Tichawa Vision GmbH

Industrial Contact Image Sensor

Operation Manual

V 5.6

18.10.2023

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Safety Notes

Damage caused by non-observance of these operating instructions will void the warranty/guarantee!
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.**

- **The CIS is intended for operation in an industrial environment.**

- **Warning**

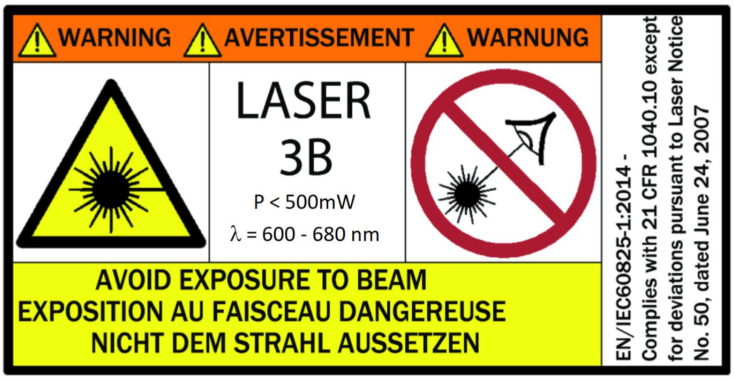
  The Contact Image Sensor is an LED and laser product (VDCIS, CIS with profilometer function) and complies with the EN/IEC 60825-1: 2014 standard. However, the VDCIS and the CIS with profilometer function cannot be considered as a single system and may only be used as part of a laser system that includes additional precautions according to the respective laser class. Depending on the version, the CIS is equipped without or with different lasers.

  – **Several class of 3B lasers with max. 20 mW power each, used as line lasers (VDCIS).**

  – **A class of 3R laser (CIS with profilometer function)**

  – **Or without laser. (Other CIS versions)**

  – **In the introduction, also note "Laser safety for class 3B lasers" and "Laser safety for class 3R lasers".**



- **DANGER - LASER RADIATION**

  DO NOT EXPOSE TO RADIATION

  LASER CLASS 3B

  According to EN/IEC 60825-1:2015

  The accessible laser radiation of a class 3B laser is dangerous for the eye, often also for the skin. This also applies to radiation reflected from a reflective surface (e.g. metal,glass). Diffusely scattered radiation is usually not dangerous.

  - **Class 3B laser products must be equipped with warnings and approval labels.**

  - **During operation, installation and alignment, the prescribed eye protection must be used.**

  The CIS is a laser product. Any operation other than that specified in this manual may result in the user being exposed to hazardous laser radiation.

- **Read the operating instructions carefully and follow all warnings.**

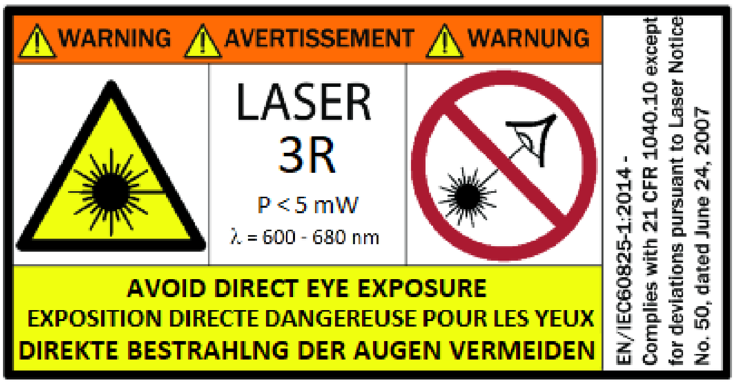
  WARNING

- **Never open the Contact Image Sensor (CIS) / the camera**

  - **The CIS does not contain any parts that can be repaired by the user. Opening the VDCIS or the CIS with profilometer function may expose the user to hazardous laser radiation.**

- **Disconnect the device from the power supply before any maintenance.**

  – **Before any maintenance, the CIS must be disconnected from the power supply. Failure to do so on the VDCIS or the CIS with profilometer function may result in the user being exposed to hazardous laser radiation.**



- **WARNING - LASER RADIATION**

  AVOID DIRECT IRRADIATION OF THE EYES

  LASER CLASS 3R

  According to EN/IEC 60825-1:2015

  The accessible laser radiation of a Class 3R laser is dangerous to the eye. This also applies to radiation reflected from a reflecting surface (e.g. metal, glass). Diffusely scattered radiation is usually not dangerous.

  – **Class 3R laser products must be equipped with warnings and approval labels.**

  – **During operation, installation and alignment, the prescribed eye protection must be used.**

LED light sources in the visible range in the CIS are classified in risk group 2 according to DIN EN 62471.
i.e. the light radiation is harmless to the eye in the case of short-term exposure.

Please clarify the procedure with your laser protection officer !

The following apply to UV LEDs

Safety Notes

UV LEDs emit intense but invisible radiation during operation, which can be dangerous to the eyes and skin even with brief exposure.

DO NOT LOOK DIRECTLY INTO THE UV-LED DURING OPERATION

*** OPERATORS AND ALL PERSONS IN THE WORK AREA MUST WEAR APPROPRIATE PROTECTIVE EYEWEAR; WHEN THE UV-LED IS IN OPERATION***

KEEP CHILDREN AWAY FROM THE WORK AREA

KEEP UV-LEDS OUT OF THE REACH OF CHILDREN

When UV LEDs are installed in a device, then the necessary safety instructions and warning signs must be attached.

- **Never look directly into the illumination !**
- **Only instructed persons may operate the Contact Image Sensor.**
- **The Contact Image Sensor heats up during operation. Sufficient cooling must be ensured!**
- **Protect the glass window from damage !**
- **Plug in or unplug only in de-energized state !**

Content

Introduction

Laser safety for class 3R lasers

The Contact Image Sensor (CIS) with profilometer function is equipped with a laser of laser class 3R. According to EN/IEC 60825-1:2015, a system with a Class 3R laser must be equipped as follows:

- A laser protection officer must be appointed
- The system must be equipped with a key switch with removable key. It must not be possible to switch on the camera's laser without the key.
- An operational connection for a remote disconnect switch (emergency stop switch, or other automatic disconnect device) must be provided in the system.
- The system must be equipped with a signal light indicating the operation of the laser.

Position of the outlet openings for laser radiation:

- The laser radiation emerges from the small window openings in the side parts of the CIS with profilometer function.

Laser safety for class 3B lasers

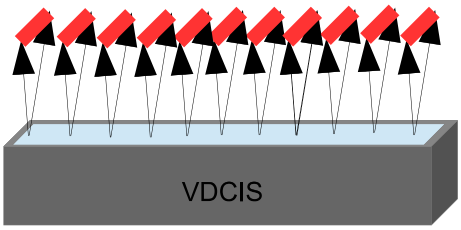
The Contact Image Sensor VDCIS is equipped with a laser of class 3B lasers. In addition to the regulations for class 3R lasers, class 3B lasers must meet further safety requirements for approval. According to EN/IEC 60825-1:2015, a system with a class 3B laser must be equipped as follows:

- A laser protection officer must be appointed
- The system must be equipped with a key switch with removable key. It must not be possible to switch on the camera's laser without the key.
- An operational connection for a remote disconnect switch (emergency stop switch, or other automatic disconnect device) must be provided in the system.
- The system must be equipped with a signal light indicating the operation of the laser.

Position of the outlet openings for laser radiation:

- At the window of the VDCIS the laser radiation is emitted in addition to the LED radiation.

- **Remark:**
  At the working distance , the length of the laser line is approx. 7mm, i.e. the full power can still hit the eye. At a distance of 120 mm, the eye-relevant power is already reduced to half. The laser output is schematically shown in the figure below. One device has SensorChipcount+1 laser line projections.



In addition to the above requirements, local regulations for the operation of Class 3B (VDCIS) or 3R lasers may need to be followed. Ensure that your system meets all country-specific guidelines for Class 3B or 3R lasers.

As a stand-alone device or system component, the VDCIS and CIS type cameras with profilometer function do not meet the above requirements. Therefore, the system must be equipped with the required safety devices (key switch with removable key, connection to a remote disconnect switch, signal light for laser operation).

1 What is a Contact Image Sensor (CIS)

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.

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 format. 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 according to the 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

It has a stable metal case with a glass window, which usually houses the sensor chips, optics, illumination, complex electronics and a high-speed interface for data transmission. The working distance has been increased to approx. 60 mm for the VDCIS.

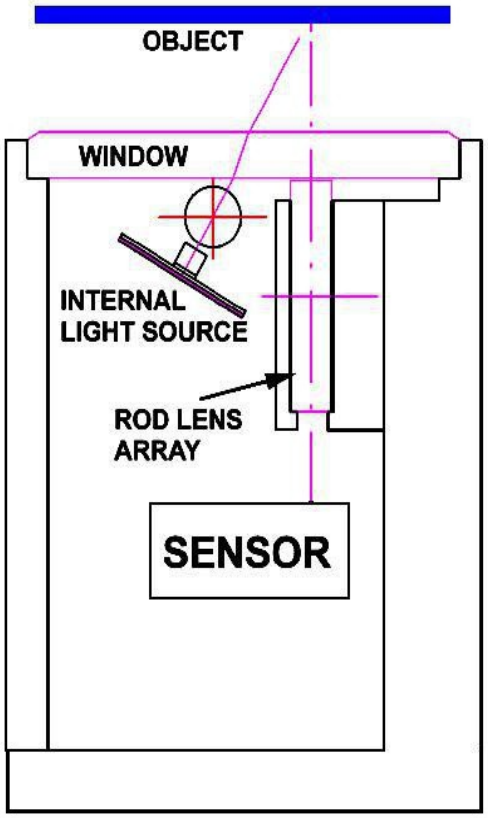
Beside standard versions we can also build special versions that satisfy customer wishes.

2 General information about Industrial Contact Image Sensor (CIS)

2.1 Core structure

2.1.1 CIS

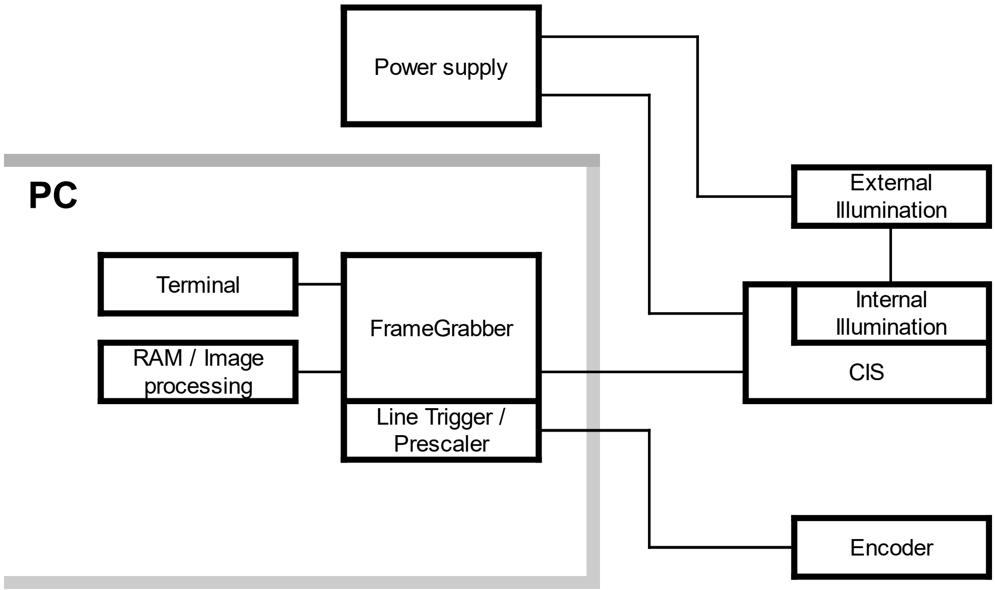
In the image 2.1.1-1 you can see core structures of a CIS and how its components work together.



Img. 2.1.1-1 Core structure of a CIS

A stable aluminum case houses protect all the components. Beneath a glass window there is a GRIN-lens-array (see 2.4.1) focussing the light reflected by the object to the sensors (see 2.2). (Inbetween there might be are laser diodes for raster/geocorrection in the VDCIS). One or more LED lines with the corresponding focusing elements, usually cylindrical lenses made of glass, are also accommodated in the housing (see also 2.3.1). For backlight applications the LED rows are in separate housings.

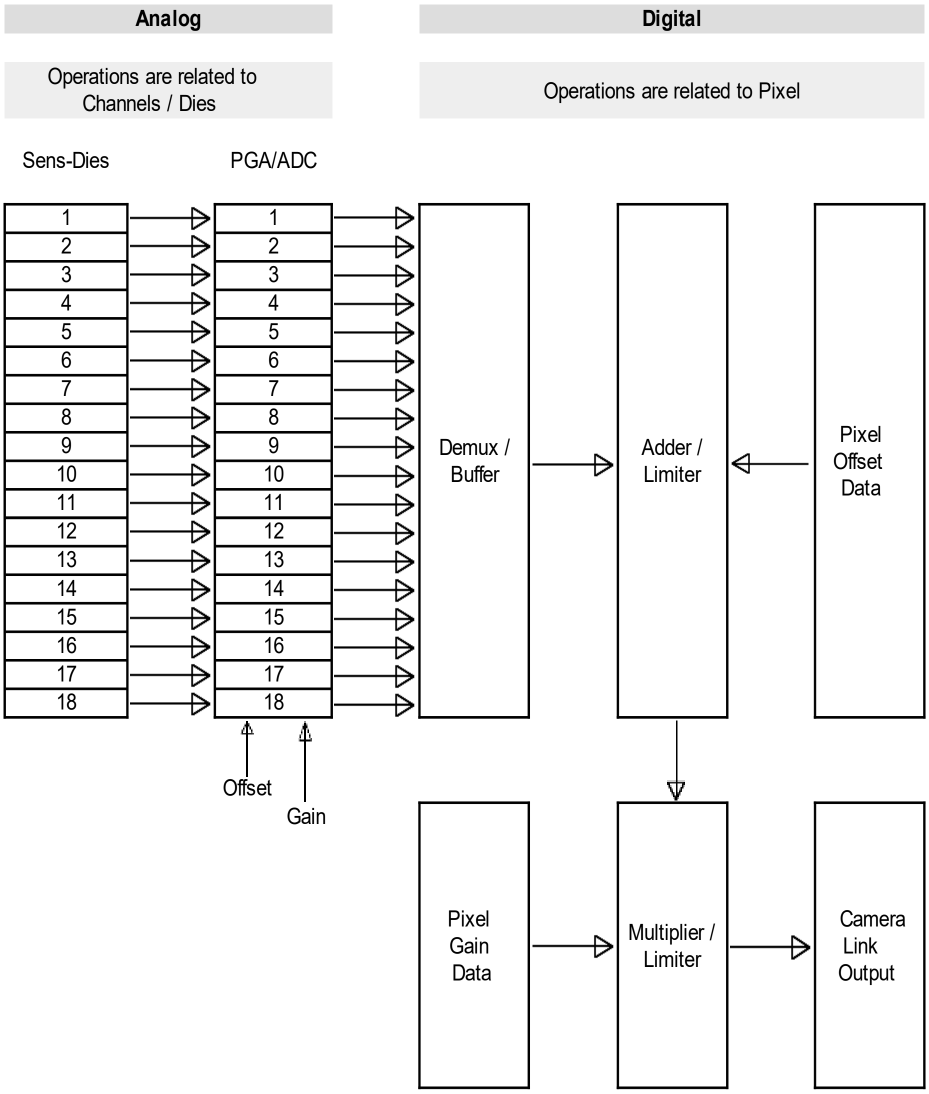
2.1.2 Image generation system



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

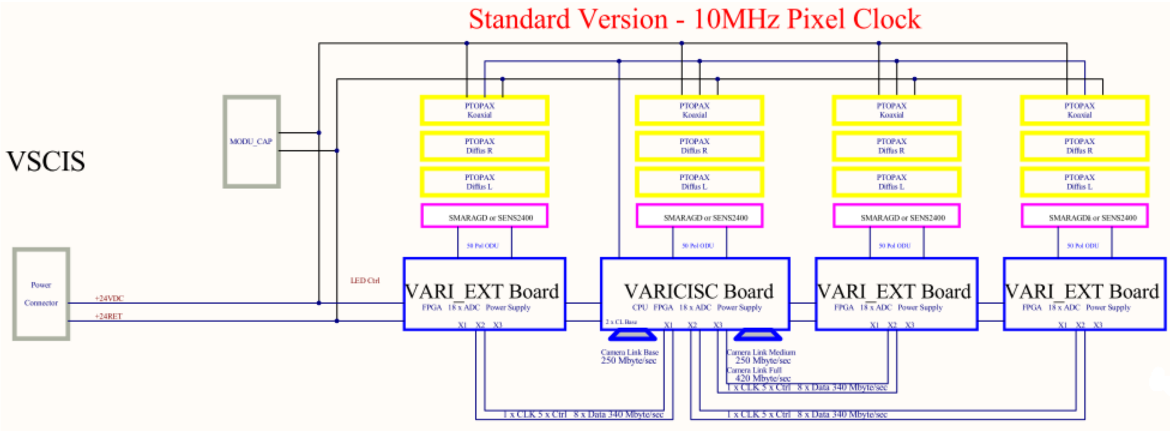
A CIS mounted in a system, scan a moving object line by line. An encoder triggers the creation of images. A scale of 1:1 requires quadratic pixels. The tune of the encoder is usually in a pre-scaler integrated in the frame grabber. It assembles the received images of lines to an full image and stores 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-diagram 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 to 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 made of image sensors of CMOS – technology.

