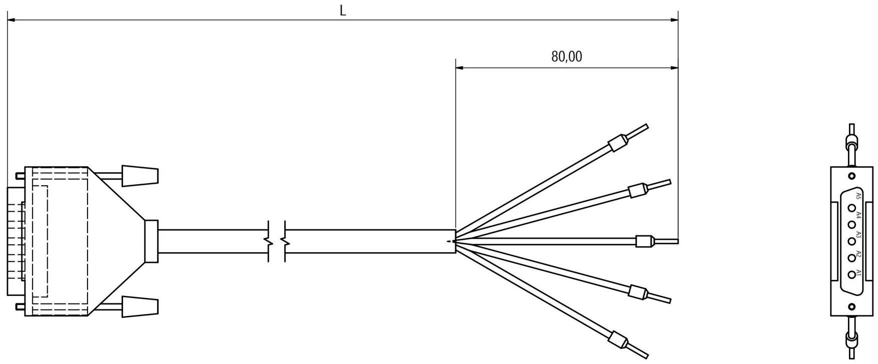
The plug-connection is an five-pole D-SUB with high-power-contacts.

Each plug-pin (except pin 3) has to be connected to an wire and every wire has to be assigned to an power-supply-clamp.

2.6.2 Power Cable

The CIS needs a supply voltage of +24 VDC and GND. It may fluctuate by maximum ± 1 V. Decisive is the voltage on the CIS and not on the output clamp of the power supply.

Suitable for the CIS we offer an assembled, flexible power cable with 5 x 1,5 mm². Here for each 2 wires are connected for +VDC and GND, so an affective line cross section of 2 x 1,5 mm² = 3 mm² is available. On the one site there is mounted a suitable power plug for the CIS, on the other end there are blank wire end ferrules, suitable to be screwed in the power supply clamps.



Img. 2.6.2-1 Power cable

Cable-length [m]	Line lenght [m]	wire-cross-section [mm²]	Resistance [Ω]	Power [A]	Voltage-drop [V]
3	6	2 x 1,5 mm² parallel = 3 mm²	0,0356	2	0,07
5	10		0,0593	2	0,12
10	20		0,1187	2	0,24
3	6	2 x 1,5 mm² parallel = 3 mm²	0,0356	5	0,18
5	10		0,0593	5	0,30
10	20		0,1187	5	0,60
3	6	2 x 1,5 mm² parallel = 3 mm²	0,0356	10	0,36
5	10		0,0593	10	0,60
10	20		0,1187	10	1,19

Tab 2.6.2-1 Voltage drop with a temperature of 20°C

The consideration of the voltage drop over the power cable should be performed with the planing, because the CIS can have a depending on the illumination high current demand.

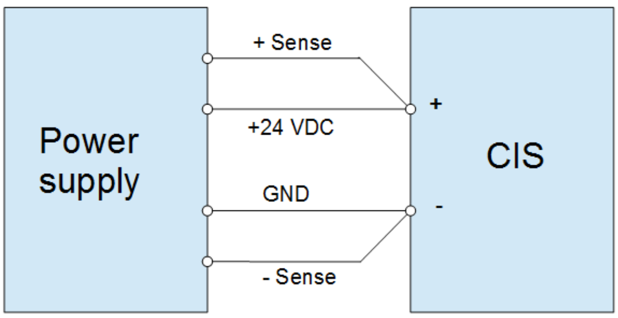
As can be seen from the table, already with a 10m-cable and a current consumption of 10 A the voltage tolerance is already over ranged.

The standard lengths of the power cable are 2 m, 3 m 5 m and 10 m. Other length are available on request.

The expected maximum current of each standard CIS is stated in the data sheet, for special designs it is noted in the offer.
On the type plate the real current demand is stated. It is measured for each CIS during the final test.

2.6.3 Remote Sense Lines

For application scenarios where is needed a very long cable or a very strong illumination, it is usefully to choose a current supply with remote sense lines.



Img. 2.6.3-1 Remote Sense Lines

The sensor lines measure the voltage directly on the CIS and the power supply can regulate the voltage drop on the charging line.
The power supply has to be equipped for such sensor lines.

Such current supplies with corresponding cables are available on request.

2.6.4 Power supply

Safety

SELV (Safety Extra Low Voltage) is with IEC/EN 60950 a safety low voltage. It may not out range 25 VAC or 60 VDC.
Even for a direct contact of parts under voltage there is no danger of body currents for the human health.
The also demanded safe separation is reached for the power supplies with a doubled or increased galvanic isolation of the primary and secondary sites with assistance of safety transformers.
A circuit corresponding to the SELV – standards may not show a galvanic connection to the ground on the secondary site.

PELV (Protective Extra Low Voltage) is with IEC/EN 60950 a safety low voltage with safe isolation. For the voltage ranges the same standards apply like for power supplies with SELV. The safe separation is reached, as like as for SELV, through doubled or increased galvanic isolation of the primary and secondary sites. The users supplied by PELV circuits may be grounded.

Functional ground

A circuit corresponding to the PELV – standards for “electrical equipment for machines“ has to show an galvanic connection to the ground.
Although it is not a safe ground but a functional ground: It serves for removing of static charges and electromagnetic interferences.

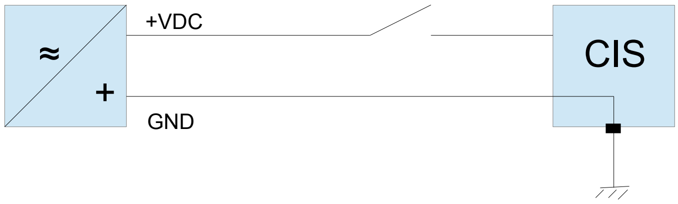
In the CIS the GND-contacts of the power plug are connected to the CIS-housing. During the mounting of the CIS attention has to be paid for a good electrical connection to the fixing support and its signal ground. It may be the only one connection of the CIS-PELV-circuit to the signal ground to avoid ground loop that could cause uncontrolled compensation currents.
A connection of the GND-clamps of the power supply to the ground is **not** allowed.

In this context a good signal ground is important, where all electrical components are connected to.
Bad or missing signal ground can cause image errors: When the ground potential difference between the CIS and the FrameGrabber/PC is greater than 200 mV, common mode interferences in the Camera Link can occur then making an appearance as image errors.

Unclean grounding can cause, for extreme illuminations driven by the CIS, a glimmer of the LED´s with power switched off.

power-circuit

It is recommended to connect the current supply of the CIS in the 24 V sector, so that with initiating phase of the CIS a clean DC voltage is present.



Img. 2.6.4-1 CIS power circuit

Power supplies are also suitable which do not apply the voltage to the output terminals until the 24 V have stabilized.

3 Software-functions of the CIS

3.1 Controls of the CIS

3.1.1 Trigger

By triggering the CIS the line rate is synchronized with the moving speed of the object. A correct image assumes square pixel. This is set if each moving forward of the object for the way length of one pixel generates a trigger pulse. There for an encoder is normally mounted on the transport device of the object.
Example:
By using a 600 dpi CIS with a pixel size of 42,3 µm the encoder has to put out <u>one</u> trigger pulse for the object has also moved forward for 42,3 µm.
The image quality depends straight on the precision of the trigger signal generating.

Each increasing signal flank of the trigger pulse initiates the capturing of one line. That means that the illumination is switched on for the duration of the exposure time „E“, next the sensor chips are selected and the system waits for the next increasing signal flank of the trigger pulse.

The number of the trigger pulses per second is called line rate. It essentially constitutes a distance:

line rate in Hz * pixel size in mm = speed of the object in mm / second

The pulse duration of the trigger pulse should be >1 µs. It normally can be adjusted in the FrameGrabber.

The CIS has 5 trigger modes, that are chosen by the command
„**M**<0-4> Set Mode“.

M0 freerunning
M1 external trigger over CC1
M2 external trigger, squaring signal X input
M3 external trigger, squaring signal Y input
M4 slave mode

In the “**M**0   freerunning“ - mode the required trigger pulses are generated in the CIS itself. By the command
„**F**<freq[Hz]>   Set Line frequency“
the line frequency is set.

For the „**M**1   external trigger over CC1“ - mode the required trigger pulses have to be supplied from the outside over the Camera Link cable to the CIS. Here for the camera control signal CC1 is used.
Also see chapter 2.5.1.3 Camera Link signals and 2.5.1.4 Camera Link FrameGrabber.
The active illumination („L1“) of the CIS is automatically switched off with missing trigger pulses and is again switched on with incoming increasing pulse flanks.
To that attention has to be paid especially when the CIS is mounted on a sled and a continuous moving forwards and backwards is present. Each moving generates trigger pulses. So the illumination is switched off only with direction reversal. If the illumination has to be switched on only in one moving direction, in the trigger input card of the FrameGrabber the direction information of the encoder signal has to be analysed.

„**M**2   external trigger, squaring signal X input”
„**M**3   external trigger, squaring signal Y input“
These are options for customized triggering. On the CIS a specific plug for the trigger pulse of an encoder is mounted. The encoder has to provide a TTL-compatible RS422 squaring signal.

The „**M**4   Slave mode“ is used for complex customized CIS when several CPU-boards are installed. Normally on such CIS several Camera Link connections are present. Only over the “Master”-connection the CIS is triggered.

