NerdCam3D Instruction Manual

IMPORTANT – READ CAREFULLY BEFORE USE
KEEP FOR FUTURE REFERENCE

Contents

List of Abbreviations

ESD	Electrostatic Discharge
CVBS	Color Video Blanking Signal
FPGA	Field Programmable Gate Array
FPV	First Person View
OSD	On-Screen Display
SELV	Separated/Safety Extra Low Voltage

Scope of Delivery

The scope of delivery comprises the following items:

- 1 x NerdCam3D board camera, optically calibrated, with two 3.6mm lenses (S-mount, M12x0.5 thread) and set up for immediate use with Zeiss cinemizer video goggles,
- 1 x instruction manual.

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Change Log

Date	Version	Comments
2014-05-11	1.0	Initial version

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1. Safety Instructions

Important! Please read carefully the following safety instructions before operating the **NerdCam3D** 3D-FPV board camera.

1.1. Designated Use

The designated use of the **NerdCam3D** camera is the operation as a First-Persion-View (FPV) camera in radio-controlled models (e.g. airplanes, helicopters, multicopters, cars and ships). Please note that there may be further legal regulations (e.g. additional observer, teacher/pupil mode operation, line-of-sight operation range) to be followed for proper use of this product. All other uses of the camera are considered improper and exclude all warranties and any liability of TMG-Ingenieurbüro UG (haftungsbeschränkt) for personal injury, pecuniary damages or property damages.

1.2. Reasonably Foreseeable Misuse

The use of the **NerdCam3D** camera as a toy, or as medical life-support or life-sustaining equipment, or as a safety device for monitoring/surveillance of persons or objects, or as a fail-safe sensor for operation of nuclear facilities, aircraft navigation or communication systems, or as part of a means for air traffic control, or as part of weapons systems is improper and excludes any liability of TMG-Ingenieurbüro UG (haftungsbeschränkt) for personal injury, property damage or pecuniary damages.

1.3. General Safety Instruction

Please note the following general safety information before and during use of the camera.

⚠ DANGER	Risk of electric shock! Risk of fire!
	Exposed electrical components!
	Danger of life through electric shock or fire outbreak!
	Operate camera only with Separated/Safety Extra-Low Voltage (SELV) power sources!

⚠ WARNING	Burn hazard!
	Exposed electrical components!
	Burns from hot electronic components!
	Operate camera only with +5V DC Separated/Safety Extra-Low Voltage (SELV) power sources!

⚠ WARNING	Risk of failure of the camera!
	Camera not suitable for use without protective enclosure!
	Loss of control of the remotely controlled vehicle in conjunction with possible personal injury, pecuniary damages or property damages.
	Install camera always in a suitable protective enclosure with proper ingress protection level (IP). Use camera always with copilot or additional observers or spotters!

NOTICE	Risk of electrostatic discharge (ESD)!
	Exposed electrical components!
	Permanent damage to parts of the camera or the whole camera with improper handling!
	Take appropriate measures to protect the camera against electrostatic discharge!

1.4. Residual Risks

The use of Head-Mounted Displays (HMD) or video goggles with 3D-playback capability is subject to technical risks, health risks and possibly other risks. Consult and follow the safety instructions of your video goggle/HMD to avoid personal injury or damage!

1.5. Regulatory Notes

1.5.1. EUROPEAN UNION

This device complies with the requirements for Information Technology Equipment (ITE) of Class B and is therefore suitable for use in residential areas. Please find all additional information in relation to the fulfillment of regulatory requirements in the accompanying EU Declaration of Conformity on page 22 of this manual.

1.5.2. UNITED STATES OF AMERICA

Note: This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

1.5.3. CANADA

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

2. Description

The **NerdCam3D** is a unique board camera which creates a stereoscopic analog video signal. Unlike other 3D-board cameras the **NerdCam3D** supports both Field-Sequential 3D and Side-by-Side 3D video in NTSC as well as in PAL. This feature makes the camera compatible with a wide variety of legacy and state-of-the-art video goggles or head-mounted displays. The video signal created by the camera can be fed either directly into the video goggle's AV-port or through single-channel wireless video transmission gear. Therefore this 3D-camera is perfectly suited for all First Person View (FPV) applications. Chapter 3.2 summarizes the currently supported video goggles.

The camera was designed to be compliant with relevant harmonized technical standards without a specific protective enclosure. This decision gives the end-user the utmost level of freedom for final integration into a carrying platform. However, it is in the end-users own responsibility to take care for a safe and rigid fixation and a suitable protection of the camera against adverse mechanical, or electrostatic, or environmental conditions. For these reasons the utilization of a suitable protective enclosure is highly recommended.

The camera requires a power supply with Separated/Safety Extra-Low Voltage (SELV) power sources. Suitable SELV power sources are all commonly used batteries or accumulators. In order to prevent accidental connection with conventional/mains power plugs, the camera's power supply entry is equipped with terminal blocks that are not matable with such improper power supplies.

3. Technical Data

3.1. General Features

Property	Value	Comment
Product name	NerdCam3D	
Model designation	Mk.1	
Size	100mm x 34mm x ca. 30mm	Size in z-direction may depend on lenses and lens holders
Mass	ca. 35g	With standard (f = 3.6mm) lenses and lens holders

3.2. Electrical Properties

Property	Value	Comment
Ingress Protection Marking	IP00	Installation of camera into a suitable protective enclosure recommended
Appliance class	III	 Use only with Separated/Safety Extra-Low Voltage (SELV) power sources
Power supply	+5V DC	+/- 5% voltage tolerance acceptable
Current consumption	ca. 340mA	
Sensor technology	CMOS	Electronic rolling shutter
Sensor resolution	640 x 480 Pixel	VGA-resolution
Pixel dynamic range	70dB	
SNR_{max}	39dB	
Video outputs	1 x 3D-CVBS 2 x CVBS 1 x 3D-digital, optional[1]	Main video output is 3D-CVBS. Separate CVBS outputs[2] at each sensor available. 3D-digital output in ITU BT.656 format on request.
Video norm	NTSC, PAL	Operation in NTSC mode is recommended. Due to given physical sensor resolution PAL is displayed with 480 active video lines only. Remaining unused active video lines in PAL mode

1 The camera contains provisions to tap the processed digital 3D video signal (before digital-to-analog conversion). This function requires the manual attachment of a SMD header (not included in scope of delivery) on the rear side of the camera board and a different firmware version. Please contact us in case of interest in this feature.

2 Requires manual installation of header pins (not included in scope of delivery) at the camera.

Property	Value	Comment
		are displayed as black bars above and below the video image.
Possible 3D-formats	Side-by-Side, Field-Sequential	Side-by-Side tested with cinemizer, cinemizer Plus, cinemizer OLED. Field-Sequential tested with HeadPlay HMD[3]. Other video goggles on request[4].

