AVT Oscar

Technical Manual

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Before operation

AVT places the highest demands for quality on its cameras.
This technical manual is the guide to the installation and setting up of the camera for operation.
Please read this manual carefully before operating the camera.
In this manual, reference is made to other technical manuals which are available both on CD or to download from our website (www.alliedvisiontec.com).

Legal notice

For customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment. The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

For customers in Canada

This apparatus complies with the Class B limits for radio noise emissions set out in the Radio Interference Regulations.

Pour utilisateurs au Canada

Cet appareil est conforme aux normes classe B pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

Life support applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Allied customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Allied for any damages resulting from such improper use or sale.

Allied Vision Technologies GmbH 05/2005

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Document History

Version	Date	Remarks
1.0	10.05.2005	First Issue

Contents

Conventions used in this manual

To optimize layout and emphasize important information in this manual,, the following typographical styles and symbols are used:

Styles

Style	Function	Example
`Courier`	Programs, inputs, etc.	“`Input`”
upper case	Register	REGISTER
italics	Modes, fields	*Mode*
parentheses and/or blue	Links	(Link)

Symbols:

ⓘ This symbol highlights important instructions that should be followed to avoid malfunctions.

1 Safety instructions

ⓘ There are no switches or items within the camera that require adjustment. The guarantee becomes void upon opening the camera casing.

ⓘ If the product is disassembled, reworked or repaired by persons other than a recommended service person, neither AVT nor its suppliers will take responsibility for the subsequent performance or quality of the camera.

ⓘ This camera does NOT generate any hazardous voltages internally. However, because the IEEE-1394a standard permits cable power distribution at voltages higher than 24 V, various international safety standards apply. Reference documents applicable in the United States include:

- Information Processing and Business Equipment, UL 478
- National Electric Code, ANSI/NFPA 70
- Standard for the Protection of Electronic Computer/Data-Processing Equipment, ANSI/NFPA 75

Reference documents applicable in Europe include materials to secure the European Union CE marking as follows:

- Telecommunications Terminal Equipment (91/263/EEC)
- EMC Directive (89/339/EEC)
- CE Marking Directive (93/68/EEC)
- LOW Voltage Directive (73/23/EEC) as amended by the CE Marking

Reference documents applicable in Japan include:

- Electronic Equipment Technology Criteria by the Ministry of Trading and Industry (Similar to NFPA 70)
- Wired Electric Communication Detailed Law 17 by the Ministry of Posts and Telecom Law for Electric Equipment
- Dentori law issued by the Ministry of Trading and Industry
- Fire law issued by the Ministry of Construction

ⓘ Make sure NOT to touch the shield of the camera cable connected to a computer and the ground terminal of the lines at the same time.

ⓘ Use only DC-power supplies with insulated cases. These are identified by having only TWO power connectors.

ⓘ Although IEEE-1394a is functionally plug and play, the physical ports may be damaged by excessive ESD (electrostatic discharge) when connected under powered conditions. It is good practice to bring the metal part, which is the shield of the IEEE-1394 cable, in contact with the housing of the camera before plugging it into the camera. Likewise on the other side in contact with metal parts of the computer before plugging it into the port of the computer. This ensures that excessive charge can flow safely to ground.

ⓘ When you feel uncomfortable with the above information or are not familiar with the connectivity of the installation, we strongly recommend that all power systems are shut down before connecting or disconnecting a camera.

1.1 Environmental conditions

Ambient temperature:		
	when camera in use:	+ 5° C ... + 45° C
	when being stored :	- 10° C ... + 60° C
Relative humidity:		20 % ... 80 % no condensed water
Protection:		IP 30

2 Oscar types and highlights

Entry into digital image-processing has never been as simple and cost effective as it is today. With the OSCAR, Allied Vision Technologies presents a new series of exciting, extremely high resolution digital cameras – naturally with Firewire™ interface.
The series consists of 3 different cameras types whose multi-mega pixel resolutions, image pre-processing functions, frame grabbing functions and robust industrial casings make them highly suitable for a wide range of different applications. In this price class the OSCAR sets new standards and offers the perfect solution for applications in medical, microscopy and general digital image-processing.

The AVT OSCAR family has three very compact IEEE1394 C-mount cameras equipped with sensitive high-resolution, high quality sensors (CCD). Each of these cameras is available in color. Operating in 12- bit mode, the cameras provide outstanding image quality under almost all conditions. The OSCAR is equipped with an asynchronous trigger, true partial scan and numerous smart features for image processing and microscopy. With resolutions of 3, 5 and 8 Mega pixels the cameras offer unrivalled solutions for many extreme high resolution applications.

The OSCAR family in details:

OSCAR F-320C
1/1.8″ Sony frame readout CCD imager; 2088 (h) x 1584 (v); up to 3.7 fps at full resolution.

OSCAR F-510C
2/3″ Sony frame readout CCD imager; 2588 (h) x 1958 (v); up to 3.4 fps at full resolution.

OSCAR F-810C
2/3 " Sony frame readout CCD imager; 3288 (h) x 2470 (v); up to 3.1 fps at full resolution.

With an output of 8 or 12-bit data, the cameras ensure very high quality images under almost all conditions. The OSCAR is equipped with an asynchronous trigger shutter, true partial scan, and integrates numerous smart features for image preprocessing.

- ⓘ All models are equipped with an optical filter to eliminate the influence of infrared light reaching the sensor. Please note that this filter also reduces the sensitivity in the visible spectrum.
- ⓘ For specific applications it is therefore recommended to remove the filter by using a special tool. This tool is available from AVT under the part number: E9020001.
- ⓘ Taking out the filter requires special care. Ask your dealer for assistance if you are unfamiliar with the procedure.
- ⓘ After removing the IR cut filter it should be replaced with a neutral glass filter (K4000024) to avoid dust collecting on the sensor. The glass filter also ensures that the lenses can be correctly adjusted in focus.

3 System components

The following components are included with each camera:

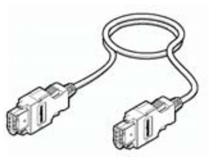
AVT Oscar

4.5m 1394 standard cable

Jenofilt 217 IR cut filter (built in)

Optional:

Tripod Adapter



4.5m latching cable

Driver and documentation

The following illustration shows the spectral sensitivity of the IR cut filter

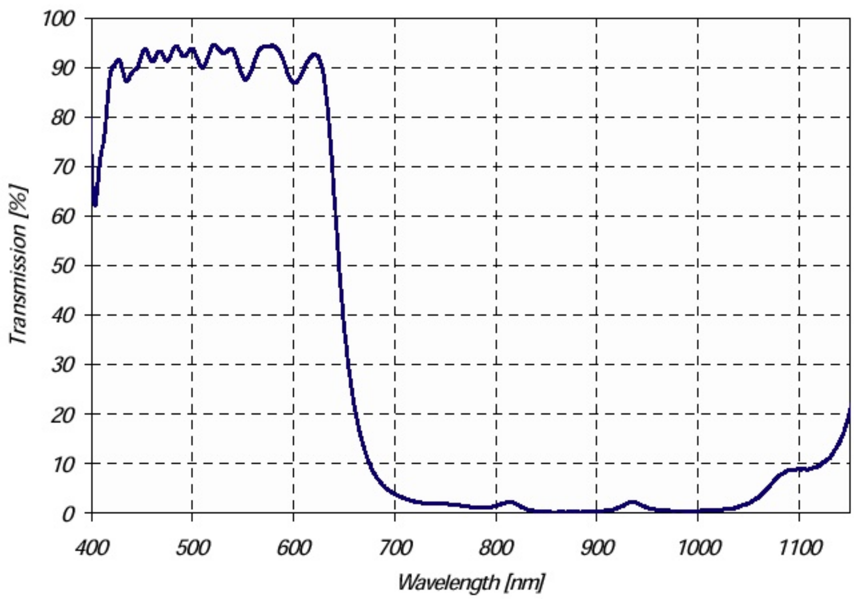


Figure 1: Spectral sensitivity of Jenofilt 217

To demonstrate the properties of the camera, all examples in this manual are based on the “FirePackage” OHCI API software and the “SmartView” application.
These utilities can be obtained from Allied Vision Technologies. A free version of “SmartView” is available for downloading at www.alliedvisiontec.com.
The camera also works with all IIDC (formerly DCAM) compatible IEEE 1394 programs and image processing libraries.

AVT offers different lenses from a variety of manufacturers. The following table lists selected image formats depending on camera type, distance and the focal width of the lens.

ⓘ Due to its extreme high resolution, OSCAR cameras place high demands on the modulation transfer function (MTF) of the lens. If in doubt, ask your dealer for the best lens to fit your application needs.

Focal Width MO-F320C	Distance = 0,5m	Distance = 1m
4.8 mm	0.55 m x 0.74 m	1.1 m x 1.47 m
8 mm	0.33 m x 0.44 m	0.66 m x 0.88 m
12 mm	0.22 m x 0.29 m	0.43 m x 0.58 m
16 mm	0.16 m x 0.21 m	0.32 m x 0.42 m
25 mm	10.1 cm x 13.4 cm	20.2 cm x 26.9 cm
35 mm	7.1 cm x 9.5 cm	14.2 cm x 18.9 cm
50 mm	4.9 cm x 6.5 cm	9.8 cm x 13 cm
Focal Width MO-F510C/810C	**Distance = 0.5m**	**Distance = 1m**
4.8 mm	0.7 m x 0.93 m	1.4 m x 1.86 m
8 mm	0.4 m x 0.53 m	0.8 m x 1.06 m
12 mm	0.27 m x 0.36 m	0.54 m x 0.72 m
16 mm	0.2 m x 0.27 m	0.4 m x 0.54 m
25 mm	12.5 cm x 16.625 cm	25 cm x 33.25 cm
35 mm	8.8 cm x 11.7 cm	17.6 cm x 23.4 cm
50 mm	6 cm x 7.98 cm	12 cm x 15.96 cm

Table 1: Focal Width vs. field of view (height x width)

4 Specifications

4.1 OF-320C

Specification	
Image Device	1/1.8" (diag. 8.93 mm) type frame readout SONY IT CCD
Effective sensor pixels	2088 (H) x 1548 (V)
Lens Mount	C-mount: 17.526 mm (in air); ∅ 25.4 mm (32 T.P.I.); adjustable from 17.3 to 22.5 mm; Mechanical Flange Back to filter distance: 10.5 mm
Picture Sizes	320 x 240 pixels ; (Format_0) centered progressive preview mode 344 x 254 pixels ; (Format_7 Mode_2) progressive preview mode 2080 x 1540 pixels (Format_7 Mode_0) frame readout, joint shutter 2080 x 1540 pixels (Format_7 Mode_1) frame readout, split shutter
Cell Size	3.45 µm x 3.45 µm
ADC	12 Bit
Color Modes	MONO8; Y8-green, Y8-red, Y8-blue; RAW8/16; RGB8; YUV4:2:2; YUV 4:1:1
Data Path	8/12 Bit
Frame Rates	3.75Hz, 7.5Hz, 15Hz, 30Hz in Format_0; up to 5.1Hz in Format_7 frame readout; up to 39.6Hz in F_7 progressive
Gain Control	Manual: 0–20 dB (0.035 dB/step); Auto gain (select. AOI)
White Balance	Manual (U/V); One_push/auto white balance; hue/saturation
Shutter Speed	20 …67.108.864 µs (~67s); Auto shutter (select. AOI)
External Trigger Shutter	Trigger_Mode_0, Trigger_Mode_1 (progr. scan,F_7 M_0); Advanced feature: Trigger_Mode_15 (bulk); image transfer by command; Trigger delay
Internal FIFO-Memory	32 Mbyte, optional up to 256 MByte
Look Up Table	One, user programmable (12 Bit -> 8/12 Bit); Gamma (0.5)
Smart Functions	Real time shading correction, color correction, High SNR-mode (image summation), two configurable inputs two configurable outputs, image mirror (L-R↔ R-L), subsampling, serial port (IIDC v. 1.31)
Transfer Rate	100 Mb/s, 200 Mb/s, 400 Mb/s
Digital Interface	IEEE 1394 IIDC v. 1.3
Power Requirements	DC 8 V – 36 V via IEEE 1394cable or 12-pin HIROSE
Power Consumption	3.6 Watts (@ 12 V d.c.)
Dimensions	58 mm x 44 mm x 44 mm (L x W x H); w/o tripod and lens
Mass	<170 g (without lens and tripod)
Operating Temperature	+5 – +45 ° Celsius
Storage Temperature	-10 – +60 ° Celsius
Regulations	EN 55022,EN61000,EN 55024,FCC Class A, DIN ISO 9022
Options	Removable IR-cut-filter, host adapter card, locking IEEE-1394 cable, API (FirePackage), TWAIN (WIA)- and WDM stream driver

Table 2: Specification OF-320C

4.2 OF-510C

Specification	
Image Device	2/3 " (diag. 11 mm) type frame readout SONY IT CCD
Effective sensor pixels	2588 (H) x 1958 (V)
Lens Mount	C-mount: 17.526 mm (in air); ∅ 25.4 mm (32 T.P.I.); adjustable from 17.3 to 22.5 mm; Mechanical Flange Back to filter distance: 10.5 mm
Picture Sizes	1024 x 768 pixels (Format_1) progressive; 1280 x 960 pixels (Format_2) progressive ; 1288 x 978 pixels (Format_7 Mode_2) progressive, centered; 2588 x 1958 pixels (Format_7 Mode_0) frame readout, joint shutter 2588 x 1958 pixels (Format_7 Mode_1) frame readout, split shutter
Cell Size	3.4 µm x 3.4 µm
ADC	12 Bit
Color Modes	MONO8; Y8-green, Y8-red, Y8-blue; RAW8/16; RGB8; YUV4:2:2; YUV 4:1:1
Data Path	8/12 Bit
Frame Rates	1.375Hz, 3.75Hz, 7.5Hz Format_1 and 2; up to 3.2 Hz in Format_7 frame readout; up to 7.5Hz in Format_7 progressive
Gain Control	Manual: 0–20 dB (0.035 dB/step); Auto gain (select. AOI)
White Balance	Manual (U/V); One_push auto white balance; Hue/saturation
Shutter Speed	20 …67.108.864 µs (~67s); Auto shutter (select. AOI)
External Trigger Shutter	Trigger_Mode_0, Trigger_Mode_1 (progr. scan,F_7 M_0); Advanced feature: Trigger_Mode_15 (bulk); image transfer by command; Trigger delay
Internal FIFO-Memory	32 Mbyte, optional up to 256 MByte
Look Up Table	One, user programmable (12 Bit -> 8/12 Bit); Gamma (0.5)
Smart Functions	Real time shading correction, color correction, High SNR-mode (image summation), two configurable inputs two configurable outputs, image mirror (L-R↔ R-L), subsampling, serial port (IIDC v. 1.31)
Transfer Rate	100 Mb/s, 200 Mb/s, 400 Mb/s
Digital Interface	IEEE 1394 IIDC v. 1.3
Power Requirements	DC 8 V – 36 V via IEEE 1394cable or 12-pin HIROSE
Power Consumption	3.6 Watts (@ 12 V d.c.)
Dimensions	58 mm x 44 mm x 44 mm (L x W x H); w/o tripod and lens
Mass	<170 g (without lens and tripod)
Operating Temperature	+5 – +45 ° Celsius
Storage Temperature	-10 – +60 ° Celsius
Regulations	EN 55022,EN61000,EN 55024,FCC Class A, DIN ISO 9022
Options	Removable IR-cut-filter, host adapter card, locking IEEE-1394 cable, API (FirePackage), TWAIN (WIA)- and WDM stream driver

Table 3: Specification OF-510C

The design and specifications for the products described above may change without notice.

4.3 OF-810C

Specification	
Image Device	2/3 " (diag. 11 mm) type frame readout SONY IT CCD
Effective sensor pixels	3288 (H) x 2470 (V)
Lens Mount	C-mount: 17.526 mm (in air); ∅ 25.4 mm (32 T.P.I.); adjustable from 17.3 to 22.5 mm; Mechanical Flange Back to filter distance: 10.5 mm
Picture Sizes	1024 x 768 pixels (F_1),frame readout, cent. ; 1088 x 822 pixels (Format_7 Mode _2) subsampled progressive ; 3272 x 2469 pixels (Format_7 Mode_0) frame readout, joint shutter 3272 x 2469 pixels (Format_7 Mode_1) frame readout, split shutter
Cell Size	2.7 µm x 2.7 µm
ADC	12 Bit
Color Modes	MONO8; Y8-green, Y8-red, Y8-blue; RAW8/16; RGB8; YUV4:2:2; YUV 4:1:1
Data Path	8/12 Bit
Frame Rates	up to 3.1 Hz in Format_7 (Mono), up to 8.9 Hz progressive
Gain Control	Manual: 0–20 dB (0.035 dB/step); Auto gain (select. AOI)
White Balance	Manual (U/V); One_push auto white balance; Hue/saturation
Shutter Speed	20 …67.108.864 µs (~67s); Auto shutter (select. AOI)
External Trigger Shutter	Trigger_Mode_0, Trigger_Mode_1 (progr. scan,F_7 M_0); Advanced feature: Trigger_Mode_15 (bulk); image transfer by command; Trigger delay
Internal FIFO-Memory	32 Mbyte, optional up to 256 MByte
Look Up Table	One, user programmable (12 Bit -> 8/12 Bit); Gamma (0.5)
Smart Functions	Real time shading correction, color correction, High SNR-mode (image summation), two configurable inputs two configurable outputs, image mirror (L-R↔ R-L), subsampling, serial port (IIDC v. 1.31)
Transfer Rate	100 Mb/s, 200 Mb/s, 400 Mb/s
Digital Interface	IEEE 1394 IIDC v. 1.3
Power Requirements	DC 8 V – 36 V via IEEE 1394cable or 12-pin HIROSE
Power Consumption	3.6 Watts (@ 12 V d.c.)
Dimensions	58 mm x 44 mm x 44 mm (L x W x H); w/o tripod and lens
Mass	<170 g (without lens and tripod)
Operating Temperature	+5 – +45 ° Celsius
Storage Temperature	-10 – +60 ° Celsius
Regulations	EN 55022,EN61000,EN 55024,FCC Class A, DIN ISO 9022
Options	Removable IR-cut-filter, host adapter card, locking IEEE-1394 cable, API (FirePackage), TWAIN (WIA)- and WDM stream driver

Table 4: Specification OF-810C

The design and specifications for the products described above may change without prior notice.

4.4 Spectral sensitivity

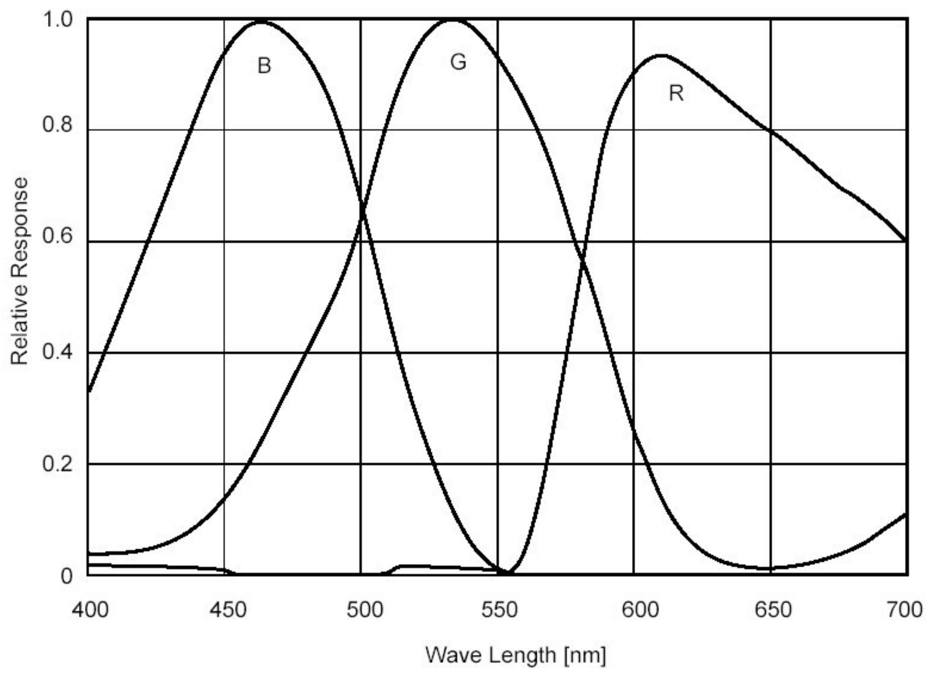


Figure 2: Spectral sensitivity of OF-320C without cut filter and optics.

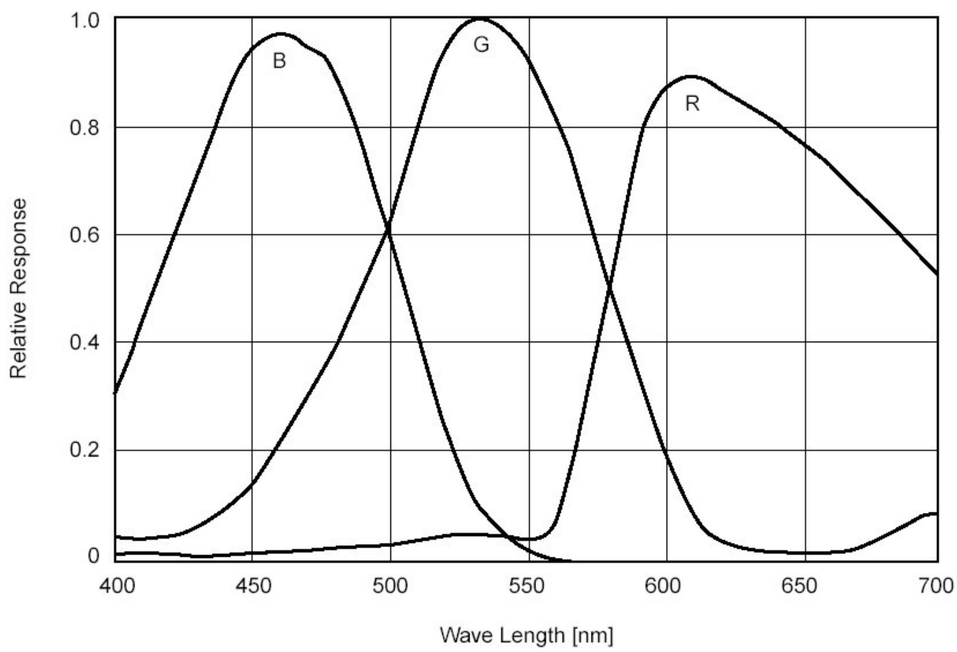


Figure 3: Spectral sensitivity of OF-510C without cut filter and optics

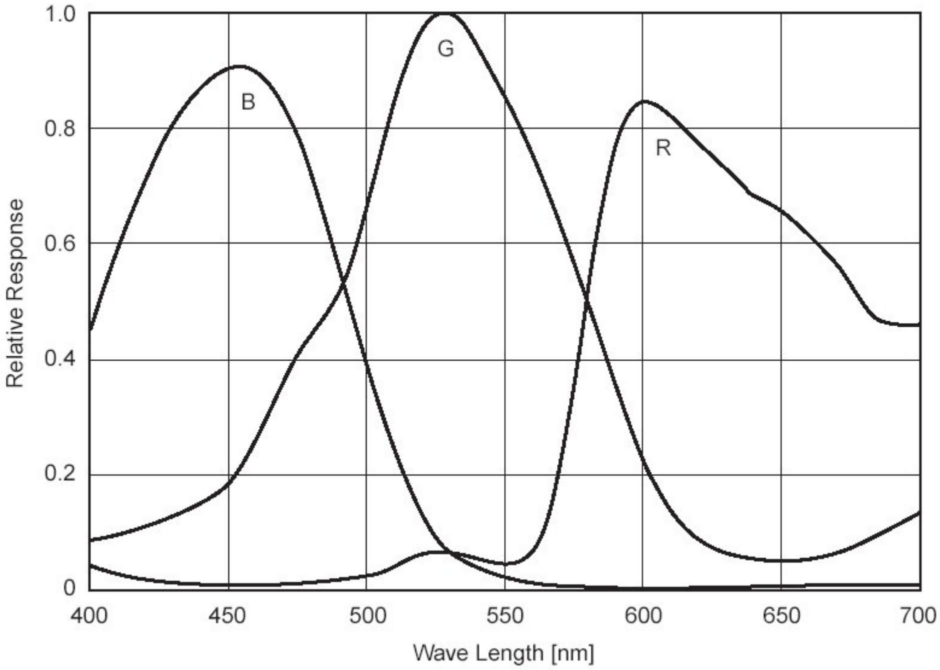


Figure 4: Spectral sensitivity of OF-810C without cut filter and optics.

5 Quick start

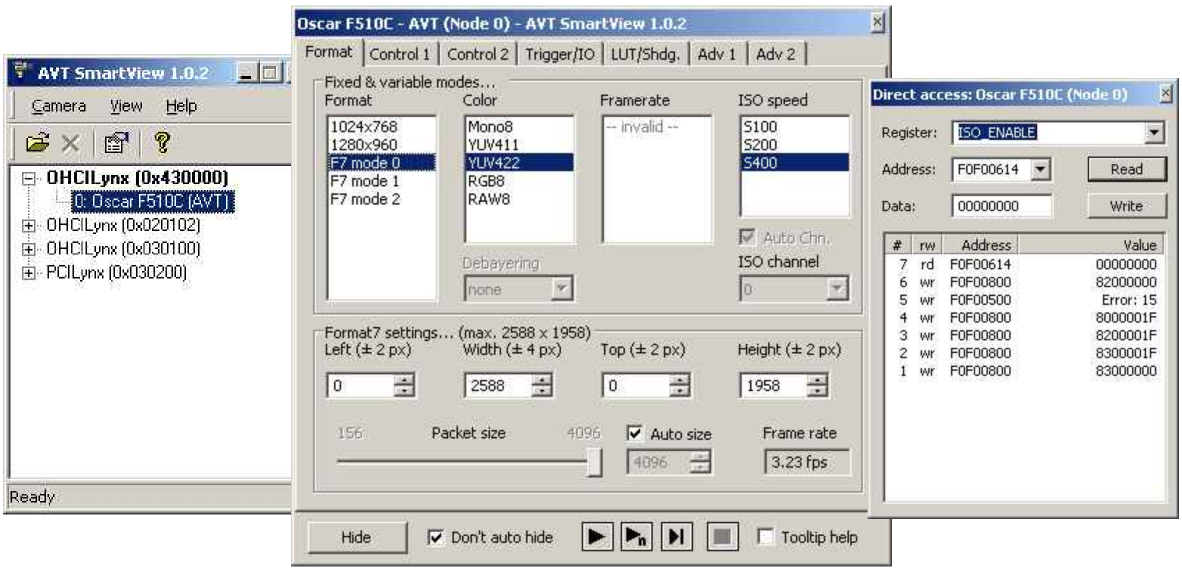
To attach an IEEE-1394 camera to a PC or laptop, the target machine must be equipped with an IEEE-1394 port and have the appropriate driver and software installed. This IEEE-1394 port is already present in many modern PCs and laptops. Should this not be the case, you can upgrade by installing one or more IEEE-1394 ports in the form of a card for the PCI slot, or as a PC card (PCMCIA) for the PC card slot. AVT offers a wide range of adaptors for different requirements.