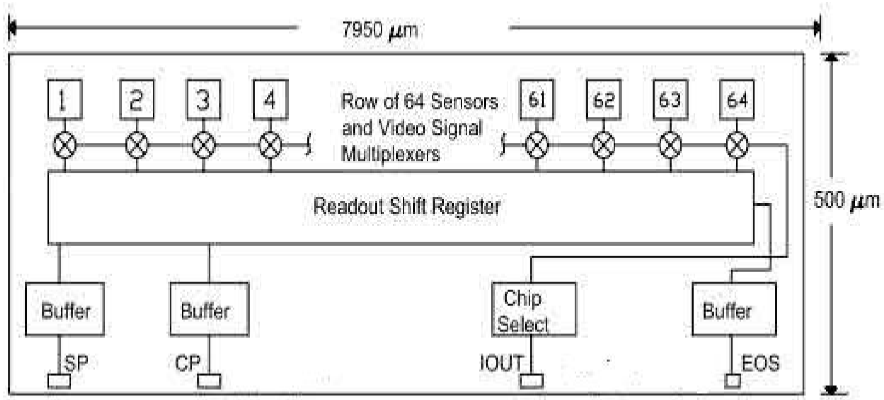
Both types of image sensor technology convert light into electric charge and process it into electronic signals. In a CCD sensor, every pixel's charge is transferred through a very limited number of output nodes (often just one) to be converted to voltage, buffered, and sent off-chip as an analog signal. 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 are in 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 a real 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 diagram of a 200dpi chip is shown on image 2.2.2-1 (see below)



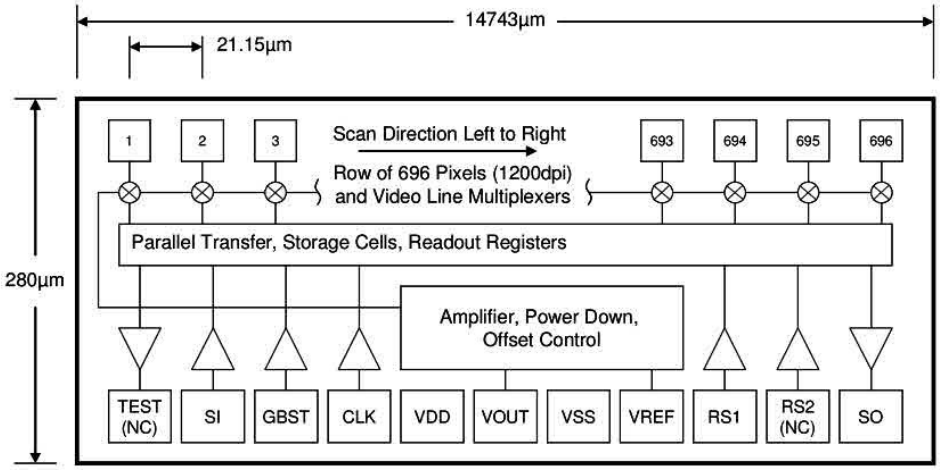
Img. 2.2.2-1 Block diagram of a 200dpi chip

"Rolling Shutter" Principle

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). In this way, all 64 pixels are read out and the start pulse appears at the EOS output, signaling the end of the readout process.

During the reading process light must not enter into 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

"Global Shutter" Principle

Each sensor contains 696 active pixels consisting of photodiode and additional transistors, which process, amplify and buffer the signal. 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 200 dpi chip, the specification is "typical 125 µm".
For the 1200 dpi chip, the specification is "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.

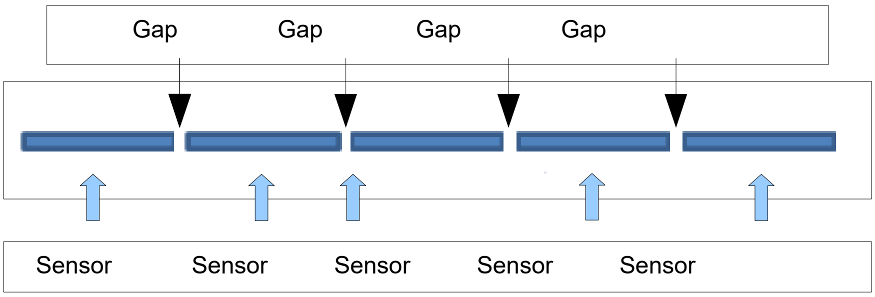
Using the “Global Shutter” - principle the brightness information of every pixel will be written in an intermediate buffer at the same time and afterwards, while the next illumination sequence is already running, it will be sent to the exit.

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 also Fig. 2.2.2-2 and the description of the 1200 dpi chip.

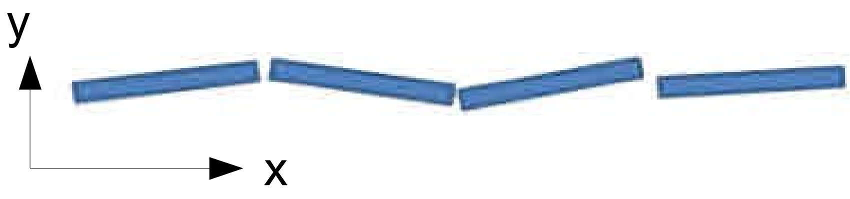
2.2.4 In-Line Sensors with Gap (MAXICIS Family)

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 additionally a chip is larger than the outer borders of the pixels.



Img. 2.2.4-1 In-Line structure

In general, the assembly of the chips on sensor boards is subject to tolerances. The production tolerance not only affect the gaps in between 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.

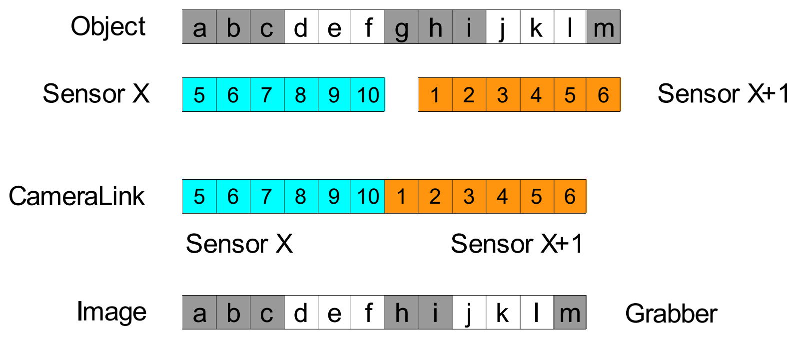


Abb. 2.2.4-3 Object and its image in FrameGrabber

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 (VARICIS Family)

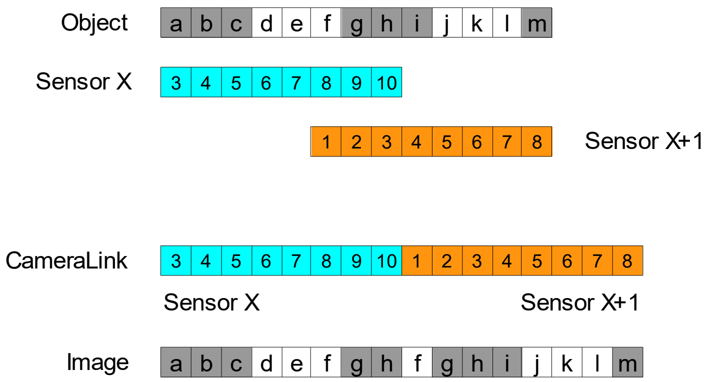
To prevent gaps sensor chips can be arranged staggered or overlapped one above the other in two rows. The angular deflection (about 100 µm) of the symmetry axis of the pixel rows is chosen as a full multiple of the pixelsize.

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 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 10 in the area a to h and buffered in the FIFO-MEMORY. Two trigger-impulses (=2 lines) later the object is being recorded 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 assembly 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.

Laser-assisted geometry correction for VDCIS

By means of several lens optics arranged in an array, partial areas of the object are imaged with an imaging scale onto the corresponding sensor chips.

Between the individual lenses, line lasers superimpose a survey grid that is used to stitch the individual sensor images together to form an overall image.

2.3 Illumination and its control

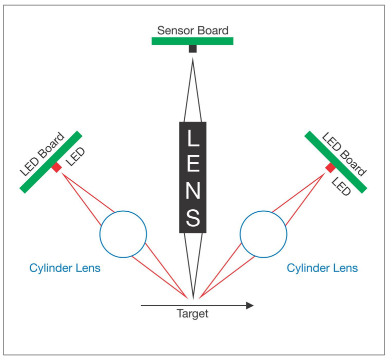
2.3.1 Illumination

LED´s are used for illumination. They are available in various colors, luminous intensities and beam angles, can be combined to form lines of any length, can be quickly controlled and operated with 24 VDC.

Structurally identical LED´s can distinguish among each other in the emitted illumination intensity. 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.

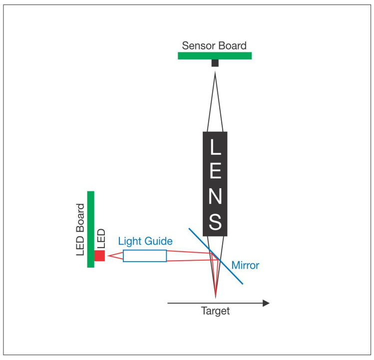
The illumination of the LED-lines can be bundled up to the working distance and focus line of the sensor by cylinder-lenses : diffuse light



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.

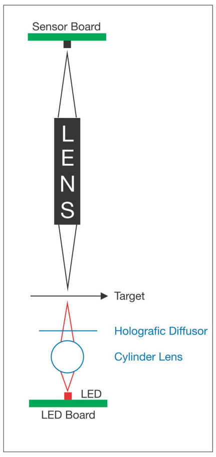


Img. 2.3.1-2 Coaxial Illumination

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".

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 special diffuser films are used, that homogenise the illumination. They own the feature to strongly stretch the round light beam 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 special diffuser film provides for a homogeneous light band.

Diffuser films usually require a longer exposure time.

Our diffuser films have 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.

Optionally 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 frequency 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 frequency, 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 linerate becomes lower than the exposure-time, the exposure control will limit the linerate. As a consequence the effective pixel may be distorted from a square to a rectangular shape. The geometry correction will no longer work exactly and even a color offset might arise.

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 may 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 on the depending on the mode 'M<0-4>' and Light on/off 'L<0,1>' the lines illumination.

M	L	Trigger pulse	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 und illumination

2.3.5 Monochrome-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 frequency. 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

An RGB CIS has its own LEDs for each color. Red, green and blue LEDs are arranged next to each other in an LED row. The exact sequence is R-G-B-G. This corresponds to the Bayer matrix.

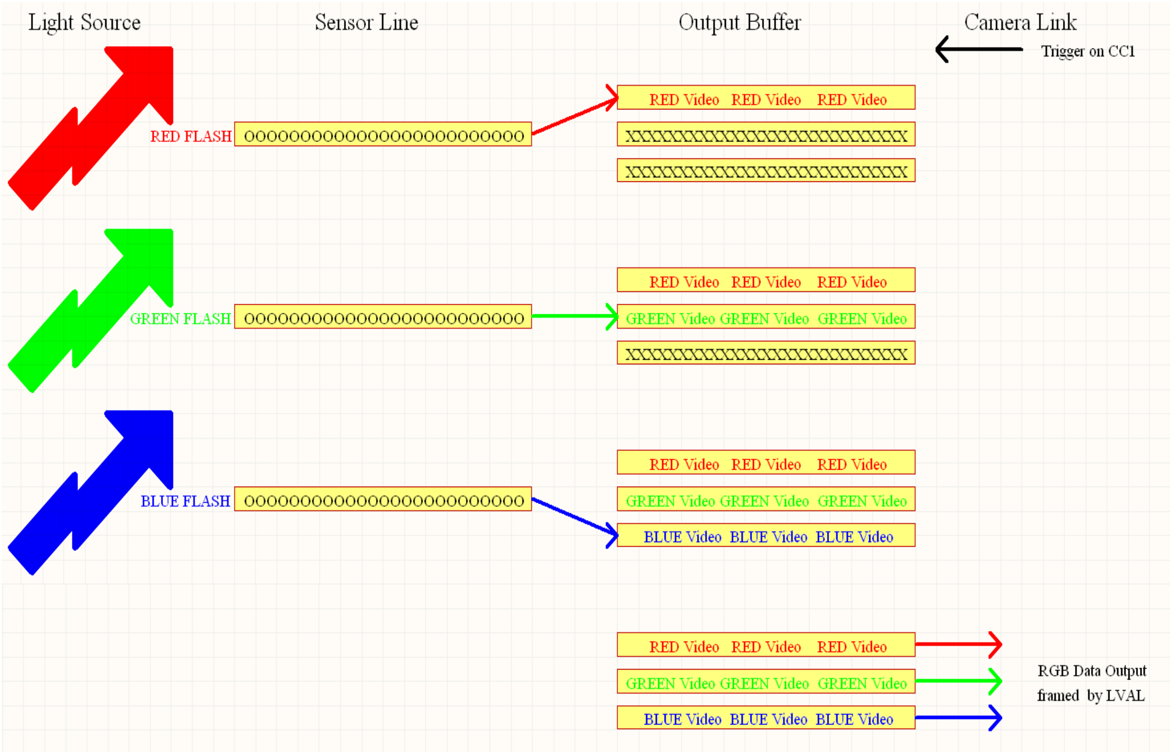
A trigger-impulse causes a triple illumination of the line. The illumination in phase 0 red, in phase 1 is green and in phase 2 is blue.

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.

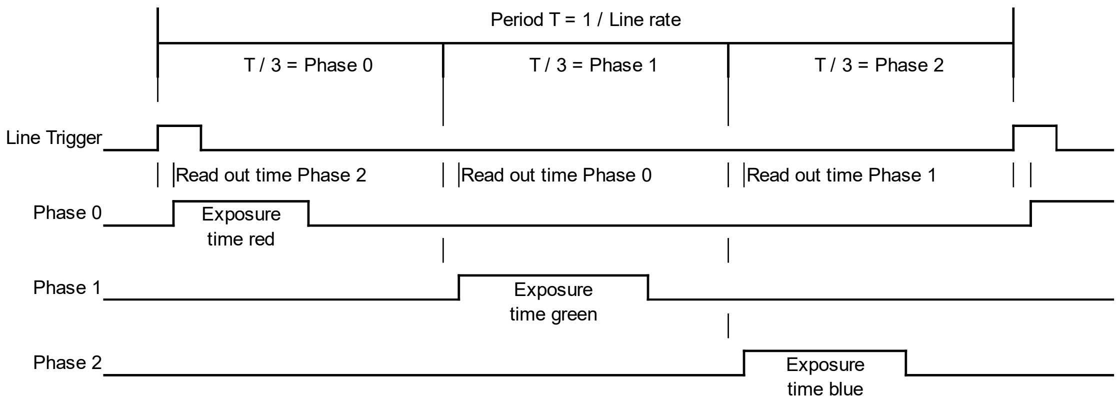
This process will be repeated for phase 1(green) and phase 2 (blue).