3.3. Optical Properties

Property	Value	Comment
Interaxial distance of both lenses	64mm	According to the average human interpupullary distance
Infrared filter	Build-in	Camera lenses equipped with IR-cut filter
Focal distance	3.6mm	Other focal distances on request.

4. Basic Camera Installation

The camera presents on its rear side a number of ports of which only a few are necessary for normal operation. A suitable minimum wiring for FPV operation is illustrated in Figure 1. The power supply and the 3D-video signal output are accessible via terminal blocks. For all other optional inputs or outputs pin headers with 2.54mm (= 0.1 ") pitch (not included in scope of delivery) are required. Please follow the instructions in chapter 7 before modifying the camera. For the connection between camera output and transmitter input a small 75Ω coaxial cable is recommended. The outer conductor of this cable must be connected to GND on both ends. Otherwise the quality of the transmitted analog video signal may be deteriorated.

The SELV power source supplies the video transmitter (not included in scope of delivery) and a voltage converter (BEC[5], not included in scope of delivery). The output of the BEC is connected to the camera via an optional LC-filter. The necessity of this filter depends highly on the electrical properties of the BEC. With linear voltage regulators the LC-filter should not be necessary. Switched voltage regulators may require such a filter. Due to the moderate power consumption of 340mA the camera can also be a supplied using an already existing power source, for example the ESC's BEC or the receiver's power supply. The connector pins for the power supply of the camera are labeled "0V" for the ground input and "+5 V" for DC voltage input.

3 With firmware version 1.20w.
4 The camera is – judged by its technical properties – also expected to be compatible with the following video goggles: EVG920V, EVG920E, Vuzix Wrap 920, Vuzix Wrap 1200, Dominator HD. However these goggles were not tested explicitly.
5 BEC: Battery Eliminator Circuit (http://en.wikipedia.org/wiki/Battery_eliminator_circuit)

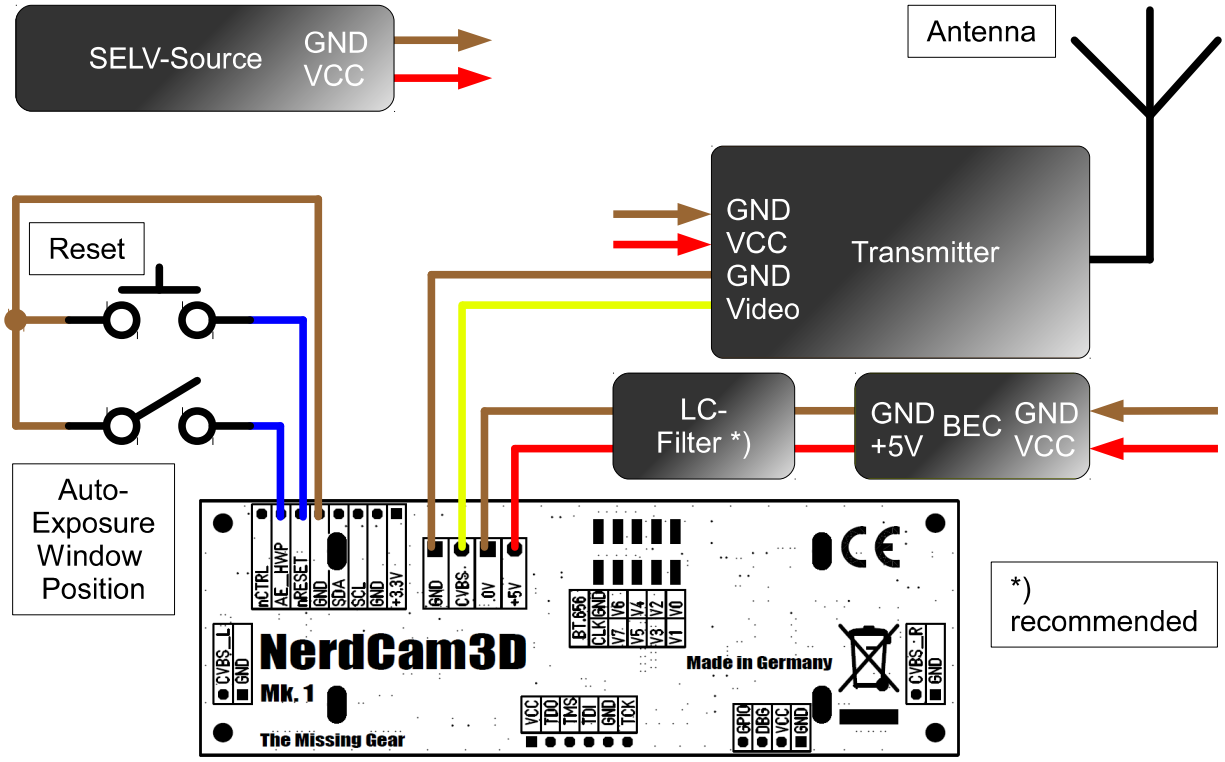

Figure 1: Basic wiring diagram of the camera

An optional Reset push button can be connected, which upon actuation pulls the “nRESET” port from +3.3V to Ground. If the push-button is released again an internal pull-up resistor restores the +3.3V signal level at the “nRESET” port. This input signal controls the FPGA's reconfiguration, which starts when the push-button is released. With this feature the camera can be reset either directly or remotely by the remote control unit of the RC-vehicle.

In an analogous way the two possible positions of the auto-exposure measurement window of both image sensors can be influenced with a second (directly or remotely controlled) switch. The actual meaning of this measurement window is shown in Figure 3. Please note chapter 7 in both cases, before you attach suitable push-buttons or switches to the camera.

5. Operation of the Camera

The camera starts to operate within a few milliseconds after the power supply is present. The mode of operation is indicated by a specific flashing sequence of the status LED, located on the front side of the camera board (Figure 2).

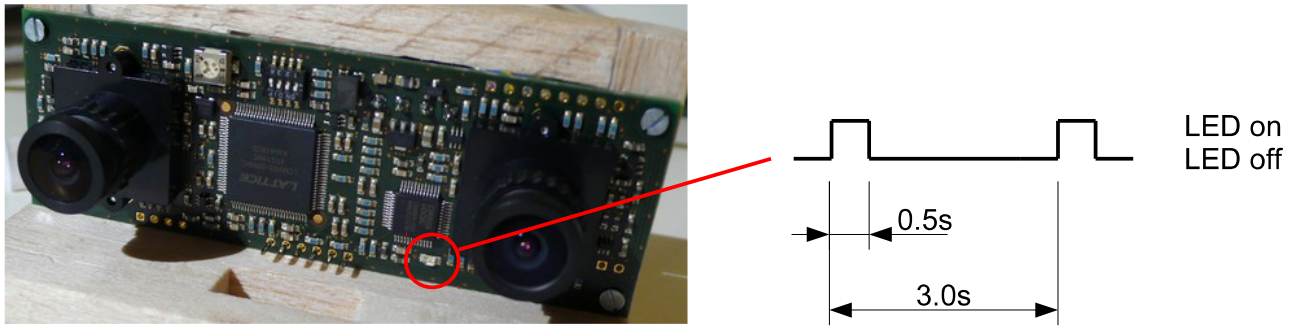

Figure 2: Position of status LED and optical indication for exposure mode 1

The flashing sequence shown in Figure 2 indicates the default exposure mode 1. In this mode the size of the image sensor's auto-exposure measurement window is limited to the lower half of the sensor's active region (Figure 3). This is an approved method for operation of the camera near ground level, where the sensor's exposure control focuses on the illumination conditions of the ground and not on those of the sky.