After starting the operating system, the plug and play mechanism on the PC should recognize the new hardware and prompt you to install the IEEE-1394 driver from Microsoft.
AVT supplies additional TWAIN (VIA) drivers and WDM stream software to integrate the images into third party software using these interfaces.
Alternatively the FirePackage API SDK can be used. This replaces the MS-IEEE-1394 driver with the driver developed by Intek.

A more detailed description of these installation routines can be found in the “FirePackage” software manuals.

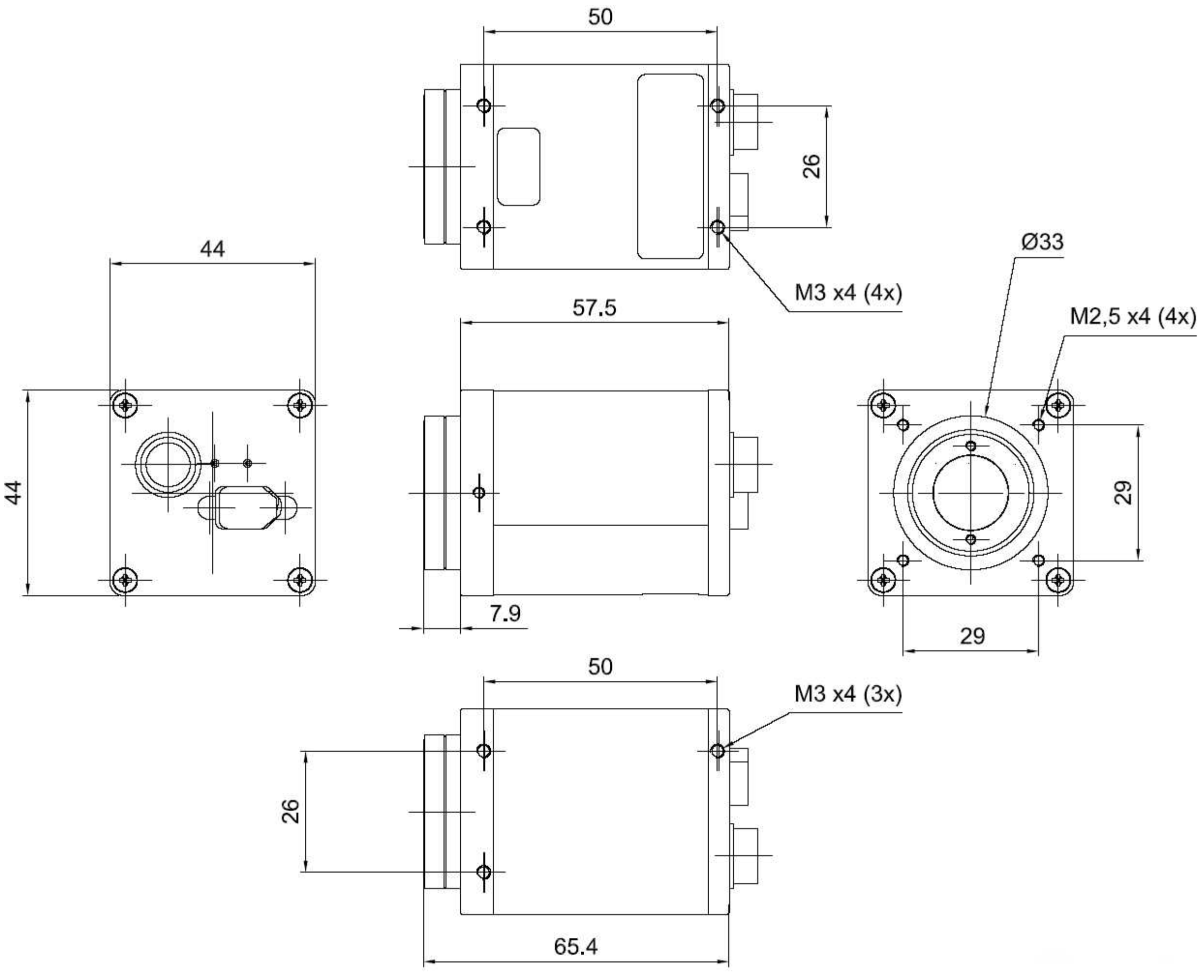
The latter driver works in conjunction with the “SmartView” program. This viewer enables not only quick and easy access to all integrated IEEE-1394 ports and connected IEEE-1394 cameras, but also supports almost all smart features of the AVT Oscar family of cameras.
After selecting a card and a camera, an image of this camera will immediately displayed.

In the *Edit settings* dialog box you can adjust the settings for the standard registers according to the IIDC specification, e.g. exposure time or gain.
Direct access to the register level, e.g. to activate the advanced features of the camera is carried out via the *Direct access* dialog box.
We refer to a separate description of this viewer and its capabilities.



6 Camera dimensions

6.1 Oscar standard housing



Body size: 58 mm x 44 mm x 44 mm (l x w x h)
Weight: 170 g (without lens and tripod)

Figure 6: Oscar standard camera dimensions

6.2 Oscar W90

This version has the sensor tilted by 90 degrees clockwise, so that it views upwards. Please note that an additional specification is required for the rotation of the sensor.

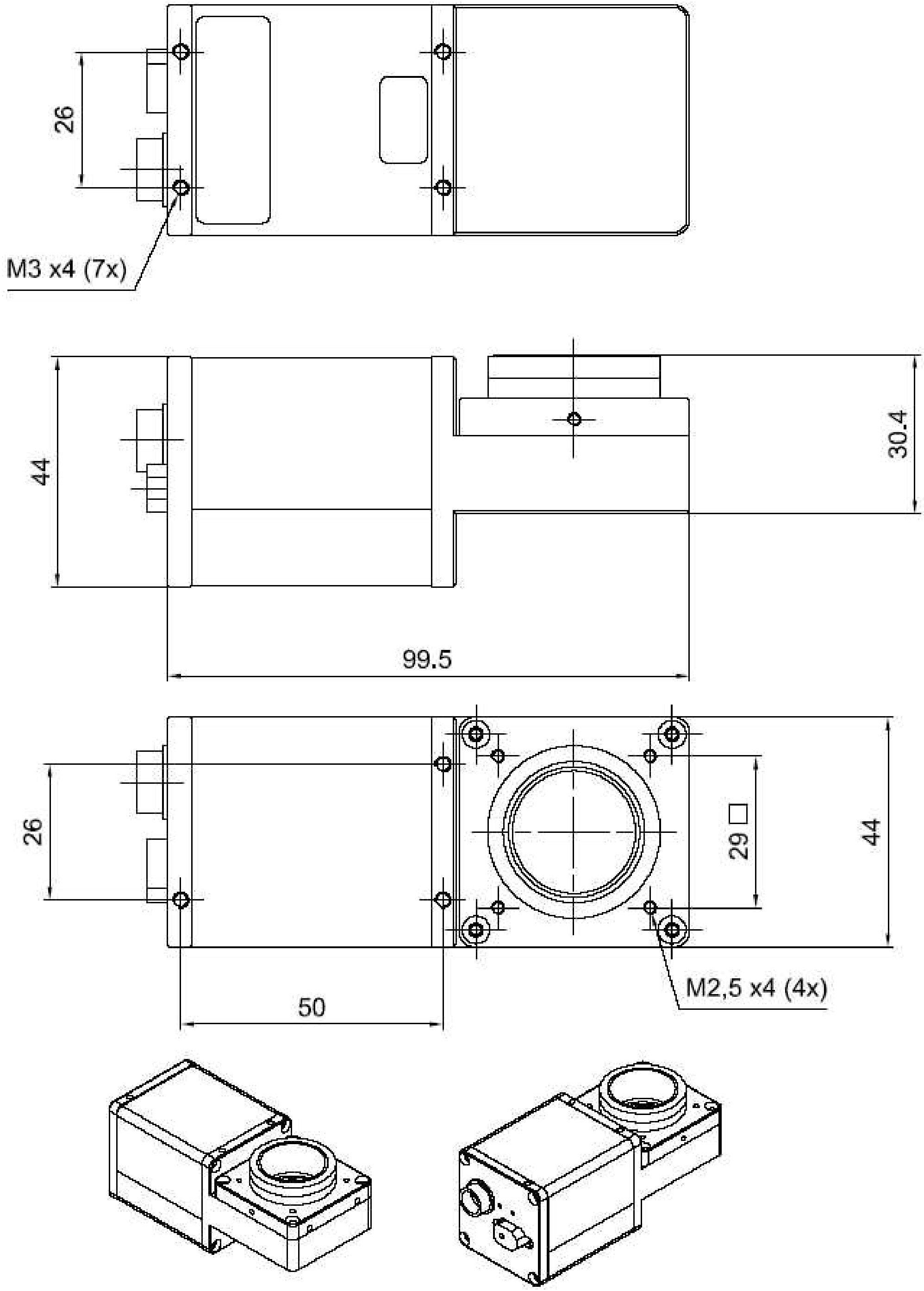


Figure 7: Oscar W90

6.3 Oscar W270

This version has the sensor tilted by 270 degrees clockwise, so that it views downwards. Please note that an additional specification is required for the rotation of the sensor.

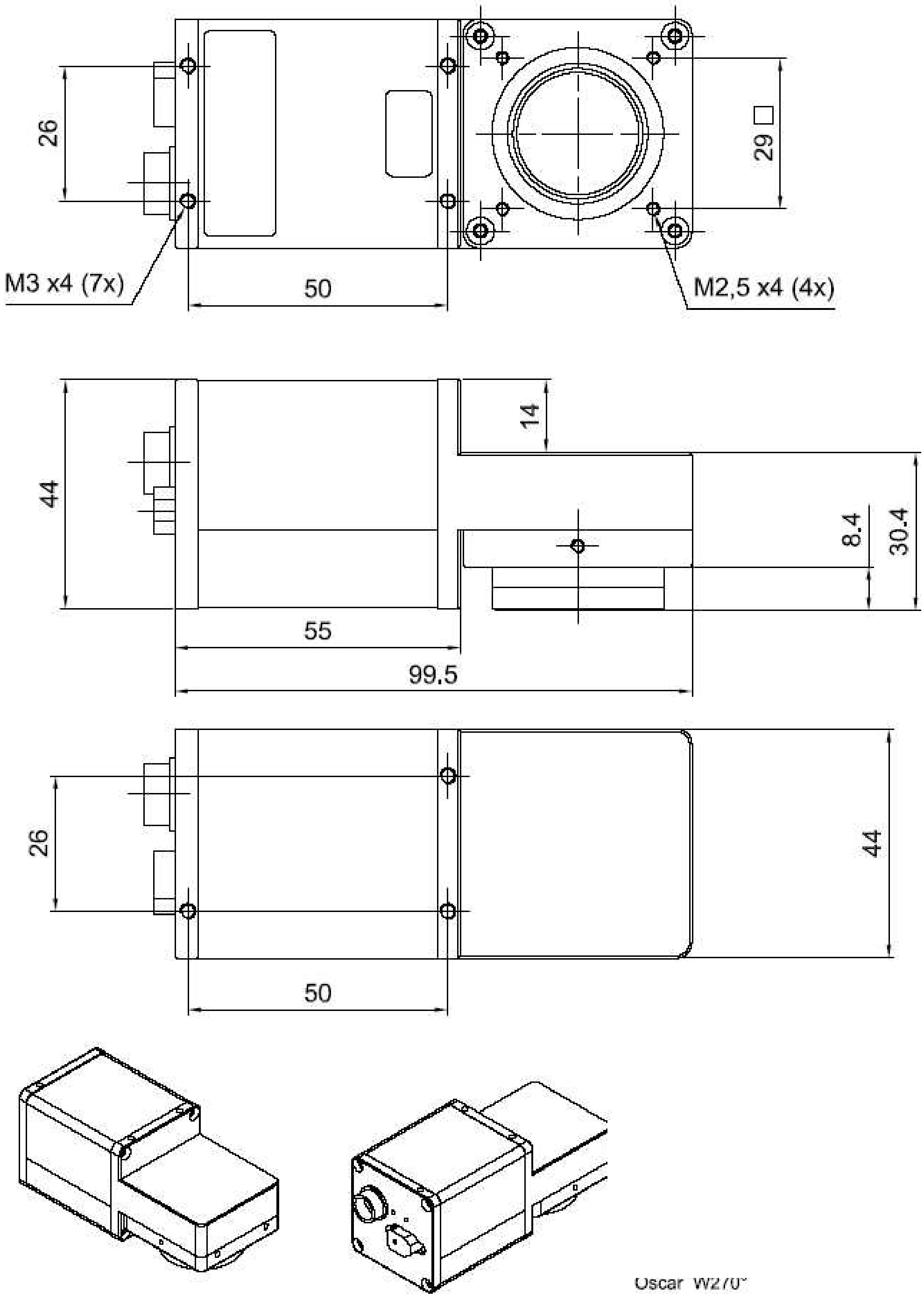


Figure 8: Oscar W270

6.4 Tripod adapter

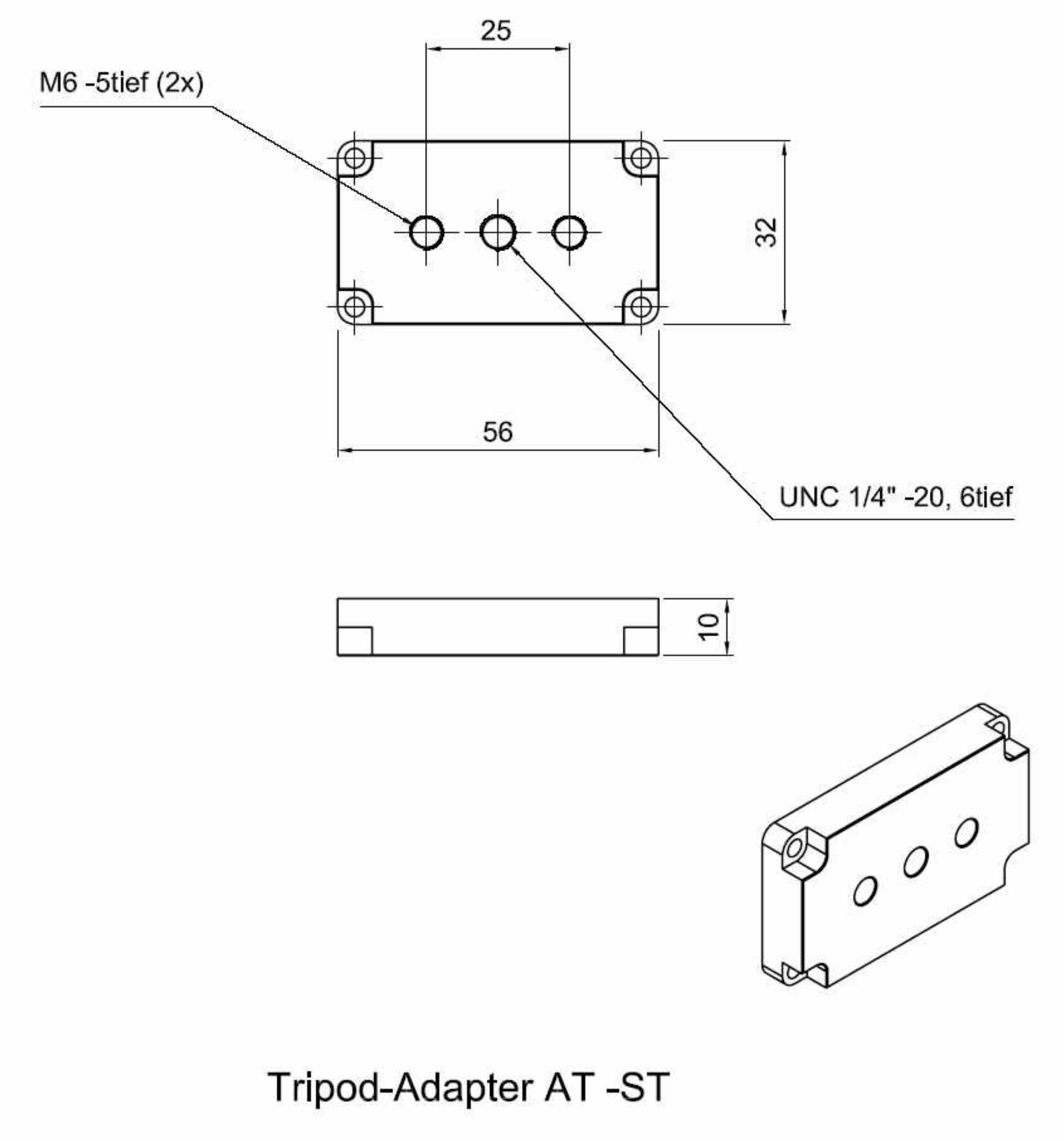


Figure 9: Tripod dimensions

6.5 Adjustment of C-mount

Oscar cameras allow the precise adjustment of the back focus of the C-mount by means of a **back focus ring** which is threaded into the C-mount and held by **two** screws on either side of the camera. The mechanical adjustment of the imaging device is important in order to achieve a perfect alignment with the focal point of the lens.

This adjustment is made before leaving the factory to conform to the standard of 17.526 mm and should normally not require adjustment in the field.

However, if the back focal plane of your lens does not conform to the C-mount back-focus specification or if you have e.g. removed the IR-cut-filter, renewed adjustment may be required in the field.

Figure 10: Back focus adjustment

How to proceed:
Loosen screws (location as shown above by arrow) with an Allen key (1.3 x 50; Order#: K 9020411)
With the lens set to infinity or a known focus distance, set the camera to view an object located at 'infinity' or the known distance.
Rotate the C-mount ring and lens forward or backwards on its thread until the object is in sharp focus. Be careful that the lens remains seated in the C-mount.

Once focus is achieved, tighten the two locking screws without applying excessive torque.

7 Camera interfaces

In addition to the two status LED's, there are two jacks located at the rear of the camera. The 12-pin HiRose plug provides different control inputs and output lines. The IEEE-1394 connector with lock mechanism provides access to the IEEE-1394 bus and therefore makes it possible to control the camera and output frames.

Figure 11: Rear view of camera

7.1 IEEE-1394 port pin assignment

The IEEE-1394 plug is designed for industrial use and has the following pin assignment as per specification:

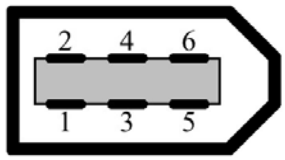


Figure 12: IEEE-1394 connector

Pin	Signal	Pin	Signal
1	Cable power	4	TPB+
2	Cable GND	5	TPA-
3	TPB-	6	TPA+

Table 5: IEEE-1394 pin assignment

7.2 HiRose jack pin assignment

The HiRose plug is also designed for industrial use. In addition to providing access to the inputs and outputs on the camera, it also provides a serial interface for the firmware update. The following diagram shows the pinning as viewed in pin direction.
AVT supplies suitable shielded I/O cables at different lengths (up to 10m) upon request.

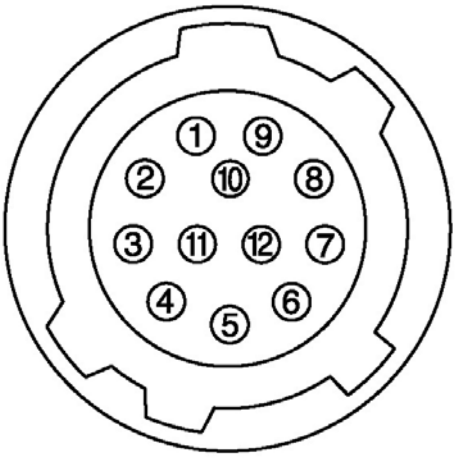


Figure 13: HiRose connector pin assignment

Pin	Signal	Use	Pin	Signal	Use
1	External GND	GND for RS232 only	7	GPInput GND	Common GND for inputs
2	Power IN	8-36V	8	RS232 RxD	
3			9	RS232 TxD	
4	GPInput 1 (default trigger)	TTL, Edge, progr.	10	OutVCC	Common VCC for outputs
5			11	GPInput 2	TTL
6	GP Output 1 (default IntEna)	Open emitter	12	GPOutput 2	Open emitter

Table 6: HiRose pinning

ⓘ Pin 1 is internally NOT bridged with pin 7 to avoid both ground noise being induced into the camera, and prevent ground loops. Use pin 1 only when you want to connect to the serial interface of the camera in combination with pin 8 and 9.

7.3 Status LEDs

On LED

The green power LED indicates that the camera is being supplied with sufficient voltage and is ready for operation.

Status LED (yellow)

The following states are displayed via the LED:

Com	asynchronous and isochronous data transmission active (indicated asynchronously to transmission over the 1394 bus)
Trg	LED off – waiting for external trigger LED on – receiving external trigger

Table 7: LED indication

Blink codes are used to signal warnings or error states:

Class S1 / Error code S2	Warning 1 blink	DCAM 2 blinks	MISC 3 blinks	FPGA 4 blinks	Stack 5 blinks
FPGA Boot error				1-5 blinks	
Stack setup					1 blink
Stack start					2 blinks
No FLASH object			1 blink		
No DCAM object		1 blink			
Register mapping		2 blinks			
VMode_ERROR_STATUS	1 blink				
FORMAT_7_ERROR_1	2 blinks				
FORMAT_7_ERROR_2	3 blinks				

Table 8: Error Codes

The longer OFF-time of 3.5 sec signals the beginning of a new class period. The error codes follow after a shorter OFF-time of 1.5 sec.

Example: 3.5 sec → one blink → 1.5 sec → 2 blinks

indicates a warning: Format_7_Error_1

7.4 Operating the camera:

Power for the camera and the bus is supplied via the HiRose connector or the FireWire™ bus. The input voltage must be within the following range:

Vcc min.: +8 V
Vcc max.: +36 V

ⓘ An input voltage of 12 V is recommended for optimum operation of the camera.

ⓘ As mentioned above, the HiRose connector supplies power (max. 1.5A) via a diode to the camera and the bus. This means that there is **no** power out at pin 2 when the camera is powered via the bus. Consult AVT or your dealer if you need power output at this pin instead of power in.

7.5 Control and video data signals

The camera has 2 inputs and 2 outputs. These can be configured by software. The different modes are described below.

7.5.1 Inputs

All inputs have been implemented as shown on the diagram below.

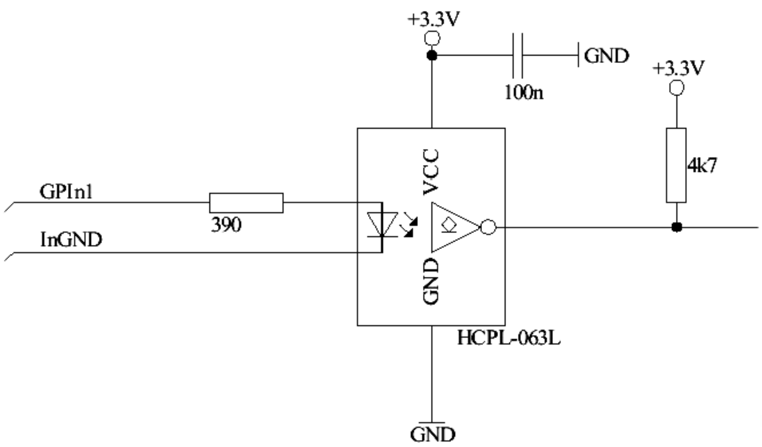


Figure 14: Input schematics

Flux voltage from LED type 1.5 V at 10 mA		Cycle delay of the optical coupler	
min. on-current:	5 mA		
max. off-current:	0.25 mA		
max. input current:	15 mA		
min. pulse width	2.2 µs (hardware) 100 µs (software)	tpdHL: tpdLH:	2275 ns 2290 ns

Table 9: Input characteristics

The inputs can be connected directly to +5 V. If a higher voltage is used, an external resistor must be placed in series. Use @+12 V a 820 Ω and @+24 V a 2.2 kΩ resistor.

Voltages above +45 V may damage the optical coupler

The optical coupler inverts all input signals. Polarity is controlled via the IO_INP_CTRL1..2 register.

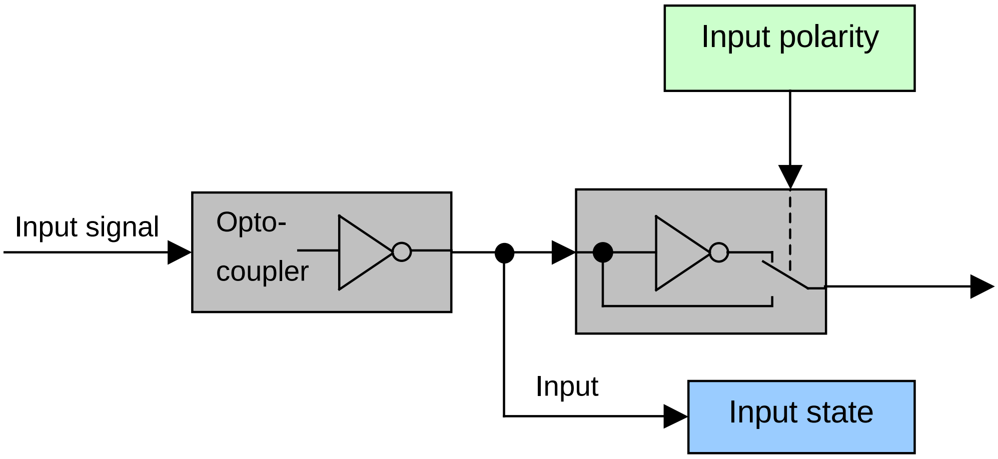


Figure 15: Input block diagram

7.5.1.1 Triggers

All inputs configured as triggers are linked by logical AND function. If several inputs are being used as triggers, a high signal must be present on all inputs in order to generate a trigger signal. The polarity for each signal can be set separately via the inverting inputs. The camera must be set to "external triggering" to trigger image capture by the trigger signal.
All input and output signals running over the HiRose plug are controlled by an advanced feature register.