It can come to conflicts between the triggering (= line rate) and the exposure-time „E“:

When the period duration of the line frequency is lower than the sum of the exposure time plus the selection time of the sensors, then either a massage in the terminal program is shown or the line-frequency is automatically is adjusted to the exposure time, that means that the line frequency is decreases and with that the period duration extended. These concerns all CIS are selected to “Rolling Shuter” principle.

For „Global Shutter“ capable sensors the selection time is dropped and the conflict arises, when the period duration of the line frequency is lower then the exposure time.

For the models with GigE-connection the supply generally takes place over an own SUB-D plug connection, because there is no possibility to transfer time sensitive trigger pulses over the network.

The frequency fluctuations of the encoder signal may be at maximum10 %.

By the command

„**T**<0-255>   Set Trigger Pulses“

a splitter of the incoming trigger pulses (prescaler) is defined. With that the encoder can be adjusted.

Example: **T**10 only each 10th trigger pulse initiates the capturing of one line.

3.1.2 Serial communication

The communication with the CIS is carried over a terminal program as a human-machine-interface. TiVi offers a suitable tool on the homepage named by TiViCISIF for the download. Surely other terminal programs can be used, e.g.HyperTerminal, ProComm, TeraTerm; here for no guarantee can be undertaken by TiVi.

ASCII-commands are used for configuration and control.

The transmissions of the commands is carried out over an integrated serial port as well for Camera Link as for GigE. Here for the port is to be set on standard parameters:

9600 Baud
no handshake
no parity
1 start bit
8 data bits
1 stop bit

The agreements are valid:

- An "Enter" (carriage return) <CR> finishes each command entering
- A command consists of one character and any number of parameters
- All numerical components are to input decimally
- The single parameters are separated by a comma.
- <*text*> stands for one parameter. The text describes either the type of the parameter e.g. *channel number* where from the range then results automatically. Or it directly indicates the range e.g. 0-255.
- the camera answers to the commands with „<CR>:" or „text n<CR>:", where “n” is a number.
  For requests e.g. “?” or “#” a variable number of digits is sent back, depending on the type of the request, followed by “<CR”.

If only the command string is set and complied with “ENTER” on the display the command syntax with its appropriate parameter is shown. So the operator can quickly learn which parameter the command requests.

3.2 Command list

The commands of the main menu are listed. It contains all commands for the CIS to adjust it on its specific operation.
There are also set-menus existing, which can be opened only by giving in a password / with an external dongle. They contain commands are needed for advanced configuration, test and evolution of the CIS. They are used by our technician. For special educated user it is possible to get the password and a dongle. The CIS of the new VRCIS-generation have an individual password.

After initializing the CIS the main menu is shown after several status indications:

?	Help
!	SW-Reset
#	List Parameters
v	Show SW-Version
A	Set ExpoPulses
B	Set BL digital
C	Pixelcorrection
D	Set DL digital
E	Set Exposure
F	Set Linefrequency
G	Set analog Gain
I	AutoSet Offset
L	Light on/off
M	Set Mode
O	Set analog Offset
Q	Set Cycles
d	Set FIFO Direction
V	Set Video Mode
X	Set DL analog
Y	Set BL analog
T	Set Trig. Pulses
Z	Clear|Rest.CorrData
S	Store Parameters
$	Store CorrData
a	Adjustment
c	Get Chan. Stat.

g	Get analog Gain
i	Get pixels to chan.
j	Get channel to pix.
o	Get analog Offset
p	Pixelstatistics
s	Get Sensor Stat.
x	Get X+Y Shift
t	Get Temperature
P	Check password
>	Switch to SETMenu

The main menus depending on the CIS-family are a little different. The listed menu comes from a VRCIS.

3.3 Command description

Main Menu — Command list VariCIS

? Help
Listing of the available main menu commands

! SW-Reset
Software reset

List perm. Par.
Listing of the set parameter

v Show SW-Version
Indication of the software version

A<0-255> **Set ExpoPulses**
no function yet

B<0-5>,<0-255> **Set BL digital**
Bright level – set value of the bright level for the pixel correction

<0-5>	0	exposure phase 0
	1	exposure phase 1
	2	exposure phase 2
	3	*no function yet*
	4	*no function yet*
	5	*no function yet*
<0-255>		digital set value

analogue and digital value (Y and B) have to be even

C<0-2> **Pixelcorrection**

<0-2>	0	pixel correction
	1	Test-Mode
	2	Test-Mode

determined pixel correction values can be saved permanently with **$**.

D<0-5>,<0-255> **Set DL digital**

Bright level – set value of the dark level for the pixel correction

<0-5>	0	exposure phase 0
	1	exposure phase 1
	2	exposure phase 2
	3	*no function yet*
	4	*no function yet*
	5	*no function yet*
<0-255>		digital set value

analogue and digital value (X and D) have to be even

E<ph>,<c>,<value> **Set Exposure**

<ph>	0	exposure phase 0 (RGB color channel red or monochrome)
<ph>	1	exposure phase 1 (RGB color channel green)
<ph>	2	exposure phase 3 (RGB color channel blue)
<c>	0	LED-row 0, diffuse, red or monochrome
<c>	1	LED- row 0, diffuse, green
<c>	2	LED- row 0, diffuse, blue
<c>	3	LED- row 1, diffuse, red or monochrome
<c>	4	LED- row 1, diffuse, green
<c>	5	LED- row 1, diffuse, blue
<c>	6	LED-row, coaxial, red or monochrome
<c>	7	LED-row, coaxial, green
<c>	8	LED-row, coaxial, blue
<c>	9	LED-row, external, red or monochrome
<c>	10	LED-row, external, green
<c>	11	LED-row, external, blue
<value>		enter of the exposure time in 100 ns

example: 10 stands for : 10*100ns = 1000 ns = 1 µs

F<freq[Hz]> **Set Linefrequency**

only for the free running mode „M0“ relevant

freq [Hz] enter the line frequency in Hz

G<ch,val> **Set analog Gain**

<ch> analogue channel number

<val> enter the desired value in decimal format

range 0...63

note: There is also a broadcast-setting where all channels can be set on the desired value: **G**999,<val>

I<start,end> **AutoSet Offset**

<start> analogue start channel – normally “0” = 1. channel

<end> analogue end channel – normally last channel

with that the analogue ADC-offset-values of the CIS are set

L<0|1> **Light on/off**

0 Light off
1 Light on
Value cannot be stored - the CIS always starts with L0

M<0-4> **Set Mode**

0 free running
1 external trigger over CC1.
2 external trigger, squaring signal X input
3 external trigger, squaring signal Y input
4 slave mode

O<ch,val> **Set analog Offset**

<ch> analogue channel number
<val> enter of the desired value in decimal format
value range 0....512, where 0..255 amplifying and
256...512 damping
Note: There is also a broadcast-setting where all channels can be set on the desired value: **O**999,<val>

Q<1-255> **Set Cycles**

<1-255> number of lines for the pixel correction

d<0|1> **Set FIFO Delay**

<0|1> selection of the direction for the shift

V<0-11> **Set Video Mode**

0 Live-image with pixel correction
1 Live-image without pixel correction
0 Live-image with pixel correction
1 Live-image without pixel correction
2 Test-image - constant null - with pixel correction
3 Test-image - constant null - without pixel correction
4 Test-image - constant 80h - with pixel correction
5 Test-image - constant 80h - without pixel correction
6 Test-image - saw tooth - with pixel correction
7 Test-image - saw tooth - without pixel correction
8 Test-image - 2D test-pattern - with pixel correction
9 Test-image - 2D test-pattern - without pixel correction
10 Test-image – saw tooth, vertical - with pixel correction
11 Test-image - saw tooth, vertical - without pixel correction

X<0-255> **Set DL analogue**

Dark Level – set value of the dark value for the auto-offset-setting of the analogue-digital-converter
<0-255> analogue set value

Y<0-255> **Set BL analogue**

Bright Level – set value of the bright value

<0-255> analogue set value

T<0-255> **Set Trig. Pulses**

no function yet

Z<0-2> **Clear|Rest.CorrData**

0 deletes the values of the pixel correction in the RAM

1 writes the values of the pixel correction from the EEPROM to the RAM

2 reserve

S **Store Parameters**

saves the actual parameter

$ **Store CorrData**

saves the actual pixel correction values

a **Adjustment**

adjust tool, shows the fluctuation of the reading line from a focus pattern

c<ch> **Get Chan. Stat.**

<ch> analogue channel number

g **Get analog Gain**

shows the analogue amplifying values

i<ch> **Get pixels to chan.**

Indicates the appropriate pixel number range for the set channel

<ch> enter the desired channel number

j<pix> **Get channel to pix.**

Indicates the appropriate channel for the set pixel number

<pix> enter the desired pixel number

o **Get analog Offset**

shows all analogue off-set values

p<col,pix> **Pixelstatistics**

<col> 0 for monochrome sensors

<pix> enter the desired pixel number

s **Get Sensor Stat.**

shows sensor statistic

x **Get X+Y Shift**
indicates the correction values for the geometrical correction in hexadecimal notation

t<0|1> **Get Temperature**
indicates the average temperature in the CIS
temperature sensors are set on almost all electronic boards
0 writes exactly 1 value
1 writes continuously values

P<password> **Check password**
enter the password
needed to get to the SET menu

> **Switch to SETMenu**
jump to the SET menu after entering the password

With the set – commands the parameter values can be changed. These changes are immediately activated after confirming with Enter, but they are located only in the actual working memory and are lost again after switching off. With the new switching on the permanent saved value is loaded to the working memory. To permanent save the changed parameter, after confirmation of the changing with Enter it has to be saved with the command **S** **Store Parameters** . With that the originally existing value is overwritten.