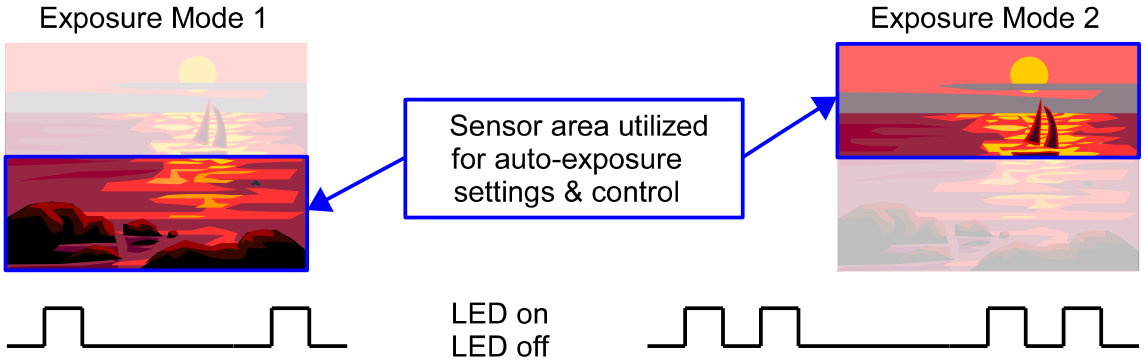

Figure 3: Exposure modes 1 & 2 and their indication with the status LED

Alternatively the exposure mode 2 can be activated, for example using a remotely controlled switch. In this mode the measurement window size is limited to the upper half of the sensor's active region. For this purpose the Pin AE_HWP (Auto Exposure Half Window Position) located on the extension port of the camera needs to be connected to Ground. The camera automatically detects this request within a few milliseconds. If the ground connection on the said pin is released again, the camera automatically switches back to default exposure mode 1. The display of the actual mode of operation with the status LED is updated accordingly.

5.1. Configuration with DIP-switch

A quadruple DIP-switch is used to influence the fundamental mode of operation of the camera. The positions of all four switches are read and processed at power-up only. All further modifications to the switch setting will be ignored as long as the camera remains uninterruptedly in operation. This feature does not apply to switch S3, which is permanently read and processed.

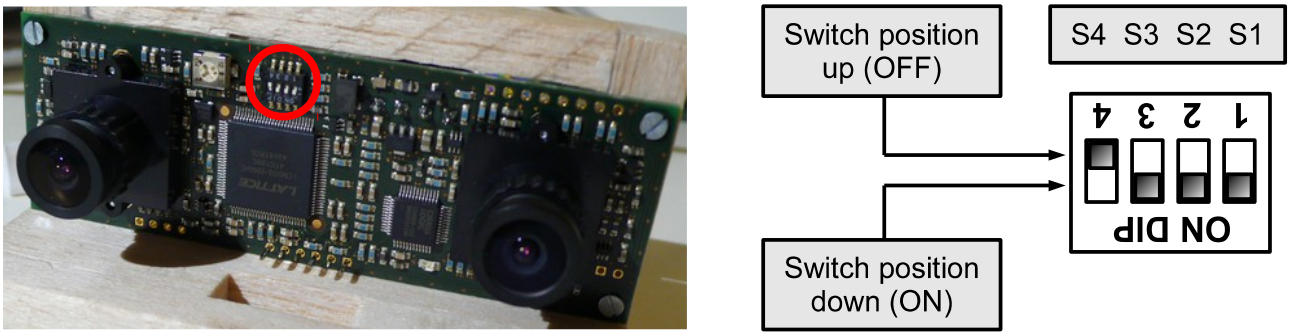

Figure 4: Location of the DIP-switch on the camera

The technical meaning of the four switches S1 to S4 is explained in the following table:

S1	Video norm	Switch OFF	PAL	
		Switch ON	NTSC	
S2	3D video format	Switch OFF	Field-Sequential (FS)	
		Switch ON	Side-by-Side (SBS)	
S3	Cross-hair for optical calibration	Switch OFF	Cross-hair enabled	
		Switch ON	Cross-hair disabled	
S4	Option switch		*When S2 = FS*	*When S2 = SBS*
		Switch OFF	Normal operation	Squeezed SBS
		Switch ON	Video fields swapped	Cropped SBS

The default position of the DIP-switch is: S1 bis S3: switch ON, S4: switch OFF. The camera can be reset simply by interrupting the power supply or by forcing a reconfiguration of the FPGA (pull pin nRESET to ground and release, see Figure 1).

Basically, the camera can generate two different stereoscopic video formats: Field-Sequential 3D[6] and Side-by-Side 3D. In addition, the camera is capable of rendering two different variants of the Side-by-Side 3D mode. This feature is controlled via the option switch S4. These two variants are shown in Figure 5.