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 Appoarch.



Img. 2.3.6-1 Multiplex Approach



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

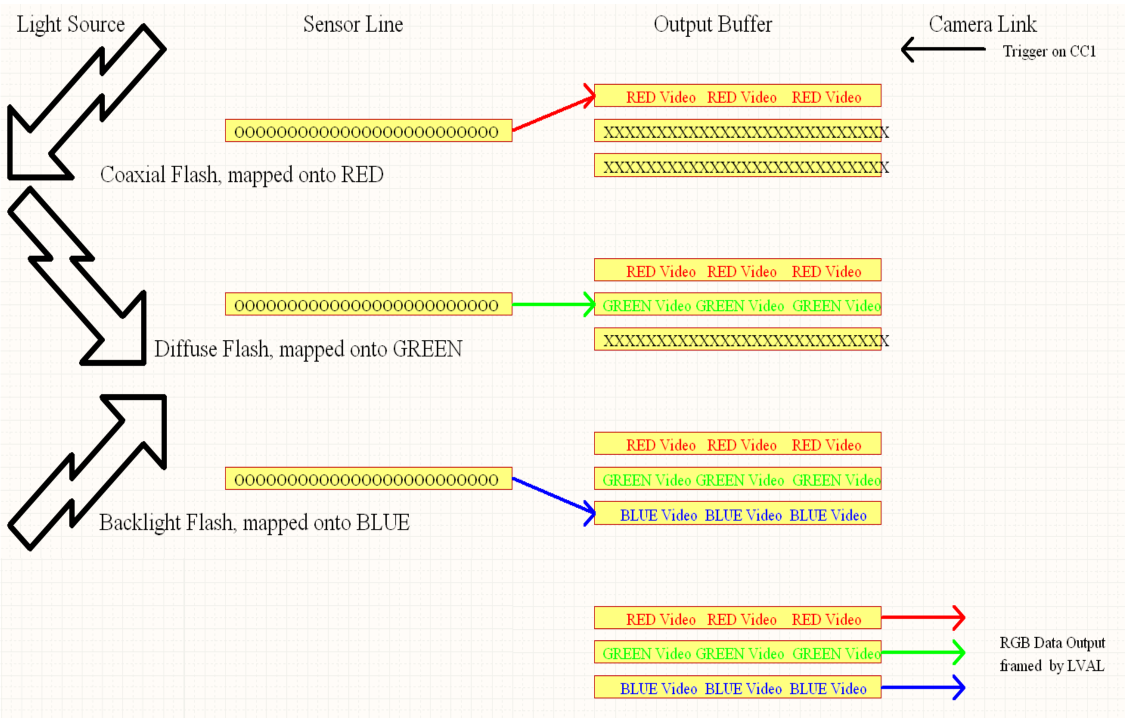
The meantime between two trigger pulses (Period T) will be equally split to the count of illumination phases.

With the serial working off the single colors it inevitably comes to a slight offset of the image. The first color channel exposes, slightly offset, a different location than the second color channel, and so on, because the scanning object has moved on minimally in the meantime. 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 special position of the respective LED-rows.



Img. 2.3.7-1 Example of a 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 sixteen 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 sixteen illumination-channels in up to thirty two 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	C12	C13	C14	C15
Phase 0:	140	0	0	140	0	0	0	0	0	0	0	0	0	0	0	0
Phase 1:	0	126	0	0	126	0	0	0	0	0	0	0	0	0	0	0
Phase 2:	0	0	136	0	0	136	0	0	0	0	0	0	0	0	0	0

Phase 0 to 2 are exposure phases.

C0 to 15 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..15 External RGB-LED-Row

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

In this case there is a RGB CIS with 2 diffuse LED rows. The channels C0 and C3 are the red LEDs with the exposure time of 14µs, C1 and C4 are the green LEDs with 12.6 µs and C2 and C5 are the blue LEDs with 13.6 µs.

Another example:

*** Exposure ***

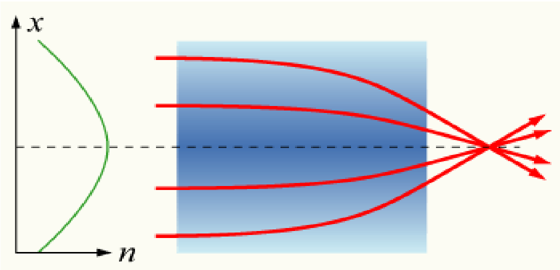
	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Phase 0:	100	0	0	100	0	0	50	0	0	0	0	0	0	0	0	0
Phase 1:	0	80	0	0	80	0	0	40	0	0	0	0	0	0	0	0
Phase 2:	0	0	85	0	0	85	0	0	45	0	0	0	0	0	0	0

In this case, there is an RGB CIS with 2 diffuse LED rows and one coaxial LED row. The channels C0 and C3 are the red diffuse LEDs with the exposure time of 10 µs, C1 and C4 are the diffuse green LEDs with 8 µs and C2 and C5 are the diffuse blue LEDs with 8.5 µs. The coaxial channels C6 red with 5 µs, C7 green with 4 µs and C8 blue with 4.5 µs light up simultaneously with the diffuse channels of the same color, so that a mixed light of diffuse and coaxial is created.

2.4 Optics

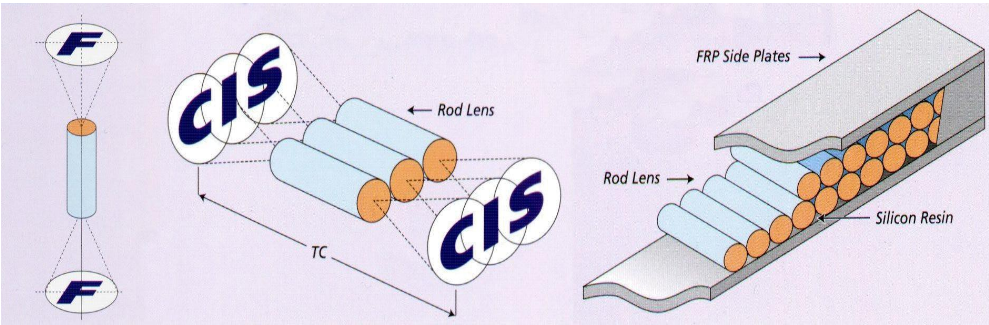
2.4.1 GRIN Lenses Array

GRIN-Lenses (Graded – Index - lenses) are cylindrical segments (Rod Lens) of a graded index fibre. It has a feature that its refractive index n decreases continuously towards the edge. As a result, there is no total reflection of coupled light beams at the cylinder edge, but they run sinusoidally curved through the fiber.



Img. 2.4.1-1 Operation of a graded index fibre

A appropriate choice of the length of a fiber section produces identical focal lengths and working distances in front of the two end faces of the cylinder 2. An object in front of one surface is identically pictured as an image on the other front surface, i.e. 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 desire picturing of an image line there are many single GRIN-lenses are joined next to each other to form a row whose images overlap. To improve the imaging features 2 rows are sticked side by side, enclose them with 2 cover plates and obtain the GRIN-lens-array shown in figure (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.

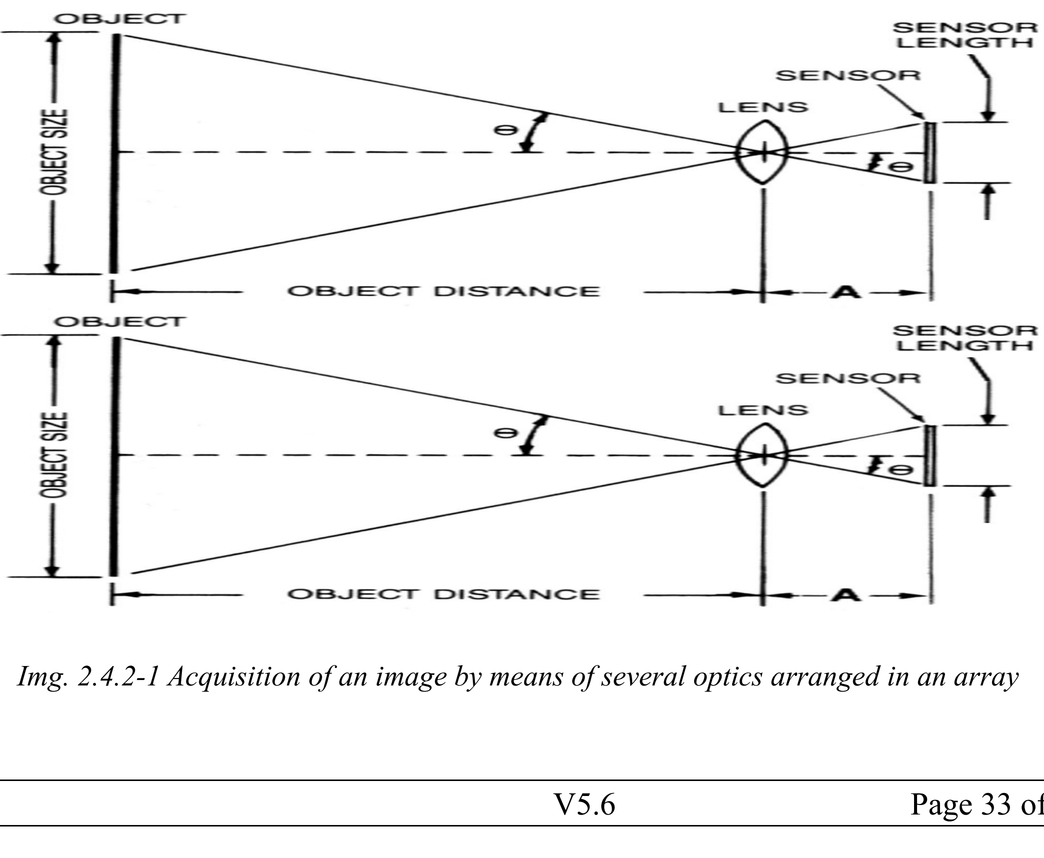
In the image 2.1.1-1 it is apparent out of the principal structure of a CIS, that there is a glass window in front of the GRIN-lens-array. It mostly owns a thickness of 2 mm. Therefore the usable working distance of the CIS is decreased by these glass thickness. Simultaneously this optical element increases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

If the CIS is equipped with a coaxial illumination (see img. 2.3.1-2), between the glass window 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 window of the CIS and the object. On the nameplate of each CIS, the controlled working distance is noted.

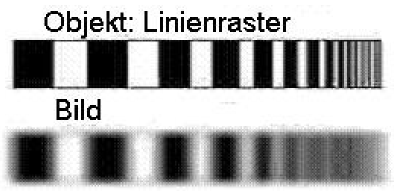
In the VDCIS with laser support, line scan camera arrays with a working distance of approx. 60 mm are installed.



Img. 2.4.2-1 Acquisition of an image by means of several optics arranged in an array

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 (object) + black (object)]

(object) line grid: 1 line pair / mm for 8 Pixel of the sensor

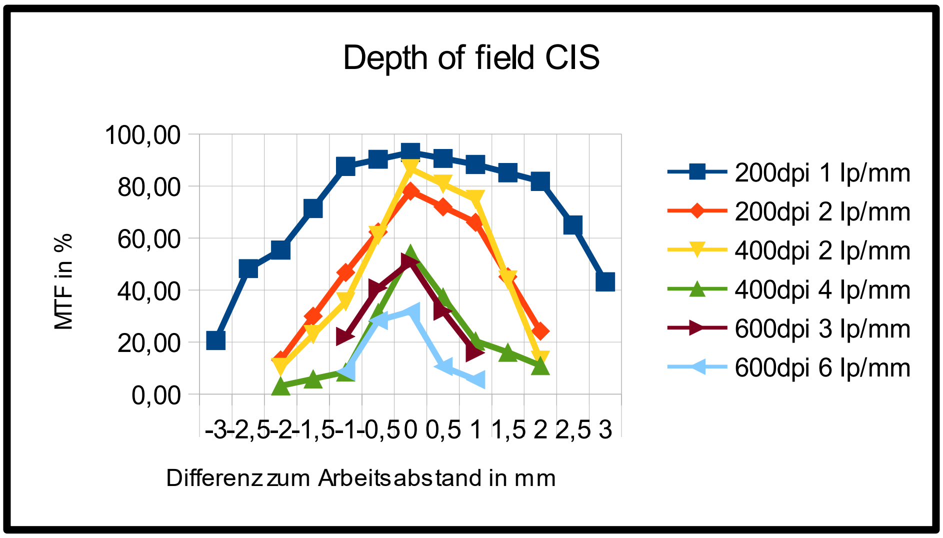
In the formula the single grey levels are to set.

The area in front of and behind of the working distance where the MTF is better than 20% is defined as depth of field and is specified 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]
Standard-VDCIS	
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
VDCIS Laser-assisted	
200	10
500	5
1000	2,5

Tab. 2.4.3-1 depth of field ranges



Img. 2.4.3-2 depth of field curves

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 (maximum 10 Bit per Tact)
- Base (maximum 24 Bit per Tact) - e.g.: 255 MB/s with 3 taps of 8 bits each
- Medium (maximum 48 Bit per Tact) - e.g.: 510MB/s
- Full (maximum 64 Bit per Tact) - e.g.: 680 MB/s with 8 taps
- Full 80 bit (maximum 80 Bit per Tact) - e.g.: 850 MB/s with 10 taps

Both monochrome and color images can be transferred.

The Lite configuration is irrelevant for the CIS.

In the base configuration, one Camera Link cable is required, for medium, full and full 80 bit configuration two cables are required. 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 enable, 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-Frame Grabber.

Standard Mono Modes

	Connector 1			Connector 2							Connector 3			Connector 4						
Base	PORT A																			
	PORT A	PORT B																		
	PORT A	PORT B	PORT C																	
Medium	PORT A	PORT B	PORT C	PORT D																
	PORT A	PORT B	PORT C	PORT D	PORT E															
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F														
Full	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G													
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H												
Full	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A									
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B								
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B	PORT C							
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B	PORT C	PORT D						
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B	PORT C	PORT D	PORT E					
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B	PORT C	PORT D	PORT E	PORT F				
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G			
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H			PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H		

	Connector 1			Connector 2							Connector 3			Connector 4						
Full 80	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I											
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J										
2x Full 80	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A									
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B								
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C							
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D						
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D	PORT E					
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F				
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G			
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H		
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT H	PORT I	PORT J

Standard RGB Modes

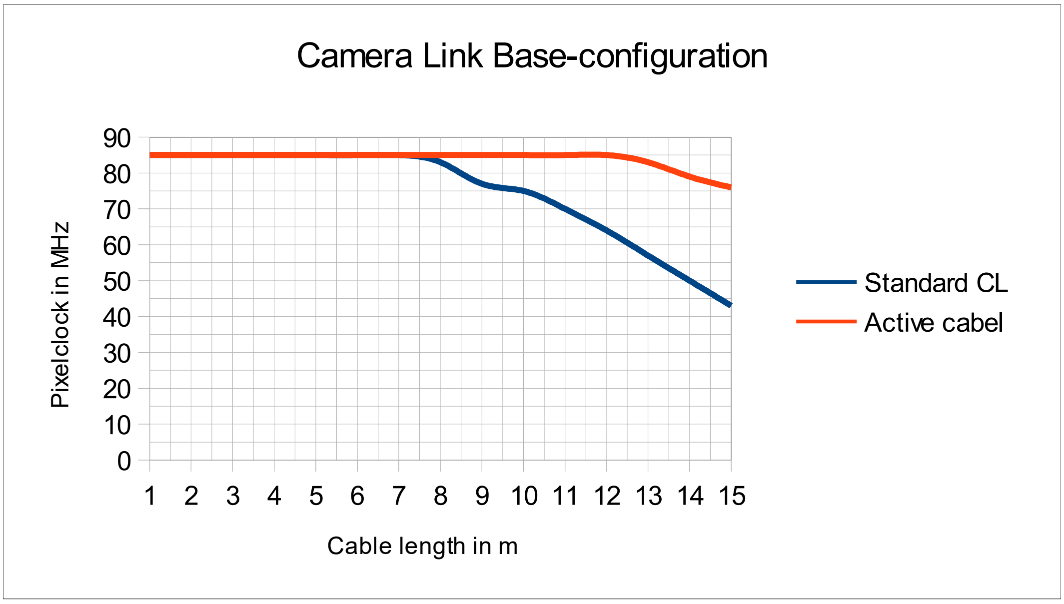
	Connector 1			Connector 2							Connector 3			Connector 4						
Base	PORT A	PORT B	PORT C																	
Medium	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F														
Full	*PORT A*	*PORT B*	*PORT C*	*PORT D*	*PORT E*	*PORT F*														
2 x Full	*PORT A*	*PORT B*	*PORT C*	*PORT D*	*PORT E*	*PORT F*					*PORT A*	*PORT B*	*PORT C*							
	PORT A	*PORT B*	*PORT C*	*PORT D*	*PORT E*	*PORT F*					*PORT A*	*PORT B*	*PORT C*	*PORT D*	*PORT E*	*PORT F*				
Full 80	PORT A	PORT B	PORT C																	
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F														
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT	PORT I											
2x Full 80	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT	PORT I		PORT A	PORT B	PORT C							
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT	PORT I		PORT A	PORT B	PORT C	PORT D	PORT E	PORT F				
	PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT	PORT I		PORT A	PORT B	PORT C	PORT D	PORT E	PORT F	PORT G	PORT	PORT I	