Register	Name	Field	Bit	Description
0xF1000300	IO_INP_CTRL1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..6]	
		Polarity	[7]	0: low active, 1: high active
		---	[8..10]	
		InputMode	[11..15]	Mode
		---	[16..30]	
		PinState	[31]	RD: Current state of pin
0xF1000304	IO_INP_CTRL2	Same as IO_INP_CTRL1		

Table 10: Input configuration register

IO_INP_CTRL 1-2

The *Polarity* flag determines whether the input is low active (0) or high active (1). The *input mode* can be seen in the following table. The *PinState* flag is used to query the current status of the input.
For inputs, the *PinState* bit refers to the inverted output side of the optical coupler. This signals that an open input sets the *PinState* bit to “1”.

ID	Mode	Default
0x00	Off	
0x01	reserved	
0x02	Trigger input	Input 1
0x03	reserved	
0x04	reserved	
0x05	tbd (SPI external DCLK)	
0x06..0x0F	reserved	
0x10..0x1F	reserved	

Table 11: Input routing

7.5.1.2 Trigger delay

Oscar cameras provides various ways to delay image capture based on an external trigger.
With 1V31 of IIDC spec. there is a standard CSR at Register F0F00534/834h to control a delay up to FFFh * timebase value. The following table explains the Inquiry register and the meaning of the various bits.

Register	Name	Field	Bit	Description
0xF0F00534	TRIGGER_DELAY_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		-	[2]	Reserved
		One_Push_Inq	[3]	One Push auto mode (Controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto Mode (Controlled automatically by the camera)
		Manual_Inq	[7]	Manual Mode (Controlled by user)
		Min_Value	[8..19]	Min. value for this feature
		Max_Value	[20..31]	Max. value for this feature

Table 12: Trigger_Delay_Inquiry register

Register	Name	Field	Bit	Description
0xF0F00834	TRIGGER_DELAY	Presence_Inq	[0]	Presence of this feature: 0:N/A; 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..5]	Reserved
		ON_OFF	[6]	Write ON or OFF this feature, ON=1 Read: Status of the feature; OFF=0
		-	[7..19]	Reserved
		Value	[20..31]	Value

Table 13: Trigger Delay CSR

In addition, the cameras have an advanced register which allows to even more precisely delay the image capture after receiving a hardware trigger.

Trigger delay advanced register

Register	Name	Field	Bit	Description
0xF1000400	TRIGGER_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	-
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	-
		DelayTime	[11..31]	Delay time in µs

Table 14: Trigger Delay Advanced CSR

The advanced register allows adjustment to delay the start of the integration by max. 2^{21} µs, which is max. 2.1s after a trigger edge was detected.

ⓘ Switching trigger delay to ON also switches external Trigger_Mode_0 to ON.

ⓘ This feature works with external Trigger_Mode_0 only.

7.5.2 Outputs

The camera has 2 non-inverting outputs with open emitters. These are shown in the following diagram:

Max. emitter current 500 mA
Max. collector emitter voltage 45 V

ⓘ Voltage above +45 V may damage the optical coupler.

ⓘ The output connection is different to the AVT Dolphin series to achieve higher output swing.

ⓘ Depending on the voltage applied at OutVCC and the type of input which you want to drive, it may be necessary to switch an external resistor in series between GPOutl and ground. The use of 1 kΩ@ 5V or 2.4 kΩ@ 12V can be recommended. Typical delay is not more than 40 µs.

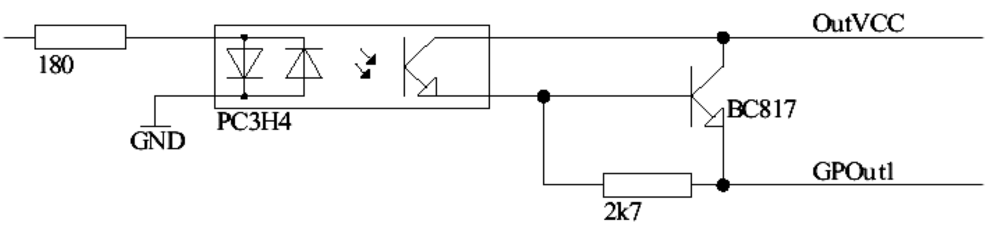


Figure 16: Output schematics

Output features are configured by software. Any signal can be placed on any output.
The main features of output signals are described below:

IntEna (Integration Enable) Signal
This signal displays the time in which exposure was made. By using a register, this output can be delayed by up to 1.05 seconds.
Fval (Frame valid) Signal
This feature signals readout from the sensor. This signal Fval follows IntEna.
Busy Signal
This indicator appears when the exposure is being made; the sensor is being read from, or data transmission is active. The camera is busy.

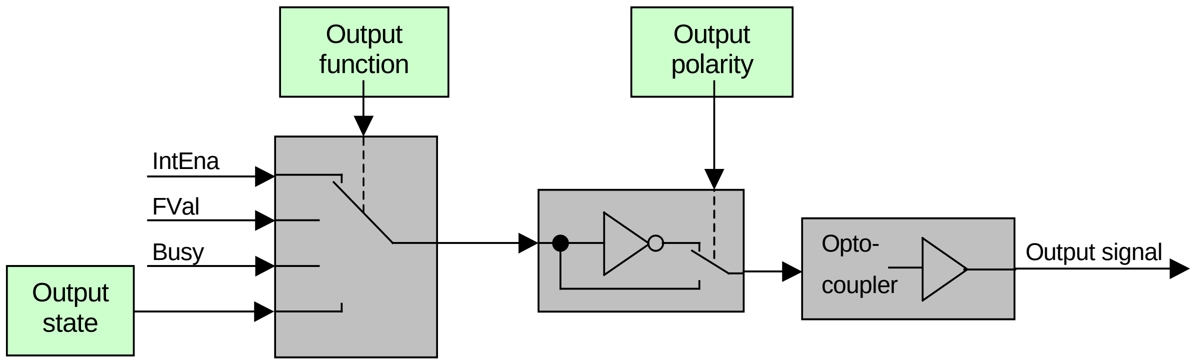


Figure 17: Output block diagram

IO_OUTP_CTRL 1-2

The outputs are controlled via two advanced feature registers.

The *Polarity* flag determines whether the output is active low (0) or active high (1). The *output mode* can be viewed in the table below. The current status of the output can be queried and set via the *PinState* flag.

It is possible to read back the status of an output pin regardless of the output mode. E.g. this allows the host computer to determine if the camera is busy by simply polling the BUSY output.

Register	Name	Field	Bit	Description
0xF1000320	IO_OUTP_CTRL1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..6]	-
		Polarity	[7]	0: active low, 1: active high (inverting)
		---	[8..10]	
		Output mode	[11..15]	Mode
		---	[16..30]	
		PinState	[31]	RD: Current state of pin WR: New state of pin
0xF1000324	IO_OUTP_CTRL2	Same as IO_OUTP_CTRL1		

Table 15: Output configuration register

Output mode

ID	Mode	Default
0x00	Off	
0x01	Output state follows ‘PinState’ bit	
0x02	Integration enable	Output 1
0x04	reserved	
0x05	reserved	
0x06	FrameValid	
0x07	Busy	Output 2
0x08	Follow corresponding input (Inp1 • Out1, Inp2 • Out2, ...)	
0x09..0x0F	reserved	
0x10..0x1F	reserved	

Table 16: Output routing

The “Polarity” setting refers to the input side of the optical coupler output; “PinState 0” switches off the output transistor and produces a low level over the resistor connected from the output to ground.

The following diagram illustrates the dependencies of the various output signals.

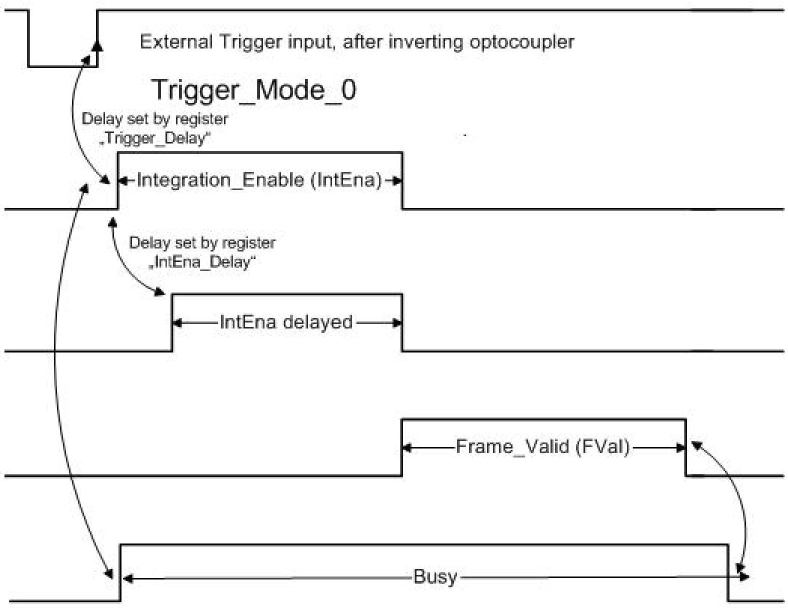


Figure 18: Output Impulse Diagram

- Note that the polarity of the signals can be changed.
- Note that trigger delay actually delays the image capture, whereas the IntEna_Delay only delays the leading edge of the IntEna output signal but does not delay the image capture.
- As mentioned before, it is possible to set the outputs by software. Doing so, the maximum achievable frequency is strongly dependent on individual software capabilities. As a rule of thumb, the camera itself will limit the toggle frequency to not exceed 700 Hz.
- In **split-shutter** mode the camera will issue two (three: OF-810C) InEna's and FrameValid's but only one Busy because it integrates the two (OF810C: three) fields separately.

7.6 Pixel data

Pixel data are transmitted as isochronous data packets in accordance with the 1394 interface described in IIDC v. 1.3. The first packet of a frame is identified by the "1" in the sync bit (sy) of the packet header.

<table>
<tr><td>0-7</td><td>8-15</td><td colspan="2">16-23</td><td colspan="2">24-31</td></tr>
<tr><td colspan="2">data_length</td><td>tg</td><td>channel</td><td>tCode</td><td>sy</td></tr>
<tr><td colspan="6">header_CRC</td></tr>
<tr><td colspan="6">Video data payload</td></tr>
<tr><td colspan="6">data_CRC</td></tr>
</table>

Isochronous Data Block Packet Format

Table 17: Isochronous data block packet format: Source: IIDC v. 1.3 specification

The video data for each pixel are outputted in either 8 or 12-bit format. Each pixel has a range of 256 or 4096 shades of gray. The digital value 0 is black and 255 or 4095 is white. In 16 bit mode the data output is MSB aligned.

The following table provides a description of the video data format for the different modes. (Source: IIDC v. 1.3 specification)

<YUV (4: 2: 2) format >

U-(K+0)	Y-(K+0)	V-(K+0)	Y-(K+1)
U-(K+2)	Y-(K+2)	V-(K+2)	Y-(K+3)
U-(K+4)	Y-(K+4)	V-(K+4)	Y-(K+5)
U-(K+Pn-6)	Y-(K+Pn-6)	V-(K+Pn-6)	Y-(K+Pn-5)
U-(K+Pn-4)	Y-(K+Pn-4)	V-(K+Pn-4)	Y-(K+Pn-3)
U-(K+Pn-2)	Y-(K+Pn-2)	V-(K+Pn-2)	Y-(K+Pn-1)

<YUV (4: 1: 1) format >

U-(K+0)	Y-(K+0)	Y-(K+1)	V-(K+0)
Y-(K+2)	Y-(K+3)	U-(K+4)	Y-(K+4)
Y-(K+5)	V-(K+4)	Y-(K+6)	Y-(K+7)
U-(K+Pn-8)	Y-(K+Pn-8)	Y-(K+Pn-7)	V-(K+Pn-8)
Y-(K+Pn-6)	Y-(K+Pn-5)	U-(K+Pn-4)	Y-(K+Pn-4)
Y-(K+Pn-3)	V-(K+Pn-4)	Y-(K+Pn-2)	Y-(K+Pn-1)

Table 18: YUV 4:2:2 and YUV 4:1:1 format: Source: IIDC v. 1.3 specification

<Y (Mono) format >

Y-(K+0)	Y-(K+1)	Y-(K+2)	Y-(K+3)
Y-(K+4)	Y-(K+5)	Y-(K+6)	Y-(K+7)
Y-(K+Pn-8)	Y-(K+Pn-7)	Y-(K+Pn-6)	Y-(K+Pn-5)
Y-(K+Pn-4)	Y-(K+Pn-3)	Y-(K+Pn-2)	Y-(K+Pn-1)

< Y (Mono16) format >

High byte	Low byte

Y-(K+0)	Y-(K+1)
Y-(K+2)	Y-(K+3)
Y-(K+Pn-4)	Y-(K+Pn-3)
Y-(K+Pn-2)	Y-(K+Pn-1)

Table 19: Y8 and Y16 format: Source: IIDC v. 1.3 specification

<Y, R, G, B>

Each component has 8bit data. The data type is "Unsigned Char".

	Signal level (Decimal)	Data (Hexadecimal)
Highest	255	0xFF
	254	0xFE
	:	:
	1	0x01
Lowest	0	0x00

<U, V>

Each component has 8bit data. The data type is "Straight Binary".

	Signal level (Decimal)	Data (Hexadecimal)
Highest (+)	127	0xFF
	126	0xFE
	:	:
	1	0x81
Lowest	0	0x80
	-1	0x7F
	:	:
	-127	0x01
Highest (-)	-128	0x00

< Y(Mono16) >

Y component has 16bit data. The data type is "Unsigned Short (big-endian)".

Y	Signal level (Decimal)	Data (Hexadecimal)
Highest	65535	0xFFFF
	65534	0xFFFE
	:	:
	1	0x0001
Lowest	0	0x0000

Table 20: Data structure: Source: IIDC v. 1.3 specification

8 Description of the data path

8.1 Block diagrams of the cameras

The following diagram illustrates the data flow and bit resolution of image data after being read from the CCD sensor chip in the camera. The individual blocks are described in more detail in the following paragraphs.

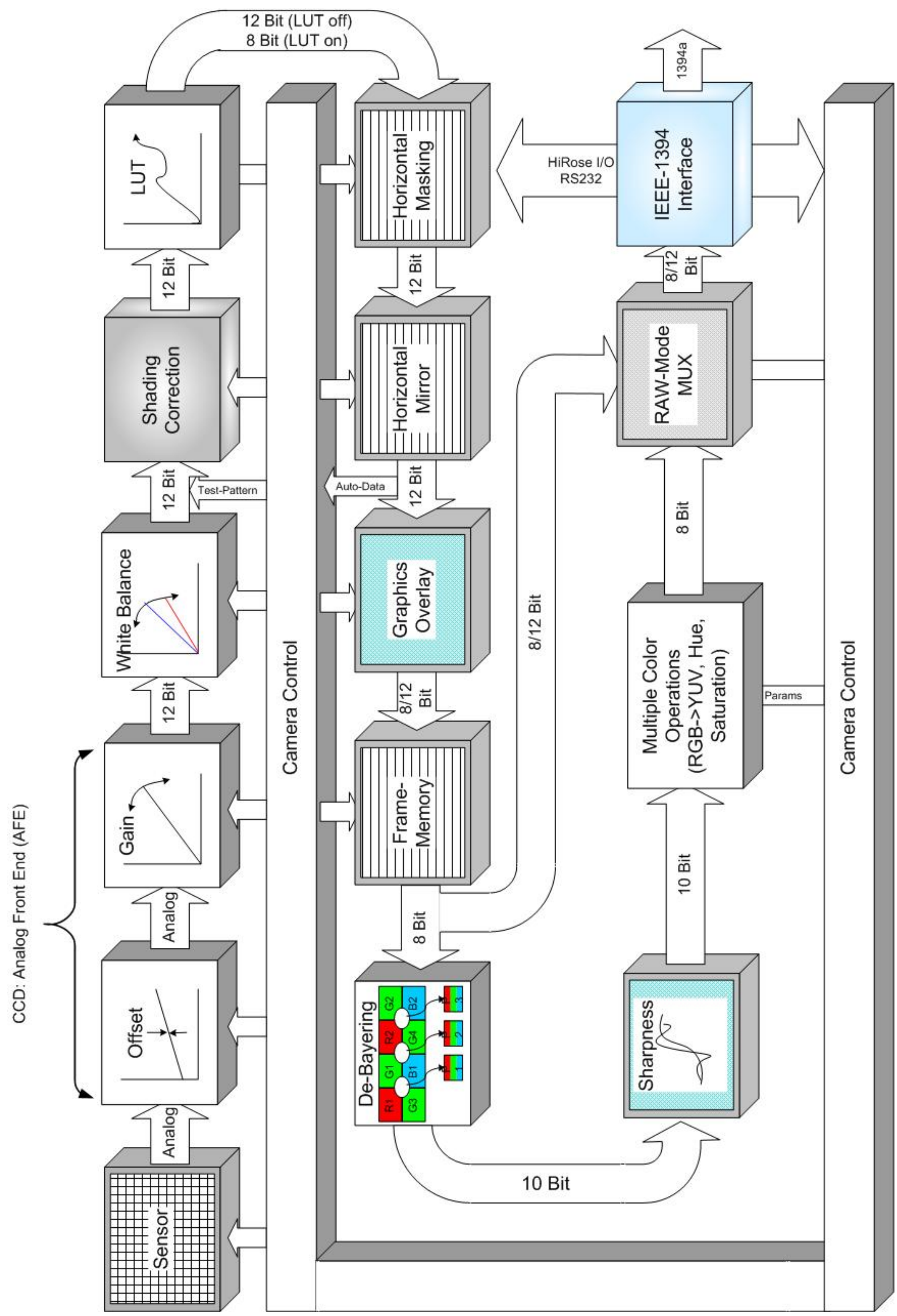


Figure 19: Block diagram Oscar camera

8.2 Sensor

The Oscar family is equipped with various sensor types and resolutions. Please note that the cameras are always equipped with **color** sensors.

The following table provides an overview of the most important sensor data:

Model	Techn.	Manu-facturer	Sensor Type	Sensor Size	Micro-lens	Chip Size [mm]	Pixel Size [µm]	Eff. Pixels H X V
OF-320C	CCD	SONY	ICX-262AQ	1/1.8"	yes	8.10(H)x6.64(V)	3.45 x 3.45	2088 x 1550
OF-510C	CCD	SONY	ICX-282AQ	2/3"	yes	9.74(H)x7.96(V)	3.4 x 3.4	2588 x 1960
OF-810C	CCD	SONY	ICX-456AQ	2/3"	yes	9.79(H)x7.93(V)	2.7 x 2.7	3288 x 2472

Table 21: Sensor data

Various **black and white** output interpolation modes have been implemented in the data path to ensure high quality black and white image output.

The cameras are able to output:

- b/w signal out of luminance interpolation formula (Y = 0.3R + 0.6G + 0.1B)
- b/w signal out of RED channel information
- b/w signal out of GREEN channel information
- b/w signal out of BLUE channel information

For certain applications where the camera is imposed to monochromatic light, it may be advantageous (in terms of reduced noise) to use only the respective color channel instead of the fully interpolated luminance signal.
Example: If you illuminate a scene with green light, the use of b/w output from the GREEN channel may give better image with less noise than b/w out of luminance.

The b/w image is also spatially interpolated, so that it has the same amount of pixels as the color image.

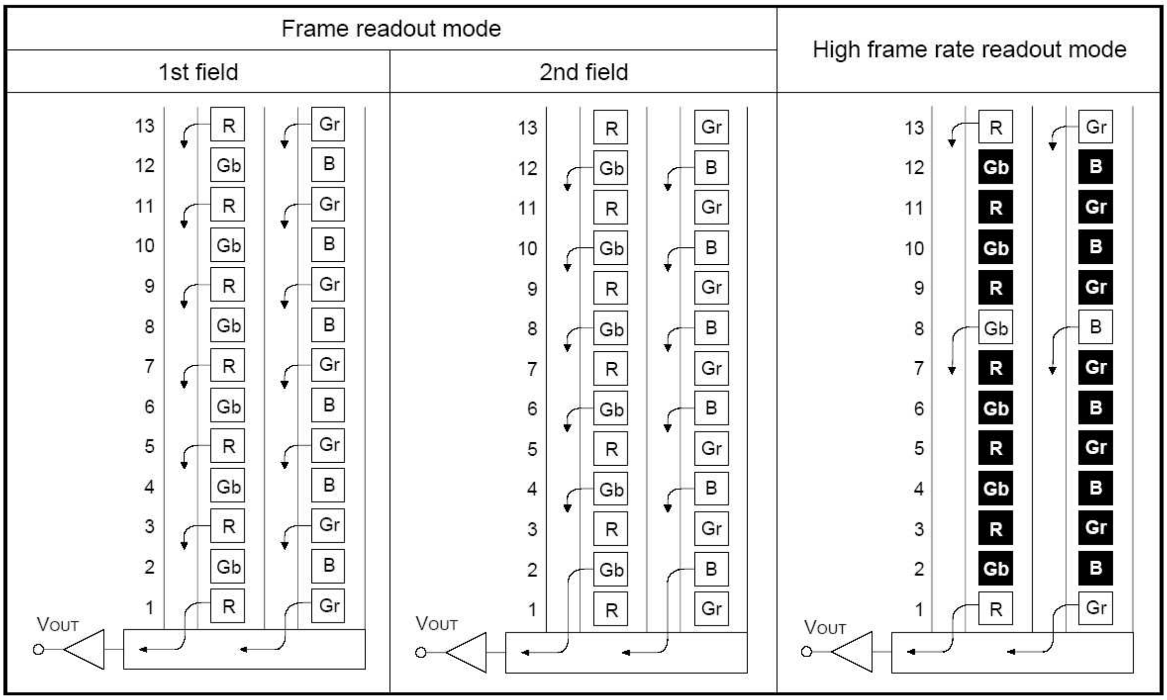
ⓘ Spatial resolution is because of the present BAYER Mosaic filter nevertheless only half of that in each direction of a (fictive) b/w sensor!

8.2.1 Read out concepts of the sensor

In order to achieve the highest possible sensitivity, all sensors are equipped with micro lenses, and read-out in the so called **frame readout mode**. This is a special frame integration interlaced field readout mode, very similar to the interlaced mode of conventional video cameras.
Whereas OF-320C and OF-510C have two field readouts, the OF-810C is equipped with a three field readout sensor.
The conversion from interlaced to progressive takes place in the camera's internal memory.

Special sub-sampling modes allow faster progressive scan readouts, while maintaining the same imaging conditions. These modes can be effectively used for focus and aperture adjustment operations.
The following samples are taken out of the data sheets of the sensors, detailing the various modes.

The screenshot below, taken from the **OF-320C** sensor's data sheet, shows the ICX-262AQ readout scheme.
Frame readout mode reads out red and green color pixels in the first field, followed by the green and blue pixels in the second field.
Please note that the high frame readout mode reads out 2 from 12 lines and thus achieves a remarkably high frame rate of nearly 40 fr/s.



Note) Blacked out portions in the diagram indicate pixels which are not read out.

1. Frame readout mode
   In this mode, all pixel signals are divided into two fields and output.
   All pixel signals are read out independently, making this mode suitable for high resolution image capturing.

2. High frame rate readout mode
   Output is performed at 30 frames per second by reading out 2 pixels for every 12 vertical pixels.
   The number of output lines is 258 lines.
   This readout mode emphasizes processing speed over vertical resolution.

Figure 20: Readout schemes of ICX-262AQ

OF-510C is equipped with the ICX-282AQ sensor.
Frame readout is again two fields and has the two primary colors, red and blue, read out in separate fields.
Progressive mode reads out two from four lines achieving a moderate speed increase but progressive scan with mega-pixel resolution.
The readout scheme of it is shown below:

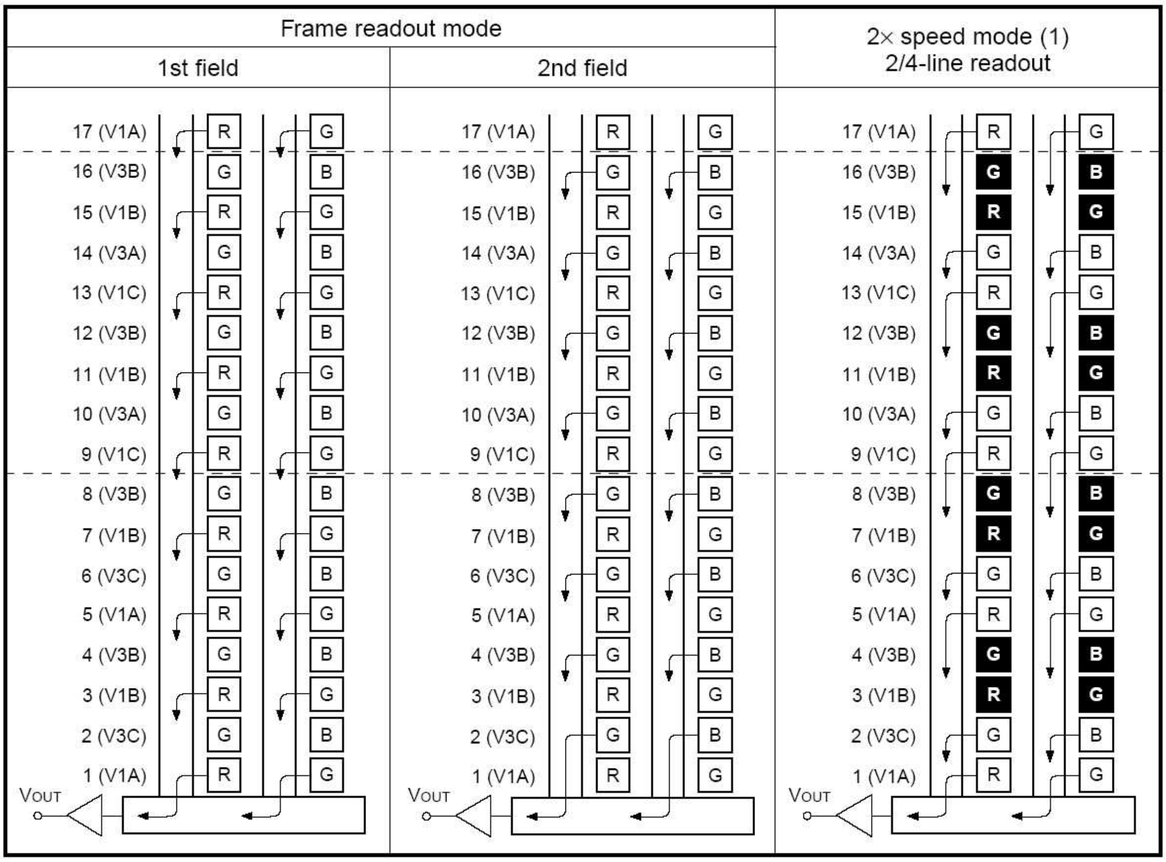


Figure 21: readout scheme of ICX-282AQ

OF-810C uses the ICX-456AQ sensor with three field readout mode. Every field skips two lines during read out, so all primary colors of the BAYER mosaic are read out in every field. Progressive scan mode reads out 2 out of 6 lines.