Get – commands indicate the actual parameter values on the terminal.

The commands **C**<0-2> **Pixelcorrection** and **I**<strt>,<end> **AutoSet Offset** cause automatic calibration procedures. For that before compilation the right requirements have to be set. Below these two commands are handled in detail.

3.4 Pixel-correction

3.4.1 General

The pixel correction, also white balance or shading correction, adjusts the CIS to the object to be scanned. This is custom specific and it is necessary to apply the pixel correction to it.

The pixel correction serves to balance the different pixel sensitivity, tolerances of the LEDs and the irregularities of the illumination and the lenses. For each pixel the dark value is set to the given set value and a gain factor is calculated that increases the actual grey value to the given set value. The pixel correction operates digitally.

The CIS owns a low frequency dependence. Because of that it is useful to carry out the pixel correction with a line rate according to the later operation.

It is necessary that the correction of the sensor is controlled from time to time and calibrated if applicable.

As balance pattern (= reference) should be used a neutral sample of the scanned object. The more regular the surface of the pattern the better later scan result.
It is advantageous when the pattern is moved during the pixel correction. Then several sampled lines (set with „**Q Set Cycles**") are implied in the correction, because from this total the mean value is determined. With that smallest defects on the pattern are balanced. The higher the chosen **Q**, the more precise is the mean value, but the longer takes the correction.

The following parameter are directly implied in the calculation of the pixel correction:

D	Dark Level Digital	To these density value (= set point setting dark) the minimal illumination is adjusted
B	Bright Level Digital	To these density value (= set point setting bright) the maximal illumination is adjusted.
Q	Cycles	The number of lines are sampled in the pixel correction. Over the sampled lines the mean value is determined and these raw value is used for the calculation.

H	Gain factor	These number sets , in which proportion can be corrected. 2 means 1:2, 3 means 1:3, etc. These value is factory set and is normally not changeable by the user. Standard value is1:2. With higher values the noise also increases.

Following command also manipulate the pixel correction data:

Z	Clear|Rest.CorrData	Delete respectively restore the correction data
$	Store CorrData	Save the correction data. As long the **$** is not activated, the correction data is lost with switch off of the device.

A condition for a successful pixel correction certainly is a clean front plane of the CIS and a suitable, clean reference pattern that is placed in the working distance of the CIS.

At the factory the pixel correction for diffuse illumination is carried out and saved as standard on white paper and for coaxial illumination on a mirror .

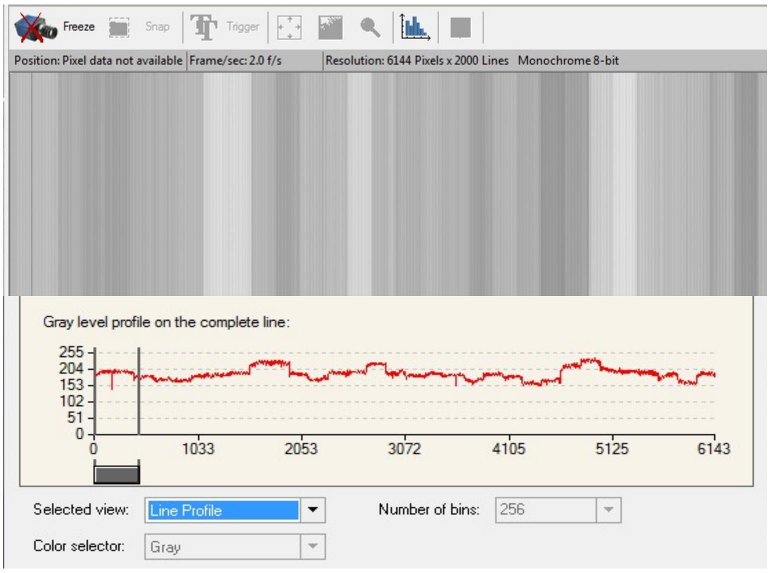
Thereby the default values are set:

Dark Level Digital	**D**10	
Bright Level Digital	**B**230	
Cycles	**Q**10	
Gain factor	**H**2	
Exposure time	**E**....	(individual value for each CIS)

3.4.2 Pixel correction for monochrome light

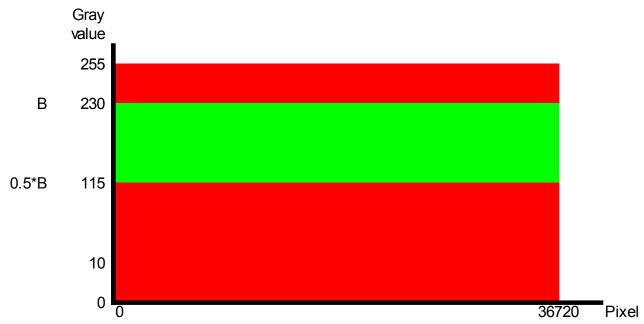
Notes to FrameGrabber activities refer to the Dalsa Xcelera – Grabber. With other models appropriate commands have to be used.

- place the suitable balance pattern moveable in the working distance (see type plate) of the CIS
- open the Frame Grabber and set to the CIS (camera file)
- open the terminal program (e.g. TiViCISIF)
- switch on the CIS
- Freerun-Mode „**M**0“ has to be active
- with „**#**“ the preset parameter values can be requested
- if applicable adjust „**D**... Dark Level Digital“ , „**B**... Bright Level Digital“ and “**Q**.. Cycles“ to the requirements
- delete the actual pixel correction with „**Z**0“
- the light is still off and no external light penetrates
- sample one image in the FrameGrabber and switch to the display „Line Profile“.
- now a graph over the whole CIS width should be shown, that corresponds to the grey value dark level analogue. If these is not the case, the procedure „**I**.. Auto Offset" is to be carried out (see chapter 3.5).
- switch on the light of the CIS with „**L**1“
- now a graph over the whole CIS width should be shown, that represents the uncorrected CIS. For that see the Grey Line Profile in Img. 3.4.2-1

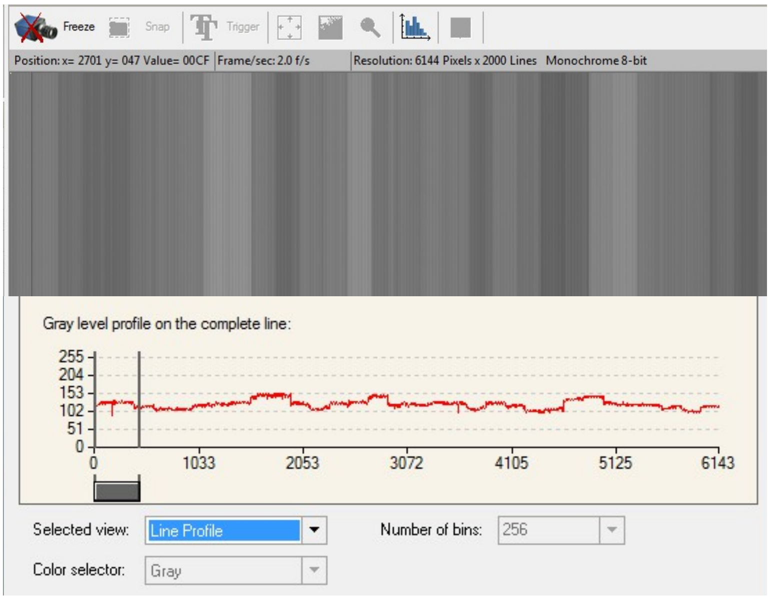


Img. 3.4.2-1 non-corrected CIS, no pixel-correction

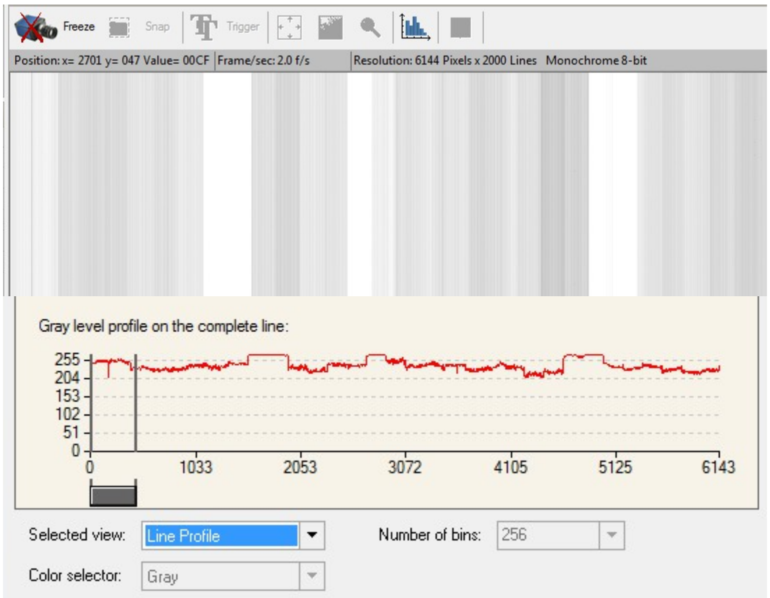
- move the graph with the exposure time „**E**...“ so that it lies in the value range 0,5***B**.....1***B** (Bright Level Digital). The pixel correction now increases each pixel so that its value lies on the set 230. Die maximum amplification **H** lies as standard an 2, so 0,5***B***2 is exactly **B** .