6 Vgl. http://stackoverflow.com/questions/3445924/what-is-field-sequential-3d

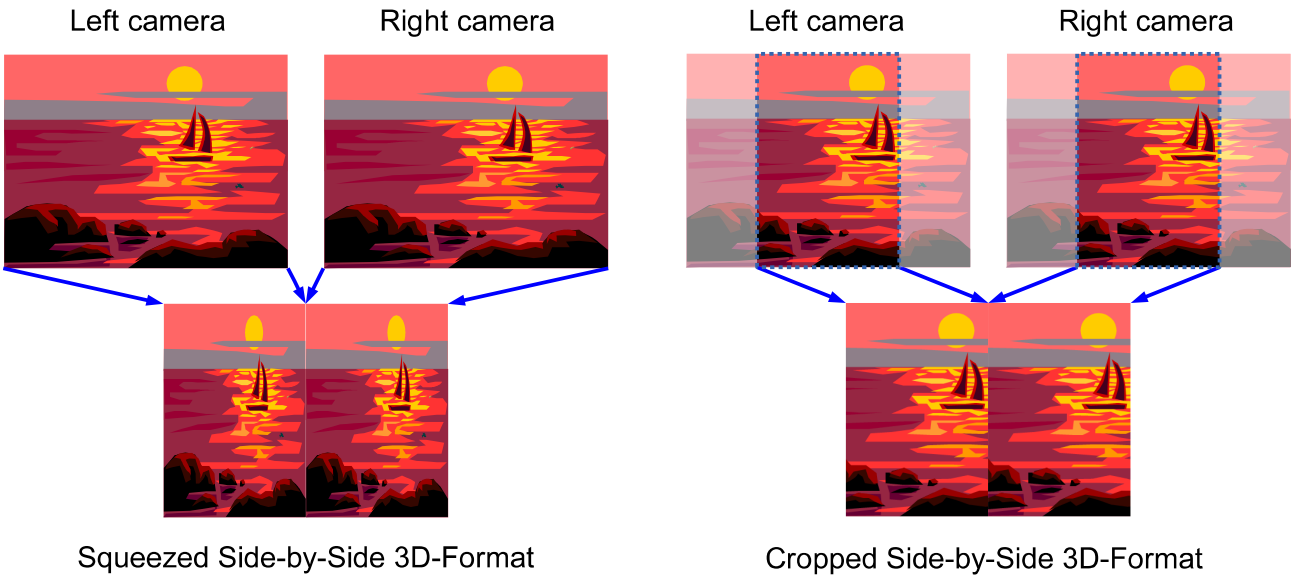

Figure 5:Supported variants of the Side-by-Side 3D-format

The squeezed Side-by-Side 3D-format is the default format, which is directly supported with many 3D video goggles. However, the cropped Side-by-Side 3D-format is best suited for use of the camera along with the Oculus Rift DevKit.

5.2. Configuration with Potentiometer

The camera is equipped with a small potentiometer which is used to control an important subset of the mentioned fundamental modes of operation. Firstly, the interaxial distance in the stereoscopic Side-by-Side video signal can be influenced gradually and secondly the 3D convergence setting of the optional on-screen display (OSD) may be adjusted. The integration of the optional OSD is described separately in chapter 7.3.

The following table outlines those DIP-switch positions for which the potentiometer fulfills a dedicated function. For all other unmentioned switch positions the potentiometer setting is ignored.

Function	**Switch S1**	**Switch S2**	**Switch S3**	**Switch S4**
Convergence OSD	Don't care	Field-Sequential	Don't care	Don't care
Convergence OSD	Don't care	Side-by-Side	Don't care	Squeezed SBS
Interaxial distance	NTSC	Side-by-Side	Don't care	Cropped SBS

Please note, that the OSD is in operation only, if a suitable analog-digital-converter (ADC) is attached to the camera's extension port, as described in chapter 7.3. At power-up the camera checks for the presence of the ADC by probing for a specific I2C-address. If the ADC is not found then the OSD remains completely inactive.

5.2.1. Interaxial Distance in Cropped Side-by-Side Mode

The camera firmware includes a specific feature which allows for an adaption of the interaxial distance of the generated stereoscopic video signal within useful limits. This function is only available for the cropped Side-by-Side mode of operation under NTSC video norm. The following figure explains the basic operation principle of the adaption of the interaxial distance.

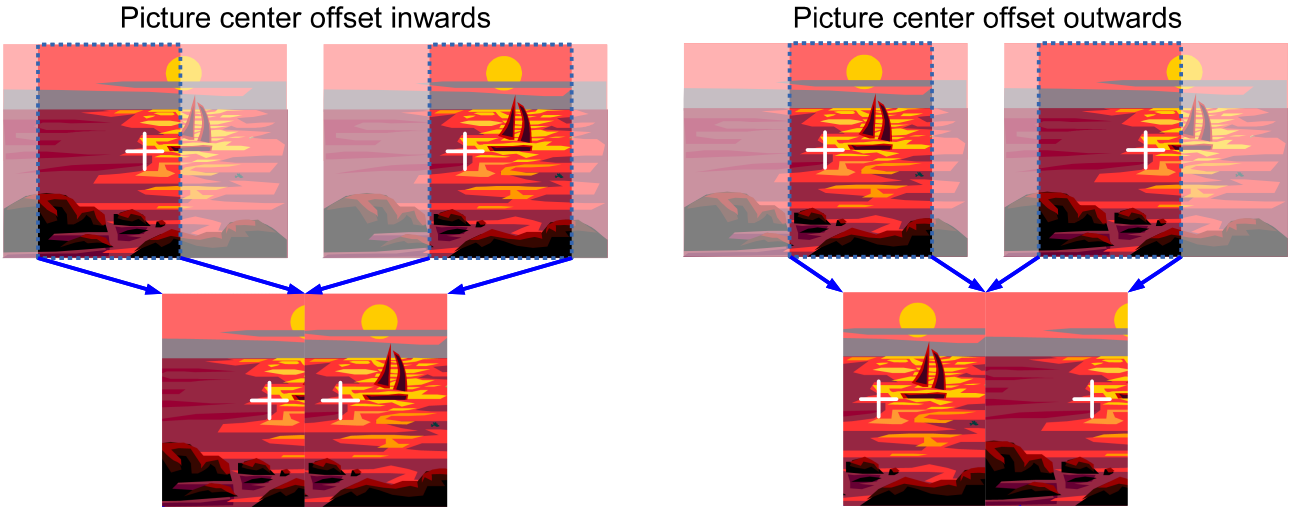

Figure 6: Adaption of interaxial distance on cropped SBS video signal

The respective horizontal offset is controlled by turning the camera's potentiometer accordingly. This setting can be made while the camera is in operation. The white cross markings for the image centers in Figure 6 are only for illustration purposes. They will not be displayed the actual generated 3D video signal.

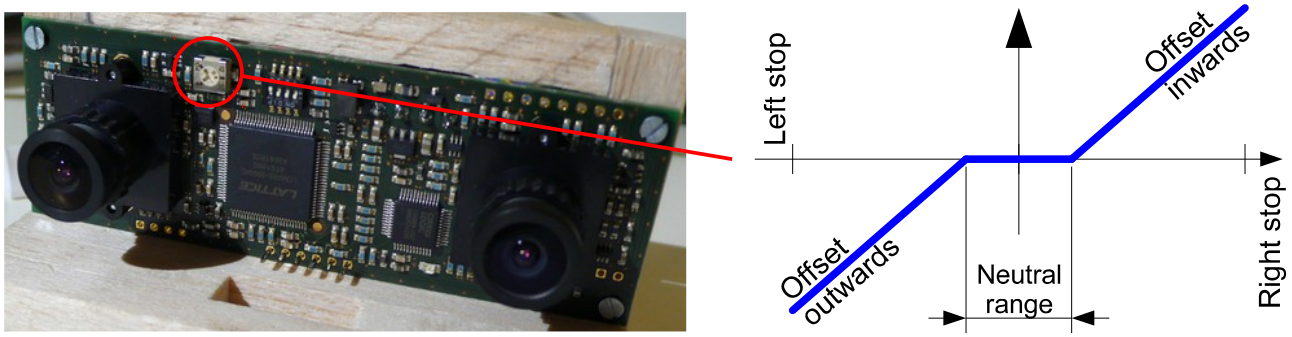

Figure 7: Potentiometer for adaption of interaxial distance

The potentiometer is set to middle position as default. Around this position there is a small neutral range in which turning the potentiometer does not have an influence on the interaxial offset. If the potentiometer is turned further the respective offset is realized depending on the sense of rotation.