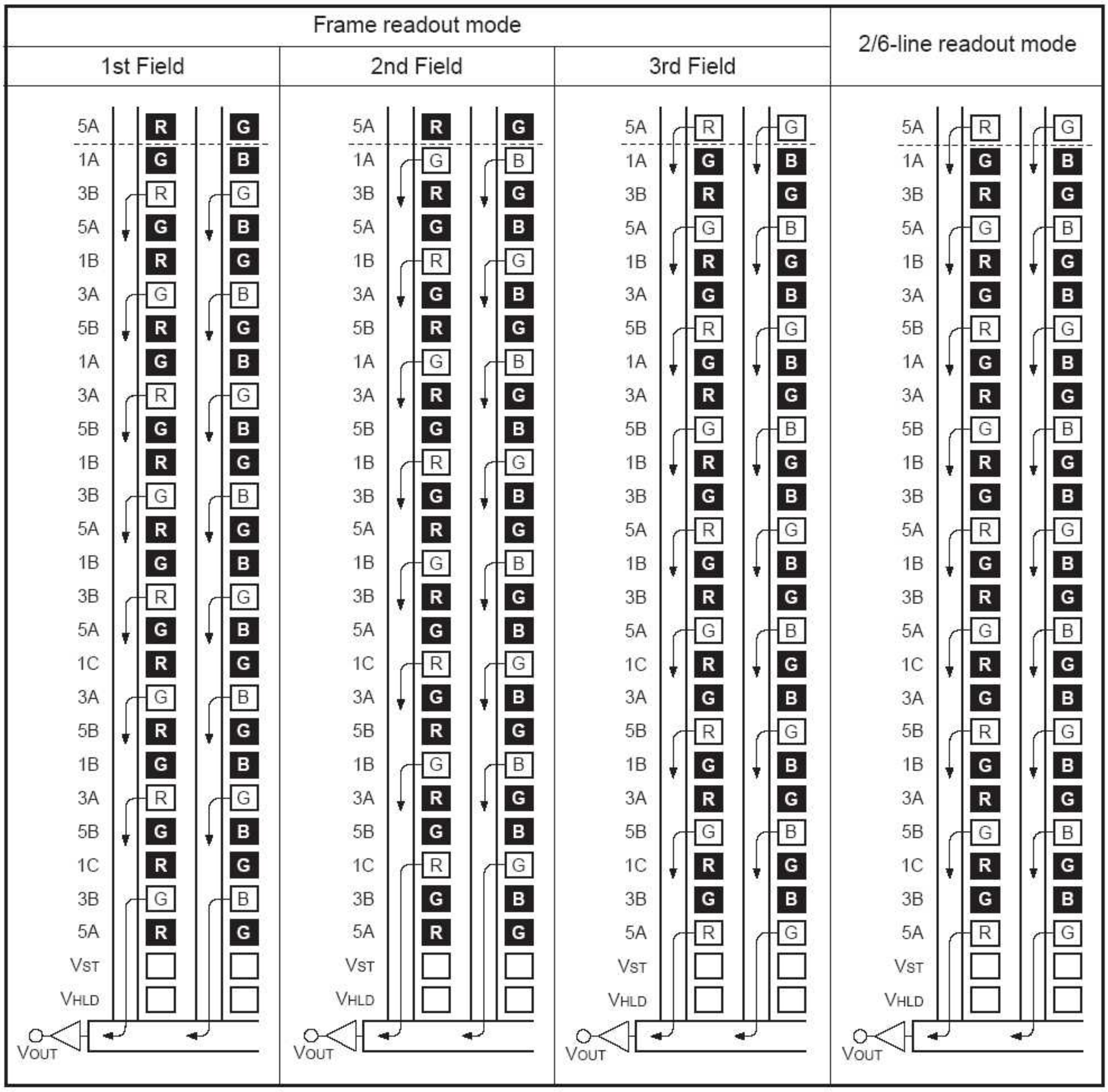


Figure 22: ICX-456 readout scheme

Frame readout has implications when shooting moving or stationary objects.

To compensate for this condition, two different shutter modes have been introduced.
The so called **split-shutter** opens and closes the shutter per field. This mode is suitable for shooting stationary objects only.

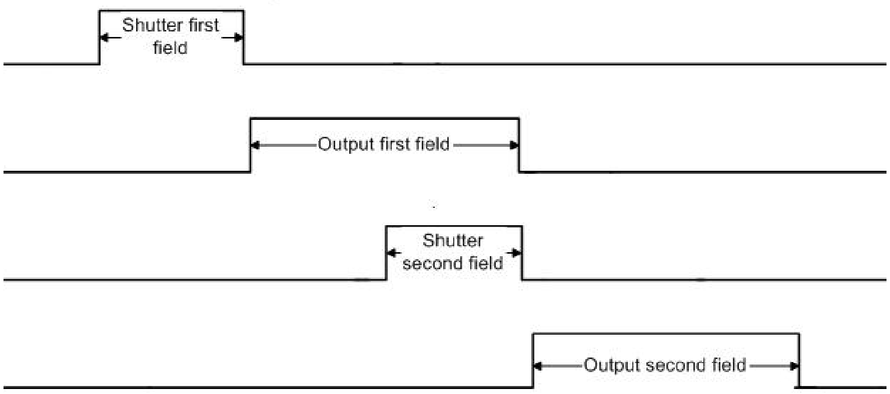


Figure 23: Split shutter

ⓘ Using this mode with moving objects introduces red/blue artefacts with the OF-320C and OF-510C, and jagged artefacts in the case of the OF-810C.

Split-shutter can be used with continuous light or strobe light because the camera outputs the IntEna signal accurately per field (this means that in the case of an OF-810C, a strobe would flash **three** times per image).

The so called **joint-shutter** opens the shutter for both fields concurrently. When the first field is shifted into the shift register its integration ends, but the integration of the second (or third) field continues until the previous field(s) has(ve) been completely shifted out.
Consequently the shutter time can only be controlled for the first field; the other field(s) always have an additional shutter time equivalent to the readout time of the first field.

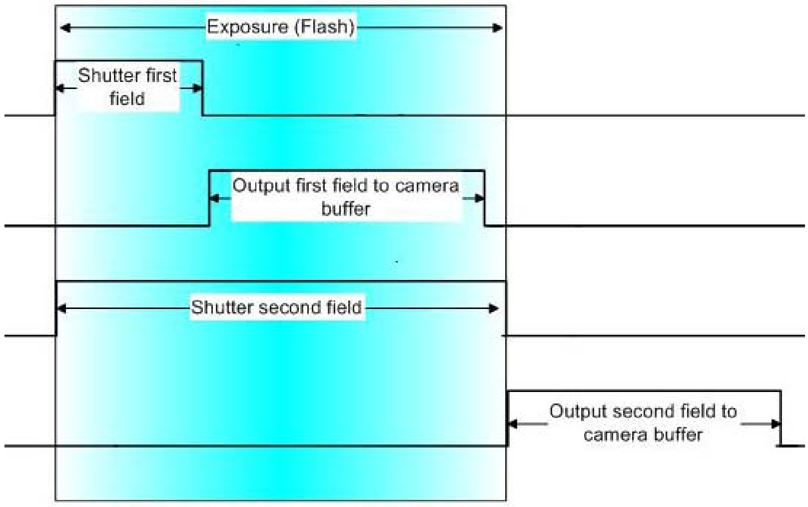


Figure 24: Joint shutter

The following pre-requisites are necessary to handle moving image acquisition in joint shutter mode:

- Strobe light and
- Ambient light reduced by proper light shields or
- Mechanical external shutter
- LCD-optical shutter

ⓘ Consult the factory or your local dealer if you have special applications requiring external shutters.

8.3 White balance

The color cameras have both manual and automatic white balance. White balance is applied so that non-colored image parts are displayed non-colored. White balance does **not** use the so called PxGA® (Pixel Gain Amplifier) of the analog front end (AFE), but a digital representation in the FPGA in order to modify the gain of the two channels with lower output by +9.5dB (in 512 steps) relative to the channel with highest output.
The following screenshot is taken from the datasheet of the AFE and illustrates the details:
The analog color signal coming in pulse amplitude modulation from the sensor is in the form of the BAYER™ color pattern sequence. It is initially processed in the CDS (correlated double sampler) and then bypasses the PxGA before further amplification and digitization.

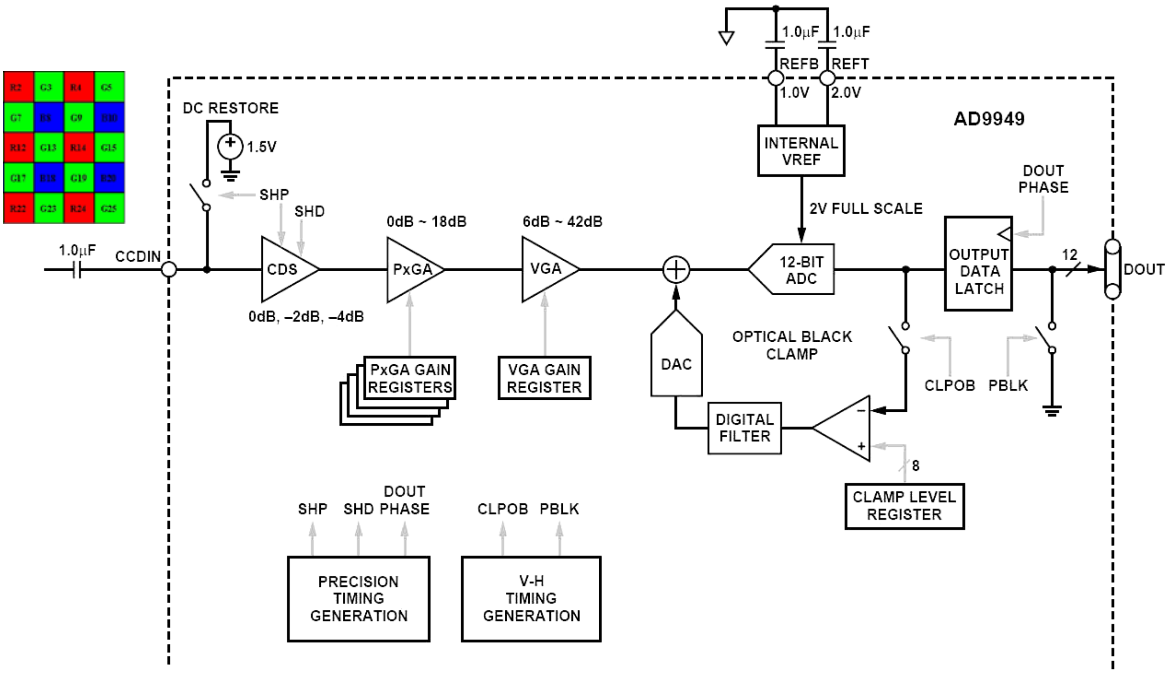


Figure 25: Block diagram of AFE (Source: Analog Devices)

From the user's point of view, the white balance settings are made in register 80Ch of IIDC v. 1.3. This register is described in more detail on the next page.

Register	Name	Field	Bit	Description
0xF0F0080C	WHITE_BALANCE	Presence_Inq	[0]	Presence of this feature: 0: N/A; 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..4]	Reserved
		One_Push	[5]	Write: Set Bit high to start Read: Status of the feature: Bit high: WIP, Bit low: Ready
		ON_OFF	[6]	Write ON or OFF this feature, ON=1 Read: Status of the feature; OFF=0
		A_M_MODE	[7]	Set bit high for Auto feature Read for Mode; 0= MANUAL; 1= AUTO
		U/B_Value	[8..19]	U/B value; Write if not Auto; Read
		V/R_Value	[20..31]	V/R Value

Table 22: White balance register

The values in the *U/B_Value* field produce changes from green to blue; the *V/R_Value* field from green to red as illustrated below.

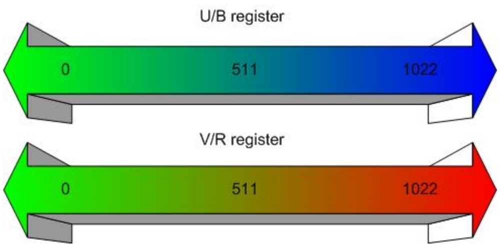


Figure 26: U/V slider range

8.3.1 One Push automatic white balance

This is activated by setting the "One Push" bit in the WHITE_BALANCE register (see WHITE-BALANCE). The camera automatically generates frames based on the current settings of all registers (GAIN, OFFSET, SHUTTER, etc.).
For white balance, a total of nine frames are processed, and a grid of at least 300 samples is equally spread over the work area. This area can be the field of view or a subset of it. The R-G-B component values of the samples are added and used as actual values for both the One Push and automatic white balance.
This feature uses the assumption that the R-G-B component sums of the samples shall be equal; i.e., it assumes that the average of the sampled grid pixels is to be monochrome.

The following ancillary conditions should be observed for successful white balance:

- There are no stringent or special requirements on the image content, it only requires the presence of monochrome pixels in the image.
- Automatic white balance can be started both during active image capture and in idle state.

If the image capture is active (e.g. "IsoEnable" set in register 614h), the frames used by the camera for white balance are also outputted on the 1394 bus. Any previously active image capture is restarted after the completion of white balance.
Automatic white balance can also be enabled by using an external trigger. However, if there is a pause of >10 seconds between capturing individual frames, this process is aborted.
The following flow diagram illustrates the automatic white balance sequence.

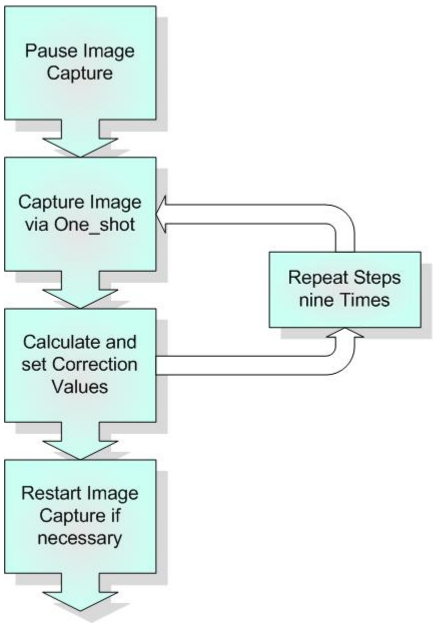


Figure 27: Automatic white balance sequence

Finally, the calculated correction values can be read from the WHITE_BALANCE register 80Ch.

8.3.2 Automatic white balance

There is also an auto white balance feature available which continuously optimizes the color characteristics of the image.
As a reference, it uses a grid of at least 300 samples equally spread over the area of interest or a fraction of it. The position and size of the control area (Auto_Function_AOI) can be set via the following advanced registers.

Register	Name	Field	Bit	Description
0xF1000390	AUTOFNC_AOI	Presence_Inq	[0]	Indicates presence of this feature (read only)
			[1..3]	-
		ShowWorkArea	[4]	Show work area
			[5]	-
		ON_OFF	[6]	Enable/Disable AOI
			[7..31]	-
0xF1000394	AF_AREA_POSITION	Left	[0..15]	work area position
		Top	[16..31]	
0xF1000398	AF_AREA_SIZE	Width	[0..15]	work area size
		Height	[16..31]	

Table 23: Advanced register: AUTOFNC_AOI

AUTOFNC_AOI affects the auto shutter, auto gain and auto white balance features and is independent of the Format7 AOI settings. If this feature is switched off, the work area position and size represent the current active image size.

The possible increment of this work-area position and size is 128 pixels. The camera automatically adjusts the settings to the allowed values (see below for valid values):

`Left, Top`	0, 128, 256, 384, 512, 768, 1024...
`Width, Height`	128, 256, 384, 512, 768, 1024...

Table 24: Legal values for AF_AREA_SIZE

Due to the fact that the active image size might not be dividable by 128 without a remainder, the auto function AOI work-area size might be greater.
This allows for the positioning of the work-area to be at the bottom of the active image.
E.g. if the active image size is 640 x 480 pixels, the camera accepts a maximum of 640 x 512 pixels as the auto function AOI work area (if the control area position is 0:0).

Another case is for outdoor applications: the sky will be excluded from the generation of the reference levels when the auto function AOI is placed at the bottom of the image.

ⓘ If the adjustment fails and the work area size and/or position becomes invalid, this feature is automatically switched off – make sure to read back the `ON_OFF` flag if this feature doesn't work as expected.

Within this area, the R-G-B component values of the samples are added and used as actual values for the feedback.

The following drawing illustrates the AUTOFNC_AOI settings in greater detail.

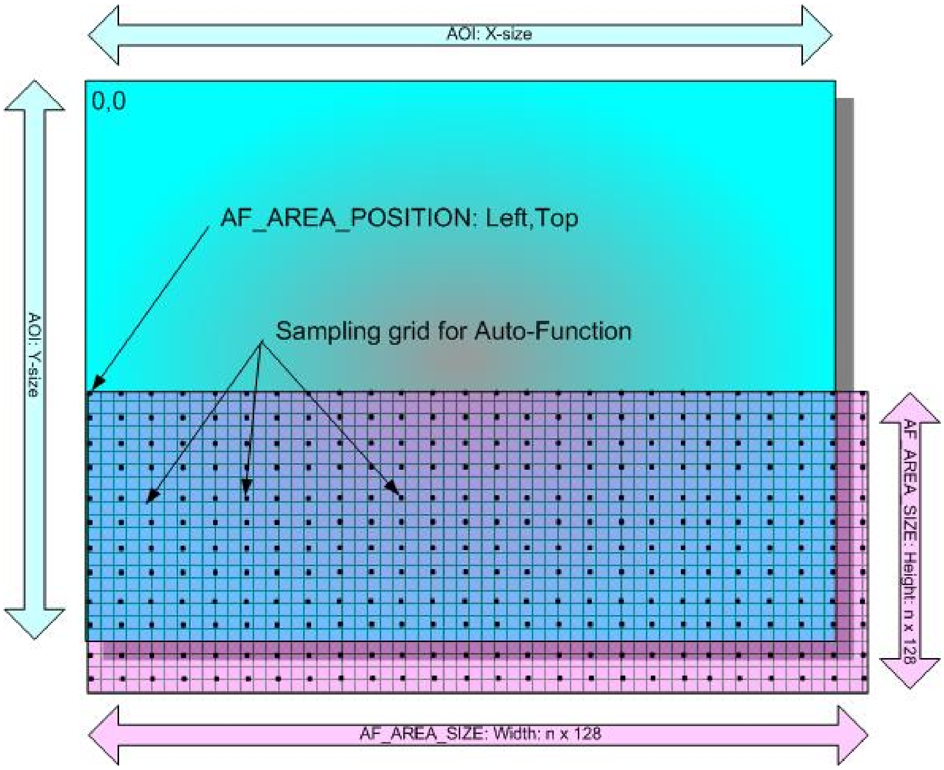


Figure 28: AUTOFNC_AOI positioning

The algorithm is based on the assumption that the R-G-B component sums of the samples shall be equal, i.e., it assumes that the mean of the sampled grid pixels is to be monochrome.

Visualization of the AUTOFNC_AOI is done with the help of the graphics overlay (see: block diagram) function of the camera. This area is highlighted when the *Show work area* bit is set high.

ⓘ Looking on a completely colored area with automatic white balance ON, be aware of the fact that the algorithm will try to turn the image uncolored.

8.4 Manual gain

As shown in figure 25, all cameras are equipped with a gain setting allowing the gain to be "manually" adjusted on the fly by means of a simple command register write.
The following ranges can be used when manually setting the gain for the analog video signal:

Type	Range	Range in dB
All OSCAR-cameras	0 … 570	0 … 20 dB

Table 25: Manual gain range of the various Oscar types

The increment length is ~0.0354 dB/step.

ⓘ Setting the gain does not change the offset (black value).

ⓘ A higher gain also produces greater image noise. This reduces image quality. For this reason, first try to increase the brightness using the aperture of the camera optics and/or use longer shutter settings.

ⓘ Generally all AVT Oscar cameras enable certain image settings to be modified on the fly, e.g. gain and shutter can be changed by the host computer by writing into the gain and shutter register even during camera operation. An uncertainty of one or two images remains because the host is unaware (especially with external trigger) of when the next image will arrive.

8.5 Auto gain

In combination with auto white balance, all models are equipped with an auto gain feature.
When enabled, auto gain adjusts the gain within the default gain limits (see table 27) or within the limits set in advanced register F1000370h so as to reach the brightness set in the auto exposure register as reference. Increasing the auto exposure value increases the average brightness in the image and vice versa.
The applied algorithm uses a proportional plus integral controller (PI controller) to achieve minimum delay with zero overshot.
The following table shows both the gain and auto exposure CSR.

Register	Name	Field	Bit	Description
0xF0F00820	GAIN	Presence_Inq	[0]	Presence of this feature: 0: N/A; 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value

				CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..4]	Reserved
		One_Push	[5]	Write: Set Bit high to start Read: Status of the feature: Bit high: WIP, Bit low: Ready
		ON_OFF	[6]	Write ON or OFF this feature, ON=1 Read: Status of the feature; OFF=0
		A_M_MODE	[7]	Set bit high for Auto feature Read for Mode; 0= MANUAL; 1= AUTO
		-	[8..19]	reserved
		Value	[20..31]	Read/Write Value; this field is ignored when writing the value in Auto or OFF mode; if readout capability is not available reading this field has no meaning
Register	**Name**	**Field**	**Bit**	**Description**
0xF0F00804	AUTO_EXPOSURE	Presence_Inq	[0]	Presence of this feature: 0: N/A; 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..4]	Reserved
		One_Push	[5]	Write: Set Bit high to start Read: Status of the

				feature: Bit high: WIP, Bit low: Ready
		ON_OFF	[6]	Write ON or OFF this feature, ON=1 Read: Status of the feature; OFF=0
		A_M_MODE	[7]	Set bit high for Auto feature Read for Mode; 0= MANUAL; 1= AUTO
		-	[8..19]	reserved
		Value	[20..31]	Read/Write Value; this field is ignored when writing the value in Auto or OFF mode; if readout capability is not available reading this field has no meaning

Table 26: Gain and Auto_Exposure CSR

The table below illustrates the advanced auto gain control register.

Register	Name	Field	Bit	Description
0xF1000370	AUTOGAIN_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
			[1..3]	-
	MAXVALUE	Max Value	[4..15]	Max value
		-	[16..19]	-
	MINVALUE	Min value	[20..31]	Min value

Table 27: Advanced register for auto gain control

ⓘ Values can only be changed within the limits of the CSR gain.
ⓘ Changes in auto exposure register only have an effect when auto gain is active.
ⓘ Auto exposure limits are 50..205.

8.6 Setting the brightness (black level or offset)

It is possible to set the black level in the camera within the following ranges:

0...+16 gray values (@ 8 bit). Increments are in 1/16 LSB (@ 8 bit).
The formula for gain and offset setting is: Y`= G*Y+Offset

ⓘ Setting the gain does not change the offset (black value).

The IIDC brightness register at offset 800h is used for this purpose. Description is identical to GAIN.

8.7 Auto shutter

In combination with auto-white balance, all models are equipped with an auto-shutter feature. When enabled, the auto-shutter adjusts the shutter within the default shutter limits or within those set in advanced register F1000360h, to reach the reference brightness set in auto exposure register. Increasing the auto exposure value increases the average brightness in the image and vice versa.
The applied algorithm uses a proportional plus integral controller (PI controller) to achieve minimum delay with zero overshot.
The following table shows the Shutter CSR.

Register	Name	Field	Bit	Description
0xF0F0081C	SHUTTER	Presence_Inq	[0]	Presence of this feature: 0: N/A; 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..4]	Reserved
		One_Push	[5]	Write: Set Bit high to start Read: Status of the feature: Bit high: WIP, Bit low: Ready
		ON_OFF	[6]	Write ON or OFF this

				feature, ON=1 Read: Status of the feature; OFF=0
		A_M_MODE	[7]	Set bit high for Auto feature Read for Mode; 0= MANUAL; 1= AUTO
		-	[8..19]	reserved

Table 28: Shutter CSR

The table below illustrates the advanced register for auto-shutter control. The purpose of this register is to limit the range within where the auto-shutter is working.

Register	Name	Field	Bit	Description
0xF1000360	AUTOSHUTTER_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
			[1..31]	-
0xF1000364	AUTOSHUTTER_LO	Min Value	[0..31]	Min value
0xF1000368	AUTOSHUTTER_HI	Max Value	[0..31]	Max value

Table 29: Auto shutter ctrl. advanced register

ⓘ Values can only be changed within the limits of shutter CSR.
ⓘ Changes in auto exposure register only have an effect when auto shutter is enabled.
ⓘ Auto exposure limits are 50..205.

When both auto shutter and auto gain are enabled, priority is given to increasing shutter when brightness decreases. This is done to achieve the best image quality with lowest noise.
For increasing brightness, priority is given to lowering the gain first for the same purpose.

8.8 Lookup table (LUT) and Gamma function

The AVT Oscar camera provides one user-defined lookup table (LUT). The use of this LUT allows any function (in the form Output = F(Input) to be stored in the camera's RAM and be applied on individual pixels of an image at run-time.
The address lines of the RAM are connected to the incoming digital data, these in turn point to the values of functions which are calculated offline, e.g. with a spreadsheet program.
This function needs to be loaded into the camera's RAM before use.

One example of using a LUT is the Gamma LUT: Output = $(Input)^{0.5}$. This is used with all models. This is known as compensation for the nonlinear brightness response of many displays e.g. CRT monitors. The lookup table converts the 12 bits from the digitizer's output to 8 bits.