Img. 3.4.2-2 green : allowed range of the line-profile



*Img. 3.4.2-2 pixel values partially lower than 0,5****B***



*Img. 3.4.2-3 pixel values partially higher than **B***

The pixel correction only can amplify. If a pixel over sizes the value of **B** before correction, so these value is maintained and can not be corrected.

- Start the automatic pixel correction with „**C**0“ , move the pattern during bright balance of the correction procedure and comply with the instructions: The light of the CIS is switched off – message: „Put on dark reference and press ENTER“- eventually the ambient light is to delete or the CIS is to darken (control in the Line Profile) - confirm with „Enter“ – the CIS determines the dark values, saves them in its working memory – the light of the CIS is switched on again – message: „Put on bright reference and press ENTER“ - put in the reference pattern - now move the pattern as long as the correction is completed – confirm with „Enter“ – CIS determines the amplifications and saves them in the working memory
- after completing of the pixel correction the graph of the Line Profile should show a straight line. The varieties of the single values among each other should I deally be ±3 Count.

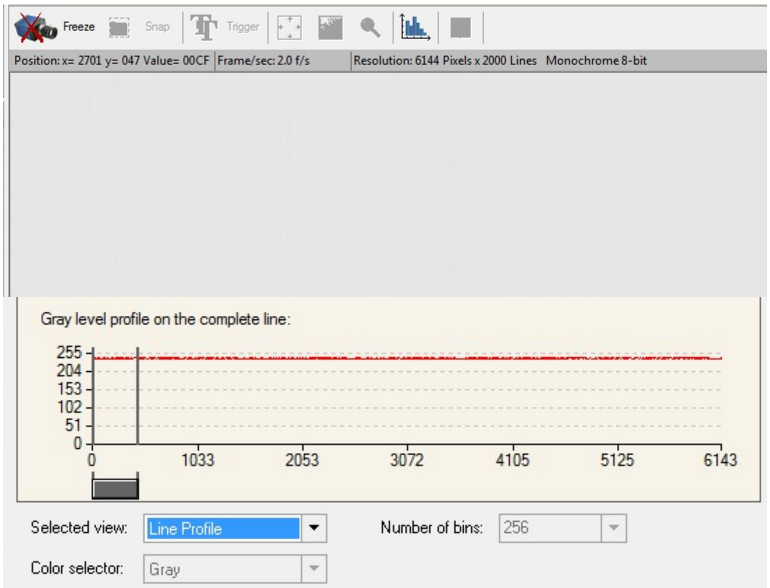
–

–

–

–

–



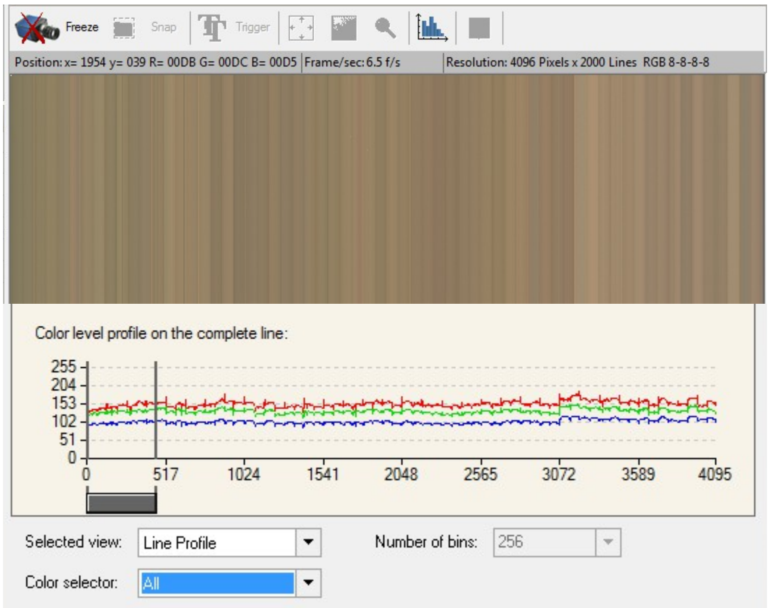
Img. 3.4.2-3   corrected CIS

- „**$**“ saves the result of the successful pixel correction permanent in the memory of the CIS
- now also should be controlled if the exposure time for the sampled object set for the pixel correction has yet to be adjusted: Enough brightness for the evaluation, but no override (values = 255) takes place.
- “**S**“ saves the set parameter of the CIS permanent in the memory.

3.4.3 Pixel correction for color (RGB)

Principally it is the same procedure like for monochrome light. The three colors are first independently set to the allowed grey value range and then all colors are corrected with a single „**C**0“ - command.

- place the suitable balance pattern moveable in the working distance (see type plate) of the CIS
- open the Frame Grabber and set to the CIS (camera file)
- open the terminal program (e.g. TiViCISIF)
- switch on the CIS
- Freerun-Mode „**M**0“ has to be active
- with „**#**“ the preset parameter values can be requested
- if applicable adjust „**D**... Dark Level Digital“ , „**B**... Bright Level Digital“ and “**Q**.. Cycles“ to the requirements. The values of **D** and **B** can be individually set for each exposure phase and should normally be equal, so there are 3 same **D** - and 3 same **B** - values
- delete the actual pixel correction with „**Z**0“
- the light is still off and no external light penetrates
- sample one image in the FrameGrabber and switch to the display „Line Profile“
- now a graph over the whole CIS width should be shown, that corresponds to the grey value dark level analogue. If these is not the case, the procedure „**I.** Auto Offset" is to be carried out (see chapter 3.5). It can be chosen between „all“, so all color channels (exposure phases) are shown at the same time or „red“, „green“, „blue“, so only one color channel (exposure phase) is shown.
- switch on the light of the CIS with „**L**1“
- now a graph over the whole CIS width should be shown, that represents the uncorrected CIS. For that see the Grey Line Profile in Img. 3.4.2-1



Img. 3.4.2-1 uncorrected CIS, before pixel correction

– the RGB-version of the CIS owns at least 3 exposure times:

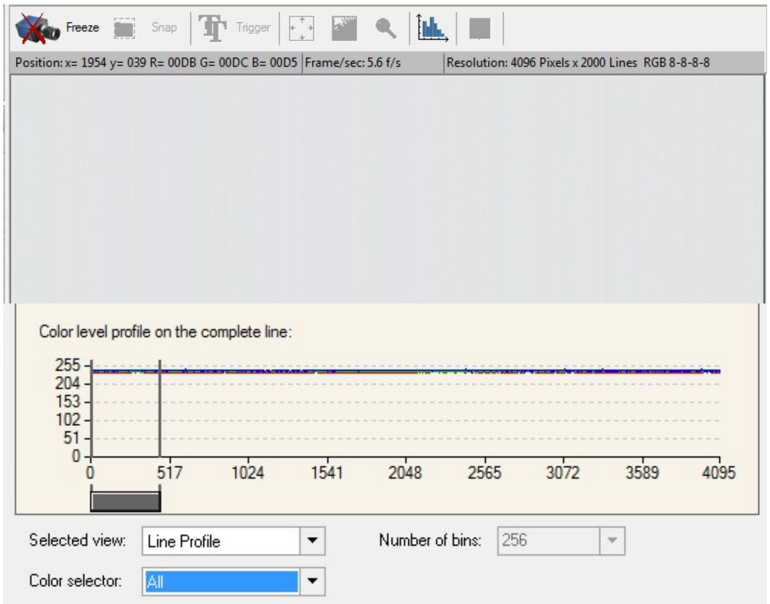
-**E**0,v,xx : LED-row v, exposure time red
- **E**1,v,yy : LED-row v, exposure time green
- **E**2,v,zz : LED-row v, exposure time blue

- move the red graph with the exposure time „**E**0,v,xx“ so, so that it lies in the value range 0,5***B**.....1***B** (Bright Level Digital). The pixel correction now increases each pixel so that its value lies on the set 230. Die maximum amplification **H** lies as standard an 2, so 0,5***B***2 is exactly **B.** The pixel correction only can amplify. If a pixel over sizes the value of **B** before correction, so these value is maintained and can not be corrected.
- set **E**1,v,yy and **E**2,v,zz so that all 3 colors give out nearly the same scan, whereby here also is valid the value range 0,5***B**.....1***B** (Bright Level Digital).
- Important hereby is that all grey-values of the three colors are equally independent of their exposure time.