Standard 2 Color Mode as RGB Subset

	Connector 1			Connector 2							Connector 3			Connector 4						
Base	PORT A	PORT B																		
Medium	PORT A	PORT B		PORT D	PORT E															
Full	*PORT A*	*PORT B*		*PORT D*	*PORT E*															
2 x Full	*PORT A*	*PORT B*		*PORT D*	*PORT E*						*PORT A*	*PORT B*								
	PORT A	*PORT B*		*PORT D*	*PORT E*						*PORT A*	*PORT B*		*PORT D*	*PORT E*					
Full 80	PORT A	PORT B																		
	PORT A	PORT B		PORT D	PORT E															
	PORT A	PORT B		PORT D	PORT E		PORT G	PORT H												
2x Full80	PORT A	PORT B		PORT D	PORT E		PORT G	PORT H			PORT A	PORT B								
	PORT A	PORT B		PORT D	PORT E		PORT G	PORT H			PORT A	PORT B		PORT D	PORT E					
	PORT A	PORT B		PORT D	PORT E		PORT G	PORT H			PORT A	PORT B		PORT D	PORT E		PORT G	PORT H		

2.5.1.2 Camera Link Cable

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 the 85 MHz pixel clock used as standard in the TiVi-CIS, a length for the standard cable of 5 m should not be exceeded to be on the safe side.

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 is 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 Signal

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

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-(Low Voltage Different Signaling)-cable-pairs each 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 two LVDS- Interface-Standard (Low Voltage Different Signalling) line pairs are available. 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.

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.

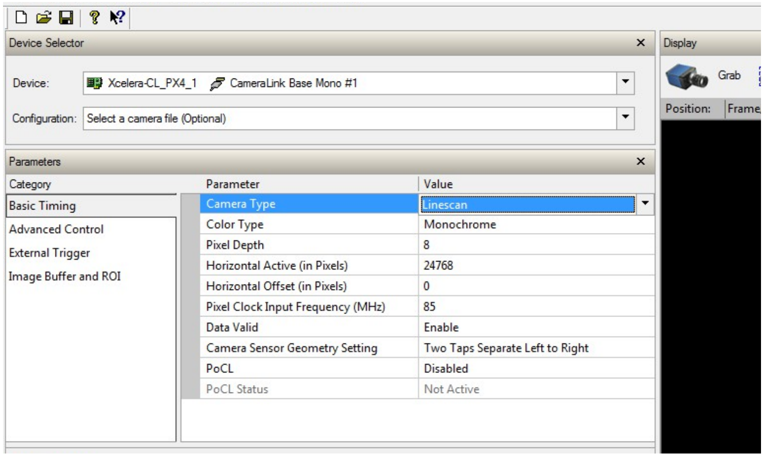
By default the serial communication uses the RS-232 interface and the trigger-impulse use the CC1-signal of the camera-link connector.

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 are 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 strung together in the FrameGrabber. For example, if 2 ports are specified in the datasheet, the FrameGrabber will set 2 taps left to right.



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

Camera Sensor Geometrie 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 be processed.

2.5.1.5 Camera Link Repeater

The Camera Link cable are limited to about 5m 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, converts it into an RGB signal, feeds it to the transmitter module and forwards the refreshed Camera Link signal to the next cable. Camera Link transmitter components can only drive a certain cable length. If this length is exceeded, the video signal may be attenuated to such an extent that interference-free reception 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 an interface standard for industrial image processing introduced in mid-2006.. 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, which was launched by around 50 companies, is intended to ensure interchangeability of hardware products based on the UDP/IP protocol and the GenICam interface and to enable vendor-independent software for any GigE Vision cameras.

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

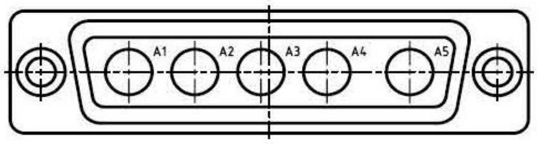
As standard the MaxiCIS is deliverable in GigE-version. There is enough space in this CIS to accommodate the Pleora IP engine.

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

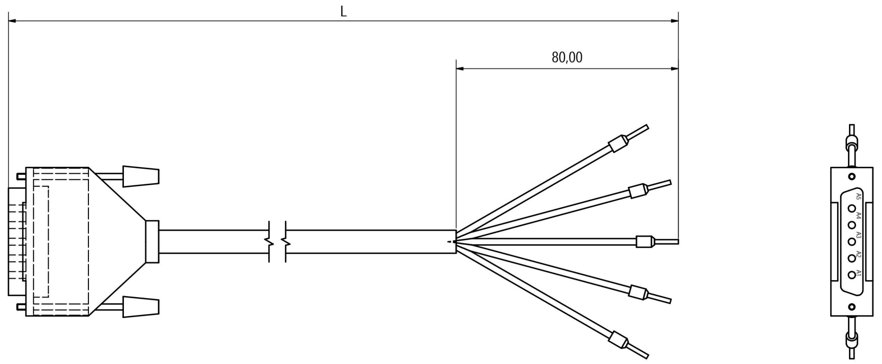
The plug-connection is an five-pole D-SUB with high-power-contacts.

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. The decisive factor is the voltage directly at the CIS and not at the output terminals of the power supply unit.

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 effective 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 may have significant power requirements depending on the illuminiation.

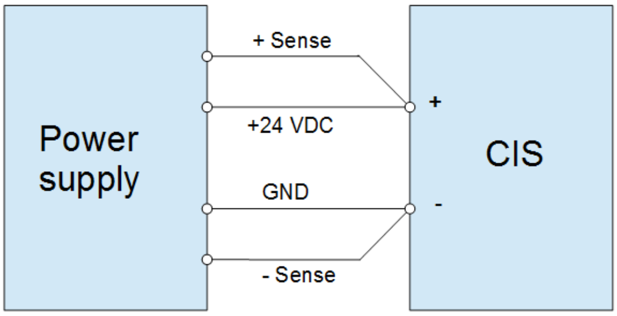
The table shows that with a 10 m cable and a current consumption of 10 A, the voltage tolerance is already exceeded.

The standard lengths of the power cable are 2m, 3m, 5m and 10m. Other length are also 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 nameplate the real current demand is stated. It is measured for each CIS during the final test.

2.6.3 Remote Sense Line

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 extra-low voltage

SELV (Safety Extra Low Voltage) is a safety over extra low voltage according to IEC/EN 60950. It must not exceed 25 VAC or 60 VDC.
Even if there is direct contact with live parts, there is no danger to human from body currents.
The demanded safe isolation is achieved with power supply units through doubled or reinforced galvanic isolation of the primary and secondary side with help 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 a protective extra-low voltage with safe isolation according to IEC/EN 60950. The same regulations apply as for power supply units according to SELV. The difference is: The loads supplied wedges may be grounded.

Functional ground

A circuit corresponding to the PELV – standard 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 mounting bracket and its opearting 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.

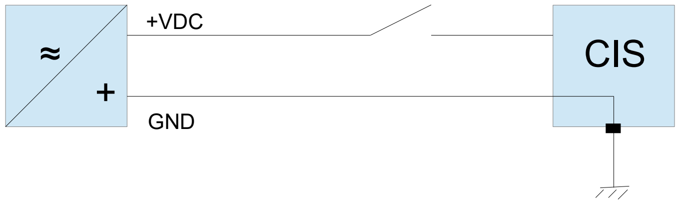
In this context a good signal ground is important, where all electrical components are connected.

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 interference in the Camera Link can then appear as image errors.

Improper grounding can cause the LEDs to glow when switched off in the case of external lighting controlled by the CIS.

Power-circuit

It is recommended to switch the power supply of the CIS in the 24 V branch so that a clean DC voltage is present in the initialization phase of the CIS.



Img. 2.6.4-1 CIS power circuit

Power supply units that only apply voltage to the output terminals when the 24 V has stabilized are also suitable.

3 Software-functions of the Industrial Contact Image Sensor (CIS)

3.1 Controls of the CIS

3.1.1 Trigger

By triggering the CIS, the line frequency is synchronized with the moving speed of the object. A correct image assumes square pixel. This is set if each forward movement of the object by the path 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 one 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 edge of the trigger pulse initiates the capturing of one line. That means the illumination is switched on for the duration of the exposure time „E“, next the sensor chips are read out and the system waits for the next increasing signal edge of the trigger pulse.

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

line frequency 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“ can be selected
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 Frame Grabber.

The active illumination („L1“) of the CIS is automatically switched off with missing trigger pulses and is again switched on with incoming increasing pulse edge. 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 movement generates trigger pulses. So the illumination is switched off only with direction reversal. If the illumination is to be switched on only in one direction of movement, the direction information of the encoder signal must be evaluated in the trigger input card of the FrameGrabber.

"**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.

There may be conflicts between triggers (= line frequency) and the exposure time "E":

When the period duration of the line frequency is less than the sum of the exposure time plus the readout time of the sensors, either a message is displayed in the terminal program or the line frequency is automatically adapted to the exposure time, i.e. the line frequency is reduced and thus the period duration is extended. This applies to all CIS which are read out with the "rolling shutter" principle.

For „Global Shutter“ capable sensors the readout 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 (= jitter) of the encoder signal must not exceed 10 %.

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.

The encoder for external triggering (lines as well as image) is to be connected to the "CONTROL" socket.

PIN	**Signal**	**Level, Direction**	**Comment**
1	(Optional 5 VDC Encoder OUT)		
2	XA+	RS-422 IN	Encoder
3	XB+	RS-422 IN	Encoder
4	(YA+)	(RS-422 IN)	Sheet Trigger
5	(YB+)	(RS-422 IN)	
6	(LEDB1+)	(RS-422 OUT)	
7	(LEDB2+)	(RS-422 OUT)	
8	(LEDB3+)	(RS-422 OUT)	
9	(LEDB4+)	(RS-422 OUT)	
10	GND		
11	(TxD232)		
12	DO NOT USE		
13	DO NOT USE		
14	GND		
15	XA-	RS-422 IN	Encoder
16	XB-	RS-422 IN	Encoder
17	(YA-)	(RS-422 IN)	Sheet Trigger
18	(YB-)	(RS-422 IN)	
19	(LEDB1-)	(RS-422 OUT)	
20	(LEDB2-)	(RS-422 OUT)	
21	(LEDB3-)	(RS-422 OUT)	
22	(LEDB4-)	(RS-422 OUT)	
23	(RxD232)		
24	GND		
25	GND		

3.1.2 Serial communication

The communication with the CIS is carried over a terminal program as a human-machine-interface. Terminal programs like TiViViewer, HyperTerminal, ProComm, TeraTerm can be used for this purpose. TiVi cannot assume any functional guarantee for this.

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 one command character is entered and confirmed with "ENTER", the syntax of the command is displayed on the screen with its associated parameters. In this way, the operator can quickly find out which parameters are requested by a command.

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:

3.3 Command description

Main Menu Instruction set VUCIS & VTVDCIS

Instruction set	VUCIS	VTVDCIS
? Help	List available main menu commands	
# List Permanent Parameters	Listing of the set parameters	
L <0|1> **Light On/Off** **L**<0|1>	Light On/Off 0 Light off 1 Light on ***Attention*** *: This parameter cannot be saved. The CIS always starts with the light switched off.*	
PC 5 **Pixelcorrection** **C**<0-5>	Performing pixel correction After pixel correction, the light must be switched on again with **L 1**. Determined pixel correction values can be stored permanently with **PCS**.	Performing pixel correction <0-4> Test-Modus 5 pixel correction After pixel correction, the light must be switched on again with **L1**. Determined pixel correction values can be stored permanently under the number N with **$N**.
PCC **Z**<0-N> **Clear|Restore Correction Data**	Deletes the values of the pixel correction	0 Deletes the values of the pixel correction in RAM 1 Load the correction table number 1 from the Flash memory N Load the correction table number N from the Flash memory
PCP <0|1>,<0|1>,<0|1>,<0|1>,<0|1>,<0|1> **PhasePixelcorrection** **K**<0|1>,<0|1>,<0|1>,<0|1>,<0|1>,<0|1>	<0|1> 0 no pixel correction for selected phase 1 Pixel correction for selected phase is performed First <0|1> Parameter is Phase 0, Second is Phase 1,.....etc. Example:PCP 1,1,1,0,0,0 Pixelcorrection only for Phase0-2 **K0,0,0,1,1,1** Pixelcorrection only for Phase3-5	
PCR **Restore Pixel correction**	Restore of pixel correction	*No Function*
PCS **Store PixelCorrection**	Store of pixel correction	*No Function*

<table>
<tr><th>Instruction set</th><th>VUCIS</th><th>VTVDCIS</th></tr>
<tr><td>PPS
S Store Parameters</td><td colspan="2">Stores current parameter.
Attention: L 1 / L1 Light on, is not stored</td></tr>
<tr><td>SWR
! SW-Reset</td><td colspan="2">Software Reset</td></tr>
<tr><td>V <M|S>,<#>,<pc>
Video Mode
V<M|S>,<#>,<pc></td><td><M|S> Master(0)|Slave No|999
<#> Pattern No
1/0x10 Hor. Gray Ramp
2/0x20 Ver. Gray Ramp
3/0x30 2D Gray Ramp
4/0x40 Sensor Index
5/0x50 Hor. RGB Ramp
6/0x60 Ver. RGB Ramp
7/0x70 2D RGB Ramp
8/0x80 2D Constant RGB Value
<pc> Pixel correction(0|1) off/on</td><td><M|S> Master =0
Slave = 1-6
<#> Pattern No
0 Live Image -true video
1 Test-Image - grayscale-ramp horizontal
2 Test-Image - grayscale-ramp horizontal
3 Test-image - 2D ramp
4 Test-image - Sensor Index
5 Test-image - RGB ramp horizontal
6 Test-image - RGB ramp vertikal
7 Test-image – RGB 2D ramp
<pc>Pixel correction (0|1) off/on</td></tr>
<tr><td>VER
v Show SW-Version</td><td colspan="2">Show Software and Firmware Version</td></tr>
<tr><td>MMI
Switch to MM Interface</td><td>Jump to MMI menu</td><td>No Function</td></tr>
<tr><td>SET
> Switch to SET Menu</td><td colspan="2">Jump to SET menu</td></tr>
<tr><td>GET
Switch to GET Menu</td><td>Jump to GET menu</td><td>No Function</td></tr>
</table>