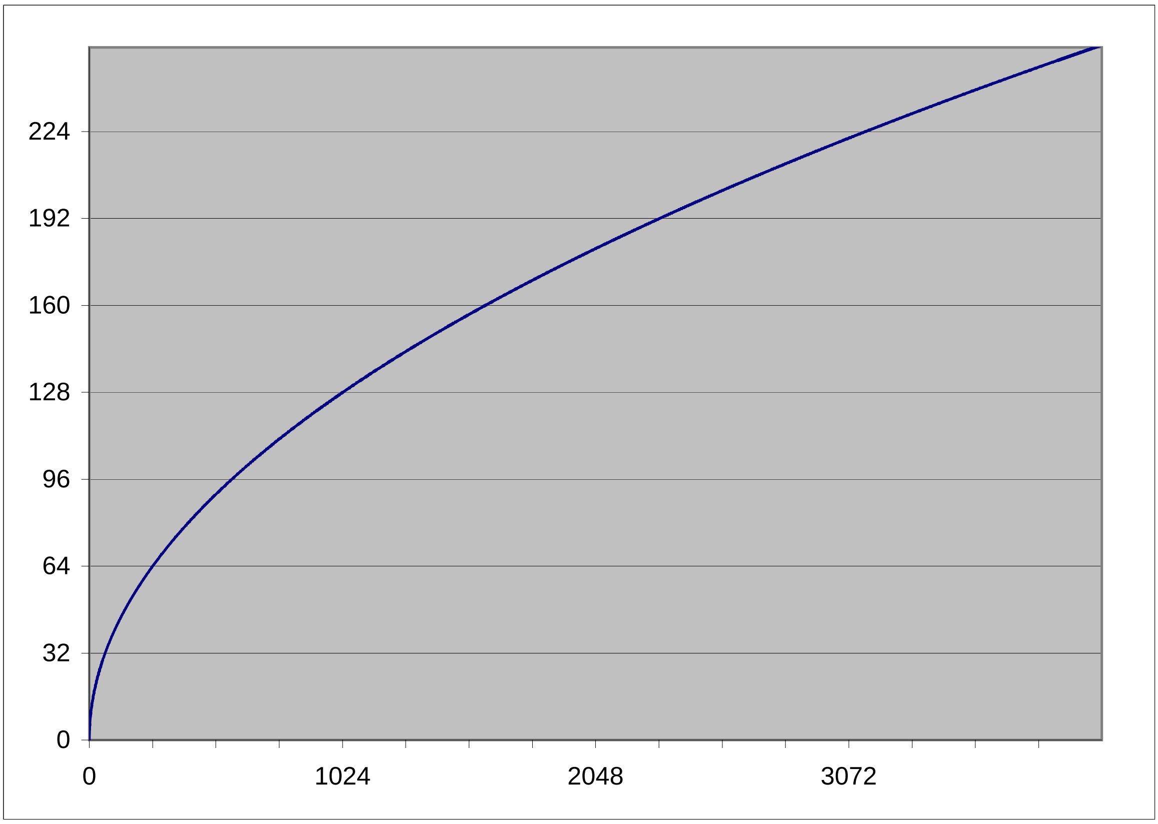


Figure 29: Gamma LUT

ⓘ The input value is the 12-bit value from the digitizer. The gamma LUT outputs the most significant 8 Bit as shown above.

ⓘ As gamma correction is also implemented via the lookup table, it is not possible to use a different LUT when gamma correction is enabled.

ⓘ The user LUT will be overridden when Gamma is enabled.

ⓘ LUT content is volatile.

8.8.1 Loading a LUT into the camera

Loading the LUT is carried out through the data exchange buffer called GPDATA_BUFFER. As this buffer can hold a maximum of 2 kB, and a complete LUT at 4026 x 8 bit is 4 kB, programming cannot take place in a one block write step. The flow diagram below shows the sequence required to load data into the camera.

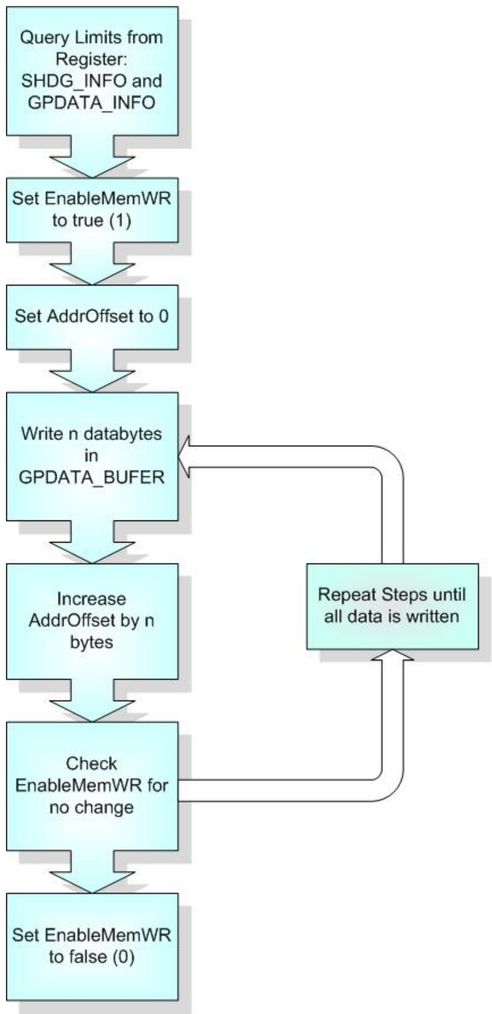


Figure 30: Loading a LUT

The table below describes the registers required.

Register	Name	Field	Bit	Description
0xF1000240	LUT_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only).
		---	[1..5]	-
		ON_OFF	[6]	Enable/Disable this feature.
		---	[7..25]	-
		LutNo	[26..31]	Use Lookup table with number LutNo.
0xF1000244	LUT_MEM_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only).
		---	[1..4]	
		EnableMemWR	[5]	Enable write access.
		---	[6..7]	
		AccessLutNo	[8..15]	
		AddrOffset	[16..31]	byte
0xF1000248	LUT_INFO	Presence_Inq	[0]	Indicates presence of this feature (read only).
		---	[1..7]	
		NumOfLuts	[8..15]	Max. # of Lookup tables.
		MaxLutSize	[16..31]	Max. Lookup Table size (bytes).

Table 30: LUT configuration register

8.9 Shading correction

Shading correction is used to compensate for non-homogeneities caused by lighting or optical characteristics within specified ranges. To correct a frame, a multiplier from 1...2 is calculated for each pixel in 1/256 steps – this allows for shading to be compensated by up to 50 %.

Besides generating shading data off-line and downloading it to the camera, the camera even allows correction data to be generated automatically in the camera itself.
The following pictures describe the process of automatic generation of correction data. The line profiles were created using MVTEC's "ActivVision Tools".

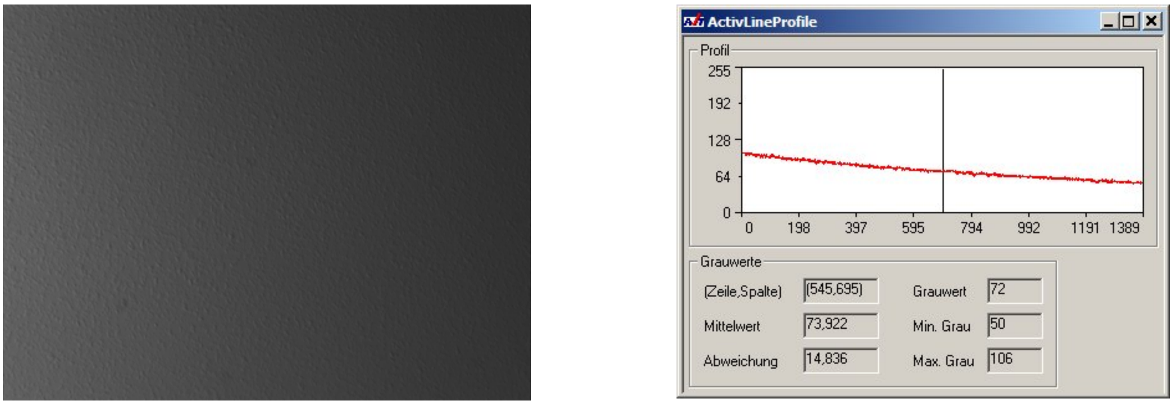


Figure 31: Shading correction: Source image with non-uniform illumination

On the left you see the source image with non-uniform illumination. The graph on the right clearly shows the brightness level falling off to the right.

By defocusing the lens, high-frequency image data is removed from the source and is therefore is not included on the shading image.

8.9.1 Automatic generation of correction data

Requirements
Shading correction compensates for non-homogeneities by giving all pixels the same gray value as the brightest pixel. This requires that only the background is visible and the brightest pixel has a gray value of less than 255 when automatic generation of shading data is initiated.
It may be necessary to use a neutral white reference, e.g. a sheet of paper instead of the real image.

Algorithm
After the start of automatic generation, the camera grabs the number of frames set in the GRAB_COUNT register. Recommended values are 4, 8 or 16. An arithmetic mean value is then calculated from them (to reduce noise).

After the grabbing procedure, a search is made for the brightest pixel in the mean value frame. A multiplication factor is then calculated for each pixel giving it the gray value of the brightest pixel.
All of these multipliers are saved in a “shading reference image“. The time required for this procedure depends on the number of frames to be processed.
Correction can compensate for shading by up to 50 % and relies on 12 bit pixel data to avoid the generation of missing codes.
Thus the output after the shading correction has potentially 11 bit accuracy.

How to proceed:

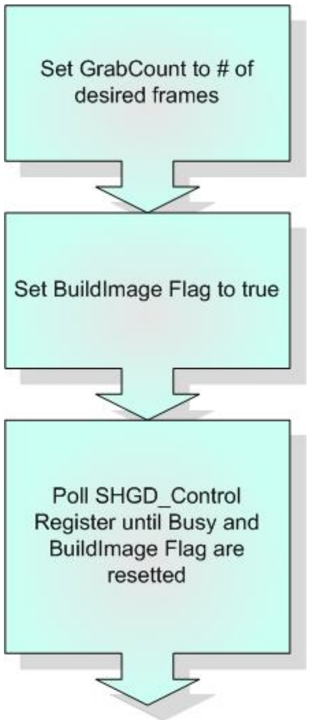


Figure 32: Automatic generation of a shading image

The table below describes the registers required.

Register	Name	Field	Bit	Description
0xF1000250	SHDG_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only).
		BuildError	[1]	tbd
		---	[2..3]	
		ShowImage	[4]	Show shading data as image.
		BuildImage	[5]	Build a new ShadingImage.
		ON_OFF	[6]	Shading On/Off.
		Busy	[7]	Build in progress.
		---	[8..23]	
		GrabCount	[24..31]	Number of images
0xF1000254	SHDG_MEM_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only).
		---	[1..4]	
		EnableMemWR	[5]	Enable write access.
		EnableMemRD	[6]	Enable read access.
		---	[7]	
		AddrOffset	[8..31]	Bytes
0xF1000258	SHDG_INFO	Presence_Inq	[0]	Indicates presence of this feature (RD only).
		---	[1..7]	
		MaxImageSize	[8..31]	Max shading Img. size (Bytes).

Table 31: Shading control register

ⓘ The maximum value of GRAB_COUNT depends on the type of camera and the number of frame buffers that exist. GRAB_COUNT is also automatically corrected to the power of two.

ⓘ The SHDG_CTRL register should not be queried at very short intervals This is because each query delays the generation of the shading image. An optimal interval time is 500 ms.

The following pictures illustrate the sequence of commands for generating the shading image. The correction sequence controlled e.g. via “Directcontrol” uses the average of 16 frames (10H) to calculate the correction frame.
The top picture shows the input image (with lens out of focus). The bottom picture shows the shading corrected output image (unfocused lens).

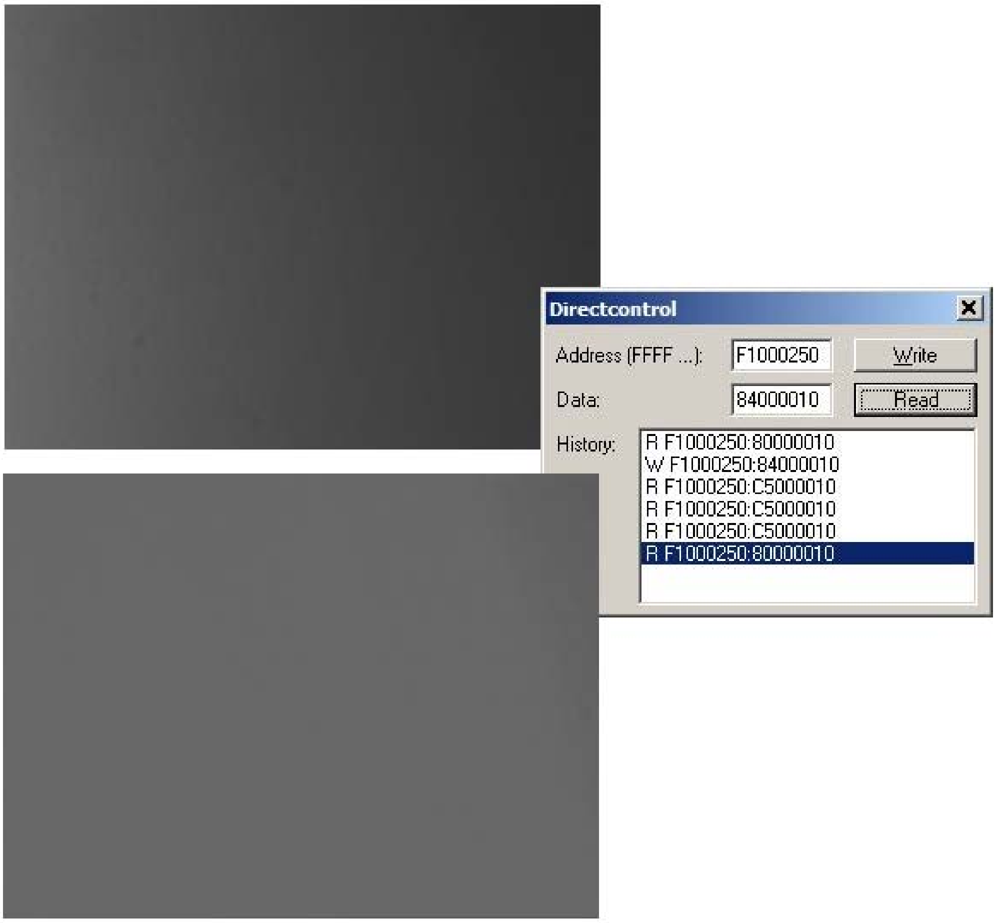
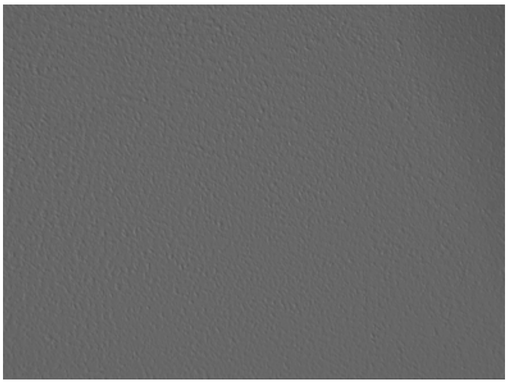


Figure 33: Generation of shading image

- ⓘ The calculation of shading data is always carried out at the current resolution setting. If the Area of Interest (AOI) is later larger than the window in which correction data was calculated, none of the pixels lying outside are corrected.
- ⓘ For Format_7 it is advisable to generate the shading image in the largest displayable frame format. This ensures that any smaller AOI’s are completely covered by the shading correction.
- ⓘ The automatic generation of shading data can also be enabled when image capture is already running. The camera then pauses the running image capture for the time needed for generation and resumes after generation is completed.
- ⓘ Shading correction can be combined with the image mirror, binning and gamma functionality.

After the lens has been focused again, the image below will be seen, however, with a much improved, uniformed gradient. This is also made apparent in the graph on the right.



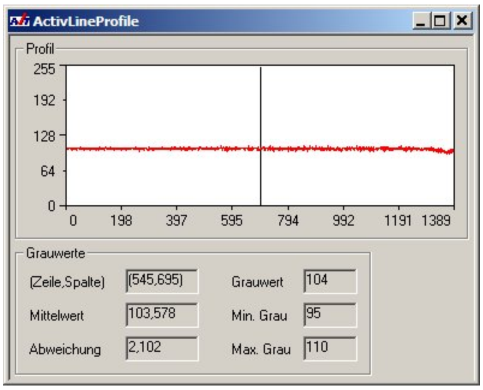


Figure 34: Example of shaded image

The shading reference image can be output for permanent storage purposes on a host system. It can be further uploaded into the camera, so that the shading procedure must not be repeated after power down of the camera.

8.9.2 Loading a shading image into the camera

GPDATA_BUFFER is used to load a shading image into the camera. Because the size of a shading image is larger than GPDATA_BUFFER, input must be handled in several steps:

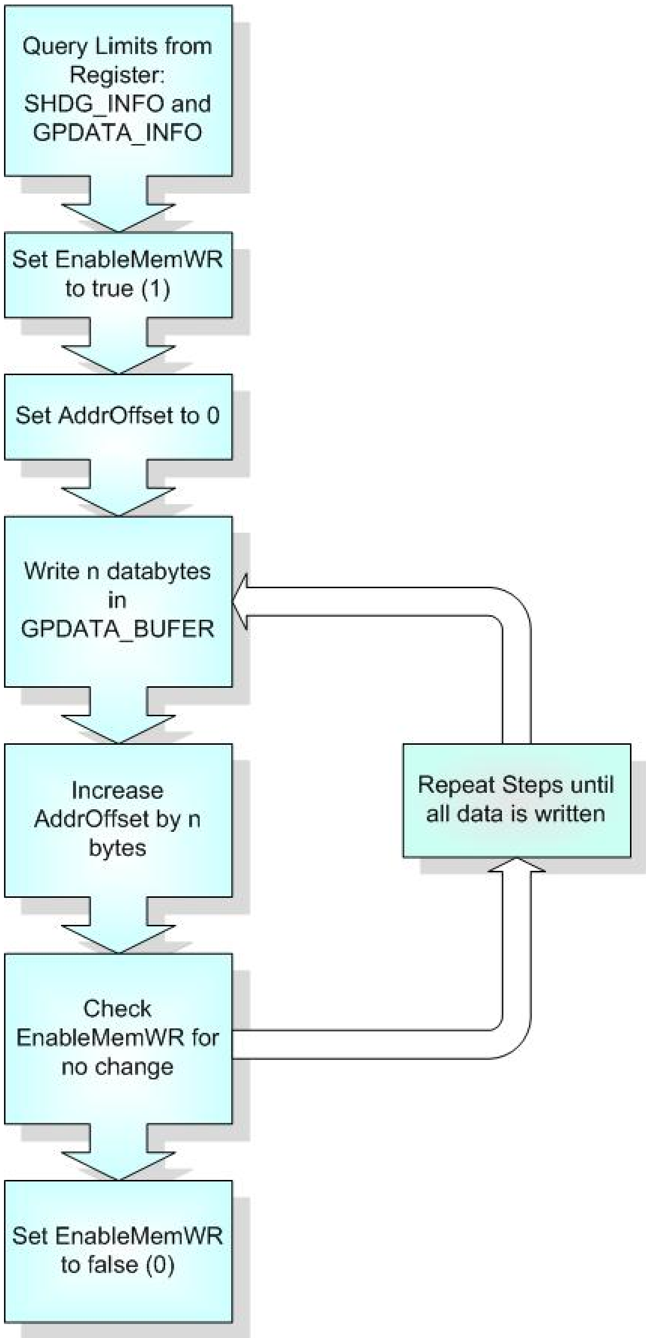


Figure 35: Loading the shading reference image

8.9.3 Loading a shading image out of the camera

GPDATA_BUFFER is used to load a shading image out of the camera. Due to the size of a shading image being larger than GPDATA_BUFFER, output must be handled in several steps:

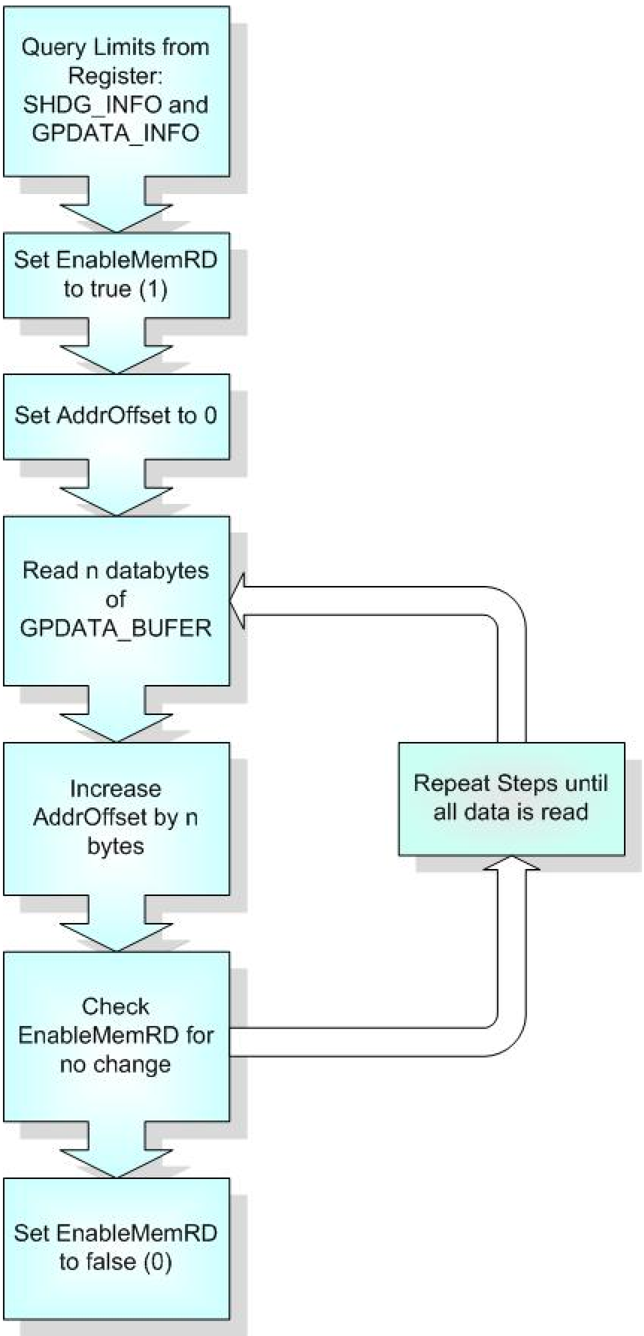


Figure 36: Uploding shading image to host

8.10 Horizontal mirror function

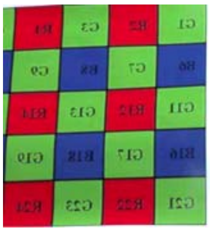
All Oscar cameras are equipped with an electronic mirror function which mirrors pixels from the left side of the image to the right side and vice versa. The mirror is centered on the actual FOV center and can be combined with all image manipulation functions: e.g. binning, shading and DSNU.
This function is especially useful when the camera is looking at objects via a mirror or in certain microscopy applications.

Mirror can be controlled with the following advanced register:

Register	Name	Field	Bit	Description
0x1000410	MIRROR_CONTROL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		-	[1..5]	
		-	[6]	ON/OFF this feature: HIGH for ON, default :OFF
		-	[7..31]	

Table 32: Mirror control register

ⓘ The use of the mirror function and image outputs in RAW format has implications on the BAYER- ordering of the colors:

Mirror OFF: R-G-G-B 

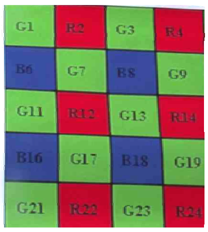
Mirror ON: G-R-B-G 

Figure 37: Mirror and Bayer order

ⓘ During switch-over one image may be temporarily corrupted.

8.11 Sub-sampling

Sub-sampling is the process of skipping neighboring pixels (with the same color) while being read out from the CCD chip. All Oscar models have this feature.

Sub-sampling is used primarily for the following reasons:

- A reduction in the number of pixels and thus reduced data while retaining the original image area angle,
- Switch the sensor to progressive mode rather than frame readout mode.
- Increase in the frame rate.

The sub-sampling mode is always h+v sub-sampling mode.

Use Format_7 Mode_3 to activate sub-sampling. The principal sub-sampling pattern is shown below. Please note that various sensors skip more than two rows in the sub-sampling mode. This is detailed in the sensor section of the manual.

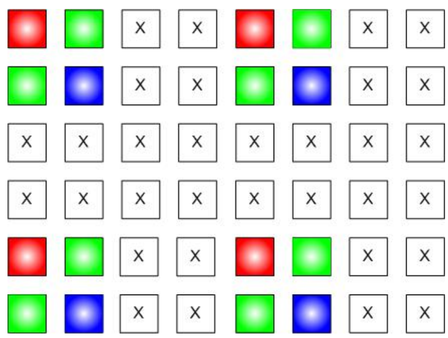


Figure 38: H+V subsampling

ⓘ Changing to sub-sampling mode involves the generation of new shading reference image due to a change in the image size.

8.12 Sharpness

All models are equipped with a two-step sharpness control, which applies a discreet horizontal high pass in the green channel as shown in the next three line profiles.

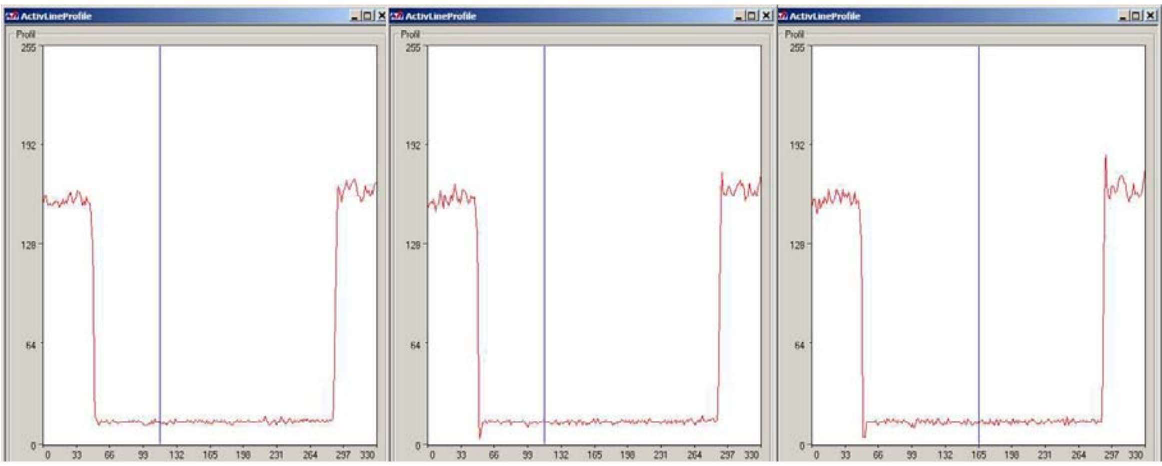


Figure 39: Sharpness: left: 0, middle: 1, right: 2

8.13 Color interpolation and correction

The color sensors capture the color information via so called primary color (R-G-B) filters placed over the individual pixels in a "BAYER mosaic" layout. An effective Bayer -> RGB color interpolation already takes place in all Oscar color version cameras. Before converting to the YUV format, color correction is done after Bayer demosaicing.