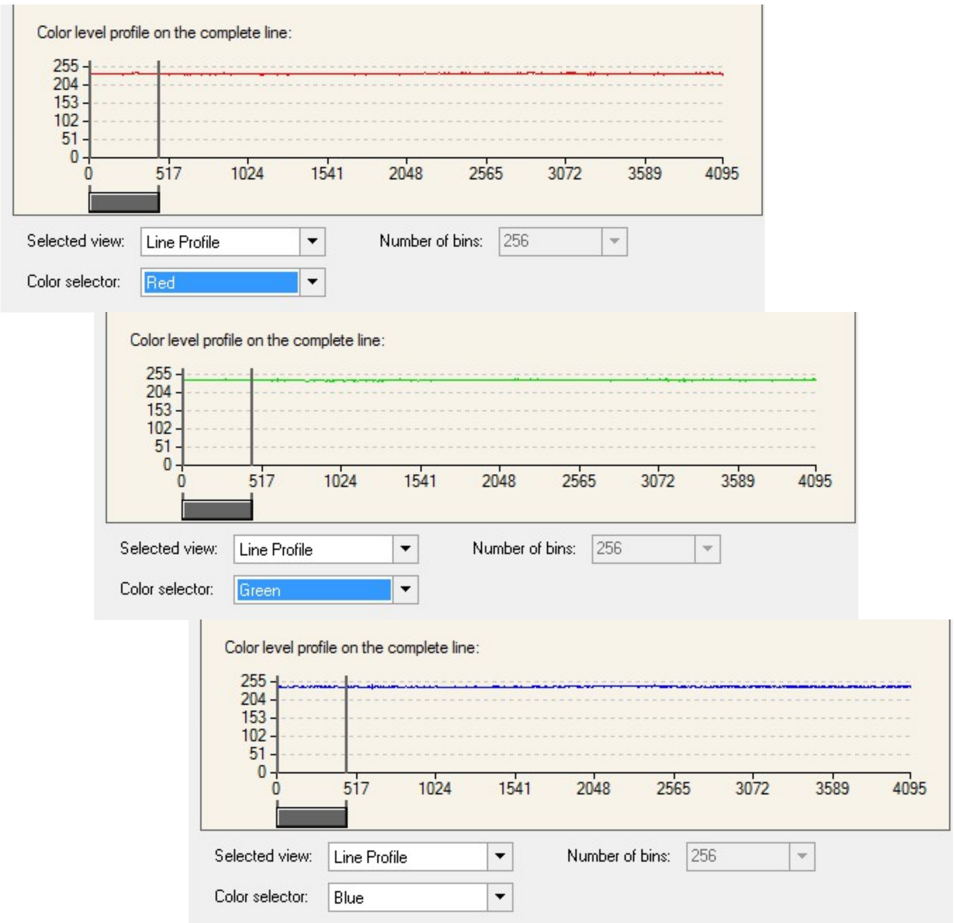
Img. 3.4.3-2 uncorrected CIS, before pixel correction

- start the automatic pixel correction with „**C**0“ , move the pattern during bright balance of the correction procedure and comply with the instructions:
  The light of the CIS is switched off – message: „Put on dark reference and press ENTER“- eventually the ambient light is to delete or the CIS is to darken (control in the Line Profile) - confirm with „Enter“ – the CIS determines the dark values, saves them in its working memory – the light of the CIS is switched on again – message: „Put on bright reference and press ENTER“ - put in the reference pattern - now move the pattern as long as the correction is completed – confirm with „Enter“ – CIS determines the amplifications and saves them in the working memory.
  „**C**0“ balances all colors in one correction run at the same time

- after completing of the pixel correction the graph of the Line Profile should show a straight line. The varieties of the single values among each other should ideally be ±5 Count



Img. 3.4.3-3 corrected CIS



Img. 3.4.3-4 corrected CIS, every color individually

- „**$**“ saves the result of the successful pixel correction permanent in the memory of the CIS
- now also should be controlled if the exposure time for the sampled object set for the pixel correction has yet to be adjusted: Enough brightness for the evaluation, but no override (values = 255) takes place.
- “**S**“ saves the set parameter of the CIS permanent in the memory.

3.4.4 Pixel correction for false colors

Generally corresponds to the RGB-version, because the single false color phases are assigned to the R-,G-,B-phases.
Up to 6 exposure phases can be managed (in prepare).

3.4.5 Pixel correction for mixed, monochrome light.

In the Illumination Guide a variety of illumination types is listed. For specific applications it is necessary to mix the illuminations, that means to use at the same time. Thereby the LEDs of the illuminations are switched simultaneously. A pixel correction for these case is then to carried out when the mix relation already is known. The same procedure like for monochrome light is valid. To move the graph of the Line Profile the different exposure times of the single illuminations have to be changed so that the mix relation remains constant.

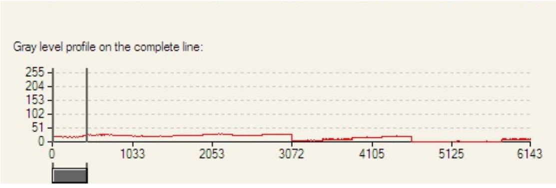
3.4.6 Checklist Pixel-correction C0

Nr	Checklist pixel correction	**no**, further with	**yes**, further with Nr.
1	Front plane of the CIS clean	clean	2
2	Working distance correctly	set	3
3	Reference pattern pixel correction prepared	prepare	4
4	FrameGrabber, display setting: Line Profile	set	5
5	Start terminal program	start	6
6	Switch on the CIS	switch on	7
7	Command # - list the perm. parameter	command #	8
8	Set value details correctly Dark Level analogue DL analogue	correct	9
9	Dark Level digital DL digital	correct	10
10	Bright Level analogue BL analogue	correct	11
11	Bright Level digital BL digital	correct	12
12	Cycles Q	correct	13
13	Line Frequency F	correct	14
14	See for value Gain facto H		15
15	Calculate and note the minimum bright value:: BL digital / Gain factor H = bright value min	calculate	16
16	Mode 0 freerunning	command M0	17
17	Command Z0 – delete pixel correction	command Z0	18
18	Illumination off	command L0	19
19	FrameGrabber Line Profile: check dark level: corresponds constantly the Dark Level analogue value	AutoOffset command I	20
20	Put in reference pattern		21
21	Command L1 – switch on the light	command L1	22
22	FrameGrabber Line Profile: check bright value: bright value in the range BL digital > bright value > BL digital / H over whole CIS width	adjust bright value with command E	23
23	Command C0 – pixel correction	command C0	
	Question: CIS darken	darken	Enter
	Question: reference pattern is put in	put in	Enter
	After status message is pixel correction	wait	24
24	FrameGrabber Line Profile: line on BL value	set mistake?	25
25	Command $ - save pixel correction permanent	command $	26
26	Command S – save parameter permanent	command S	done

3.5 AutoSet Offset

I<start,end> **AutoSet Offset**
<start> analogue start channel – normally “0” = 1. channel
<end> analogue end channel – normally last channel
with that all analogue offset-values of the CIS are set

These command offers the possibility to carry out the automatic offset balance.



Img. 3.5-1 Example of a line scan without offset adjustment

To see an offset scan, switch off the light L0 and delete the pixel correction with Z0 or switch to video mode V1.

If the whole CIS is to balance you have to set the 1. channel for <start>, so the number “0” and for <end> the number of the last analogue channel. These you can read out with the command „**+ Sensor Character.**“:
Example:

***** SENSOR *****
Resolution : 1200 dpi
Half Sensor Boards : 2
Colors : 3
Binning : 1
Physical Pixels : 12384
Logical Pixels (without overlap) : 12384

***** ANALOG *****
VISAVIS : 2
Analog channels : 18

***** DIGITAL *****
ADCs : 6
Channels/ADC : 3
ADC Channels : 18

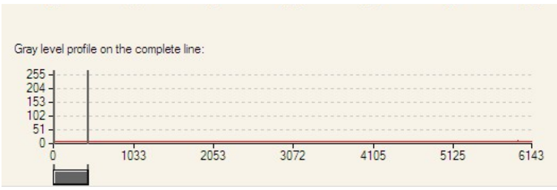
In the example there are 18 analogue channels (see grey highlighted line) and for <end> the number „17“ has to be set.

So the whole command is: **I0,17**

The set value of the analogue dark value for the balance is to set with the command
X<0-255> **Set DL analog.**

Also in the balance goes the **Q**<1-255> **Set Cycles**. With **Q**1 only one line is taken for the balance. To mean the noise the value of **Q**5 is recommendable. With that first the mean value out of 5 lines is taken to then balance to the chosen set value **X**<0-255>.

A proper balance requires a darken CIS. After an offset-balance a new pixel correction is to be carried out.



Img. 3.5-2 Example of a Line Scan with offset-balance

For the sake of completeness is also to note:

o **Get analog Offset**
shows the analogue offset values

After entering **o** in the terminal window a list of all channels with associated offset-values is shown. The values are indicated in hexadecimal format.

O<ch>,<val> **Set analog Offset**
<ch> analogue channel number
<val> enter the required value

There is also a broadcast setting with that all channels can be set to a pre-defined value:

O999,<val>

After entering the channel number a free selectable value can be assigned to the channel. The entering has to be in decimal format.
The first channel has the number 0.
The result can be controlled in the Line Profile of the FrameGrabber.

Identifying the concrete channel number:

In the Line Profile of the FrameGrabber first a pixel number is to identify that lies in the range to be balanced. The associated channel number is shown with the command

j<pix> **Get channel to pix.**
<pix> enter the acquired pixel number

in the terminal program window.