In particular the inwards offset of the image centers depicted in Figure 6 is necessary, in case the camera is used for operation with the Oculus Rift (DevKit as well as successor models) video goggle. Please note that for proper operation with these goggles special fish-eye lenses with focal distances around 1mm are necessary in order to realize a natural three-dimensional perception. Larger focal distances are possible in general, however they will introduce a zoom-effect on the perceived image.

Due to the fact that the video goggles made by Oculus VR do not have a dedicated AV-input port for analog video so far, a separate AV-HDMI-converter may be required between analog video receiver and video goggle. This converter may have further negative influence on the quality of the video signal, for instance by insufficient conversion of aspect ratio 4:3 to 16:9, blue screen effect at low video signal strength or by introducing additional signal latency.

Currently market-entering latency-reduced digital video transmission sets may be suited to overcome this problem, provided the video transmitter is equipped with an analog video input port and the video receiver with a respective HDMI output port for the Rift goggles.

5.2.2. On-Screen Display Convergence Setting

The camera's firmware is prepared to overlay simple status information like battery voltage, current consumption and flight time on the stereoscopic video signal, in case a commercial ADC-module with the PCF5891 chip made by NXP is attached. Due to the stereoscopic nature of the video signal generated by the camera, this OSD information has to be embedded into both left and right video frame concurrently. In addition a certain horizontal offset of the displayed information is necessary to optimally support the user's 3D perception. The connection of the supported ADC-module to the camera is described extensively in chapter 7.3. The functional principle of adjusting the 3D-convergence of the OSD is depicted in Figure 8.

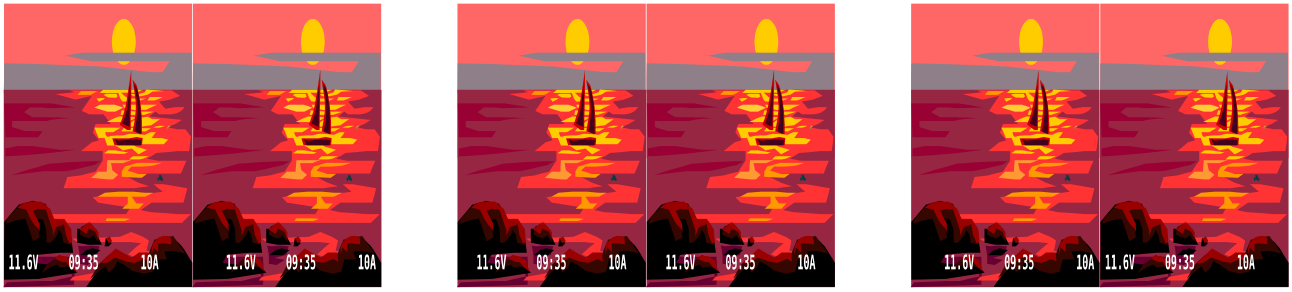

Figure 8: Influencing 3D-convergence of the OSD

The respective horizontal offset is achieved by turning the potentiometer. This setting can be made while the camera is in operation. Field tests with the camera have shown that a slight inward offset is advantageous for best 3D-OSD perception.

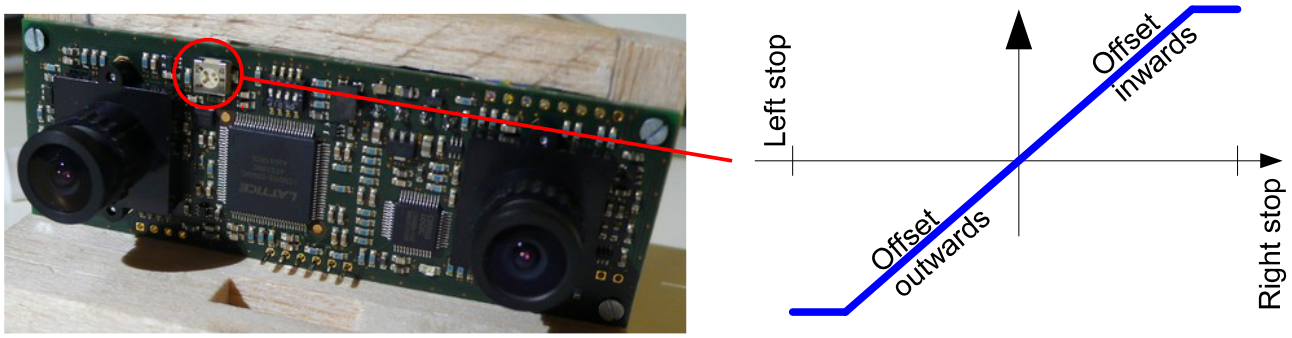

Figure 9: OSD offset control

The OSD is available for both squeezed Side-by-Side as well as Field-Sequential mode of operation. However, it is not available for cropped Side-by-Side mode.

5.3. Error Indication and Troubleshooting

The mechanical alignment between both optical lenses on the camera may be influenced adversely by mechanical stress (transient shocks, hard vibrations, etc.). Consequently, the tree-dimensional perception of the user wearing a video goggle may suffer, for instance by headache or dizziness. In this case immediately stop the use of the camera and perform an optical calibration of the lenses as described in chapter 7.1.

The camera does not possess additional operation indicators apart from the flashing of the LED and the permanent generation of a video signal. During operation the LED **must** flash in one of the two described sequences. If this is not the case the following table may be helpful for troubleshooting.

Symptom	Comments / Suggestions
LED permanently off, no video signal	Supply voltage too low or absent.
LED stays off, no video signal or video signal is distorted or flickering, but power supply voltage present	Check BEC, exchange BEC and install LC filters optionally. Some BEC operate near or at a multiple of the camera's clock frequency (27MHz) and consequently cause strong interferences, which the internal camera power filter cannot eliminate. **In case the camera works with a conventional battery pack (e.g. 4x1.2V NiMH batteries) but not with the present BEC then the BEC is the root cause of the problem.**
Transient interferences within the video signal, which do not originate from the utilized wireless video transmission gear	Missing ground connection between the video output of the camera and video input of the transmitter. The video signal is an RF signal and should be guided using 75Ω coaxial cable from the camera to the transmitter.