SET Menu — Instruction set VUCIS & VTVDCIS

Instruction set	VUCIS	VTVDCIS
? Help	List available SET menu commands	
# List Permanent Parameters	Listing of the set parameters	
AOF <ch>,<val> **Set Analog Offset** **O**<ch,val>	Set Analog Offset Values <ch> <0-999> analog channel number , 999 all <val> <0-255> Input of the desired value	
BL <0-5>,<0-255> **Set BL Digital** **B**<0-5>,<0-255>	Set bright level value for pixel correction <0-5> n Exposure phase n <0-255> Digital set value	
BS <1-12> **Set Binnig Skal**	Number of pixels combined **BS 2** : 2 pixels become 1 , 600 dpi becomes 300 dpi	
DL <0-5>,<0-255> **Set DL Digital** **D**<0-5>,<0-255>	Set dark value for pixel correction <0-5> n Exposure phase n <0-255> Digital set value	
EXP <ph>,<c>,<u.>,<.u> **Set Exposure** **E**<ph>,<c>,<value>	Set the Exposure-Table <ph> n Exposure phase n / 99 set all phases <c> n Channel number n / 99 set all Channels	
	<us.> Exposure time in µs <.us> Exposure time in **0,**µs	<value> Input of the exposure time in 100 ns units. Example: 10 means : 10*100ns = 1000 ns = 1 µs

```
Example:              E0,0,300                                  VTVDCIS
                      EXP 1,1,200,0    VUCIS
                         *** Phase Sequence ***
                   CH  VF RF  CM   C0   C1   C2   C3   C4   C5   C6 ... C15
Phase  0:  Video    0   0  0   0   300   0    0   300   0    0    0 ...  0
Phase  1:  Video    1   0  0   1    0  200.0  0    0   200   0    0 ...  0
Phase  2:  Video    2   1  0   2    0    0   200   0    0   200   0 ...  0
Phase  3: AutoCorr  3   0  1  15    0    0    0    0    0    0   25 ...  0
     |              |   |  |   |  LED-Row 0
     |              |   |  |   CM Colormix: Number in CM-Tabelle
     |              |   |  RF ReturnFlag: 1 = Goto Start
     |              |   VF Video Flag: 1 = Videodata Output
     |              CH Channel in FPGA: 0-5
     Sequenz Phase Number(0 – 31)
```

Instruction set	VUCIS	VTVDCIS
FFD <0|1> **<u>Set</u> FIFO Direction** **d**<0|1>	Adjusting the Y geo values to the scan direction <0|1> Direction selection of the Y correction	
FTM <0-4> **<u>Set</u> FrameTrigger Source** **N**<0-4>	Set Mode : 0 Free running 1 External trigger over CC2 2 External trigger, XA,XB 3 External trigger, YA,YB **4 not aktiv**	
LFR <frequency> **<u>Set</u> Line-Frequency** **F**<freq[Hz]>	only relevant for free running mode **LTM 0 / M0** freqency [Hz] Input of the line frequency in	
	Hz Example: **LFR 100** = 100Hz	10Hz steps Example:**F**100=100*10Hz
LTM <0-4> **<u>Set</u> Mode** **M**<0-4>	Set Mode : 0 Free running 1 External trigger over CC1 2 External trigger, XA,XB 3 External trigger, YA,YB **4 not aktiv**	
PPS **S Store Parameters**	Store current parameter Attention: **L 1** / **L1** Light on, is not stored!	
RES <idx>	Set Resolution	No Function
SEQ <value>,<T>,<ch>,<V>,<R>,<C> **<u>Set</u> Sequence** **D**<ph>,<T>,<CH>,<VF>,<RF>,<CM>	<value> Sequence No. <T>Target Type 1 Video, 5 Auto Correction <ch> Channel in FPGA <V>Video Flag 0 Get Video Data 1 Video data output <R>Return Flag 0 Goto next, 1 Goto Start <C>ColorMixTable No. Example: Monochrom **SEQ 0,1,0,1,1,0**	<ph>Sequenz Phase No. <T>Target Type 1 Video, 5 Auto Correction <Ch>Channel in FPGA <VF>VideoFlag 0 Get Video Data 1 Video data output <RF>ReturnFlag 0 Goto next, 1 Goto Start <CM>ColorMixTable No. Example: Monochrom **D0,1,0,1,1,0**
TP <uint> **<u>Set</u> Trigger Pulses** **T**<0-uint>	Prescaler for trigger (encoder) pulses <uint> Each uint edge starts the acquisition of a new line	
	E.g. **TP 3** Every third edge starts a new line	E.g. **T3** Every third edge starts a new line.

Instruction set	VUCIS	VTVDCIS
XG <sens>,<s>, <si>,<e> **Set X GEO** **X<sens,s,si,e>**	Set X shift <sens> Sensor number <s> Sensor start: delete number of whole pixel <si> Sensor start: delete number of $^{1}/_{16}$ pixel <e> End of sensor: Number of the last valid pixel Example: **XG 0,10,0,860** Sensor number 0, Startpixel number 10, 0$^{1}/_{16}$, Endpixel 860	
YG <sens>,<s>,<si> , <e>,<ei> **Set Y GEO** **Y<sens,s,si,e,ei>**	Set Y shift <sens> Sensor number <s> Sensor start, shift numbers of whole pixel <si> Sensor start, shift number of $^{1}/_{16}$ pixel <e> Sensor end, shift numbers of whole pixel <ei> Sensor end, shift number of $^{1}/_{16}$ pixel Example: **YG 0,10,0,11,8** Sensor number 0, Sensor start shift of 10, 0 $^{1}/_{16}$ pixel, Sensor end shift of 11, 8 $^{1}/_{16}$ pixel	
GET **Switch to GET Menu**	Jump to GET menu	No Function
PWD <password> **Check Password** **P**<password>	Password input	
< **Switch to Main**	Jump to Main menu	

GET Menue   Instruction set VUCIS & VTVDCIS

<table>
<tr><th>Instructionset</th><th>VUCIS</th><th>VTVDCIS</th></tr>
<tr><td>? Help</td><td colspan="2">List available GET menu commands</td></tr>
<tr><td># List Permanent Parameters</td><td colspan="2">Listing of the set parameters</td></tr>
<tr><td>CLP
<u>Get</u> CL Patch</td><td>Shows the CL Tap-Chip# / Phase-Pixel# assignment</td><td>No Function</td></tr>
<tr><td>DMP
@<0|1> Dump Perma</td><td colspan="2">Writes the permanent data to the terminal</td></tr>
<tr><td>EXP
<u>Get</u> Exposure</td><td>Shows the exposure table</td><td>No Function</td></tr>
</table>

Example:

```
                         *** Phase Sequence ***
                   CH  VF RF  CM   C0    C1    C2   C3    C4   C5   C6  ... C15
Phase  0:   Video   0   0  0   0  300.0   0     0  300.0  0     0    0  ...  0
Phase  1:   Video   1   0  0   1    0   200.0   0    0   200.0 0     0  ...  0
Phase  2:   Video   2   1  0   2    0     0  200.0   0     0  200.0  0  ...  0
Phase  3: AutoCorr 3   0  1  15    0     0     0    0     0    0  25.0...   0
       |            |   |   |   |   LED-Row 0
       |            |   |   |   CM Colormix: Number in CM-Table
       |            |   |   RF ReturnFlag: 1 = End of Sequence
       |            |   VF Video Flag: 1 = Video Data Output
       |            CH Channel of FPGA: 0-5
       Sequenz phase number(0 – 31)
```

<table>
<tr><td>GEO <0|1>
<u>Get</u> X+Y Shift
x<0|1></td><td colspan="2">Shows the X,Y geo values
0 As table (in hexadecimal notation). Output format:
Sens# Xstartpixel,$^1/_{16}$ Xendpixel Ystartshift,$^1/_{16}$ Yendshift,$^1/_{16}$
1 As command list in decimal notation. Output format:
XG Sensor number, Startpixel number,$^1/_{16}$, Endpixel
YG Sensor number, Sensor start shift,$^1/_{16}$ pixel, Sensor end shift,$^1/_{16}$ pixel</td></tr>
<tr><td>HUM <0|1>
<u>Get</u> Humidity</td><td>Shows the humidity %</td><td>No Function</td></tr>
<tr><td>O
<u>Get</u> Offset
o</td><td colspan="2">List of Offsetvalues
Channel# ch , Offset val</td></tr>
<tr><td>REG <0|slave#>
<u>Get</u> FPGA Registers
r<0,n></td><td colspan="2">Output of FPGA Register
0 - Master
1-n - Slave</td></tr>
</table>

<table>
<tr><th>Instructionset</th><th>VUCIS</th><th>VTVDCIS</th></tr>
<tr><td>SC
Get Sensor Chip</td><td>Get used sensor-chip
marked by a *</td><td>No Function</td></tr>
<tr><td>TMP <0|1>
Get Temperature
t<0,1></td><td colspan="2">Shows average temperature in CIS.
0 Writes exactly 1 value
1 Continuously writes values</td></tr>
<tr><td>SET
Switch to SET Menu
></td><td colspan="2">Jump to SET menu</td></tr>
<tr><td><
Switch to Main</td><td colspan="2">Jump to Main menu</td></tr>
</table>

Main Menu Command list VTVHCIS & VTVDCIS

Command List	VTVHCIS	VTVDCIS
? Help	List available main menu commands	
! SW-Reset	Software Reset	
# List Permanent Parameters	Listing of the set parameters	
v Show sw-version	Show Software and Fimware Version	
Set ExpoPulses **A** <0-255>	No function	
Set BL Digital **B**<0-5>,<0-255>	Bright level – Set bright level value for pixel correction <0-5> 0 Exposure phase 0 <0-5> 1 Exposure phase 1 <0-5> 2 Exposure phase 2 <0-5> 3 Exposure phase 3 <0-5> 4 Exposure phase 4 <0-5> 5 Exposure phase 5 <0-255> Digital set value analog and digital value (Y& B) should be the same size	Bright level – Set bright level value for pixel correction <0-5> 0 Exposure phase 0 <0-5> 1 Exposure phase 1 <0-5> 2 Exposure phase 2 <0-5> 3 Exposure phase 3 <0-5> 4 Exposure phase 4 <0-5> 5 Exposure phase 5 <0-255> Digital set value
Pixel Correction **C**<0-5>	Execution of the pixel correction 0 Real data in uC (Q Lines) **not implemented** 1 Offset 0 - 255 -Test mode **do not use** 2 Gain 0 – 255 – Test mode **do not use** 3 Testpattern 1 periodically **do not use** 4 Offset 5 * (i / 256) **do not use** 5 Real data in FPGA with Q Lines After pixel correction, the light must be switched on again with L1.Pixel correction values can save permanently with $	Execution of the pixel correction <0-4> Test mode 5 Pixel correction After pixel correction, the light must be switched on again with **L1**. Determined pixel correction values can be stored permanently under the number N with **$N**.

Command List	**VTVHCIS**	**VTVDCIS**
Set DL digital **D**<0-5>,<0-255>	Set dark value for pixel correction <0-5> 0 Exposure phase 0 1 Exposure phase 1 2 Exposure phase 2 3 Exposure phase 3 4 Exposure phase 4 5 Exposure phase 5 <0-255> Digital set value	Set dark value for pixel correction <0-5> 0 Exposure phase 0 1 Exposure phase 1 2 Exposure phase 2 3 Exposure phase 3 4 Exposure phase 4 5 Exposure phase 5 <0-255> Digital set value
Set Exposure **E**<ph>,<c>,<value> **or** **E**<CM>,<c>,<value>	**E**<ph>,<c>,<value> <ph> 0 Exposure phase 0 <ph> 1 Exposure phase 1 <ph> 2 Exposure phase 2 <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> 11 LED-Row 11 <value> Input of the exposure time in 100 ns units Example: 10 means : 10*100ns = 1000 ns = 1 µs	E<CM>,<c>,<value> CM:= ColorMix → Entry in ColorMix table <ph> and <CM> need not match. However for most application they will match. Set the Color Mix table <CM> 0 Exposure phase 0 <CM> 1 Exposure phase 1 … … … <CM> 31 Expo. phase 31 <CM> 99 Set all phases <c> 1 LED-Row 1 <c> 2 LED-Row 2 <c> 3 LED-Row 3 <c> 4 LED-Row 4 <c> 5 LED-Row 5 <c> 6 LED-Row 6 <c> 7 LED-Row 7 <c> 8 LED-Row 8 <c> 9 LED-Row 9 <c> 10 LED-Row 10 <c> 11 LED-Row 11 … … … <c> 15 LED-Row 15 <c> 99 Set all LED rows <value> Input of the exposure time in 100 ns units Example: 10 means : 10*100ns = 1000 ns = 1 µs

Command List	**VTVHCIS**	**VTVDCIS**

```
Example:              E0,0,300                               VTVDCIS
                        *** Phase Sequence ***
                    CH  VF RF  CM   C0   C1   C2   C3   C4   C5   C6 ... C15
Phase  0:   Video    0   0  0   0   300   0    0   300   0    0    0 ...  0
Phase  1:   Video    1   0  0   1     0  200   0    0   200   0    0 ...  0
Phase  2:   Video    2   1  0   2     0   0   200   0    0   200   0 ...  0
Phase  3: AutoCorr 3   0  1  15     0   0    0    0    0    0   25 ...  0
       |             |   |  |   |
       |             |   |  |   CM Colormix: Number of the exposure phase
       |             |   |  RF ReturnFlag: 1 = End Sequence
       |             |   VF Video Flag: 1 = Video Data Output
       |            CH Channel of FPGA: 0-5
       Sequence phase number(0 – 31)
```

Set Sequence ***D***<*ph*>*,*<*T*>*,*<*CH*>*,* <*VF*>*,*<*RF*>*,*<*CM*>	No function	e.g. for monochrome/1 phase: **D0,1,0,1,1,0**
Set Line Frequency **F**<freq[Hz]>	only relevant for free-running mode "M0" <Freq [Hz]> Input of the line frequency in 10Hz steps Example: F100 = 100*10Hz = 1000Hz	only relevant for free-running mode "M0" <Freq [Hz]> Input of the line frequency in 10Hz steps Example: F100 = 100*10Hz = 1000Hz
G<ch,val> **Set Analog Gain**	No Function	
I<start,end> **AutoSet Offset**	No Function	
K<0|1>,<0|1>,<0|1>, <0|1>,<0|1>,<0|1> **Phase Pixelcorrection**	Phase pixelcorr. <0|1> 0 no pixel correction for selected phase 1 Pixel correction for selected phase is performed First <0|1> Parameter is phase 0, Second is phase 1, ...etc. Example: K1,1,1,0,0,0 Pixel correction is performed only for Phase 0-2 K0,0,0,1,1,1 Pixel correction is performed only for phase 3-5	Phase pixelcorr. <0|1> 0 no pixel correction for selected phase 1 Pixel correction for selected phase is performed First <0|1> Parameter is phase 0, Second is phase 1, ...etc. Example: K1,1,1,0,0,0 Pixel correction is performed only for Phase 0-2 K0,0,0,1,1,1 Pixel correction is performed only for phase 3-5

Command List	VTVHCIS	VTVDCIS
L<0|1> **Light On/Off**	Light On/Off 0 Light off 1 Light on ***Attention*** *: This parameter cannot be saved with S. The CIS always starts with the light switched off.*	Light On/Off 0 Light off 1 Light on ***Attention :*** *This parameter cannot be saved with S. The CIS always starts with the light switched off.*
M<0-4> **Set Mode**	Set Mode : 0 Free running 1 External trigger over CC1 2 External trigger, quadrature signal X input 3 External trigger, quadrature signal Y input 4 Slave mode	Set Mode : 0 Free running 1 External trigger over CC1 2 External trigger, quadrature signal X input 3 External trigger, quadrature signal Y input 4 Slave mode
N<0-4> **Frame TriggerSource**	No Function	0 Free Running 1 External trigger via CC2 2 External trigger XA,XB to D-SUB control input 3 External trigger YA,YB to D-SUB control input 4 Not active
Set Analog Offset **O**<ch,val>	No function	<ch> analog channel number <val> Input of the desired value in decimal notation
Set Cycles **Q**<1024|512|256|128>	Set cycles: <1024-128> Number of lines for pixel correction	Set cycles: <1024-128> Number of lines for pixel correction
Set FIFO Direction **d**<0|1>	<0|1> Selection of the direction for the shift	<0|1> Selection of the direction for the shift
Set Trigger Pulses **T**<0-uint>	Prescaler for trigger (encoder) pulses <0-uint> Each uint edge starts the acquisition of a new line e.g. T3 - Every third edge starts a new line 0 is without meaning **Attention:** No effect in free-running mode.	Prescaler for trigger (encoder) pulses <0-uint> Each uint edge starts the acquisition of a new line e.g. T3 - Every third edge starts a new line 0 is without meaning **Attention:** No effect in free-running mode.