A permanent saving of the new identified offset values is carried out with the command:

S **Store Parameters**
saves the actual parameters

3.6 Analogue Gain

An adjusting of the analogue Gain has to be corrected only in exceptional cases.

Attention: The image brightness is set with the command E Set Exposure

The setting is carried out during the parametrisation of the CIS at the factory. An adjusting is carried out by:

g **Get analog Gain**
shows the analogue amplifying values

After entering of **g** in the terminal program window is shown a list of all channels with associated gain-values. The values are shown in hexadecimal format.

G<ch>,<val> **Set analog Gain**
<ch> analogue channel number
<val> enter the acquired value

There is also a broadcast setting with that all channels can be set to a pre-defined value:

G999,<val>

After entering the channel number a free selectable value can be assigned to the channel. The entering has to be in decimal format.
The first channel has the number 0.
The result can be controlled in the Line Profile of the FrameGrabber.

Identifying the concrete channel number:

In the Line Profile of the FrameGrabber first a pixel number is to identify that lies in the range to be balanced. The associated channel number is shown with the command

j<pix> **Get channel to pix.**
<pix> enter the acquired pixel number

in the terminal program window.

A permanent saving of the new identified offset values is carried out with the command:

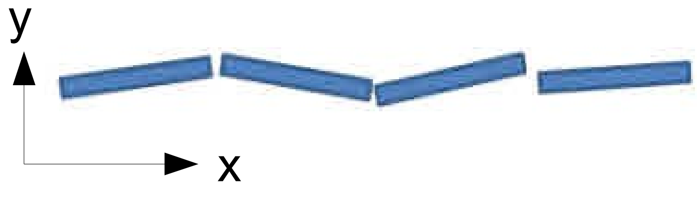
S **Store Parameters**
saves the actual parameters

3.7 Geometry correction

3.7.1 Generally for geometric correction

The geometric correction is carried out at the factory and is unchangeable by the user. Only the coarse alignment of the sensors in Y-direction (see chapter 3.7.2) for Zero Gap sensors can be adjusted to the scan direction.

As already noted in chapter 2.2.4 and 2.2.5 the mounting of the chips on the sensor boards shows tolerances. The production tolerances concern not only the split between the chips but also the offset of two side by side lying chip ends.



Img. 3.7.1-1   production tolerances

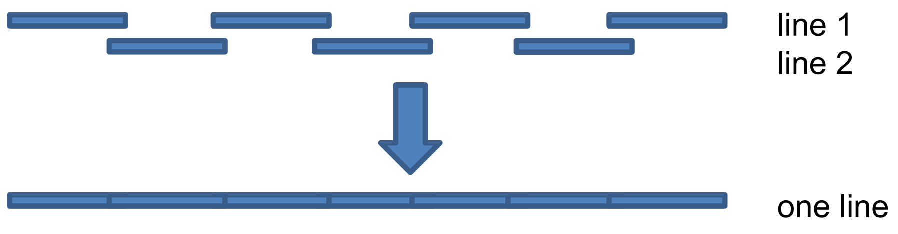
An exaggerated representation of a tolerance affected chip array is shown in the Image 3.7.1-1. The gaps in the x-direction are about 20...50 µm, the offset in y-direction is about ± 30 µm to the ideal line.

An optional available geometric correction for some CIS-types can calculate the tolerances in y-direction and delete the overlapping pixel in x-direction.

For the correction calculation in y-direction a FIFO-memory is used.
On the starting of the image sampling the FIFO-memory has there to be filled first, before the first valid image lines can be shown. That can task up to 16 image lines. That means that the first lines can not be used for evaluation of the image.

3.7.2 Coarse alignment of the sensors in Y-direction

In the Zero Gap sensors, staggered plus the sensor chips a arrayed in 2 rows. One feature of an object is with that sampled at different times. The data of the first sampled row are therefore temporarily saved in the FIFO-memory and then given out at the right time together with the data of the 2. sampled row.
The nominal offset (ca. 100 µm) of the symmetry axes of the pixel rows is thereby selected as a whole multiple of the pixel size. Because of that after a determinable number of lines the image data of both lines can be given out together.



Img. 3.7.2-1   two read lines brought to cover

These can be set with a command in the Set-menu:

A switching of the direction adjusts the temporarily saving of the moving direction of the objects. It also affects the geometric correction, so its value are also automatically adjusted to the moving direction.

d<0|1>	**Set FIFO Direction**
<0|1>	direction selection of the moving

3.7.3 Fine alignment of the sensors in Y-Direction

This fine-alignment is done by factory. The functionality is explained below.

There is the opportunity to correct the sensors in transport direction (y-direction)

Img. 3.7.3-1 Y-correction shifting points

When an sensor-chip is selected, the beginning and end of the chip can be raised in 1/16 pixel-steps.

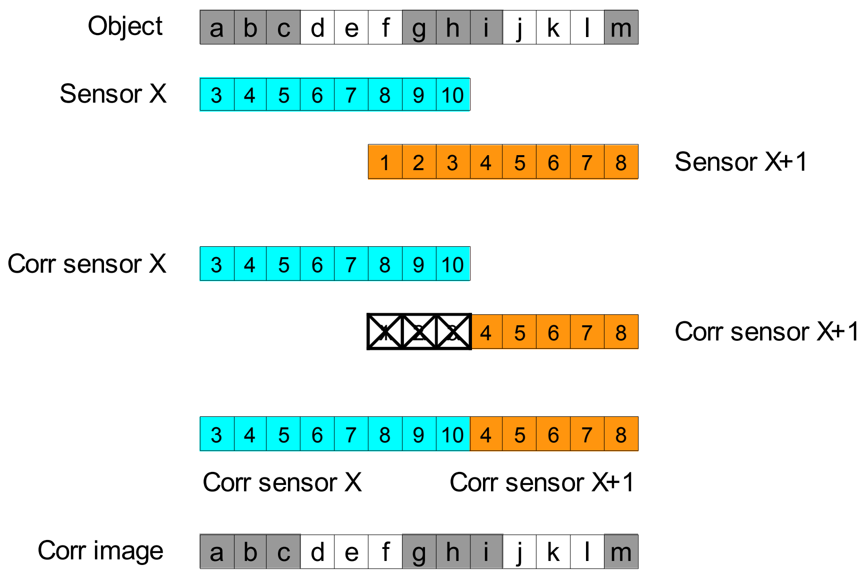
Img. 3.7.3-2 Alignment after Y-correction

3.7.4 Deleting overlapping Pixels in X-Direction

Deleting of overlapping pixels is done at factory. Here the functionality should be explained.

On Zero Gap Sensors, staggers plus FIFO the sensor chips are aligned in two rows. This overlap leads to pixels being illustrated as duplicate. (see 2.2.5)

Using the geometrical correction, the overlapped pixels can be deleted.



Img. 3.7.4-1 Object and it´s corrected image

Img. 3.7.4-1 illustrates the overlapped pixel. The object is sampled with the sensor X, with the pixel numbers 3...10, in the range a...h and temporarily saved in the FIFO. 2 trigger pulses (= 2 lines) later the object is sampled with the sensor X+1, with the pixel numbers 1...8, in the range f...m. Using a calibration pattern the double presented object pixel can now be filtered and selective deleted in the sensor X+1. The correction always attacks a the sensor start. The temporarily saved pixel of the sensor X and the actual, but corrected pixel of the sensor X+1 are now continuously given over to the Frame Grabber. So one image arises that is identical to the object in all pixel.

Here also not only whole pixel can be deleted, but also in 1/16 pixel steps.

4 Installation and Operation

4.1 Installation

4.1.1 Mounting space

A step file is available for the CIS for planning the customer system. This prevents collisions with other machine elements in advance.

The connection cables of the CIS and its cooling must also be observed.
The connector housings of the standard cables have a straight cable entry. If space is limited, plugs with cable entry on the side can be ordered.
When using CameraLink transmission for the image signals, please note that their standard cable length must not exceed 5m.

4.1.2 Mounting position

The window of the CIS ideally faces the bottom or the CIS is vertical.
On an window facing upwards, dust can deposit on the window.

4.1.3 Support Beam

The CIS is to be screwed on a straight and smooth support beam to achieve a well heat coupling. A part of the waste heat is discharged over the beam.
The construction is to carry out so that a vibration free operation of the CIS is possible.

4.1.4 Fixing screws

The fixing of the beam is carried out with metric threaded screws.

In the housing of the CIS there are threaded bushes pressed in. They have pocket holes so no dust or foreign object can enter the CIS.
The usable threat length is noted in the drawing.

The position and size of the needed fixing screws is also stated in the drawing.

4.1.5 Adjustment possibility

The beam should ideally have an adjustment possibility to optimally arrange the CIS to the scanned object.

On the type plate of the CIS its working distance is noted.

4.1.6 Accessibility

In mounted state, you should be able to plug in the cables and to tighten their locking screws.

Crucial is a possibility to clean the window of the CIS.

To carry out the pixel correction at least one bright reference pattern is needed that has to be placed in the working distance in front of the CIS.
In this context it is important to note that despite the well accessibility no direct view into the LED-light bar may be possible.

4.1.7 Heat discharging via the support beam

With a well heat coupling a part of the waste heat is discharged via the beam.
Especially for CIS with passive cooling particular attention on that has to be paid.