Color processing can be bypassed by using the so called RAW image transfer.

RAW-mode is primarily used to:

- save bandwidths on the IEEE-1394 bus
- achieve higher frame rates
- use different BAYER demosaicing algorithms on the PC

RAW-mode is accessible only via Format_7.

ⓘ If the PC does not perform BAYER to RGB post-processing, the b/w image will be superimposed with a checkerboard pattern.

8.13.1 Color interpolation (BAYER demosaicing)

In color interpolation, a red green or blue value is determined for each pixel. Three lines are needed for this bilinear interpolation:

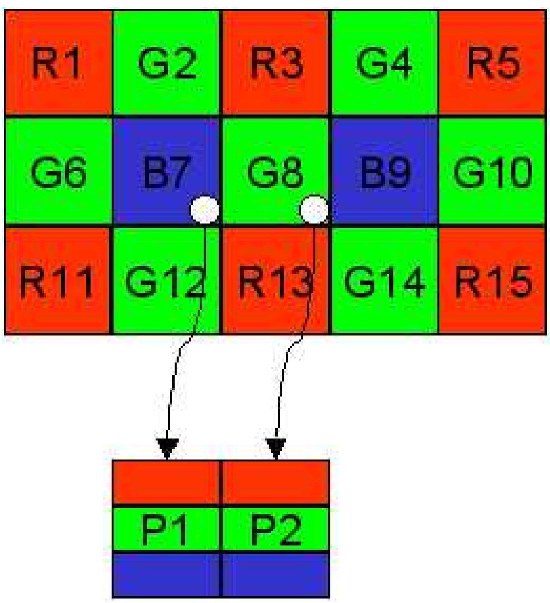


Figure 40: Bayer demosaicing (interpolation)

$$P1_{red} = \frac{R1+R3+R11+R13}{4} \qquad P2_{red} = \frac{R3+R13}{2}$$

$$P1_{green} = \frac{G2+G6+G8+G12}{4} \qquad P2_{green} = G8$$

$$P1_{blue} = B7 \qquad P2_{blue} = \frac{B7+B9}{2}$$

Formula 1: Bilinear Bayer demosaicing

8.13.2 Color correction

Color correction is performed before YUV conversion and mapped via a matrix as follows.

$$red^* = Crr \cdot red + Cgr \cdot green + Cbr \cdot blue$$
$$green^* = Crg \cdot red + Cgg \cdot green + Cbg \cdot blue$$
$$blue^* = Crb \cdot red + Cgb \cdot green + Cbb \cdot blue$$

Formula 2: Color correction matrix

Sensor specific coefficients C_{xy} are scientifically generated to ensure that GretagMacbeth™ ColorChecker®-colors are displayed with highest color fidelity and color balance.

ⓘ Color correction is deactivated in Mono8 or Mono16 mode (raw image transport).
ⓘ Color correction can also be switched off in YUV mode with the help of the following register:

0xF10003A0	COLOR_CORR	Oscar C-type CCD cameras only: Write: 02000000h to switch Color correction OFF Write: 00000000h to switch Color correction ON (Default)

8.13.3 RGB → YUV conversion

The conversion from RGB to YUV is made using the following formulae:

$$Y = 0.3 \cdot R + 0.59 \cdot G + 0.11 \cdot B$$
$$U = -0.169 \cdot R - 0.33 \cdot G + 0.498 \cdot B + 128$$
$$V = 0.498 \cdot R - 0.420 \cdot G - 0.082 \cdot B + 128$$

Formula 3: RGB to YUV formulae

ⓘ As mentioned above: Color processing can be bypassed by using the so called RAW image transfer.
ⓘ RGB -> YUV conversion can be bypassed by using RGB8 format and mode. This is advantageous from the edge color definition but needs more bandwidth (300% instead of 200% relative to b/w or RAW consumption) for the transmission, so that the maximal frame frequency will drop.

8.13.4 Hue and saturation

Oscar models are equipped with hue and saturation registers.
Hue and saturation are terms best understood with the homonymous HIS (Hue Intensity Saturation) color model.
The Hue register at offset 810h allows to change the color of objects by +/- 40 steps (+/- 10°) from the nominal perception without changing the white balance. Use this setting to manipulate the color appearance after having done the white balance.
The Saturation register at offset 814h allows changing the intensity of the colors by +/-100%.
This means a setting of zero, changes the image to black and white and a setting of 511 doubles the color intensity compared to the nominal one at 256.
Consider Hue changes as a change in the angle of the vector, the Saturation a change in the length of the vector S, and all starting from the intensity coordinate (vector from black to white).
The following picture illustrates the transformation.

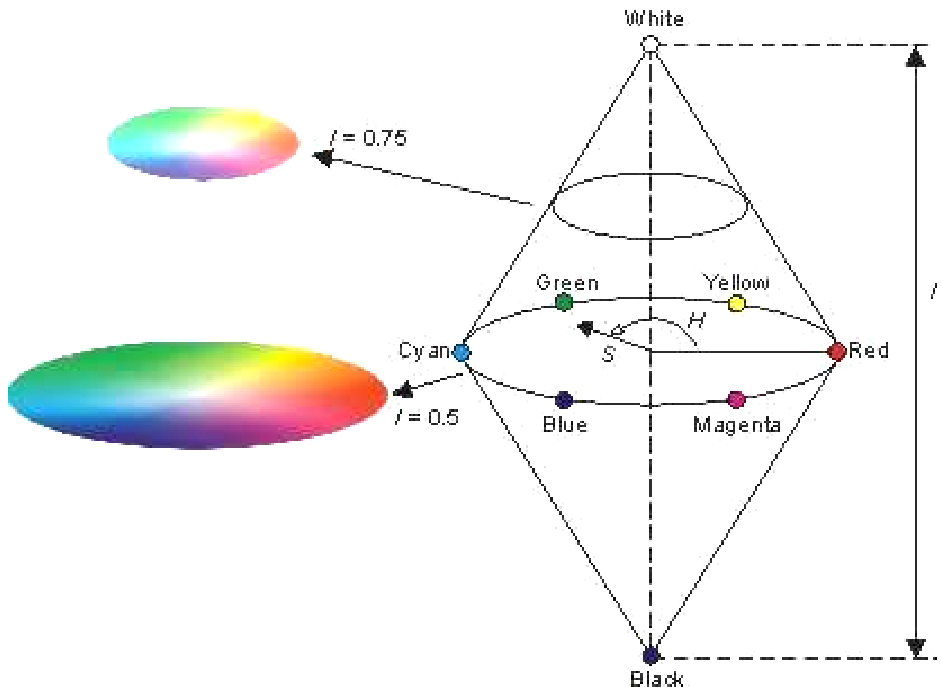


Figure 41: Hue and Saturation explanation

ⓘ Please note that this transformation is not accessible from outside.

8.14 Serial interface

All Oscar cameras are equipped with the SIO (serial input/output) feature as described in IIDC 1v31. This means that the Oscar's serial interface which is used for firmware upgrades can further be used as a general RS232 interface.
Data written to a specific address in the IEEE-1394 address range will be sent through the serial interface. Incoming data of the serial interface is put in a camera buffer and can be polled via simple read commands from this buffer. Controlling registers enable the settings of baud rates and the check of buffer sizes and serial interface errors.

ⓘ Note that hardware handshaking is not supported.
ⓘ Note that typical PC hardware is not supporting 230400 bps.

Base address for the function is: F0F02100h. The following registers give an overview:

Offset	Name	Field	Bit	Description
000h	SERIAL_MODE_REG	Baud_Rate	[0..7]	Baud rate setting WR: Set baud rate RD: Read baud rate 0: 300 bps 1: 600 bps 2: 1200 bps 3: 2400 bps 4: 4800 bps 5: 9600 bps 6: 19200 bps 7: 38400 bps 8: 57600 bps 9: 115200 bps 10: 230400 bps Other values reserved
		Char_Length	[8..15]	Character length setting WR: Set data length (7 or 8 bit) RD: Get data length 7: 7 bits 8: 8 bits Other values reserved
		Parity	[16..17]	Parity setting WR: Set parity RD: Get parity setting 0: None 1: Odd 2: Even
		Stop_Bit	[18..19]	Stop bits WR: Set stop bit

				RD: Get stop bit setting 0: 1; 1: 1.5; 2: 2
		-	[20..23]	Reserved
		Buffer_Size_Inq	[24..31]	Buffer Size (RD only) This field indicates the maximum size of receive/transmit data buffer If this field is 1, Buffer_Status_Control and SIO_Data_Reg. Char 1-3 should be ignored
0004h	SERIAL_CONTROL_REG	RE	[0]	Receive enable RD: Current status WR: 0: disable 1: Enable
		TE	[1]	Transmit enable RD: Current status WR: 0: disable 1: Enable
		-	[2..7]	Reserved
	SERIAL_STATUS_REG	TDRD	[8]	Transmit data buffer ready Read only 0: not ready; 1: ready
		-	[9]	Reserved
		RDRD	[10]	Receive data buffer ready Read only 0: not ready; 1: ready
		-	[11]	Reserved
		ORER	[12]	Receive data buffer overrun error Read: current status 0: no error WR: 0 to clear status (1: Ignored)
		FER	[13]	Receive data framing error Read: current status 0: no error WR: 0 to clear status (1: Ignored)
		PER	[14]	Receive data parity error

				Read: current status 0: no error WR: 0 to clear status (1: Ignored)
		-	[15..31]	Reserved
008h	RECEIVE_BUFFER_STATUS_CONTRL	RBUF_ST	[0..7]	SIO receive buffer status RD: Number of bytes pending in receive buffer; WR: Ignored
		RBUF_CNT	[8..15]	SIO receive buffer control WR: Number of bytes to be read from the receive FiFo RD: Number of bytes left for readout from the receive FiFo
		-	[16..31]	Reserved
00Ch	TRANSMIT_BUFFER_STATUS_CONTRL	TBUF_ST	[0..7]	SIO output buffer status RD: Space left in TX buffer; WR: Ignored
		TBUF_CNT	[8..15]	SIO output buffer control RD: Number of bytes written to transmit FiFo WR: Number of bytes to transmit
		-	[16..31]	Reserved
010h .. 0FFh		-		Reserved
100h	SIO_DATA_REGISTER	CHAR_0	[0..7]	Character_0 RD: Read char. from receive buffer WR: Write char. to transmit buffer
	SIO_DATA_REGISTER	CHAR_1	[8..15]	Character_1 RD/WR
	SIO_DATA_REGISTER	CHAR_2	[16..23]	Character_2 RD/WR
	SIO_DATA_REGISTER	CHAR_3	[24..31]	Character_3 RD/WR

Table 33: SIO CSR

Reading data requires the following series of actions:

- Query RDRD flag, (buffer ready?) and write the number of bytes the host wants to read to RBUF_CNT.
- Read the number of bytes pending in the receive buffer RBUF_ST, (more data in the buffer than the host wanted to read?) and the number of bytes left for reading from the receive FiFo in RBUF_CNT (more data the host wanted to read than were in the buffer?).
- Read received characters from SIO_DATA_REGISTER, beginning at char 0.
- To input more characters, repeat from step 1.

Writing data requires the following series of actions:

- Query TDRD flag (buffer ready?) and write the number of bytes to send (copied from SIO register to transmit FiFo) to TBUF_CNT.
- Read the available data space left in TBUF_ST (in the case the buffer can hold more bytes than are to transmit) and number of bytes written to transmit buffer in TBUF_CNT (in the case that more data is to transmit than fits in the buffer).
- Write character to SIO_DATA_REGISTER, beginning at char 0.
- To output more characters, repeat from step 1.

ⓘ Contact your local dealer if you require further information or additional test programs or software.

ⓘ AVT recommends the use of Hyperterminal™ or other communication programs to test the functionality of this feature.

9 Controlling image capture

The cameras support the SHUTTER_MODES specified in IIDC V1.3. For all models this shutter is a global (field) shutter; meaning that all pixels (in the same field) are exposed to the light at the same moment and for the same time span.
In continuous modes the shutter is opened shortly before the vertical reset happens, thus acting in a frame-synchronous way.
Combined with an external trigger, it becomes asynchronous in the sense that it occurs whenever the external trigger occurs. Individual images are recorded when an external trigger impulse is present. This ensures that even fast moving objects can be grabbed with the help of a strobe with no image lag and with minimal image blur.
The external trigger is fed as a TTL signal through Pin 4 of the HiRose connector.

9.1 Trigger modi

The cameras support IIDC conforming Trigger_Mode_0 and Trigger_Mode_1 (in progressive modes only) and special Trigger_Mode_15.
Trigger_Mode_0 sets the shutter time according to the value set in the shutter (or extended shutter) register. Trigger_Mode_1 sets the shutter time in the progressive modes according to the active low time of the pulse applied (or active high time in the case of an inverting input).

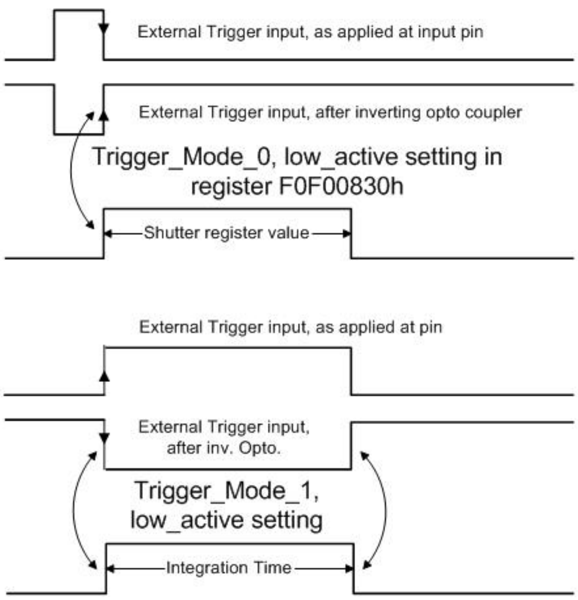


Figure 42: Trigger_mode_0 and 1

Trigger_Mode_15 is a bulk trigger, combining one external trigger event with continuous, one-shot, or multi-shot internal trigger.
It is an extension to the IIDC trigger modes. One external trigger event can be used to trigger a multitude of internal image intakes.

This is especially useful for:

- Grabbing exactly one image based on the first external trigger.
- Filling the camera's internal image buffer with one external trigger without overriding images.
- Grab an unlimited amount of images after one external trigger (Surveillance)

The figure below details this mode.

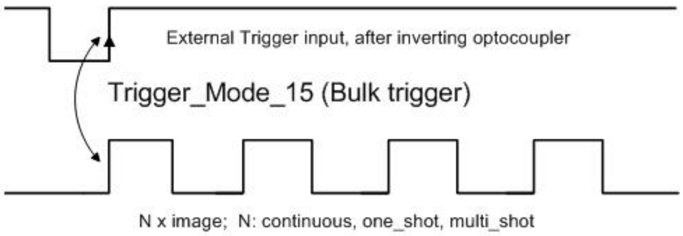


Figure 43: Trigger_Mode_15

The functionality is controlled via bit [6] and bitgroup [12-15] of the DCAM register:

Register	Name	Field	Bit	Description
0xF0F00830	TRIGGER_MODE	Presence_Inq	[0]	Presence of this feature: 0:N/A; 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..5]	Reserved
		ON_OFF	[6]	Write ON or OFF this feature, ON=1 Read: Status of the feature; OFF=0
		Trigger_Polarity	[7]	If Polarity_Inq = 1: W: 0 for low active input; 1 for high active input If Polarity_Inq = 0:

				Read only
		Trigger_Source	[8..10]	Select trigger source ID from trigger source ID_Inq.
		Trigger_Value	[11]	Trigger input raw signal value (read only)
		Trigger_Mode	[12..15]	Trigger_Mode (0-15)
		-	[16..19]	Reserved
		Parameter	[20..31]	Parameter for trigger function, if required

Table 34: Trigger_Mode_15

The screenshots below illustrate the use of Trigger_Mode_15 on a register level:
The first line switches continuous mode off, leaving viewer in listen mode.
The second line prepares 830h register for external trigger and Mode_15.

Left:
The last line switches camera back to cont. mode. Precisely one image is grabbed with the first external trigger. To repeat rewrite line three.

Middle:
Toggle One_Shot Bit [0] of the One_Shot register 61C so that only one image is grabbed, based on the first external trigger. To repeat rewrite line three.

Right:
Toggle Multi_Shot bit [1] of the One_Shot register 61C so that Ah images are grabbed, starting with the first external trigger. To repeat rewrite line three.

Figure 44: Using Trigger_Mode_15; Continuous, oneshot, multishot

ⓘ Shutter for the images is controlled by shutter register.

9.1.1 Trigger delay

As mentioned earlier, the cameras feature various ways to delay image capture based on external trigger.
With 1V31 of IIDC spec. there is a standard CSR at Register F0F00534/834h to control a delay up to FFFh * time-base value. The following table explains the Inquiry register and the meaning of the various bits.

Register	Name	Field	Bit	Description
0xF0F00534	TRIGGER_DELAY_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		-	[2]	Reserved
		One_Push_Inq	[3]	One Push auto mode (Controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto Mode (Controlled automatically by the camera)
		Manual_Inq	[7]	Manual Mode (Controlled by user)
		Min_Value	[8..19]	Min. value for this feature
		Max_Value	[20..31]	Max. value for this feature

Table 35: Trigger_Delay_Inquiry register

	Name	Field	Bit	Description
0xF0F00834	TRIGGER_DELAY	Presence_Inq	[0]	Presence of this feature: 0:N/A; 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field

				1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		-	[2..5]	Reserved
		ON_OFF	[6]	Write ON or OFF this feature, ON=1 Read: Status of the feature; OFF=0
		-	[7..19]	Reserved
		Value	[20..31]	Value

Table 36: Trigger Delay CSR

In addition, the cameras have an advanced register which allows the setting to delay the image capture after receiving a hardware trigger to be precisely adjusted.

Trigger delay advanced register

Register	Name	Field	Bit	Description
0xF1000400	TRIGGER_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	-
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	-
		DelayTime	[11..31]	Delay time in µs

Table 37: Trigger Delay Advanced CSR

The advanced register allows a delay in the start of the integration by max. 2^{21} µs, which is max. 2.1s after a trigger edge was detected.

ⓘ Switching trigger delay to ON also switches external Trigger_Mode_0 to ON.
ⓘ This feature works with external Trigger_Mode_0 only.

9.2 Shutter modes

Due to the frame readout (interlaced) concept of the sensors, two different shutter modes exist for the maximum resolution formats accessible via the mode register in Format_7.
The conversion from interlaced to progressive takes place in the camera's internal memory.

9.2.1 Split shutter

The term *split shutter* results from the fact that two (OF-810C: three) fields are exposed and read out of the sensor one after the other. Format_7 Mode_1 is to be used for this mode, suitable for stationary objects and when no strobe light is available. Because of the time difference between the two shutters, which is dependant on the length of the shutter, this mode is only useful for stationary objects.

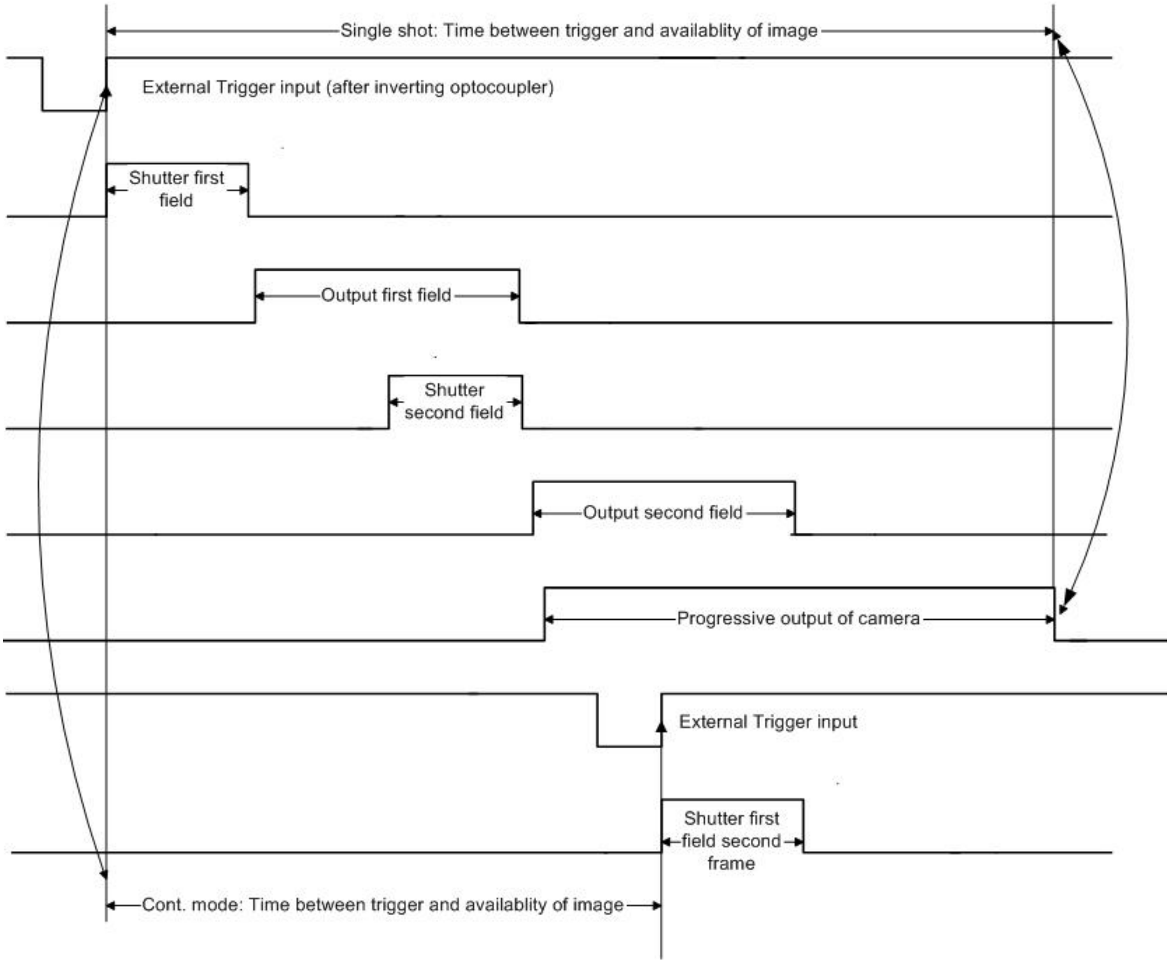


Figure 45: Split shutter

ⓘ Combining split-shutter with one-shot operation it can also be seen from the above figure that the frame rate in one-shot mode is lower than that in continuous mode. This is a result of the additional delay of one or two (OF-810C) fields before the progressive output of the camera can start.

ⓘ Using split shutter with a flash device connected to IntEna, you will notice that it flashes twice (or three) times per single image capture.

9.2.2 Joint-shutter

Use Format_7 Mode_0 when a **strobe light** flashes moving objects. The exposure for the two (three: F-810C) fields starts concurrently so that the strobe freezes odd and even lines at the same time. Field one is read out first, field two (and three) are read out after field one. Make sure that the ambient light can be neglected, otherwise it will contribute to the illumination of the scene and introduce image oddities. The following picture illustrates this mode.

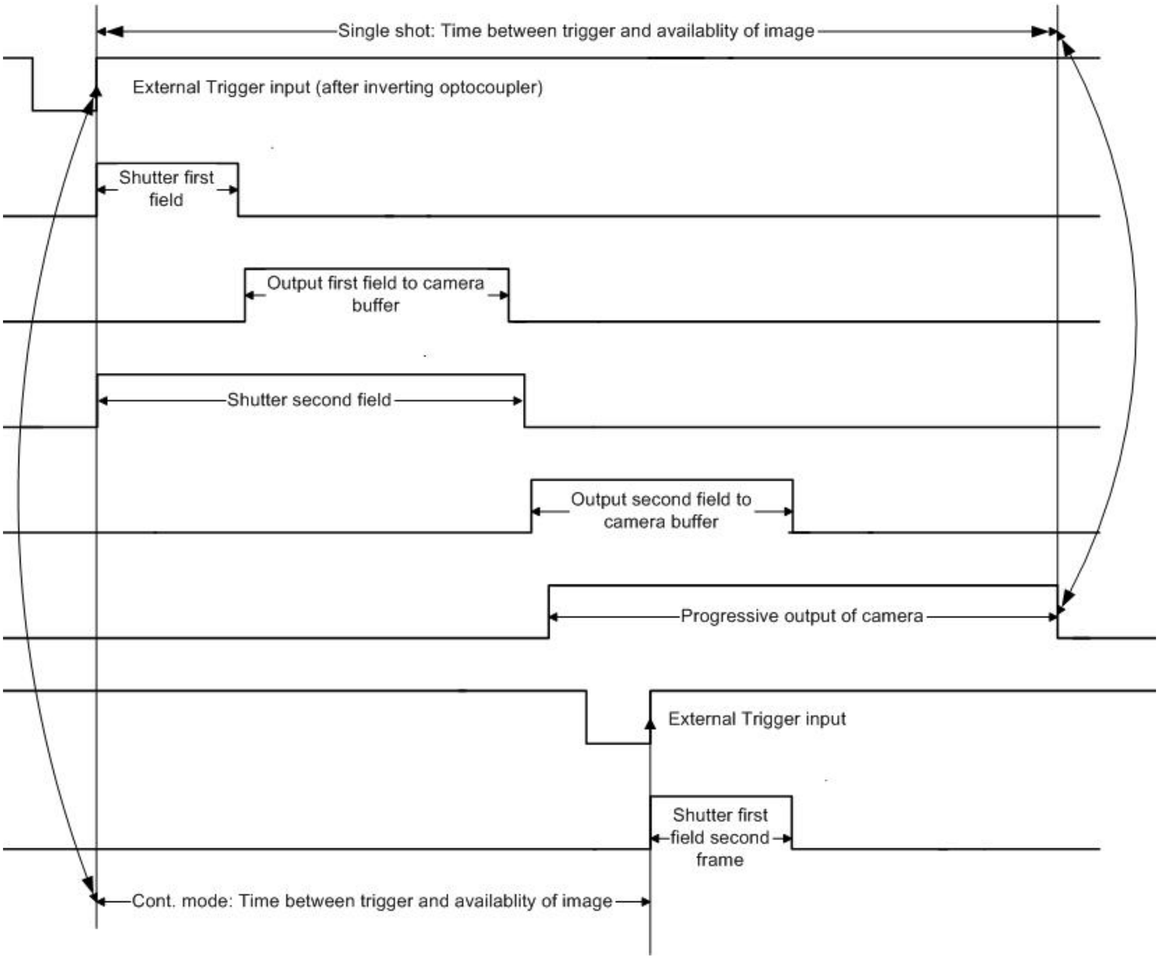


Figure 46 Joint shutter mode

ⓘ Changing the shutter time only affects the first field. The second (and third) field has a constant shutter time of one (two) field length(s).