6. Maintenance and Repair

For maintenance of the camera no further measures are necessary. It is recommended to check from time to time the optical calibration of the two lenses (see chapter 7.1), for example after accidental hard landings of RC-controlled airplanes or multicopters.

7. Modifications

The camera provides the opportunity to perform mechanical and electronic modifications by expert intervention. The mechanical modifications relate to the replacement of the standard lenses and lens holder by alternative models. The electronic modifications include the attachment of additional headers to the appropriate locations on the camera board and the connection of the camera with other electronic devices.

CAUTION!
Consolidated knowledge and appropriate tools necessary!

Basically, a modification of the camera by the end user is not recommended, because an improperly conducted intervention may destroy the camera partially or completely. Consolidated knowledge, special tools and calibration devices may be necessary in order to conduct the modification in a professional manner. For these reasons the warranty on the camera becomes void in case of improperly conducted modifications.

CAUTION!
Modification of the camera may affect technical conformity!

Implementing the camera's modification can adversely affect or entirely prevent its conformity with regulatory directives and technical standards. Take appropriate measures in order to ensure the conformity of the camera along with the modifications made!

NOTICE
Electrostatic Discharge!

The camera contains sensitive electronic components that can be destroyed by electrostatic discharge. Handle electronic components with care! Implement a suitable grounding for persons, workplace and packing! Do not touch any electrically conductive parts, when not absolutely necessary!

7.1. Replacement of Lenses and Lens Holders

The camera is equipped with standard lenses of 3.6mm focal length which are placed and locked in S-mount lens holders. These lens holders are also suitable to carry alternative lenses with M12x0.5 thread. The camera is also designed for attachment of C-mount lens holders. The board of the camera provides slot holes for various lens holders with 18mm to 23mm mounting hole distance.

After changing the lenses or lens holders a mechanical calibration is necessary. The purpose of this calibration is to realize an exact alignment of the lenses in relation to each other and in relation to the position of each image sensor. This optical calibration is ideally performed using an optical

table with the necessary accessories. However, acceptable and mostly sufficient results can also be achieved with much simpler means. The basic structure of such a calibration device is shown in Figure 10.

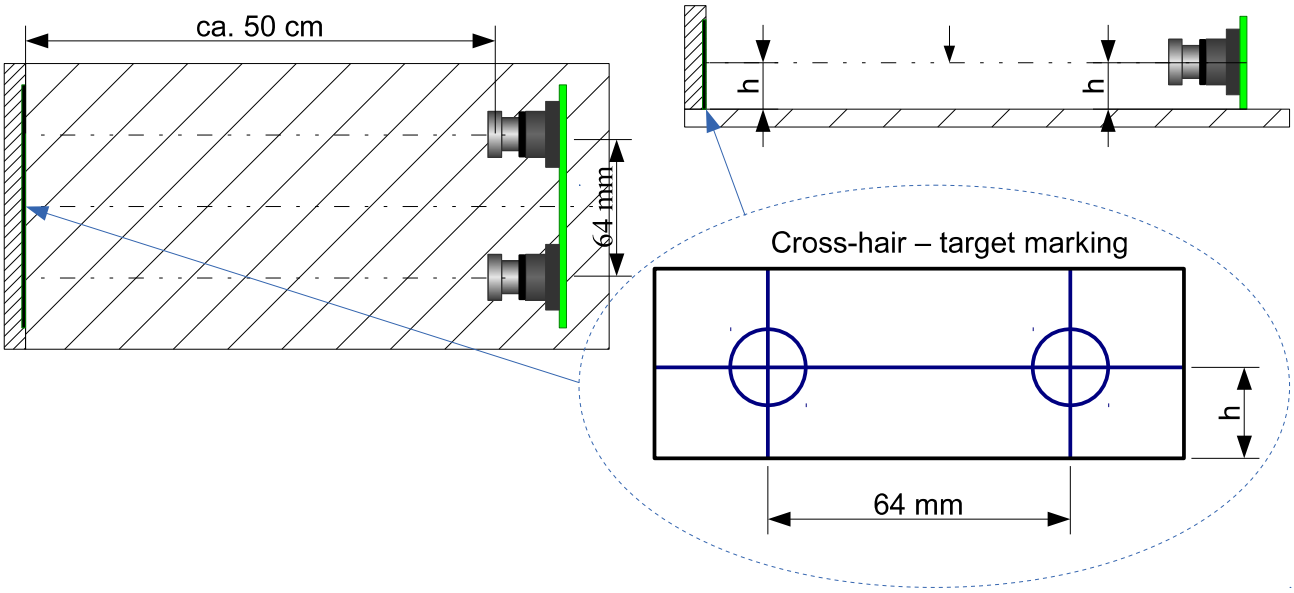

Figure 10: Basic optical calibration device

The calibration device consists of a flat base plate on which the camera and the cross-hair target marking are fixed on opposite sides. The camera and the target marking must be perpendicular to the base plate. The center points of camera board and target must be facing, as precisely as possible.

The target marking may be for example a drawing on a sheet of paper with two cross-hairs and other symbols for orientation. However, the marking must meet the following two conditions:

1. The horizontal distance of the cross-hairs on the target marking must be 64mm, the value of the interaxial distance between the two image sensors of the camera.
2. The specified height h must be identical to the corresponding height h on the camera board. For example, if the camera is mounted on a pedestal for mechanical fixing, this additional height of the pedestal is to be taken into account, when calculating the height h on the target marking.

For the calibration procedure the camera is mounted into the calibration device and the camera's DIP-switch S3 is switched to OFF-position in order to activate the calibration cross-hair overlay symbols. Now there are two different groups of cross-hairs visible in the generated video signal – the target marking (see Figure 10) and the statically overlaid cross-hair symbols generated by the camera. The aim of the calibration procedure is to align the centers of the facing cross-hair pairs to each other by mechanical movement of the lens holders. During the calibration the camera should tun in compressed side-by-side 3D-mode (Figure 11).