4.1.8 Heat discharging via air-cooling

A CIS an active and passive air cooling is being offered.

With the active air cooling an air circulation is forced by the external installed ventilators. It has to be provided that a sufficient air circulation is possible and appropriate intake and exhaust air openings are intended.

The passive air cooling is realized by external installed cooling elements with a low thermal resistance. With the rising warmed up air a natural air circulation is generated. Here it is important that the intake and exhaust air openings are places in a way that the circulation is not hindered. The cooling fins have to stay vertically.

4.1.9 Heat discharging via liquid cooling

For the CIS a liquid cooling is offered. It consists of two large area aluminium blocks that are bolted externally. They contain each two longitudinal holes where through a suitable cooling liquid can be conducted.

The cooling system has to be provided by the operating company.

4.1.10 Connection cables

A CIS needs several cable:

- a power cable (see also 2.6.2)
- at least one Camera Link cable (see also chapter 2.5.1.2) or a GigE network cable (see also chapter 2.5.2)
  Information about the number of the Camera Link or network cables are given by the order confirmation and the data sheet.
- eventually an encoder cable
- eventually a control cable for an external illumination device

The laying of the cable has to be carried out in a way that no tensions act through the cables on the plug connections especially when the CIS is mounted moveable.

If possible a spatial separation of power and signal connections has to be aimed.

The plug connections of the connection cables are intended for plugs with fixing screws. The cables offered by Tichawa Vision as fittings all have plugs with fixing screws. They also should be screwed in terms of a safe operation.

4.1.11 Connection sequence

In the current-less mode of the PC and the power device first plug in the signal connections (Camera Link and Trigger) and only then the power connector.

The signal connections should be statically discharged on a metallic part leading the ground potential before plugging in.

DO NOT TOUCH THE CONTACT PINS !

4.1.12 Grounding and EMV

As also described in chapter 2.6 there is grounding of the CIS necessary. The operating voltage is 24 VDC, so these grounding is not a protective grounding but a function grounding. It avoids the building of static voltages and serves for the eliminating of electromagnetic interferences.
Inside the CIS the GND-contacts of the power plug are connected to the CIS-housing. By the mounting of the CIS attention has to paid for a well electrical connection to the support beam and its operating grounding. It may be the only connection of the CIS-PELV-circuit to the operating grounding to avoid ground loops that can cause compensation currents.

4.1.13 Protection classification

The term „IP-connection class” (International Protection) is defined by IEC/EN 60529 „Protection classes through the housing (IP-Code)“.

The protection class of a housing is determined by normed test methods. To classify these protection class the IP-Code is used.
It consists of the both letters IP (International Protection) and a two-digit code figure.

The definition of the both digits explains the following table:

1. digit	foreign matter protection	2. digit	water protection
0	No protection	0	No protection
1	Foreign matter < 50 mm	1	Dripping water, vertical
2	Foreign matter < 12 mm	2	Dripping water, 15° to the vertical
3	Foreign matter < 2,5 mm	3	Dripping water, 60° to the vertical
4	Foreign matter < 1 mm	4	Dripping water from all directions
5	Dust protected	5	Water beam from all directions
6	Dust proof	6	Powerful water beam from all directions
		7	Temporary immersion
		8	Continuous immersion

Tab. 4.1.13-1 IP-protection classes

Code figure 1 characterizes the protection of the housing against the entering of solid foreign matters including dust (foreign matter protection).

Code figure 2 characterizes the protection of the housing against the entering of water (water protection).

The standard-CIS can be assigned to the protection class IP51.
5 dust protected
1 protected against vertical dripping water

4.2 Operation and service

4.2.1 Ambient conditions

4.2.1.1 Case-temperatures

The operation temperature range of the CIS is 0°.....40° Celsius (32°....104° Fahrenheit). For temperatures beneath the dew point water can condense on the inside and outside of the plane. In such cases the plain has to be warmed up with hot air.

In the CIS temperature sensors are located on the electronic boards. With the command „ **t**<cont> Get Temperature“ in the main menu the mean value of all sensors can be indicated.

If the temperature monitoring should be used, so there has to be empirically determined at the operation site of the CIS, which CIS inside temperature prevails for a housing outside temperature of 40° C.

For the storage a temperature range of -10°.....60° Celsius is allowed. The storage has to be carried out with discharged cooling fluid.

The CIS has to be acclimatized to the ambient temperature before switching on.

4.2.1.2 Air humidity

The air humidity should not overage the range of 10....60 % rel F.

The relative humidity depends on temperature, with lower temperatures it increases, so the dew point has to accounted.

The dew point describes the one temperature at that the air humidity on the plain starts to condense.

4.2.1.3 Concussion resistance

Concussion resistance indicates as well a singular hit, also named shock resistance, as vibration.

Vibration resistance:

Indicates at which amplitude or acceleration with a defined frequency range yet no function interferences or damages occur.

A vibration poor mounting of the CIS is at least because of the image quality necessary, otherwise the image “blurs”.

The resistance ability against vibration:

by operating 0,1 g rms (f = 5 - 500 Hz, duration 10 min each axe)
by storage 1,0 g rms (f = 5 - 500 Hz, duration 10 min each axe)

Shock resistance:

Indicates at which mechanical hit (a multiply of the acceleration of the gravity "g" semi-sinusoidal and 11 ms duration) yet no function interferences occur.

Resistance ability by transport 5 g / 11 msec

In the CIS normally a „Shock-watch“ is installed. These registers mechanical hits during transport. Is a set value exceeded so the indication tube colors red. Although it does not mean that the CIS is already malfunctioning, but a function test is to be carried out immediately.

On the transport packaging there are also shock-watch-sensors pasted.
When they are red coloured, it has to be noted in the transport / shipping documents, for any potential damage claims and as evidence for the transport insurance.

4.2.2 Working on the CIS

LED-light sources in the visible range of the CIS are to classify according to DIN EN 62471 to the risk group 2, that means the light radiation is not dangerous for human eyes by short timed exposition.

<u>Never look directly into the illumination !</u>

For all working carried out on the CIS, the CIS is fundamentally **always** to switch to the **power free** mode and to secure against restart.

- the illumination is the dark – **protection for the eyes !**
- with pulling off and plugging in of the power plug therefore no light bows can arise.
- with pulling off the Camera Link plugs or the trigger plugs no undefined voltages can arise on the transmitter or transceiver modules.
  These can be destroyed by voltage peaks.

The screwed housing is protected against unauthorized opening with guaranty seals. The user can not make any reparations in the inside of the CIS. There are no wear parts like protective fuses etc. installed.

4.2.3 Electrostatic charge

The CIS contains optical sensors and high sensible electronics that is sensible against electrostatic voltages. Because of that please treat the sensor and especially the Camera Link connectors according to the usual ESD-directives
(ESD – electrostatic discharge) :

- avoid static charge
  (sensor and operating as like as service personal)
- make contact to a grounded object
- always ground the plug and the sensor before plugging in

Special caution is to be paid for electrical isolating objects like plastics or paper on which very high static voltages can build up.

Because of that ground the CIS as like as its support beam with a as short as possible, adequately dimensioned copper strip.

4.2.4 Protection against dust

The operating of the CIS is only allowed with electrical isolating dust particles.

If conductive dust should enter the electronic chamber of the CIS, so the short circuits can cause the destroying of the CIS.

The window of the CIS is a part of its optics and should be handled as like as any other optical device with extreme caution.

Deposited dust changes the image information in a way that dark areas are permanent caused. Dust makes a stronger appearance when the illumination or the focal plane lie near the window surface. For diffuse illumination the dust is less visible cause the focus is further away from the glass.

Dust can normally be removed with oil-free compressed when it is not sticking on the plane with static charge. In that case ionized compressed air can help.

If further cleaning is needed then lens cleaning paper is recommended that is eventually wetted with alcohol or acetone.

Lint free ESD-protected clothes not consisting any particles that can scratch the plane can also be used.

Which ever cleaning method is used, please tread carefully and gently.

4.2.5 Protection against oil and fat

With works on the CIS it can come in touch with oil and fat. Even one touch of the plane with a buff hand leaves a fat traces on it.
For the cleaning lens cleaning paper is recommended that is eventually wetted with alcohol or acetone .

Lint free ESD-protected clothes not consisting any particles that can scratch the plane can also be used eventually wetted with windscreen cleaning fluid.

Which ever cleaning method is used, please tread carefully and gently.

By using the robber gloves an electrostatic charge can arise through friction on the plane. To avoid ESD-damages (ESD – electrostatic discharge), there for a good grounding of the CIS is necessary (for that see also 4.2.3).

4.2.6 Protection against scratches

Scratches on the plain can be caused by the contact with the object, careless treatment, abrasive cleaners, unprotected storage and transporting.

For works in close proximity it is recommended to cover the front plane, to protect it against falling objects or touching by assembly tools.

The CIS should only be stocked and transported in its own packaging. The plain should here by have no direct contact with the packaging material.

Scratches change the beam flow of the light. Normally it causes brighter pixel that are located in close neighbourhood with the darker pixel.

4.3 Tips for fault rectification

If the CIS is not working satisfying, please follow the following list one point after an other.

Mechanical check:

- Plane of the CIS clean?
- Housing temperature of the CIS lower than 40 °C?
- Cooling functional?