ⓘ Combining joint-shutter with one shot operation it can also be seen from the above figure that the frame rate in one shot mode is lower than in continuous mode. This is a result of the additional delay of one or two (OF-810C) fields before the progressive output of the camera can start.

9.3 Exposure time (Shutter)

The exposure (shutter) time for continuous mode and Trigger_Mode_0 is based on the following formula:

Shutter register value x timebase + offset

The register value is the value set in the corresponding IIDC register (SHUTTER [81Ch]). This number is in the range between 1 and 4095.
The shutter register value is multiplied by the time base register value (see TIMEBASE). The default value here is set to 20 µs.
A camera-and mode specific offset of 42 to 85 µs is also added to this value.

OF-320C:	42/50 µs	(interlaced/progressive)
OF-510C:	64.25/71 µs	(interlaced/progressive)
OF-810C:	85/85 µs	(interlaced/progressive)

Example
Camera: OF-510C in interlaced (frame readout) mode
Register value: 100
Timebase: 20 µs
100 x 20 µs + 64.25 µs = 2064.25 µs exposure time.

The minimum adjustable exposure time set by register is 10 µs. => the real minimum exposure time of an OF-510C is then 10 µs + 64.25 µs = 74.25 µs in frame readout mode.

ⓘ Generally all AVT Oscar cameras enable certain image settings to be modified on the fly, e.g. gain and shutter can be changed by the host computer by writing into the gain and shutter registers even during camera operation. An uncertainty of one or two images remains as the host is unaware of (especially with external trigger) when the next image will arrive.

9.3.1 Extended shutter

The exposure time for long-term integration of up to 67 sec can be extended via the EXTENDED_SHUTTER register.

Register	Name	Field	Bit	Description
0xF100020C	EXTD_SHUTTER	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1.. 5]	
		ExpTime	[6..31]	Exposure time in µs

Table 38: Extended shutter configuration

The longest exposure time, 3FFFFFFh, corresponds to 67.11 sec.

- Exposure times entered via the 81Ch register are mirrored in the extended register, but not vice versa.
- Longer integration times not only increase sensitivity, but may also increase some unwanted effects such as noise and pixel-to-pixel non uniformity. Depending on the application, these effects may limit the longest useable integration time.
- Changes in this register have immediate effect, even when the camera is transmitting (running).
- Extended shutter becomes inactive after writing to a format/mode/frame rate register.

9.4 One-Shot

The camera can record an image by setting the "`OneShot bit`" in the 61Ch register. This bit is automatically cleared after the image is captured. If the camera is placed in *Iso_Enable* mode (see ISO_Enable / Free-Run), this flag is ignored.
If *OneShot mode* is combined with the external trigger, the "`OneShot`" command is used to arm it. The following screenshot shows the sequence of commands needed to put the camera into this mode. It enables the camera to grab exactly one image with an external trigger edge.
If there is no trigger impulse after the camera has been armed, OneShot can be cancelled by clearing the bit.

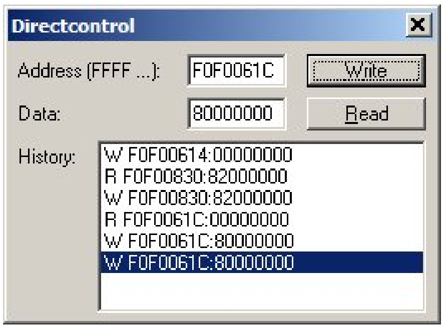


Figure 47: One_shot control

9.4.1 One-Shot command on the bus to start the exposure

The following sections describe the time response of the camera using a single frame (OneShot) command. As set out in the IIDC specification, this is a software command that causes the camera to record and transmit a single frame.

The following values apply only when the camera is idle and ready for use. Full resolution must also be set.

OneShot->Microcontroller-Sync: <=250 µs (processing time in the microcontroller)

µC-Sync/ExSync->Integration-Start 8 µs

Microcontroller-Sync is an internal signal. It is generated by the microcontroller to initiate a trigger. This can either be a direct trigger or a release for ExSync if the camera is externally triggered.

9.4.2 End of exposure to first packet on the bus

After the exposure, the CCD- sensor is read out; some data is written into the FRAME_BUFFER before being transmitted to the bus.

The time from the end of exposure to the start of transport on the bus is:

500µs ± 62.5µs

This time 'jitters' with the cycle time of the bus (125µs).

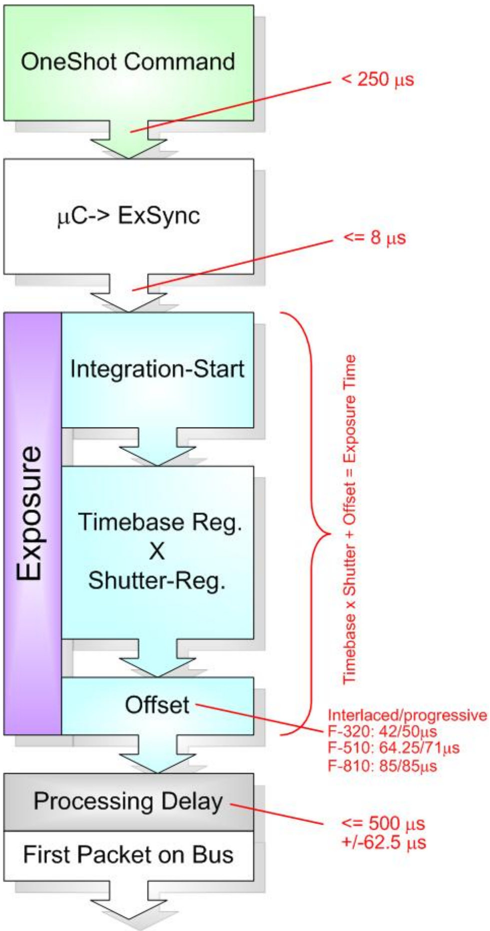


Figure 48: Data flow and timing after end of exposure

9.5 Multi-Shot

Setting "MultiShot" and entering a quantity of images in *Count_Number* in the 61Ch register enables the camera to record a specified number of images.

The number is indicated in bits 16 to 31. If the camera is put into *Iso_Enable* mode (ISO_Enable / Free-Run), this flag is ignored and deleted automatically once all the images have been recorded.

If *MultiShot* mode is activated and the images have not yet all been captured, it can be cancelled by resetting the flag. The same result can be achieved by setting the number of images to "0".
Multi-Shot can also be combined with the external trigger in order to grab a certain number of images based on an external trigger. This is especially useful in combination with the so called Deferred_Mode to limit the amount of grabbed images to the FIFO size.

9.6 ISO_Enable / Free-Run

Setting the MSB (bit 0) in the 614h register (ISO_ENA) puts the camera into *ISO_Enable mode* or *Continuous_Shot*. The camera captures an infinite series of images. This operation can be quit by deleting the "0" bit.

9.7 Asynchronous broadcast

The camera accepts asynchronous broadcasts. This involves asynchronous write requests that use node number 63 as the target node with no acknowledge.

This makes it possible for all cameras on a bus to be triggered by software simultaneously - e.g. by broadcasting a "One_Shot". All cameras receive the "One_Shot" command in the same IEEE-1394 bus cycle. This creates uncertainty for all cameras in the range of 125 µs.
Inter-camera latency is described in the next chapter.
The following screenshot shows an example of broadcast commands sent with the Firedemo example of FirePackage (version 1V51 or newer):
Line 1 shows the broadcast command, which stops **all** cameras connected to the same IEEE-1394 bus. It is generated by holding the <shift> key down while clicking on <Write>.
Line 2 generates a "broadcast One_Shot" in the same way, this forces all connected cameras to simultaneously grab one image.

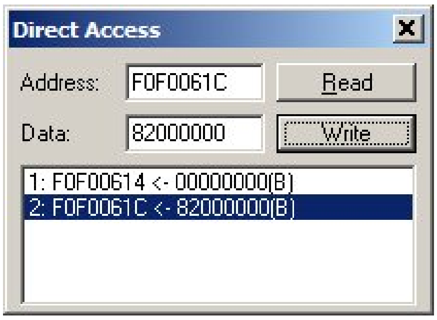


Figure 49: Broadcast One_Shot

9.8 Jitter at start of exposure

The following chapter discusses the latency time which exists for all cameras from when either a hardware or software trigger is generated, up and until the actual image exposure starts.
Due to the fact that an Interline Transfer CCD-sensor has both a light sensitive and separate storage area, it is normal to interleave the image exposure of a new frame with the output of the previous one. This technique will produce a continuous image flow, even with an external trigger.
The uncertain time delay before the start of exposure depends on the state of the sensor. A distinction is defined as follows:

FVal is active → the sensor is reading out, camera is busy

In this case the camera should not change horizontal timing so that the trigger event is synchronized with the current horizontal clock. This introduces a max. uncertainty which is equivalent to the line-time. The line-time depends on the sensor used and therefore can vary from model to model.

FVal is inactive → the sensor is ready, the camera is idle

In this case the camera can resynchronize the horizontal clock to the new trigger event, leaving only a very short uncertainty time of the master clock period.

Model	Camera idle	Camera busy
OF-320C	< 100 ns	98 µs
OF-510C	< 100 ns	134 µs
OF-810C	< 100 ns	128 µs

Table 39: Jitter at exposure start

ⓘ Jitter at the beginning of an exposure has no effect on the length of exposure, i.e. it is always constant.

9.9 Frame memory and deferred image transport

An image is normally captured and transported in consecutive steps. The image is taken, read out from the sensor, digitized, and sent over the 1394 bus.
As all Oscar cameras are equipped with built in image memory, this sequence of events can be paused or delayed by using the *deferred image transport* feature.
Oscar cameras, by standard, are equipped with 32 (OF-810C: 64) MB of RAM. As an option, the memory can be extended at the factory to a maximum of 256 MB.
The table below shows how many frames can be stored by each model. The memory is arranged in a FiFo (First in First out) manner. This makes addressing for individual images unnecessary.

Model	#frames (32764MB)	# frames (256MB)
OF-320C	3	31
OF-510C	2	23
OF-810C	3	15

Table 40: FiFo memory size

Deferred image transport is especially useful for multi camera applications where a multitude of cameras grab a certain number of images without having to take consideration of the available bus bandwidth, DMA- and ISO-channels into account. The image transfer is controlled from the host computer by addressing individual cameras and reading out the desired number of images. Functionality is controlled by the following register:

Register	Name	Field	Bit	Description
0xF1000260	DEFERRED_TRANS	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	
		SendImage	[5]	Send NumOfImages now (auto reset)
		HoldImg	[6]	Enable/Disable deferred transport mode
		FastCapture	[7]	Enable/disable fast capture mode
		---	[8..15]	
		FiFoSize	[16..23]	Size of FiFo in number of images (read only)
		NumOfImages	[24..31]	W: Number of images to send R: Number of images in buffer

Table 41: Deferred mode configuration register

9.9.1 HoldImg mode

By setting the *HoldImg* flag, transport of the image over the 1394 bus is stopped completely. All captured images are stored in the internal ImageFiFo. The camera reports the maximum possible number of images in the FiFoSize variable.

ⓘ Pay attention to the maximum number of images that can be stored in FiFo. If more images are captured than the number in FiFoSize, the oldest images are overwritten.

ⓘ The extra *SendImage* flag is set to “true” to import the images from the camera. The camera sends the number of images that are entered in the *NumOfImages* parameter.

ⓘ If *NumOfImages* is “0” all images stored in FIFO are sent.

ⓘ If *NumOfImages* is not “0”, the corresponding number of images is sent.

ⓘ If the *HoldImg* field is set to “false”, all images in *ImageFIFO* are deleted. No images are sent.

ⓘ The last image in the FiFo will be corrupted when simultaneously used as input buffer while being read out. In this case, one image less than max. buffer size should be read out.

The following screenshot displays the sequence of commands needed to work with deferred mode.

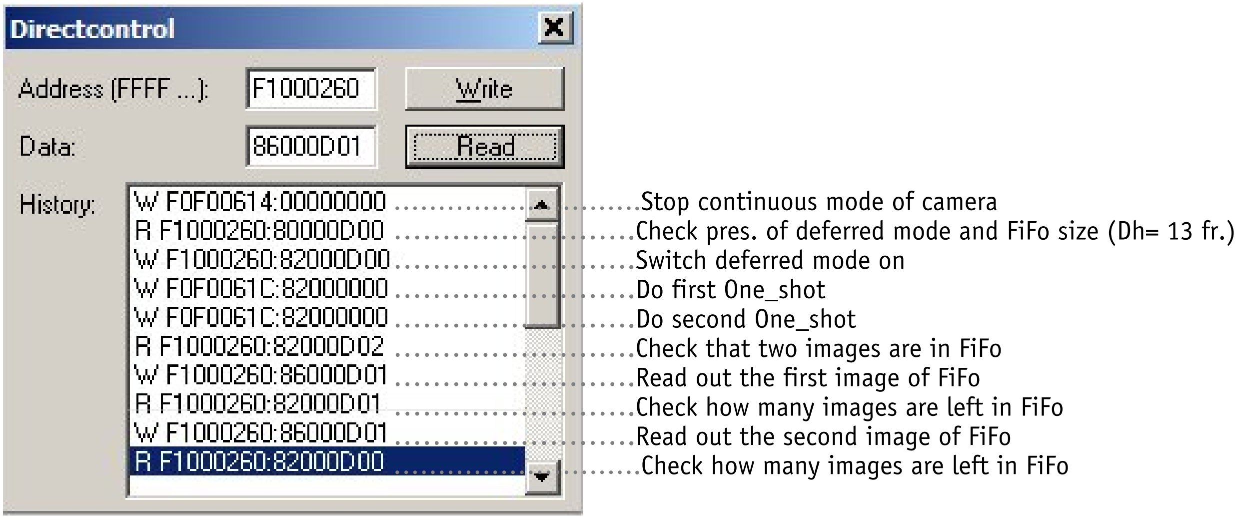


Figure 50: Example of controlling deferred mode

9.9.2 FastCapture

This mode can be activated only in Format_7.

When *FastCapture* is set to “false”, the maximum frame rate both for image acquisition and read out is associated with the packet size set in the BYTE_PER_PACKET register. The lower this value is, the lower the attainable frame rate is.

By setting *FastCapture* to “true“, all images are recorded at the highest possible frame rate, i.e. the setting above does not affect the frame rate for the image intake, but only the read out. This mode is ideal for applications where a burst of images is required to be recorded at the highest sensor speed, but the output can be at a lower frame frequency to save bandwidth.

10 Video formats, modes and bandwidth

The different Oscar models support different video formats, modes and frame rates, according to DCAM. Resolutions in Format_0, 1 and 2, which are smaller than the generic sensor resolution are generated symmetrically from the center of the sensor and without binning.

10.1 OF-320C

Format	Mode	Resolution	60 fps	30 fps *	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120 YUV444						
	1	320 x 240 YUV422		x	x	x	x	
	2	640 x 480 YUV411						
	3	640 x 480 YUV422						
	4	640 x 480 RGB8						
	5	640 x 480 MONO 8						
	6	640 x 480 MONO 16						
7	0	2080 x 1540 Mono8*			@ 6.59fps Joint Shutter			
	0	2080 x 1540 YUV411			@ 6.59fps Joint Shutter			
	0	2080 x 1540 YUV422			@ 5.11fps Joint Shutter			
	0	2080 x 1540 RGB8			@ 3.41fps Joint Shutter			
	0	2080 x 1540 Raw8*			@ 6.59fps Joint Shutter			
	0	2080 x 1540 Raw16*			@ 5.11fps Joint Shutter			
	0	2080 x 1540 Y8red, Y8green, Y8 blue*			@ 6.59fps Joint Shutter			
7	1	2080 x 1540 Mono8*			@ 6.59fps Split Shutter			
	1	2080 x 1540 YUV411			@ 6.59fps Split Shutter			
	1	2080 x 1540 YUV422			@ 5.11fps Split Shutter			
	1	2080 x 1540 RGB8			@ 3.41fps Split Shutter			
	1	2080 x 1540 Raw8*			@ 6.59fps Split Shutter			
	1	2080 x 1540 Raw16*			@ 5.11fps Split Shutter			
	1	2080 x 1540 Y8red, Y8green, Y8 blue*			@ 6.59fps Split Shutter			
7	2	344 x 254 Mono8*			@ 39.41fps*progr. scan, subsampl.			
	2	344 x 254 YUV411			@ 39.41fps*progr. scan, subsampl.			
	2	344 x 254 YUV422			@ 39.41fps*progr. scan, subsampl.			
	2	344 x 254 RGB8			@ 39.60fps*progr. scan, subsampl.			
	2	344 x 254 Raw8*			@ 39.41fps*progr. scan, subsampl.			
	2	344 x 254 Raw16*			@ 39.41fps*progr. scan, subsampl.			
	2	344 x 254 Y8red, Y8green, Y8 blue*			@ 39.41fps*progr. scan, subsampl.			

Table 42: Video formats OF-320C

*: Camera outputs RAW image which needs to be converted outside of camera.
*: Camera outputs interpolated B/W image using luminance interpolation formula
*: Camera outputs interpolated B/W image using one of the R-G-B color planes
*: Only achievable with shutter settings that don’t exceed 1/framerate

10.2 OF-510C

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
1	0	800 x 600 YUV422						
	1	800 x 600 RGB8						
	2	800 x 600 MONO8				x*	x*	
	3	1024 x 768 YUV422				X	x	
	4	1024 x 768 RGB8				X	x	
	5	1024 x 768 MONO 8						
	6	800 x 600 MONO16						
	7	1024 x 768 MONO16						
2	0	1280 x 960 YUV422				X	x	x
	1	1280 x 960 RGB8				X	x	x
	2	1280 x 960 MONO 8				x*	x*	x*
	3	1600 x 1200 YUV422						
	4	1600 x 1200 RGB8						
	5	1600 x 1200 MONO8						
	6	1280 x 960 MONO16						
	7	1600 x 1200 MONO16						
7	0	2588 x 1958 Mono8*			@ 3.80fps Joint Shutter			
	0	2588 x 1958 YUV411			@ 3.80fps Joint Shutter			
	0	2588 x 1958 YUV422			@ 3.23fps Joint Shutter			
	0	2588 x 1958 RGB8			@ 2.16fps Joint Shutter			
	0	2588 x 1958 Raw8*			@ 3.80fps Joint Shutter			
	0	2588 x 1958 Raw16*			@ 3.23fps Joint Shutter			
	0	2588 x 1958 Y8red, Y8green, Y8 blue*			@ 3.80fps Joint Shutter			
7	1	2588 x 1958 Mono8*			@ 3.80fps Joint Shutter			
	1	2588 x 1958 YUV411			@ 3.80fps Joint Shutter			
	1	2588 x 1958 YUV422			@ 3.23fps Joint Shutter			
	1	2588 x 1958 RGB8			@ 2.16fps Joint Shutter			
	1	2588 x 1958 Raw8*			@ 3.80fps Joint Shutter			
	1	2588 x 1958 Raw16*			@ 3.23fps Joint Shutter			
	1	2588 x 1958 Y8red, Y8green, Y8 blue*			@ 3.80fps Joint Shutter			
7	2	1288 x 978 Mono8*			@ 7.59fps progr. scan, subsampl.			
	2	1288 x 978 YUV411			@ 7.58fps progr. scan, subsampl.			
	2	1288 x 978 YUV422			@ 7.59fps progr. scan, subsampl.			
	2	1288 x 978 RGB8			@ 7.59 fps progr. scan, subsampl.			
	2	1288 x 978 Raw8*			@ 7.59fps progr. scan, subsampl.			
	2	1288 x 978 Raw16*			@ 7.59fps progr. scan, subsampl.			
	2	1288 x 978 Y8red, Y8green, Y8 blue*			@ 7.59fps progr. scan, subsampl.			

Table 43: Video formats OF-510C

10.3 OF-810C

For-mat	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
1	0	800 x 600 YUV422						
	1	800 x 600 RGB8						
	2	800 x 600 MONO8						
	3	1024 x 768 YUV422				x	x	
	4	1024 x 768 RGB8				x	x	
	5	1024 x 768 MONO 8				x*	x*	
	6	800 x 600 MONO16						
	7	1024 x 768 MONO16						
7	0	3272 x 2469 Mono8*	@ 3.15fps Joint Shutter					
	0	3272 x 2469 YUV411	@ 2.70fps Joint Shutter					
	0	3272 x 2469 YUV422	@ 2.03fps Joint Shutter					
	0	3272 x 2469 RGB8	@ 1.35fps Joint Shutter					
	0	3272 x 2469 Raw8*	@ 3.15fps Joint Shutter					
	0	3272 x 2469 Raw16*	@ 2.03fps Joint Shutter					
	0	3272 x 2469 Y8red, Y8green, Y8 blue*	@ 3.15fps Joint Shutter					
7	1	3272 x 2469 Mono8*	@ 3.15fps Joint Shutter					
	1	3272 x 2469 YUV411	@ 2.70fps Joint Shutter					
	1	3272 x 2469 YUV422	@ 2.03fps Joint Shutter					
	1	3272 x 2469 RGB8	@ 1.35fps Joint Shutter					
	1	3272 x 2469 Raw8*	@ 3.15fps Joint Shutter					
	1	3272 x 2469 Raw16*	@ 2.03fps Joint Shutter					
	1	3272 x 2469 Y8red, Y8green, Y8 blue*	@ 3.15fps Joint Shutter					
7	2	1088 x 822 Mono8*	@ 8.87fps progr. scan, subsampl.					
	2	1088 x 822 YUV411	@ 8.89fps progr. scan, subsampl.					
	2	1088 x 822 YUV422	@ 8.89fps progr. scan, subsampl.					
	2	1088 x 822 RGB8	@ 8.89fps progr. scan, subsampl.					
	2	1088 x 822 Raw8*	@ 8.87fps progr. scan, subsampl.					
	2	1088 x 822 Raw16*	@ 8.89fps progr. scan, subsampl.					
	2	1088 x 822 Y8red, Y8green, Y8 blue*	@ 8.87fps progr. scan, subsampl.					

Table 44: Video formats OF-810C

10.4 Area of interest (AOI)

The image sensor on the camera has a defined resolution. This indicates the maximum number of lines and pixels per line that the recorded image may have.

However, often only a certain section of the entire image is of interest. The amount of data to be transferred can be decreased by reducing the image to a smaller area when reading it from the camera. At a lower vertical resolution the sensor can be read out faster and thus the frame rate be increased.

ⓘ The setting of AOI's is supported only in video Format_7.

While the size of the image for most other video formats and modes is fixed by the IIDC specification, thus determining the highest possible frame rate, in Format_7 mode the user can set the "upper left corner" and "width and height" of the section (Area of Interest) of interest to determine the size and thus the highest possible frame rate.

Setting the AOI is done in the IMAGE_POSITION and IMAGE_SIZE registers.
Attention should be paid to the increments entered in the UNIT_SIZE_INQ and UNIT_POSITION_INQ registers when configuring IMAGE_POSITION and IMAGE_SIZE.

IMAGE_POSITION and IMAGE_SIZE contain in the respective bits values for the column and line of the upper left corner and values for the width and height.

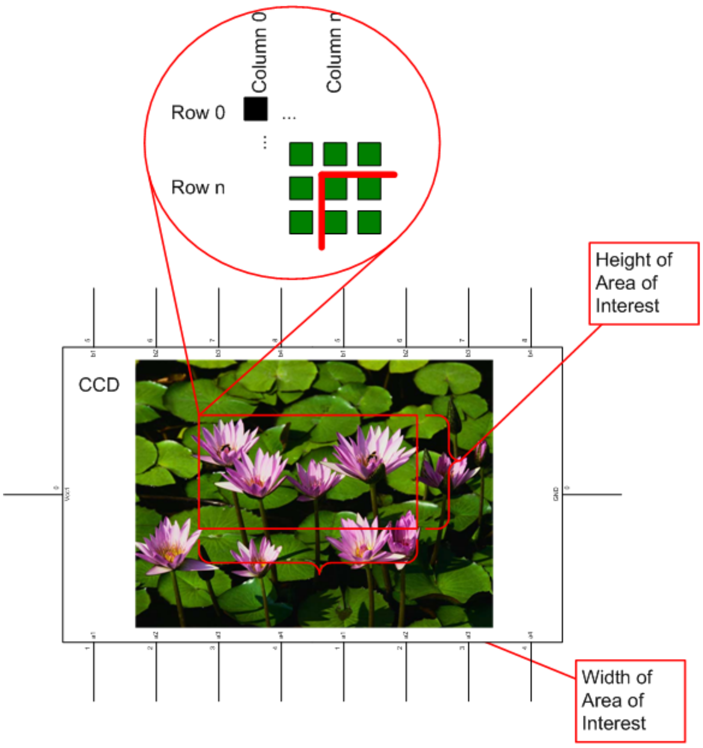


Figure 51: Area of Interest

ⓘ The left position + width and the upper position + height may not exceed the maximum resolution of the sensor. The increments may vary from model and mode.

ⓘ The coordinates for width and height must be divisible by a factor which is depending on the camera model.

The following table lists the various increments in pixel (px) as a function of the camera model and mode.