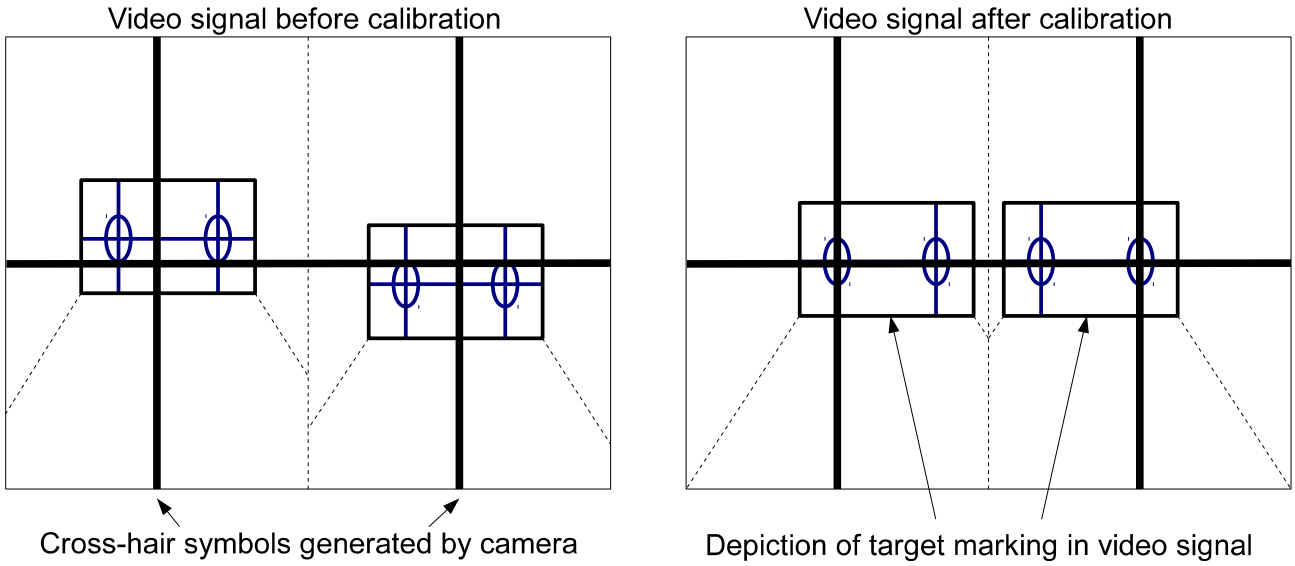

Figure 11: Video signal before and after optical calibration

The calibration sequence may be as follows:

1. Enable the camera-generated cross-hairs with DIP switch No. 3,
2. Mount the camera into the calibration device, attach an auxiliary video monitor to the output of the camera and focus the video signal by rotating the lenses,
3. Compare the position of the facing cross-hair centers from depicted target marking and overlaid calibration marking in the video signal,
4. Loosen the screws of the lens holders on the rear of the camera board and manually move the lens holders until the facing cross-hairs match as shown in Figure 11,
5. Tighten the screws of the lens holder to fix the holder in the current position.

The described calibration procedure requires some patience and practice. The match of the facing cross-hairs does not need not be perfect to 100%. Slight deviations from the ideal lens holder position are tolerable.

7.2. Attachment of Headers / Connection Overview

The camera has a number of soldering positions at which header pins or cables can be attached. Those positions are arranged in seven different groups (Figure 12).

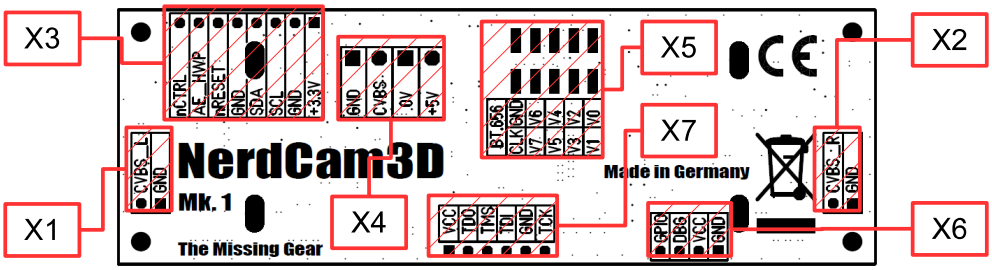

Figure 12: Overview of camera ports and connectors

The following table shows the respective meaning and function of the camera ports together with relevant technical remarks and comments.

X1: Optional output for analog video signal of the left camera sensor			
CVBS_L	CVBS video signal for 75Ohm coaxial cable		DC-coupled video output, directly from the sensor, but with additional video filter. Not OSD-capable.
GND	Electrical ground		

X2: Optional output for analog video signal of the right camera sensor			
CVBS_R	CVBS video signal for 75Ohm coaxial cable		DC-coupled video output, directly from the sensor, but with additional video filter. Not OSD-capable.
GND	Electrical ground		

X3: Camera extension port			
nCTRL	Not connected		With 47kΩ pull-up resistor to 3.3V. Input may be connected to GND or may be left floating.
AE_HWP	Auto-Exposure Half Window Position	Chapter 5	With 47kΩ pull-up resistor to 3.3V. Input may be connected to GND or may be left floating.
nRESET	Reset and reconfiguration of camera	Chapter 4	With 47kΩ pull-up resistor to 3.3V. Input may be connected to GND or may be left floating.
GND	Electrical ground		
SDA	I²C data line for external devices	Chapter 7.3	Observe 3.3V bus level! Camera contains a 1.5kΩ pull-up resistor to 3.3V.
SCL	I²C clock line for external devices	Chapter 7.3	Observe 3.3V bus level! Camera contains a 1.5kΩ pull-up resistor to 3.3V.
GND	Electrical Ground		
+3.3V	Power supply for external devices	Chapter 7.3	Maximum sourcing capacity ca. 500mA.

X4: Camera Main Port			
GND	Electrical Ground	Chapter 4	
CVBS	CVBS video signal for 75Ohm coaxial cable	Chapter 4	DC-coupled video output with additional video filter.
0V	Primary power supply input for electrical ground	Chapter 4	Use only with Separated/Safety Extra-Low Voltage (SELV) power sources.
+5V	Primary power supply input for +5V DC	Chapter 4	Use only with Separated/Safety Extra-Low Voltage (SELV) power sources.

X5: Optional digital video signal output port			
CLK	Clock output for digital (BT.656) video signal	Foot note 1 on page 6	The digital video output port is not activated by default. Please contact us in case of interest in this feature. Logic level is 3.3V.
GND	Electrical ground		
V0...V7	Bit 0 to bit 7 of the BT.656 video signal		

X6: Optional port for LCD-display			
GND	Electrical ground		Power supply for 16x2 LCD-display
VCC	+3.3V DC power supply for external devices		Power supply for 16x2 LCD-display Maximum sourcing capacity ca. 500mA
DBG	Signal output for LCD-display[7]		UART port for 16x2 LCD-display
GPIO	Not connected		Without external Pull-Up resistor. Not activated by default.

X7: Programming port			
VCC	Secondary power supply input for +5V DC		Only for temporary supply of the camera via the JTAG programming adapter. Port **X4:+5V** must not be used in parallel with this power supply port.
TDO	JTAG-port Test Data Out		3.3V logic level
TMS	JTAG-port Test Mode Select		3.3V logic level
TDI	JTAG-port Test Data In		3.3V logic level
GND	Electrical ground		Only for temporary supply of the camera via the JTAG programming adapter.
TCK	JTAG-port Test Clock		3.3V logic level with AC-termination.