Check of the connections:

- All Camera Link connections are plugged in and the fixing screws are tightened?
- Length of the Camera Link-cable right?
- Computer is switched on and appropriate software started?
- Power connector is plugged in and the fixings screws are tightened?
- Power supply device is switched on and the secondary voltage is 24 VDC?

Check of the communication:

- open terminal program (TIVICISIF)
- to test communication enter the command „**?**“ - now the CIS sends its complete storage of commands to the terminal program where it is listed.
- to indicate the base settings enter the command „**#**“ - the actual CIS-settings are listed
- the CIS can create test samples and send it the Frame Grabber They can be requested with the command „**V**<val>“. Particularly interesting is the grey ramp that is created with „**V**6“ and „**V**7“.
  With the test samples the signal transfer way from the CIS to the Frame Grabber and its configuration can be controlled.
- GND-potential difference between pc and CIS lower than 0,2 Volt?

Optical check:

- Is the sensor plane clean?
- Open terminal program (TIVICISIF).
- Change to mode „**M**0“ (free-running), delete the actual pixel correction with the command „**Z**0“ and switch on the light with „**L**1“.
- Diffuse illumination: are the LEDs glowing? - **Attention : Do not look directly in the LEDs!** - Is a white test stripe in front of the CIS recognized?
- Coaxial illumination: are the LEDs glowing? - **Attention : Do not look directly in the LEDs!** - Is the beam way from the illumination the CIS free? Is a reflecting test stripe in front of the CIS recognized?
- Glow with a flashlight in to the CIS. Is the light spot clean?

4.4 Support by Tichawa Vision

Are the tests for independent trouble shooting without success, than our support can be enabled.

There by important informations have to communicated:

- CIS-Type
- serial number
- trouble description
- test image(s)
  - ✗ 1951 USAF, IEEE or equal
  - ✗ grey value ramp produced with the command „V7“
  - ✗ whole CIS width
  - ✗ structures over the whole width
  - ✗ some hundred lines of the hight
  - ✗ bitmap format
  - ✗ image size less than 5 Mbyte

5 Norms and Standards

5.1 EG – conformity declaration

- IEC 60204-1
“Electrical equipment of machines – Part 1: General requirements”

- EN 60825-1
”Safety of Laser Products – Part 1: classification of systems and requirements”

- EN 61010-1
Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements

- VDE 110/111
Terms, principles and requirements.
Isolation coordination for electrical equipment in low-voltage systems – partial discharge tests; application guideline

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Qualitätsmanagement

Technische Dokumentation

EG-Konformitätserklärung

EG-Konformitätserklärung

gemäß der EG-Richtlinie 2004/108/EG (elektromagnetische Verträglichkeit)

Hiermit erklären wir, dass das nachstehend bezeichnete Gerät in seiner Konzeption und Bauart sowie in der von uns in Verkehr gebrachten Ausführung den grundlegenden Sicherheits- und Gesundheitsanforderungen der EG-Richtilinie 2004/108/EG entspricht. Bei einer mit uns nicht abgestimmten Änderung des Gerätes verliert diese Erklärung ihre Gültigkeit.

Hersteller: Tichawa Vision GmbH
Burgwallstr. 14
86316 Friedberg

Beschreibung des Geräts:

Typbezeichnung:	G_MXCIS_0820_0300_RGBIR_1.3_AZ
Seriennummer:	05818.1203.0000617
Baureihe:	MaxiCIS

Es wird Übereinstimmung mit weiteren, ebenfalls für das Produkt geltenden EG-Richtlinien erklärt:

- **DIN EN 60204-1** **Elektrische Ausrüstung von Maschinen**
- **DIN EN 60825-1** **Sicherheit von Lasereinrichtungen**
- **DIN EN 61010-1** **Sicherheitsbestimmungen für elektronische Mess-, Steuer-, Regel- und Laborgeräte**

Friedberg, 16.07.2012

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Nikolaus Tichawa

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5.2 BGV A8 Safety and health protection signage

5.3 Normen und regulations

The device corresponds to EN / VDE 110/111.

The device complies with EN 62471, risk group 2

The device is not designed for UL

The device meets the regulation RoHS

The device is not designed for different national norms

The device is not designed for branch specific norms

The device corresponds to BGV A8

6 FAQ - Frequently Asked Questions

1.1 What is a CIS sensor?

A CIS scanner is a compact line scan camera which is mounted directly above the object under inspection. It is the same type camera used in many fax or document scanners. The CIS consists of a row of silicon photodiodes, a graded index (GRIN) lens array and a light source.

1.2 What is the difference between a CIS and a conventional line scan camera?

The sensor of a conventional line scan camera is small (10 – 50 mm length) with small pixels (5 – 20 µm). The image is produced by reducing optics.The sensor of a CIS is as wide as the object under inspection (up to 4 m). The image is produced by 1 :1 optics. The pixel size ranges from 11 µm to 127 µm.

1.3 What are the advantages of a CIS compared to a conventional line scan camera?

- Simple to mount, no large stand off distance is necessary
- Simple to adjust, no multi camera alignment problems
- Constant picture angle over the total reading width
- No distortion by the lens
- Clearly sharper images

1.4 What are the advantages of a conventional line scan camera compared to a CIS?

- Bigger depth of field (DOF)
- Lower weight

1.5 Why can't I buy an industrial CIS at the price of a scanner?

- Higher quality (pictures)
- Higher line rate by more complicated electronics (pictures)
- Large reading distance (10 mm instead of 0.3 mm) through more complex lenses
- Robust design (Solid metal housing)
- Standardized interface to the frame grabber

1.6 How do I control the exposure of a CIS?

By an internal or external light source controlled either via the Camera Link serial port or an internal timer in the CIS scanner.

1.7 The sharper imaging of a CIS in contrast to a conventional camera may cause interferences if periodical patterns are inspected. What can I do?

The option "multiple flashing" suppresses interferences as far as possible.

1.8 What distance between object and sensor (= working distance) is possible?

The industrial CIS allows a maximum working distance of up to 11 mm. The nominal working distance is set at the factory.

1.9 What is the depth of field of a CIS?

As a rule, 1 –2 mm depending on the stand off distance and the application.

1.10 Which is the local resolution of a CIS?

Tichawa Vision offers CIS units from 25 dpi (1.016 mm pixel pitch) up to 2400 dpi (10.85 µm pixel pitch).

1.11 Which local resolution do I need for my application?

This very much depends on the processing to be done. Generally speaking, the smallest object to be recognized should at least be 2-5 pixels across. Typical interpolation tasks such as gravity determination, etc. can be done very much finer than the pixel grid.

1.12 Which line rate does my application require?

The line rate is the result of the object transport speed divided by pixel size.

For example: The pixel size of a 200 dpi sensor is 127 µm. At a feed speed of 1 m/sec the line rate required is

1m/sec / 0.000127 m = 8000 Hz = 8 kHz

The sensor should be operated at a line rate of 8 kHz.

1.13 What kind of illumination is best for my requirement?

One-sided reflective light is sufficient for flat structures (print).

Textured materials require double-sided reflective light (in feeding direction in front and behind the sensor).

Transparent and printed materials often require transmissive light.

Special applications (e.g. scanning of security papers) often require a combination of reflective and transmissive light. CIS supports multiplex operation up to 6 light sources.

See also the "Illumination guide".

1.14 Which color of lighting is best for my application

Red light is usually sufficient for simple B/W applications..

1.15 How does the PRNU of the CIS compare to a conventional line scan camera under uniform lighting?

Under ideal conditions a conventional line scan camera shows a typical PRNU of 10 %.
But in real conditions the amplitude falls at the edge of the image area due to the wide angle of view. Correction is often used to reduce this. Typical uncorrected.
PRNU for a CIS is around 30 %, but the internal correction supplied can reduce this to 1-2 %.

1.16 What is the CIS bit depth?

Internal calculation in the CIS are carried out at 10 bits. After correction, 8 bits are read-out through the CameraLink port.

1.17 How sharp does a CIS image compared to a line scan camera?

The sharpness of a line scan camera is mostly limited by the lens. Typically the lens aperture is run at or near its maximum and black/white transitions usually span 3-5 pixels.
The transition width of a CIS is typically 1-2 pixels at 300 dpi (84 µm) and 3-4 Pixel at 1200 dpi (21 µm)

1.18 What is the spectral sensitivity of a CIS like?

As in with CCD or CMOS cameras the pixels of a CIS are made of silicon with high visible sensitivity and response extending into the near infrared.

1.19 Does the CIS sensor have gaps?

At the joints of the lined-up sensor chips to about 300 dpi, the disturbance is usually negligible since it is less than ½ pixel. With overlapping sensor chips will not occur joints. Its double pixel in the overlap region can be deleted with a correction.
All in all the distortion observed with a CIS is lower than the distortion of a lens and easier to correct because the geometry is very linear.

1.20 What do I have to take care of when I install a CIS?

A CIS is much closer to the object under inspection than a conventional camera. Therefore:

- Provide protection to avoid having objects jam up against the sensor or fall on it.

- Take precautions against ESD, especially in applications with glass and fast running synthetic fabrics as well as with all other materials which generate static electricity.

- CIS with internal light source is classified to the lamp safety standard IEC 62471 in the risk group RG 2. Follow the relevant regulations.