Command List	VTVHCIS	VTVDCIS
Set Video Mode **V**<M|S>,<#>,<pc>	Set video Mode V<#> Uses always Master 0 Live-image -with pixel correction 1 Live-image -without pixel correction 2 Test-image -constant zero -with pixel correction 3 Test-image -constant zero -without pixel correction 4 Test-iamge -constant 80h -with pixelcorrection 5 Test-Image -constant 80h -without pixel corr. 6 Test-Image -gray ramp horizontal -with pixel correction 7 Test-Image -gray ramp horizontal -without pixel correction 8 Test-Image -2D Ramp -with pixel correction 9 Test-Image -2D Ramp -without pixel correction 10 Test-Image -gray ramp vertical -with pixel correction 11 Test-Image -gray ramp vertical -without pixel correction 12 Test-Image -Tap Marker -with pixel correction 13 Test-Image -Tap Marker -without pixel correction	Set video Mode <M|S> Master =0 Slave = 1-6 <#> Pattern No 0 Live Image -true video 1 Test-Image - grayscale-ramp horizontal 2 Test-Image - grayscale-ramp vertical 3 Test-Image -2D ramp 4 Test-Iamge -Sensor index 5 Test-Image -RGB ramp horizontal 6 Test-Image -RGB ramp vertical 7 Test-Image -RGB 2D ramp <pc> Pixelcorrection (0|1) off/on
Set DL Analog **X**<0-255>	No function	
Set BL Analog **Y**<0-255>	No function	
***<len>,<delay>**	No function	*<len>,<delay> fval length & sheet delay

Command List	**VTVHCIS**	**VTVDCIS**
Z<0-N> **Clear|Restore Correction Data**	0 Deletes the values of the pixel correction in RAM 1 Writes the values of the pixel correction from EEPROM into RAM	0 Deletes the values of the pixel correction in RAM 1 Load the correction table number 1 from the Flash memory . . N Load the correction table number N from the Flash memory
S Store Parameters	Stores current parameter into EEPROM. **Attention:** L1 Light on, is not stored	Store current parameter
$<N> **Store Correction Data**	$ saves pixelcorrection data	$**<N>** e.g.: $**1** saves pixelcorrection data wiith additional memory chip N is memory number. Wihout N has non function, but a value must be entered
c<ch> **Get Chan Stat**	No function	
f Get color mix	No function	Displays the Color Mix table entries

Example: **VTVDCIS**

```
30  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 RED diffuse
 0 30  0  0  0  0  0  0  0  0  0  0  0  0  0  0 GREEN diffuse
 0  0 30  0  0  0  0  0  0  0  0  0  0  0  0  0 BLUE diffuse
```

g Get Analog Gain	No function	
i<ch> **Get Pixels to Chan**	Indicates the corresponding pixel number range for the entered channel <ch> Enter the desired channel number	Indicates the corresponding pixel number range for the entered channel <ch> Enter the desired channel number

Command List	**VTVHCIS**	**VTVDCIS**
j<pix> **Get Channel to Pix**	Indicates the corresponding channel for the pixel number entered <pix> Enter the desired pixel number	Indicates the corresponding channel for the pixel number entered <pix> Enter the desired pixel number
o Get Analog Offset	No function	shows analog offset values
p<col,pix> **Pixel Stat**	No function	
s Get Sensor Stat	No function	
x<0|1> **Get X+Y Shift**	Shows the correction values of the geometry correction (in hexadecimal notation) 0 As table 1 As command list	Shows the correction values of the geometry correction (in hexadecimal notation)
t<0|1> **Get Temperature**	Shows average temperature in CIS. Temperature sensors are located on almost all electronic boards 0 Writes exactly 1 value 1 Continuously writes values. Stop with enter key	Shows average temperature in CIS. Temperature sensors are located on almost all electronic boards 0 Writes exactly 1 value 1 Continuously writes values. Stop with enter key
@<0|1> **Dump Perma**		Writes the permanent data to the terminal
P<password> **Check Password**	Enter the password Necessary to get into the SET Menu	Enter the password Necessary to get into the SET Menu
> Switch to SET Menu	Jump to SET menu after password entry	Jump to SET menu after password entry
R<hex> **Set digital IO**		set digital outputs to pattern <hex> e.g.: 05 (=00000101 -> Set output 0 and 2)
r Get Digital IO		Read digital inputs, the output is a two-digit hex number e.g.: 70 (=1110000 -> inputs 4,5,6 are set)

Main Menu Command list VRCIS

? **Help**
List of available main menu commands

! **SW-Reset**
Software Reset

**List perm. Par.**
Listing of the set parameters

v **Show SW-Version**
Shows the Software Version

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

B<0-5>,<0-255> **Set BL digital**
Bright Level - Setpoint of the brightness value 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
analog and digital value (Y and B) should be the same size

C<0-2> **Pixelcorrection**
<0-2> 0 Pixelcorrection
1 Test-Mode
2 Test-Mode
determined pixel correction values can be saved permanently with $.

D<0-5>,<0-255> **Set DL digital**
Dark Level – Setpoint of the dark value 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
analog and digital value (X and D) should be the same size

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 2 (RGB color channel blue)
<c> 0 LED-Row 0, diffuse, red oder 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 the exposure time in 100 ns
Example: 10 means: 10*100ns = 1000 ns = 1 µs

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

only relevant for free-running mode "M0"
freq [Hz] Input of the line frequency in Hz

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

<ch> analog channel number
<val> Input of the desired value in decimal notation.
range 0...63
Note: There is also a broadcast setting that allows all channels can be set to a desired value: G999, <val>

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

<start> analog start channel - usually "0" = 1st channel
<end> analog end channel - usually last channel
this sets all analog ADC offset values of the CIS

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 via CC1.
2 external trigger, quadrature signal X input
3 external trigger, quadrature signal Y input
4 slave mode

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

<ch> analog channel number

<val> Input of the desired value in decimal notation

Value range 0....512, where 0..255 gain and 256...512 attenuation

Note: There is also a broadcast setting that allows all channels can be set to a desired value: O999, <val>

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

<1-255> Number of lines for 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
2 Test-Image - constant zero - with pixel correction
3 Test-Image - constant zero - without pixel correction
4 Test-Image - constant 80h - with pixel correction
5 Test-Image - constant 80h - without pixel correction
6 Test-Image - Sawtooth - with pixel correction
7 Test-Image - Sawtooth - without pixel correction
8 Test-Image - 2D Test-Template - with pixel correction
9 Test-Image - 2D Test-Template - without pixel correction
10 Test-Image - Sawtooth, vertical - with pixel correction
11 Test-Image - Sawtooth, vertical - without pixel correction

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

Dark Level – Setpoint of the dark value for the auto-offset setting of the analog-digital converters

<0-255> analog set value

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

Bright Level - Set point of the brightness value

<0-255> analog 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 RAM
1 writes the values of the pixel correction from EEPROM into RAM
2 Reserved

S **Store Parameters**

Store current parameter

$ **Store CorrData**

store current pixel correction value

a **Adjustment**

setup tool, indicates a deviation of the reading line from a guide template

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

<ch> analog channel number

g **Get analog Gain**

shows the analog gain values

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

indicates the corresponding pixel number range for the entered channel

<ch> Enter the desired channel number

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

indicates the corresponding channel for the entered pixel number

<pix> Enter the desired pixel number

o **Get analog Offset**

shows all analog offset values

p<col,pix> **Pixelstatistics**

<col> 0 for monochrome Sensor

<pix> Enter the desired pixel number

s **Get Sensor Stat.**

shows minimum and maximum gray value

x **Get X+Y Shift**

Displays the correction values of the geometry correction in hexadecimal notation

t<0|1> **Get Temperature**

shows average temperature in CIS
Temperature sensors are located on almost all electronic boards

0 writes exactly 1 value
1 writes continuously values

P<password> **Check password**

Enter the password
necessary to get into the SET Menu

> **Switch to SET Menu**

Jump to SET menu after password entry

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.

Main Menu Command list MXCIS

? **Help**
List of available main menu commands

! **SW-Reset**
Software Reset

**List perm. Par.**
Listing of the set parameters

v **Show SW-Version**
Show the Software Version

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

0	Light off
1	Light on

M<0-7> **Set Mode**

0	free running
1	triggered
2-7	not active

F<freq [Hz]> **Set Linefrequency**
only relevant for free-running mode "M0"

freq [Hz]	Input of the line frequency in Hz

E<0-5>,<time [µs]> **Set Exposuretime**
with 0-5 the different illumination channels are selected
for monochrome the 0 is used

0	red 1 or monochrome 1
1	green 1
2	blue 1
3	red 2
4	green 2
5	blue 2
time [µs]	Enter the exposure time in µs

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

Dark Level – Setpoint of the digital dark values for pixel correction

0-5
- 0 red 1 or monochrom 1
- 1 green 1
- 2 blue 1
- 3 red 2
- 4 green 2
- 5 blue 2

0-255 digital set value

analog and digital value (X and D) should be the same size

B<0-5>,<0-255> **Set BL digital**

Bright Level - Setpoint of the digital brightness values for pixel correction

0-5
- 0 red 1 or monochrome 1
- 1 green 1
- 2 blue 1
- 3 red 2
- 4 green 2
- 5 blue 2

0-255 2. Value digital set value

analog and digital value (Y and B) should be the same size

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

Dark Level – Setpoint of the analog dark values for pixel correction

0-255 analog set value

analog and digital value (X and D) should be the same size

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

Bright Level - Setpoint of the analog brightness values for pixel correction

0-255 analog set value

analog and digital value (Y and B) should be the same size

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

Input of the lines for the pixel correction

s **Get Sensor Stat**.

shows sensor statistics

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

ch analog channel number

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

start analog start channel - usually "0" = 1st channel

end analog end channel - usually last channel so the whole CIS is set

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

ch analog channel number

val Input of the desired value

There is also a broadcast setting that can be used to set all channels and all colors equally to a given value:O999,<val>

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

ch analog channel number

val Input of the desired value

There is also a broadcast setting, which can be used to set all channels and all colors can be set to a given value: G9,999,<val>

o **Get analog Offset**

shows the analog offset values

g **Get analog Gain**

shows the analog gain values

C<0-2> **Pixelcorrection**

0 Pixel correction

1 Test-Mode

2 Test-Mode

Z<0-1> **Clear|Rest.CorrData**

0 deletes the values of the pixel correction in RAM

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

S **Store Parameters**

store current parameter

$ **Store CorrData**
store current pixel correction value

T<2-63> **Set Trigger Pulses**
2-63 Prescaler for the encoder pulse

t<cont> **Get Temperature**
shows average temperature in CIS
Temperature sensors are located on almost all electronic boards

cont	0	writes exaxctly 1 value
cont	1	writes continuous value

+ **Sensor Character**
Outputs CIS data

-<0-3> **Set Port Mapping**
not active

p<col>,<pix> **Pixelstatistics**

col	=0	red
col	=1	green
col	=2	blue
pix	Enter the desired pixel number	

i<ch> **Get pixels to chan**.
indicates the corresponding pixel number range for the entered channel
ch Enter the desired channel number

j<pix> **Get channel to pix.**
indicates the corresponding channel for the entered pixel number
pix Enter the desired pixel number

r **Get Replace Flag**
not active

R **Set Replace Flag**
not active

U **Clear Replace-Flags**
not active

V<0-9> **Set Video Mode**

0	Live-Image - with pixel correction
1	Live-Image - without pixel correction
2	Test-Image - constant zero - with pixel correction
3	Test-Image - constant zero - without pixel correction
4	Test-Image - constant 80h - with pixel correction
5	Test-Image - constant 80h - without pixel correction
6	Test-Image - Sawtooth - with pixel correction
7	Test-Image - Sawtooth - without pixel correction
8	Test-Image - 2D Test-Template - with pixel correction
9	Test-Image - 2D Test- Template - without pixel correction

P<password> **Check password**
Enter the password

> **Switch to HWMenu**
switches to the HWMenu

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.

3.4 Pixel Correction

3.4.1 General information on pixel correction

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 is used to compensate for different pixel sensitivities, tolerances of the LEDs and the irregularities of the illumination and the lenses. For each pixel, the dark value is set to the specified target value and a gain calculates the factor that increases the current gray value to a specified target value. The pixel correction operates digitally.

The CIS owns a low frequency response. Because of that it is useful to carry out the pixel correction with a line frequency 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 uniform the surface of the original, the better the subsequent scan result.

It is advantageous when the pattern is moved during the pixel correction. Then several sampled lines (set with „**Q - Set Cycles**“) are included in the correction, because from this total the mean value is determined. The smallest errors in the template are thus compensated. The higher the chosen **Q**, the more precise is the mean value, but the longer the correction takes.

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

D	Dark Level Digital	To this brightness value (= set point setting dark) the minimal illumination is adjusted
B	Bright Level Digital	To this brightness 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	This number indicates the ratio in which correction can be made. 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 or 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 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**128	
Gain factor	**H**2	
Exposure time	**E**....	(individual value for each CIS)

Externer Flash (optional)

From SW V1.50

Camera Start:

When the CIS is switched on, the software checks wheather the flash memory extension is present. If this is the case, then the internal flash is deactivated and only the expansion flash is used. If the expansion flash is used, the correction set with the number 1 is always loaded.

Indication:

If you enter #, the section "Memory" shows which flash is used. The number indicates how many data sets can be stored with the current configuration.
This number depends on the resolution, number of colors and the length of the CIS. With the internal flash, only one correction set is stored at a time.

Commands for saving and loading:

The command "$" has been extended by an index. The index indicates under which number the current correction is to be stored. The Z command is used to retrieve the corresponding correction set from the Flash.

Example:

$2 - Save current correction table under number 2
Z2 - Load the correction table number 2 from the Flash

If only the internal flash is available, the commands for saving and loading are $1 and Z1.

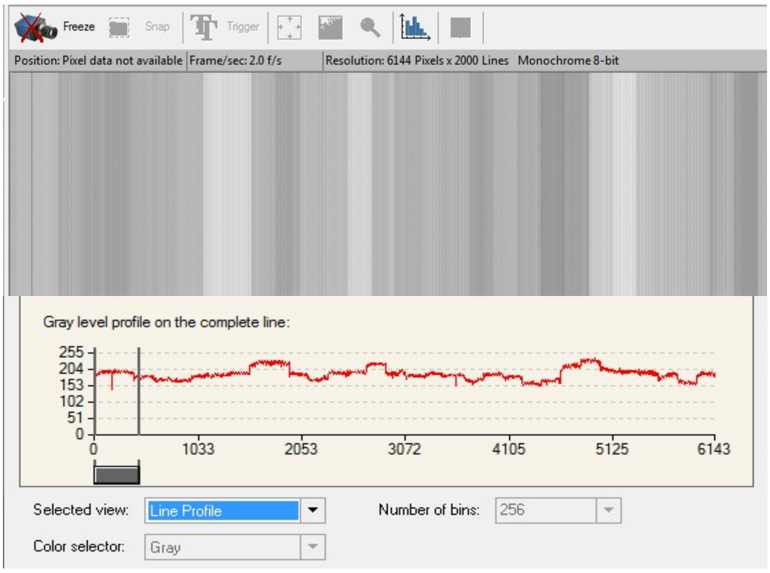
3.4.2 Pixel correction for monochrome light

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

- mount the appropiate adjustment template movably in the working distance (see typeplate) of the CIS
- open the Frame Grabber and set to the CIS (camera file)
- open the terminal program
- 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 **Z0** on VUCIS with **PCC**
  or switch to rawdata view with:

VU	VTVD	VTVH	VR	MX
V 0,0,0	**V0,0,0**	**V1**	**V1**	**V1**

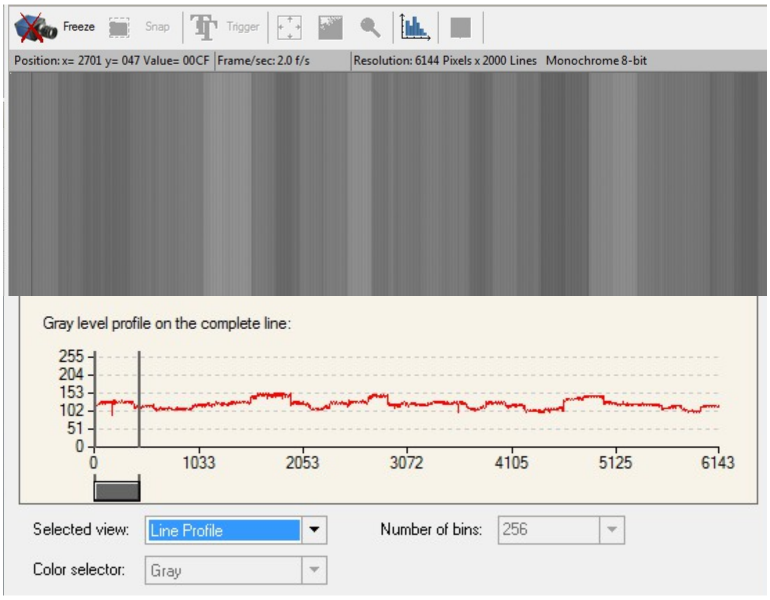
- the light is still off and no external light penetrates
- sample one image in the FrameGrabber and switch to the display „Line Profile“.
- a graph should now be shown over the entire CIS width, corresponding to the gray value Dark Level Digital.
- switch on the light of the CIS with **L1** or **L 1** on VUCIS.
- 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



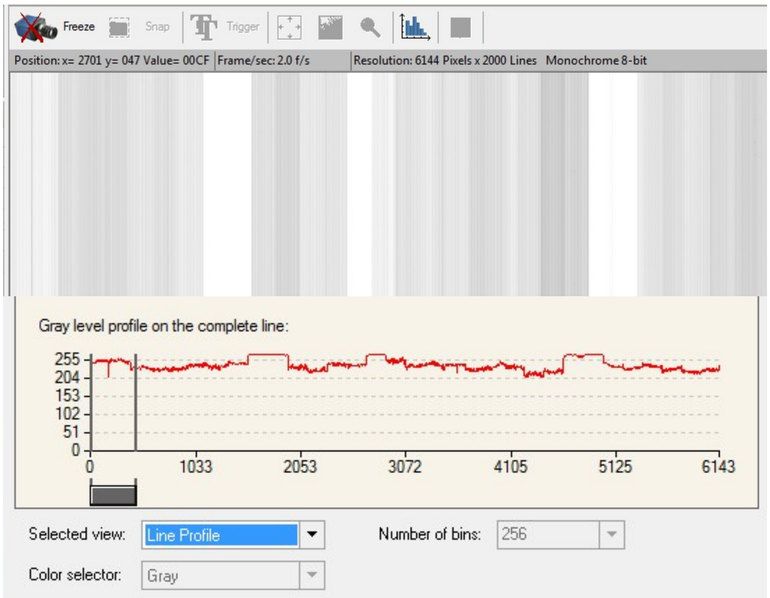
Img. 3.4.2-1 non-corrected CIS, no pixel-correction

- 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. The maximum amplification **H** lies as standard is 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 partly larger than B

The pixel correction only can amplify. If a pixel exceeds the value of B before correction, this value will be kept and cannot be corrected.

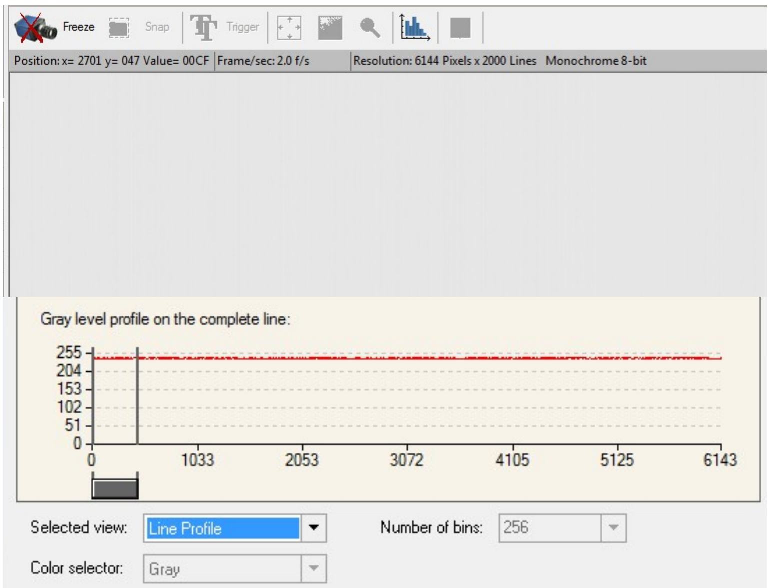
- start the automatic pixel correction with

VU	VTVD	VTVH	VR	MX
PC 5	**C5**	**C5**	**C0**	**C0**

- move the template until the correction is completed
- CIS determines the gains and writes them to the RAM
- switch on the light of the CIS with **L1** , **L 1** on VUCIS
- switch to the pixel-corrected display if necessary

VU	VTVD	VTVH	VR	MX
V 0,0,1	**V0,0,1**	**V0**	**V0**	**V0**

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



Img. 3.4.2-3   Corrected CIS

- save the result of successful pixel correction permanent in the memory of CIS

VU	VTVD	VTVH	VR	MX
PCS	**$1**	**$**	**$**	**$**

- now it should check whether the exposure time set for the pixel correction still has to be adjusted for the object to be scanned: Sufficient brightness for the evaluation, but no overload (values >= 255) takes place.

- **S** / **PPS** (VUCIS) saves the set parameter of the CIS permanent in the memory.

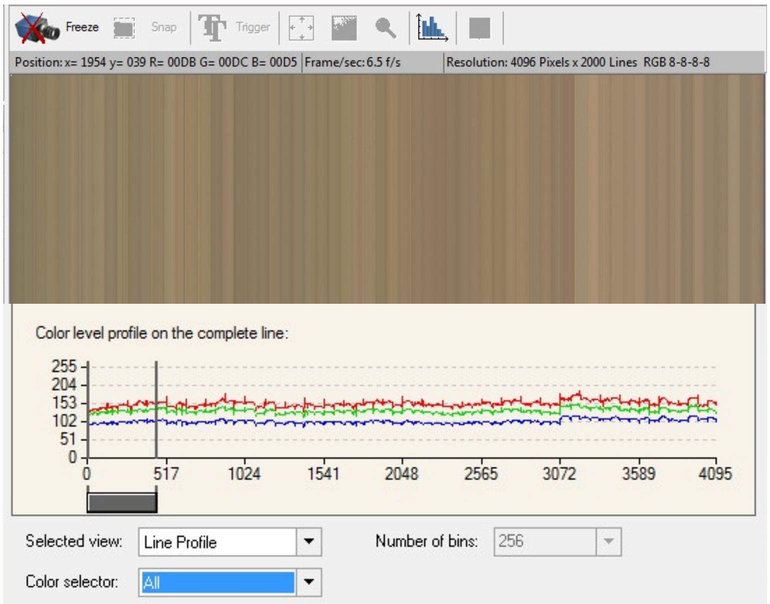
3.4.3 Pixel correction for color (RGB)

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.

- mount the appropiate adjustment template movably in the working distance (see typeplate) of the CIS
- open the Frame Grabber and set to the CIS (camera file)
- open the terminal program
- 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 **Z0 ,** on VUCIS with **PCC**
  or switch to rawdata view with:

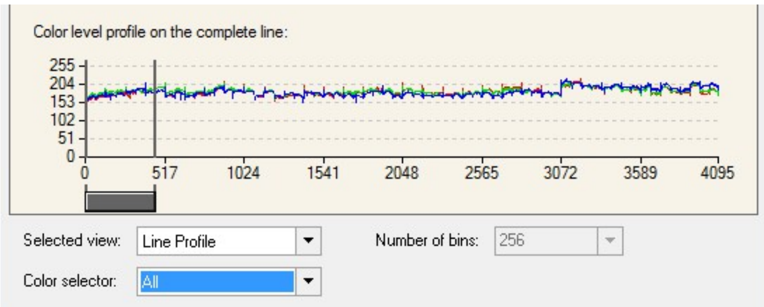
VU	VTVD	VTVH	VR	MX
V 0,0,0	**V0,0,0**	**V1**	**V1**	**V1**

- the light is still off and no external light penetrates
- sample one image in the FrameGrabber and switch to the display „Line Profile“
- three graphs should now be displayed over the entire CIS width, corresponding to the gray value Dark Level Digital of each color.
- switch on the light of the CIS with **L1 ,** on VUCIS with **L 1**
- three graphs over the entire CIS width should now be displayed, representing the uncorrected CIS. See the Gray Line Profile in Fig. 3.4.3-1.



Img. 3.4.2-1 uncorrected CIS, before pixel correction

- the RGB-version of the CIS owns at least 3 exposure times:
  - **E**0,u,xx : LED-Row u, Exposuretime Red xx
  - **E**1,v,yy : LED-Row v, Exposuretime Green yy
  - **E**2,w,zz : LED-Row w, Exposuretime Blue zz
- move the red graph with the exposure time „E0,u,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. The maximum amplification **H** lies as standard is 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,w,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

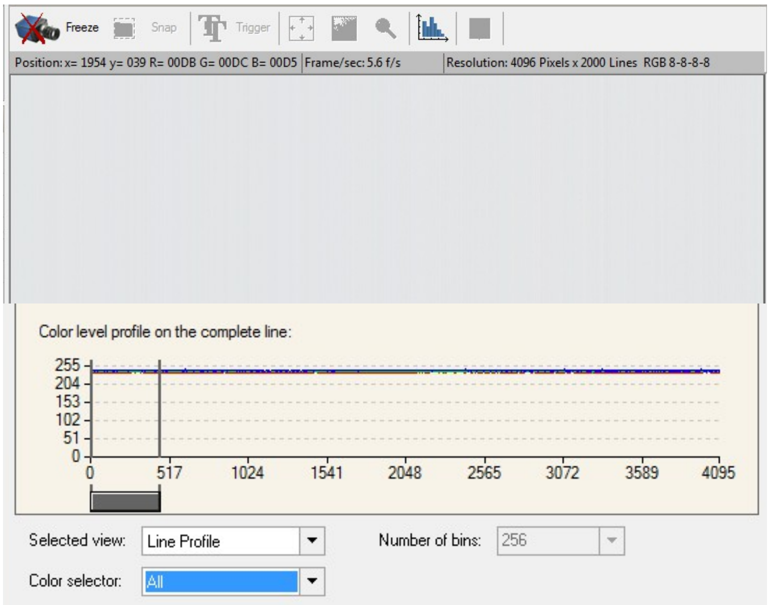
- start the automatic pixel correction with

VU	VTVD	VTVH	VR	MX
PC 5	**C5**	**C5**	**C0**	**C0**

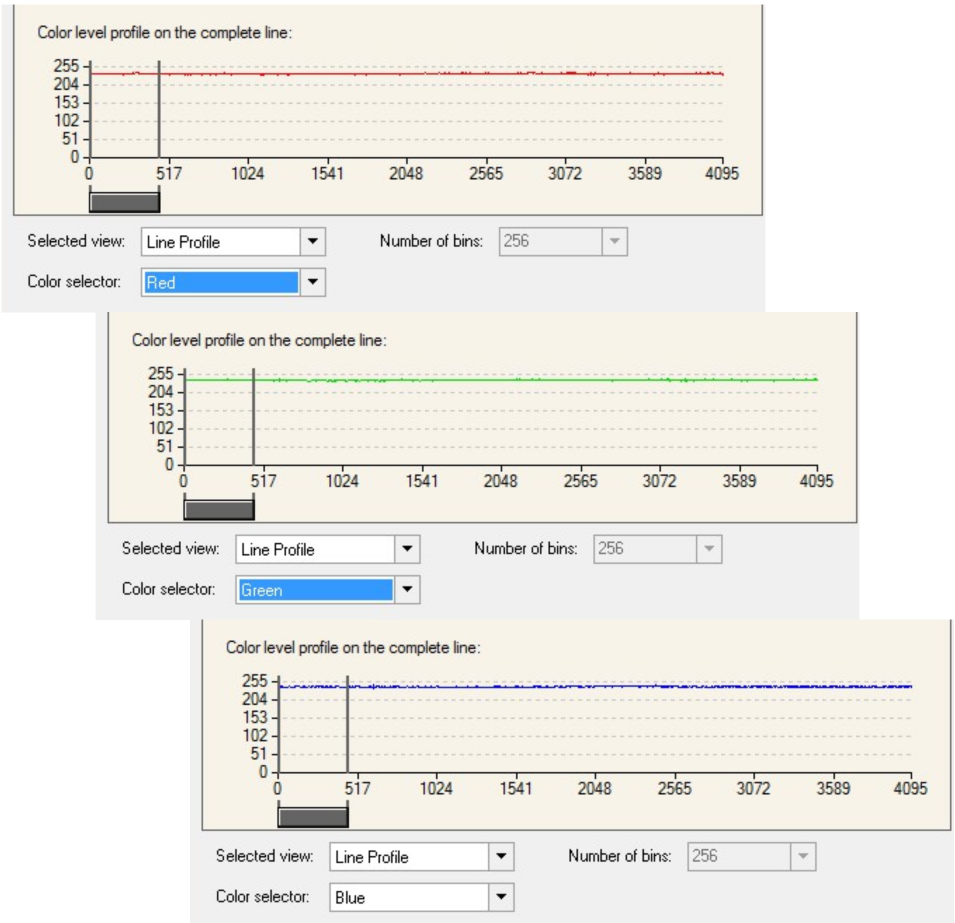
- move template now until correction is complete
- CIS determines the gains and writes them to the RAM
- pixel correction matches all colors simultaneously in one correction pass
- switch the light of the CIS on again with **L1 ,** on VUCIS with **L 1**
- switch to the pixel-corrected display if necessary

VU	VTVD	VTVH	VR	MX
V 0,0,1	**V0,0,1**	**V0**	**V0**	**V0**

- 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

-

VU	VTVD	VTVH	VR	MX
PCS	**$1**	**$**	**$**	**$**

saves the result of the successful pixel correction permanent in the memory of the CIS

- now it should check whether the exposure time set for the pixel correction still has to be adjusted for the object to be scanned:Sufficient brightness for the evaluation, but no overload (values >= 255) takes place.
- **S** saves the set parameter of the CIS permanent in the memory (**PPS** VUCIS)

3.4.4 Pixel correction for false color

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.

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 for Pixel-correction

Nr	Checklist pixel correction	**no**, further with	**yes**, further with Nr.
1	Front plane of the CIS clean	clean	2
2	Working distance correction	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 digital **DL digital**	correct	9
9	Bright Level digital **BL digital**	correct	10
10	Cycles **Q**	correct	11
11	Line Frequency **F**	correct	12
12	Look up Gain Factor value **H**	check	13
13	Calculate and note the minimum bright value: BL digital / Gain factor H = bright value min	calculate	14
14	Mode 0 freerunning	command **M0**	15
15	Command Z0 – delete pixel correction	command **Z0**	16
16	Illumination off	command **L0**	17
17	Insert reference template	insert	18
18	Command L1 – switch on the light	command **L1**	19
19	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**	20
20	Command pixel correction VTVD **C5** ,VTVH **C5** ,VR **C0**, MX **C0**	command	21
	after the status message / s, pixel correction is finished	wait	21
21	switch on the light of the CIS again with **L1**	command **L1**	22
22	FrameGrabber Line Profile: Line at BL value	setting error?	23
23	Command **$** - save pixel correction permanent	command **$**	24
24	Command **S** – save parameter permanent	command **S**	done

3.5 Offset

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> analog 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 freely selectable value can be assigned to the channel. The value range is 0....512, where 0..255 means amplification and 256...512 attenuation. The input must be made in decimal notation.

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:

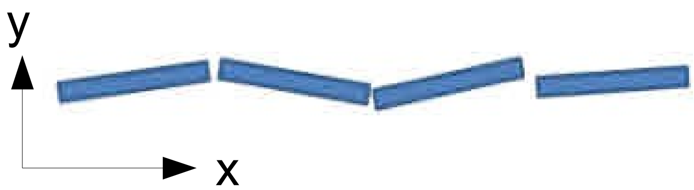
S **Store Parameters**
saves the actual parameters

3.6 Geometry correction

3.6.1 General information on geometry 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 manufacturing tolerances affect not only the gap between chips, but also the offset of two adjacent chip ends.