7 Suitable 16x2 LCD-display modules (e.g. https://www.sparkfun.com/products/9067 – „*Serial Enabled 16x2 LCD - White on Black 3.3V*“) must have a serial (UART) input port at 3.3V logic level. The camera is configured by default to output at port X6 the firmware version (2 digits) and the so-called TraceID of the FPGA (14 digits). Each camera comprises a unique and unchangeable identification number.

7.3. Optional On-Screen Display (OSD)

For the OSD an analog-to-digital converter (ADC) is required which converts the analog signals of the utilized sensors into digital values that the camera can process. The camera's primary I2C bus running at 3.3V logic level is the interface between the converter and camera. The following figure shows a suitable wiring. The power supply of the ADC must be realized through the camera, such that the logic level at the I2C bus connector pins is at 3.3V.

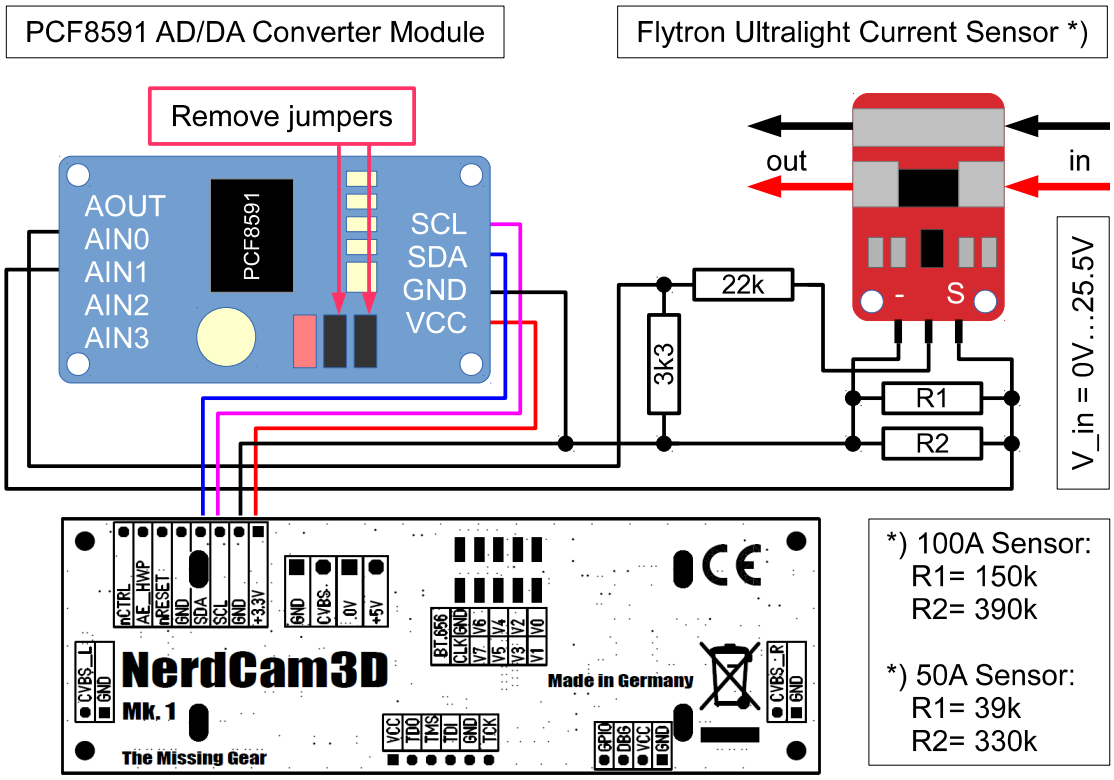

Figure 13: Connection of ADC and power/current sensors

The "PCF8591 AD / DA Converter Module" is an inexpensive and completely assembled solution. However, other ADC-modules can be used as well, as long as they are based on the PCF8591 chip. In this case, make sure that the hexadecimal write/read address of the chip is configured to 0x90/0x91. Only these addresses are tested for accessibility when the camera powers up. In case the ADC is not detected with the above mentioned I2C addresses the OSD is disabled automatically.

8. Warranty

For this product the German statutory warranty applies. The warranty is fulfilled at the seller's option by repair, replacement or withdrawal of the purchase contract.

The warranty becomes void when the error was caused by third party, or by improper installation, or commissioning or modification, by incorrect or negligent handling, or improper transport, or excessive stress, by unsuitable operating resources, by inadequate video transmission systems, by improper use or operation of the product.

Please note that the technical realization of the wireless video transmission from the camera to the end user's video receiver, or video goggle, or head-mounted display has a significant impact on the video quality. Inappropriate video quality caused by the use of unsuitable video transmission systems is therefore no error of the product.

9. Limitation of Liability

TMG-Ingenieurbüro UG (haftungsbeschränkt), THE MANUFACTURER, SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOSS OF PROFITS, REVENUE OR DATA (WHETHER DIRECT OR INDIRECT) OR COMMERCIAL LOSS FOR BREACH OF ANY EXPRESS OR IMPLIED WARRANTY ON YOUR PRODUCT EVEN IF THE MANUFACTURER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. Some jurisdictions do not allow the exclusion or limitation of special, indirect, incidental or consequential damages, so the above limitation or exclusion may not apply to You, but the remainder of this Limited Warranty shall remain in full force and effect.

10. Disposal and Environmental Protection

Electrical and Electronic Equipment (EEE) can be recycled when no longer needed and must not be disposed together with usual household waste. Therefore we kindly ask you to support us with your active contribution to the conservation of resources and the protection of the environment by disposing this device at the official EEE collection points.

11. Manufacturer Information and Technical Support

This camera was developed for you by:

TMG-Ingenieurbüro UG (haftungsbeschränkt)	Sales tax ID:
Römerstraße 14	WEEE ID:
89077 Ulm	Website: www.themissinggear.eu
GERMANY	Contact: support@themissinggear.eu

Please feel free to contact us using the above mentioned e-mail address for technical assistance or other questions about the product.

EU-Declaration of Conformity

We,

TMG-Ingenieurbüro UG (haftungsbeschränkt)

Römerstraße 14

89077 Ulm

GERMANY

declare under our sole responsibility, that the product

Product name	NerdCam3D
Trade name	The Missing Gear
Model	Mk. 1

to which this declaration relates, is in conformity with the following directives and harmonized standards:

EMC Directive 2004/108/EG	EN 55022:2010
	EN 55024:2010
RoHS Directive 2011/65/EU	EN 50581:2012
WEEE Directive 2012/19/EU	EN 50419:2006

The technical documentation is kept at the above mentioned address open for inspection.

Ulm, 05/11/2014

Dr.-Ing. Michael Sabielny
Managing Director