Img. 3.6.1-1 Production tolerances

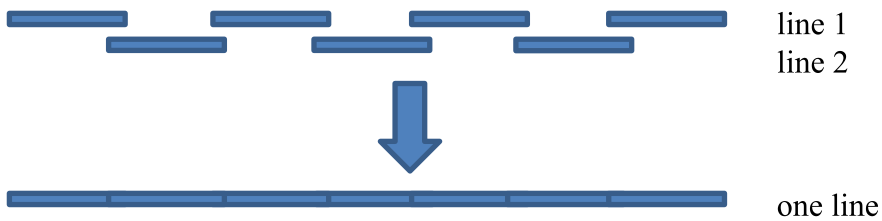
An exaggerated representation of a tolerance affected chip array is shown in the Image 3.7.1-1.The gaps in the x-direction are about 20...50 µm, the offset in y-direction is about ± 30 µm to the ideal line.

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. When starting the image acquisition, the FIFO memory must therefore first be filled before the first valid image lines can be shown. This can take up to 16 image lines. That means that the first lines can not be used for evaluation of the image.

3.6.2 Coarse alignment of the sensors in Y-direction

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



Img. 3.6.1-2 two read lines brought to cover

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

A direction switch adjusts the buffering to the running direction of the objects. It also affects the geometric correction, so its value are also automatically adjusted to the moving direction.

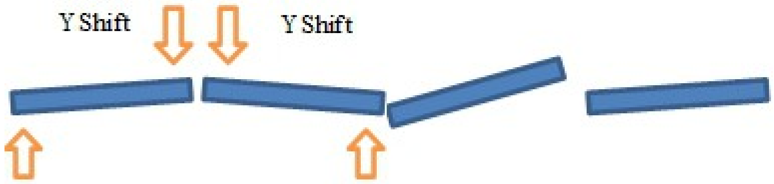
d<0|1> **Set FIFO Direction**

<0|1> direction selection of the moving

3.6.3 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. 3.6.3-1   Y-correction shifting point

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

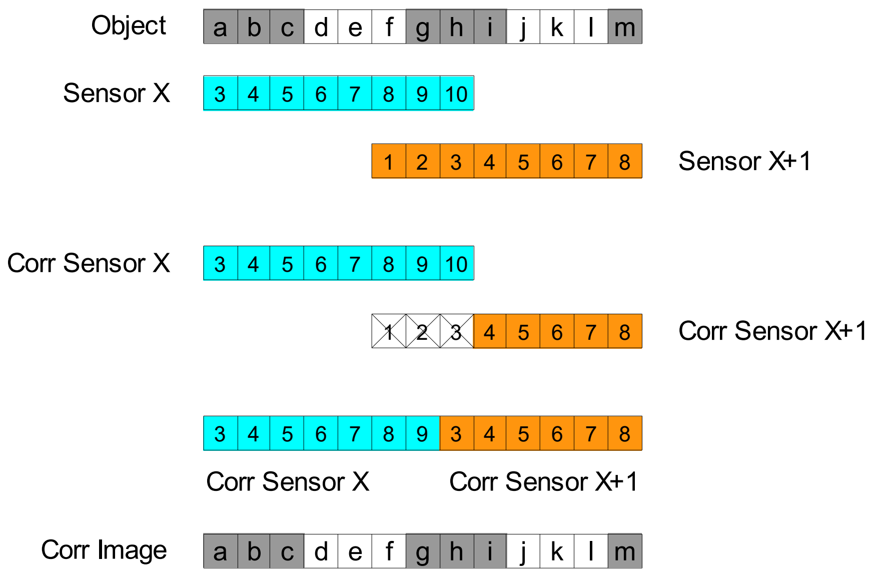
Img. 3.6.3-2   Alignment after Y-correction

3.6.4 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. The overlapping of the individual chips results in the overlapped pixels being displayed twice. (see 2.2.5)

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



Img. *3.6.4-1 Object and it´s corrected image*

Fig. 3.6.4-1 illustrates the overlapped pixels. The object is detected by sensor X, with pixel numbers 3...10, in the area a...h and temporarily stored in the FIFO. Two trigger pulses (= 2 lines) later, the object is detected by sensor X+1, with pixel numbers 1...8, in the range f...m. With the help of a calibration template, the duplicate object pixels can now be filtered out and specifically deleted in sensor X+1. The correction always starts at the beginning of the sensor. The temporarily stored pixels of sensor X and the current, but corrected pixels of sensor X+1 are now transferred to the frame grabber one after the other. This creates an image that is identical to the object in all pixels.

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

4 Installation und Operation

4.1 Installation

4.1.1 Mounting space

A step file is available for the CIS for planning the customer installation. 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, connectors with a 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 must be screwed onto a straight and smooth support to achieve a tight fit and good thermal coupling. A part of the waste heat is dissipated via the carrier. 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 outside object can enter into 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 carrier should ideally have adjustment possibilities in all 3 axes in order to be able to set up the CIS optimally for the object to be scanned.
Proceed as follows:

- Preset the working distance noted on the type plate of the CIS.
- Delete the existing pixel correction with the **Z0** command.
- Check the set brightness value (230). Adjust if necessary.
- Make sure that the gray value is almost at the same value over the entire length of the CIS and is smaller than the brightness value.
- Adjust only a few lines in TiViViewer to adjust the hardware and look at the LineProfile window.

Take the following steps depending on the intended use

For Backlight:

- Then move the lighting to one side until you reach the maximum gray value. When you reach 255, then reduce the exposure time.
- If you move the backlight in the same direction, you will get a reduced value and then a second maximum.
- The ideal position is between the 2 maximums.
- Repeat these steps on the other side of the backlight, making sure that the side already set is fixed.

For shiny surfaces like glass:

- Align the CIS parallel to the scanning surface.
- The lens must be absolutely perpendicular to the shiny surface.
- Tilt the front of the CIS minimally.
- You will now see 2 maxima in the TiViViewer which have a rectangular waveform.
- Position the CIS between them.

4.1.6 Accessibility

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

Absolutely necessary is a cleaning option for 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 must not 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 carrier. Especially for CIS with passive cooling particular attention on that has to be paid.

4.1.8 Heat discharging via air-cooling

Active and passive air cooling are offered for the CIS.

Active air cooling forces air circulation throughout attached fans. It must be ensured that sufficient air circulation is enabled and appropriate supply and exhaust air openings are provided.

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 sink using liquid cooling

Older CIS models have two large aluminum blocks which are screwed on the outside. They each contain two longitudinal holes through which a suitable coolant can be passed. There are G 1/4"-threads for connection fittings at the ends of the holes.

Newer CIS models from VTVH onwards have several copper tubes which, among other things, are routed directly through the LED support profiles. These tubes have an outer diameter of 6 mm and an inner diameter of 5 mm. They protrude approx. 30-50 mm from the CIS housing.

Hoses can be pushed directly onto them (slip-off protection !), pipe fittings can be screwed on, pipe fittings can be brazed on (heat dissipation !).

Please keep in mind that the fittings have to work properly under all circumstances ! Flooding the CIS sensor with a conductive liquid like water while powered will destroy the sensor !

Terms

Conductivity S [Siemens] = reciprocal of the electrical resistance
μS [MicroSiemens]

Ultrapure water	0......2 μS	
Distilled water	0....10 μS	
Osmosis water	5....50 μS	
Deionized water	0....50 μS	fully demineralized water
	(= deionized water, demineralized water)	
Deionized water	30..50 μS	corresponds to rainwater

Ethylene glycol („EWG“) Corrosion inhibitor, colorless and odorless liquid with slightly sweetish taste, harmful to health

Propylene glycol („PWG“) Corrosion protection agent, clear, colorless, almost odorless and strongly hygroscopic liquid, less harmful to health than ethylene glycol, mixed with water as a heat transfer medium in refrigeration systems for food processing

Dew point The temperature at which the humidity begins to condense.

Attention:
High purity water with conductivity between 0....5 µS extracts from the environment

Minerals: Metals corrode,
Plastics become hard,
Aluminum is attacked.

As a rule, mixtures of deionized water with EWG or PWG are used. The glycol supplier can recommend the mixing ratio.

The material composition in the entire cooling circuit must also be taken into account, especially if different metals are used.

Suitable for copper:

- VE Water with conductivity of 30...50 µS.
- EWG Ethylene-glycol / deionized water mixture - harmful to health.
- PWG Propylene-glycol / deionized water mixture - applicable in the food industry

Suitable for aluminum:

- EWG 25 % ethylene glycol / 75 % deionized water mixture - harmful to health.
- PWG 25 % propylene glycol / 75 % deionized water mixture - can be used the food industry

Suitable for stainless steel:

- VE Water
- EWG Ethylene-glycol / deionized water mixture- harmful to health.
- PWG Propylene-glycol / deionized water mixture- applicable in the food industry

Recommendation:

The parameters for the cooling medium strongly depend on the conditions of use (ambient temperature) and purpose of use (heat dissipation, stable color temperatures of the LEDs). Guide values for initial setting are:

- Flow temperature 18°C
- Return temperature 19°C
- Temperature difference return - flow < 1°C
- Volume flow 3 l/min per cooling pipe
- Pressure < 1 bar

Care must be taken to ensure that the CIS does not become colder than the dew point temperature of the environment, otherwise moisture will condense on the housing and / or front window.

If moisture condensation forms inside the CIS, immediately de-energize the CIS and wait until the precipitation has dissipated. This moisture precipitation could cause electrical short circuits.

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 as 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 as accessories by Tichawa Vision all have the locking screws. They also should be screwed in terms of a safe operation.

Documentation Digital IO
Stand: 08.12.20

From SW Version 1.70
FW is not affected

- **Pin assignment:**

8 Digital inputs: Pin 1-8
8 Digital outputs: Pin 9-13 und Pin 14-16

Dongle and DigitaleIO cannot be used at the same time.

- **Switch on the Digital IO option:**

SET-Menu: "E<0|1>" (only visible with dongle)

0 – Switch off Digital IO option

1 – Switch on Digital IO option

Whether the option is switched on can be seen with #:

In the last section you will find the following text:

*** Options ***
DigIO Option: 1

When Dig IO is switched on, the "R" and "r" commands are activated.

- **Commands**

"R<hex>" : set digital outputs to the pattern <hex> z.B: 05 (=00000101 -> Set output 0 and 2)

r: read digital inputs, the output is a two-digit hex-number
e.g.: 70 -> inputs 4,5,6 are set

- **Restrictions**

When listing the menu with the "?" command, there is a short switch-on (1 ms) of all outputs. This is due to the fact that the software must determine whether the dongle is plugged into the device.

Inputs 0 Volt <= VIN <= 24 Volt
No permanent dwell between 5 and 20 volts

Outputs 0 Volt <= VOUT <= 24 Volt
max. 0,3 A / output
max. 1 A for all outputs together
ohmic loads only
there is no debouncing for the inputs

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 this grounding is not a protective grounding but a function grounding. It avoids the build up 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. When mounting the CIS, make sure that there is a good electrical connection to the mounting bracket and its operating ground. 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- Protection 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 number 1 characterizes the protection of the housing against the entering of solid foreign matters including dust (foreign matter protection).

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

The standard VDCIS can be assigned to protection class IP20.
- 2 Protection against foreign objects larger than 12 mm in diameter
- 0 no protection against water

4.2 Operation and service

4.2.1 Ambient conditions

4.2.1.1 Case-temperatures

The operating 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.

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

If the temperature query is used for status messages, it must be determined empirically at the location where the CIS is used, which CIS internal temperature prevails at an external housing 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 exceed 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 temperature at which the air humidity begins to condense on the window.

4.2.1.3 Vibration resistance

Vibration resistance refers to both a single impact, also called shock resistance, and vibration as shock.

Vibration resistance :

It indicates at which amplitude or acceleration in a defined frequency range no malfunctions or damage occur yet.

A low-vibration mounting of the CIS is necessary for the image quality alone, otherwise the image will be "blurred".

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:

It 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 become 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 glued. 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 such as 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 personnel)

- make contact to a grounded object

- always ground the plug and the sensor before plugging in

- only plug in when de-energized

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

Therefore, ground the CIS or its mounting bracket with the shortest possible, sufficiently 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 enters the electronic chamber of the CIS,
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 working on the CIS it can come in touch with oil and fat. Even one touch of the plane with bare hand leaves a fat traces on it.
For the cleaning the 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 does not work satisfactorily, please go through the following list point by point.

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?
- Is the length of the Camera Link-cable correct?
- Is the computer switched on and appropriate software started?
- Is the power connector plugged in and the fixings screws are tightened?
- Is the power supply device switched on and the secondary voltage is 24 VDC?

Check of the communication:

- open terminal program (TIVICISIF,Tera Term, Hzperterm....)
- 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 generate test patterns and send them to the frame grabber. Particularly interesting is the gray ramp that is generated with

VTVD	VTVH	VR	MX
V0,1,0	**V7**	**V7**	**V7**

  The test patterns can be used to check the signal transmission path from the CIS to the frame grabber and its configuration.
- GND-potential difference between pc and CIS lower than 0,2 Volt?

Optical check:

- Is the sensor plane clean?
- Open terminal program (TIVICISIF, Tera Term, Hzperterm....).
- 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

If the tests for independent troubleshooting are unsuccessful, our support can be called in.

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

VTVD	VTVH	VR	MX
V0,1,0	**V7**	**V7**	**V7**

  - ✗ full CIS width
  - ✗ structures over the whole width
  - ✗ some hundred lines of the hight
  - ✗ uncompressed image format (bitmap)
  - ✗ image size less than 5 Mbyte

5 Norms und Standards

5.1 EG – conformity declaration

- IEC 60204-1

"Electrical equipment of machines – Part 1: General requirements"

- EN 60825-1

"Safety of Laser Products"
"Safety of Laser Products – Part 1: classification of systems and requirements"

- EN 62471

"Photobiological safety of lamps and lamp systems (IEC-62471:2006, modified)"

- 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 labeling

5.3 Norms and 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 ?

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) and reducing optics. The sensor of a CIS is as wide as the original (up to 4 m) , the optics image 1:1.

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

- Easy mounting, no large distance required
- Simple adjustment
- Constant viewing angle across the entire reading width
- No distortion
- 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 frequency by more complicated electronics (pictures)
- Large reading distance (10 mm instead of 0.3 mm) through more complex lenses
- Robust design (Solid metal housing)

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.

1.9 What is the depth of field of a CIS?

Depending on the requirement, focal length and light wavelength, typically 0.5 - 10 mm.

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 3-5 pixels across. Typical interpolation tasks such as gravity determination, etc. can be done very much finer than the pixel grid.

1.12 Which line frequency does my application require?

The line frequency 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 frequency required is

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

The sensor should be operated at a line frequency 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 %.
Under real conditions, the amplitude at the edge of the image field typically drops to half, due to the lens and Lambert's law.
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.
In scanners, CIS elements are operated with resolutions between 12 and 16 bits.

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 ?

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 How is the construction of a gapless sensor possible?

The elements of a CIS are chips in a row. At the joints (gaps) either no significant disturbance occurs (25 to 200 dpi) or the CIS has “staggered” chips.Overall, the resulting distortion is less than the distortion of a lens and easier to correct (linear relationship, no polynomial required).

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.

1.21 What to consider when cooling a CIS ?

Flow rate

According to the data sheet, your device draws a maximum of 5.8 +20% amps or approx. 7 amps.
At 24 volts this results in 168 watts.

The specific heat of water are 4190 Wsec / kg /°K.
1 l of water is heated with 4 kW by 1 degree in the second.

If we allow 5 degrees of heating, then we transport from
20 kW with 1 l/ sec = 60 l/min

2 kW with 0.1 l/sec = 6 l/min

0.2 kW with 0.01 l/sec = 0.6 l/min

We should be well on our way with the 0.6 liters per second
even at 100% operating time

Temperature

Please above 15 degrees (dew point is at 14 degrees)
and please below 25 degrees

Quality of the cooling water

Tube diameter are 4 mm -
please use coolant free from contamination !
Please observe the electrochemical series for conductive liquids such as water:

> The cooling tube is made of copper. If the cooling liquid flows also through other metals, then you get corrosion, comparable to the blackened aluminum part in the dishwasher.

Alternatively, you can use a non-conductive liquid, which should preferably not be highly flammable.