Camera	OF-320C	OF-510C	OF-810CF_7 Mode_0/1	OF-810C F_7 Mode_2
H-Pos	2 px	2 px	2 px	2 px
V-Pos	2 px	2 px	6 px	2 px
H-Size	4 px	4 px	4 px	4 px
V-Size	2 px	2 px	3 px	2 px

Table 45: AOI increments per camera model and Format_7 mode

In addition to the Area of Interest, other parameters have an effect on the maximum frame rate:

- the time for reading the image from the sensor and transporting it into the FRAME_BUFFER
- the time for transferring the image over the FireWire™ bus
- the length of the exposure time.

The next chapter illustrates this in more detail.

10.5 Frame rates

An IEEE-1394 camera requires bandwidth to transport images.

The IEEE-1394a bus has very large bandwidth of at least 32 MB/s for transferring (isochronously) image data. Per cycle up to 4096 bytes (or around 1000 quadlets = 4 bytes) can therefore be transmitted.
Depending on the video format settings and the configured frame rate, the camera requires a certain percentage of the maximum available bandwidth. The larger the image and the higher the frame rate is, the higher the data transmission will be.
The following tables indicate the volume of data in various formats and modes to be sent within one cycle (125µs) at 400 Mb/s of bandwidth.
The tables are divided into three formats; F_0 up to VGA, F_1 up to XGA, and F_2 up to UXGA.
They enable you to calculate the required bandwidth and to ascertain the number of cameras that can be operated independently on a bus and in which mode.

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps
0	0	160 x 120 YUV (4:4:4) 24 bit/pixel		1/2H 80p 60q	1/4H 40p 30q	1/8H 20p 15q	
	1	320 x 240 YUV (4:2:2) 16 bit/pixel		1H 320p 160q	1/2H 160p 80q	1/4H 80p 40q	1/8H 40p 20q
	2	640 x 480 YUV (4:1:1) 12 bit/pixel		2H 1280p 480q	1H 640p 240q	1/2H 320p 120q	1/4H 160p 60q
	3	640 x 480 YUV (4:2:2) 16 bit/pixel		2H 1280p 640q	1H 640p 320q	1/2H 320p 160q	1/4H 160p 80q
	4	640 x 480 RGB 24 bit/pixel		2H 1280p 960q	1H 640p 480q	1/2H 320p 240q	1/4H 160p 120q
	5	640 x 480 (MONO8) 8 bit/pixel	4H 2560p 640q	2H 1280p 320q	1H 640p 160q	1/2H 320p 80q	1/4H 160p 40q
	6	640 x 480 Y (MONO16) 16 Bit/pixel		2H 1280p 640q	1H 640p 320q	1/2H 320p 160q	1/4H 160p 80q
	7	640 x 480 Y (MONO16) Reserved					

Table 46: Format_0

As an example, VGA MONO8 @ 60 fps requires four lines (640 x 4 = 2560 pixels/byte) to transmit every 125 µs: this is a consequence of the sensor's line time of about 30 µs, therefore no data needs to be stored temporarily. It takes 120 cycles (120 x 125 µs = 15 ms) to transmit one frame, these arriving every 16.6 ms from the camera. Again there is no requirement to store the data temporarily.
Thus around 64 % of the available bandwidth is used.

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
1	0	800 x 600 YUV (4:2:2) 16 bit/pixel		5/2H 2000p 1000q	5/4H 1000p 500q	5/8H 500p 250q	6/16H 250p 125q	
	1	800 x 600 RGB 24 Bit/pixel			5/4H 1000p 750q	5/8H 500p 375q		
	2	800 x 600 Y (MONO8) 8 bit/pixel	5H 4000p 1000q	5/2H 2000p 500q	5/4H 1000p 250q	5/8H 500p 125q		
	3	1024 x 768 YUV (4:2:2) 16 bit/pixel			3/2H 1536p 768q	3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q
	4	1024 x 768 RGB 24 bit/pixel				3/4H 768p 576q	3/8H 384p 288q	3/16H 192p 144q
	5	1024 x 768 Y (MONO) 8 bit/pixel		3H 3072p 768q	3/2H 1536p 384q	3/4H 768p 192q	3/8H 384p 96q	3/16H 192p 48q
	6	800 x 600 (MONO16) 16 bit/pixel		5/2H 2000p 1000q	5/4H 1000p 500q	5/8H 500p 250q	5/16H 250p 125q	
	7	1024 x 768 Y (MONO16) 16 bit/pixel			3/2H 1536p 768q	3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q

Table 47: Format_1

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
2	0	1280 x 960 YUV (4:2:2) 16 bit/pixel				1H 1280p 640q	1/2H 640p 320q	1/4H 320p 160q
	1	1280 x 960 RGB 24 bit/pixel				1H 1280p 960q	1/2H 640p 480q	1/4H 320p 240q
	2	1280 x 960 Y (MONO8) 8 bit/pixel			2H 2560p 640q	1H 1280p 320q	1/2H 640p 160q	1/4H 320p 80q
	3	1600 x 1200 YUV(4:2:2) 16 bit/pixel				5/4H 2000p 1000q	5/8H 1000p 500q	5/16H 500p 250q
	4	1600 x 1200 RGB 24 bit/pixel					5/8H 1000p 750q	5/16 500p 375q
	5	1600 x 1200 Y (MONO) 8 bit/pixel			5/2H 4000p 1000q	5/4H 2000p 500q	5/8H 1000p 250q	5/16H 500p 125q
	6	1280 x 960 Y (MONO16) 16 bit/pixel				1H 1280p 640q	1/2H 640p 320q	1/4H 320p 160q
	7	1600 x 1200Y(MONO16) 16 bit/pixel				5/4H 2000p 1000q	5/8H 1000p 500q	5/16H 500p 250q

Table 48: Format_2

As already mentioned, the recommended limit for transferring isochronous image data is 1000q (quadlets) per cycle or 4096 bytes (with 400 Mb/s of bandwidth).

The third table shows that in Format_2 Mode_2 @ 7.5 fps a camera has to send 1280 pixels or 1 line of video per cycle. The camera therefore uses 32 % of available bandwidth. This allows up to three cameras with these settings to be operated independently on the same bus.

ⓘ If the cameras are operated with an external trigger, the maximum trigger frequency should not exceed the highest continuous frame rate as this will prevent frames from being dropped or corrupted.

ⓘ IEEE-1394 adapter cards with PCILynx™ chipsets have a lower limit of 4000 bytes per cycle.

The frame rates in video modes 0 to 2 are specified and set fixed by IIDC V. 1.3.

In video Format_7 frame rates are no longer fixed but can be varied dynamically by the parameters described below.

The following formula is used to calculate for the CCD models the highest frame rate in Format_7:

$$FPS_{In} = FPS_{CCD} = \frac{1}{T_{ChargeTrans} + T_{Dummy} + T_{Dump} + T_{Scan}}$$

Formula 4: Frame rate calculation

It assumes that the maximum frame rate is the inverse of the sum of all events in a CCD, which consume time such as:

- time to transfer the charge to the vertical shift register (Charge transfer time)
- time to shift out the dummy lines
- time to dump the lines outside the AOI
- time to shift out the lines of the AOI. (Scanning time)

For the different sensors, different values apply.
Frame rates may be further limited by longer shutter times and/or bandwidth limitation from the IEEE-1394 bus.
This is not part of the formulae below.

10.5.1 OF-320C

Frame rates differ for the **progressive scan** mode and the **field read out** (or interlaced) mode. For progressive scan mode (i.e. fixed formats and Format_7, Mode_2), the following formulae apply:

$$fps = \frac{1}{T_{ChargeTrans+TDummy} + T_{Dump} + T_{Scan}}$$

$$fps = \frac{1}{290\mu s + (257 - AOI\_HEIGHT) \cdot 6.8\mu s + AOI\_HEIGHT \cdot 98\mu s}$$

Formula 5: Frame rate calculation progressive scan mode OF-320C

Progressive

AOI_HEIGHT	Tframe/s	FPS
254	0,025	39,679
240	0,024	41,796
120	0,013	77,032
60	0,008	133,163
30	0,005	209,486

Table 49: Frame rates progressive OF-320C

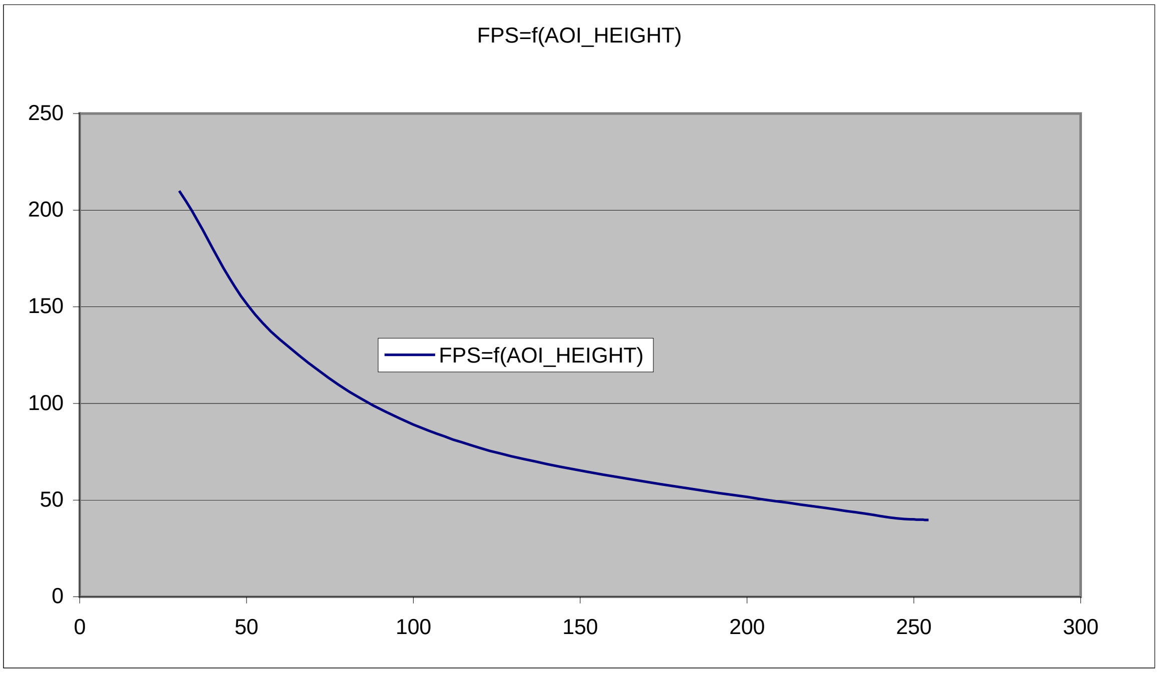


Figure 52: Graph of frame rates in progresive scan mode OF-320C

For interlaced mode, the following formula applies:

$$fps = \frac{1}{T_{ChargeTrans+TDummy} + T_{Dump} + T_{Scan}}$$

$$fps = \frac{1}{580\mu s + (1542 - AOI\_HEIGHT) \cdot 6.8\mu s + AOI\_HEIGHT \cdot 98\mu s}$$

Formula 6: Frame rate calculation interlaced mode OF-320C

Interlaced (Format7, Mode0 und Mode1)

AOI_HEIGHT	Tframe/s	FPS
1540	0,152	6,600
1536	0,151	6,616
1200	0,121	8,298
1024	0,104	9,574
960	0,099	10,140
600	0,066	15,201
480	0,055	18,234
240	0,033	30,346
120	0,022	45,435
60	0,017	60,468

Table 50: Frame rates interlaced mode OF-320C

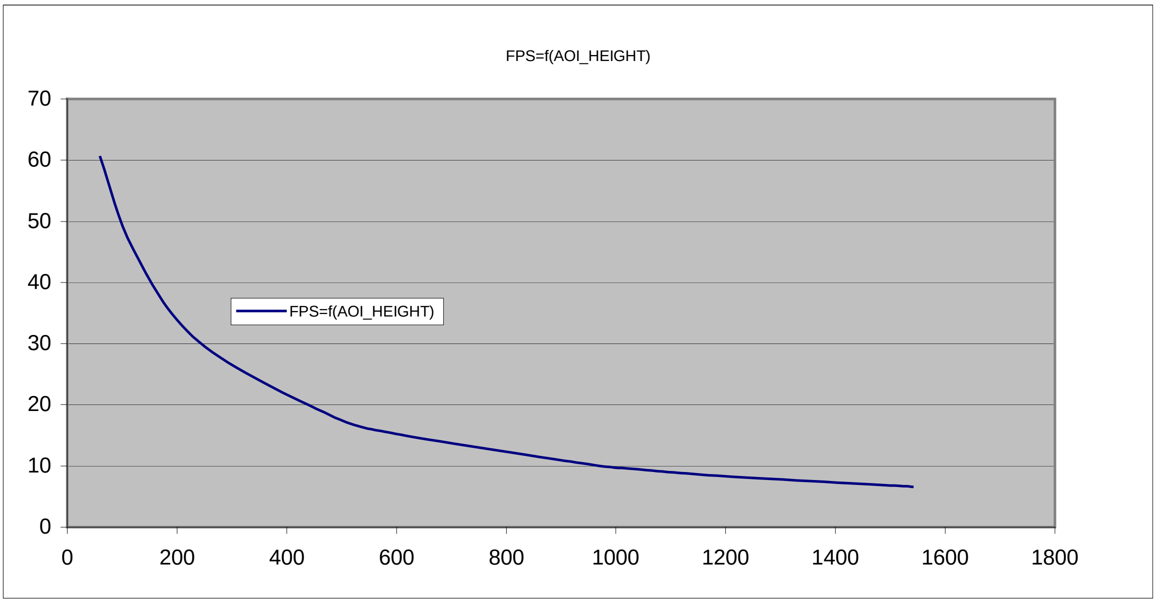


Figure 53: Graph of frame rates interlaced mode OF-320C

10.5.2 OF-510C

Frame rates differ for the **progressive scan** mode and the **field read out** (or interlaced) mode.

For progressive scan mode (i.e. fixed formats and Format_7, Mode_2), the following formulae apply:

$$fps = \frac{1}{T_{ChargeTrans+TDummy} + T_{Dump} + T_{Scan}}$$

$$fps = \frac{1}{230\mu s + (1038 - AOI\_HEIGHT) \cdot 4.9\mu s + AOI\_HEIGHT \cdot 134\mu s}$$

Formula 7: Frame rate calculation progressive scan mode OF-510C

AOI_HEIGHT	Tframe/s	FPS
980	0,132	7,585
960	0,129	7,737
960	0,129	7,737
600	0,083	12,081
480	0,067	14,862
240	0,036	27,548
120	0,021	48,058

Table 51: Frame rates progressive scan OF-510C

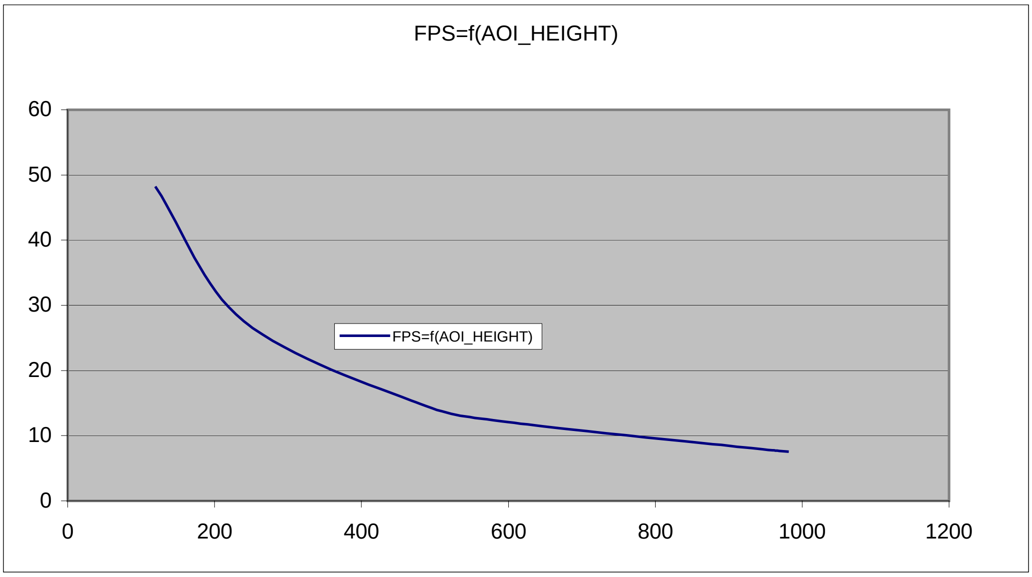


Figure 54: Graph of frame rate in progressive scan mode OF-510C

For all **interlaced** modes (i.e. Format_7 Mode_0 and 1), the following formula applies:

$$fps = \frac{1}{2*(233\mu s + (987 - \frac{AOI\_HEIGHT}{2}) \cdot 4.9\mu s + \frac{AOI\_HEIGHT}{2} \cdot 134\mu s}$$

Formula 8: Frame rate calculation interlaced modes OF-510C

AOI_HEIGHT	Tframe/s	FPS
1960	0,263	3,800
1536	0,208	4,798
1200	0,165	6,058
1024	0,142	7,025
960	0,134	7,458
600	0,088	11,415
480	0,072	13,868
240	0,041	24,316

Table 52: Frame rates interlaced modes OF-510C

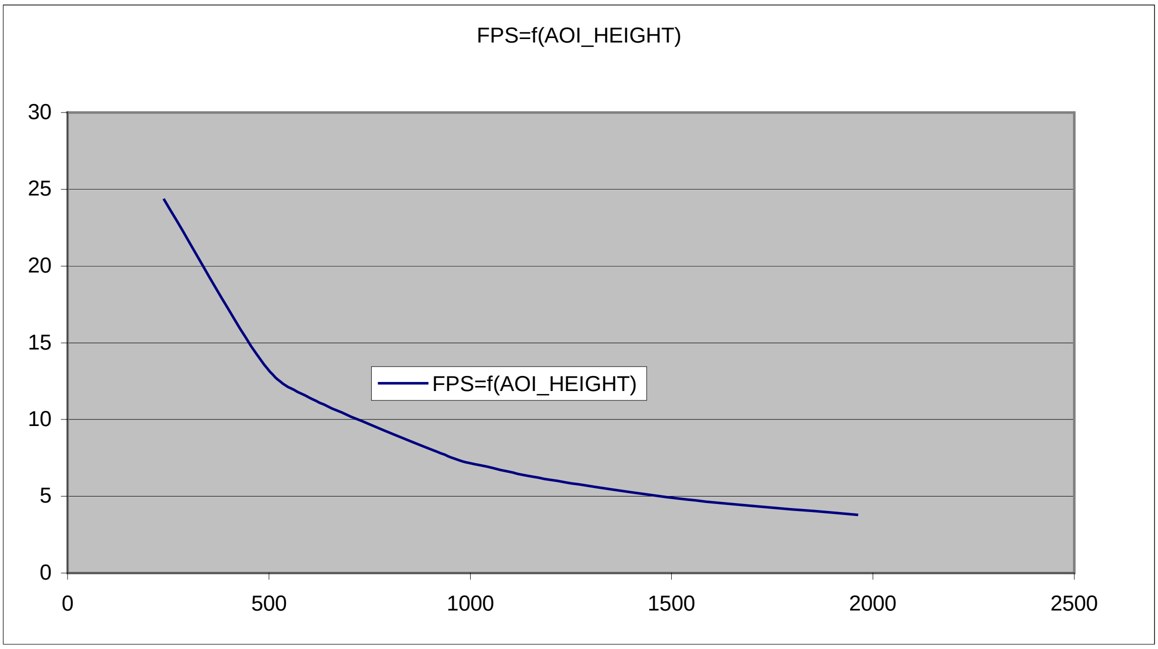


Figure 55: Graph of frame rates interlaced mode OF-510C

10.5.3 OF-810C

Frame rates differ for the **progressive scan** mode and the field read out mode.

For progressive scan mode (i.e. fixed formats and Format_7, Mode_2), the following formulae apply:

$$fps = \frac{1}{T_{ChargeTrans+TDummy} + T_{Dump} + T_{Scan}}$$

$$fps = \frac{1}{276\mu s + (1246 - AOI\_HEIGHT) \cdot 16\mu s + AOI\_HEIGHT \cdot 128\mu s}$$

Formula 9: Frame rate calculation progressive modies OF-810C

The table details the frame rates for representative image heights.

AOI_HEIGHT	Tframe/s	FPS
822	0,112	8,907
600	0,087	11,440
480	0,074	13,519
240	0,047	21,235
120	0,034	29,716

Table 53: Frame rate and readout times progressive scan modes

The graph below shows the frame rate as a function of AOI height for the progressive scan modes.

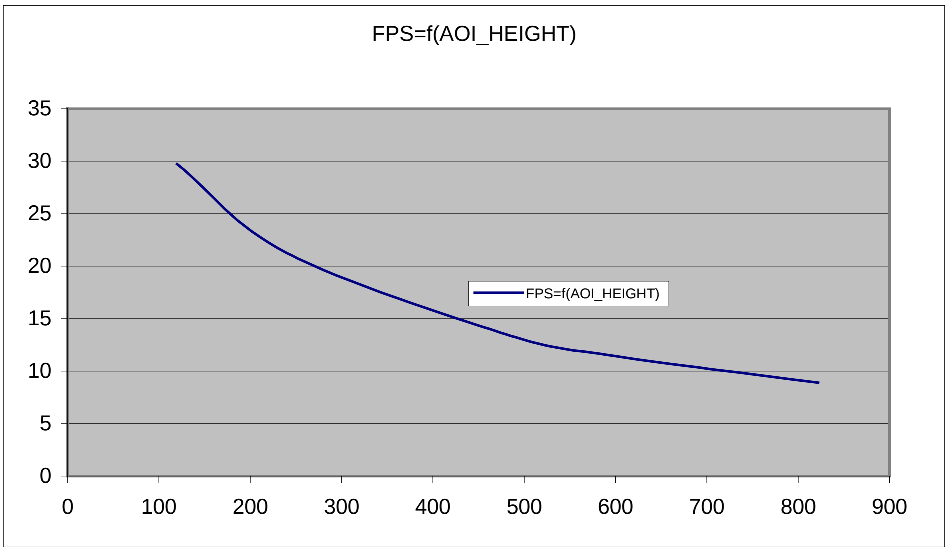


Figure 56: Graph of frame rate as function of image height for progressive scan formats

For all **interlaced** modes (i.e. Format_7 Mode_0 and 1), the following formula applies:

$$fps = \frac{1}{3*(291\mu s + (831 - \frac{AOI\_HEIGHT}{3}) \cdot 16\mu s + \frac{AOI\_HEIGHT}{3} \cdot 128\mu s}$$

Formula 10: Frame rate calculation interlaced modes OF-810C

AOI_HEIGHT	Tframe/s	FPS
2470	0,317	3,151
2400	0,310	3,230
1536	0,213	4,699
1200	0,175	5,709
1024	0,155	6,433
960	0,148	6,744
600	0,108	9,263
480	0,095	10,580
240	0,068	14,784

Table 54: Frame rates interlaced modes OF-810C

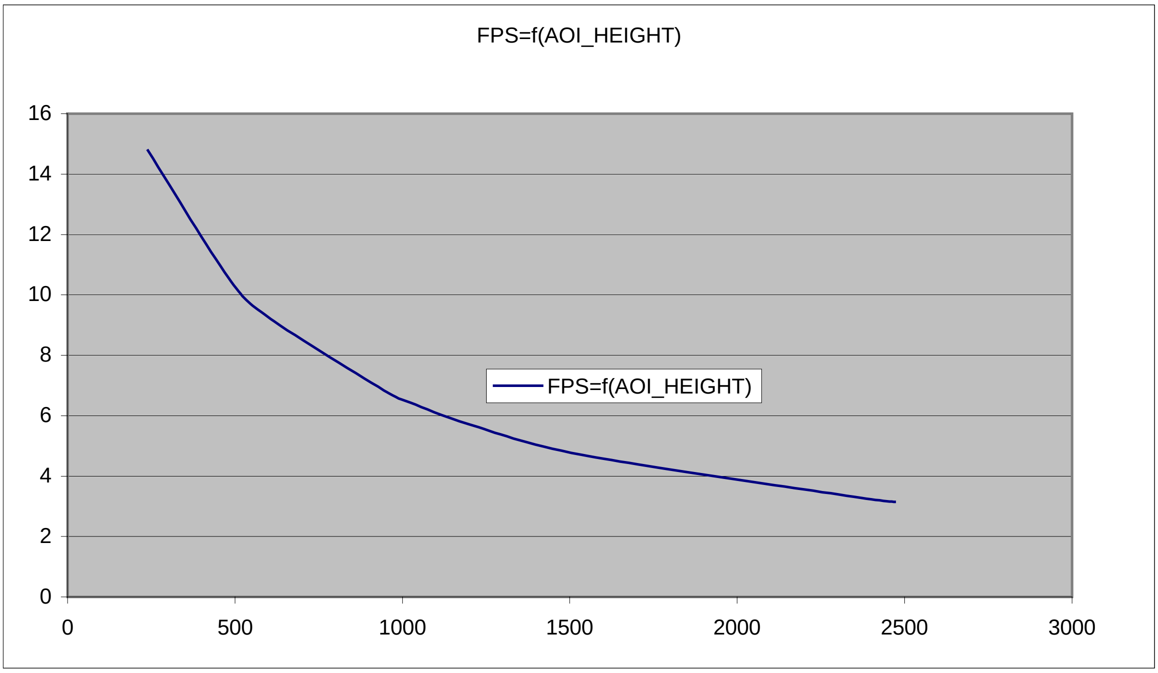


Figure 57: Graph of frame rate as function of image height for interlaced scan formats OF-810C

11 How does bandwidth affect the frame rate?

In some modes, the IEEE-1394a bus limits the attainable frame rate. According to the 1394a specification on isochronous transfer, the largest data payload size of 4096 bytes per 125 µs cycle is possible with bandwidth of 400 Mb/s. In addition, because of a limitation in an IEEE-1394 module (GP2Lynx), only a maximum number of 4095 packets per frame are allowed.

The following formula establishes the relationship between the required Byte_Per_Packet size and certain variables for the image. It is valid only for Format_7.

$$BYTE\_PER\_PACKET = fps \bullet AoiWidth \bullet AoiHeight \bullet ByteDepth \bullet 125\mu s$$

Formula 11: Byte_per_Packet calculation

If the value for "BYTE_PER_PACKET" is greater than 4096 (the maximum data payload), the required frame rate cannot be attained. The attainable frame rate can be calculated using this formula:

(Provision: "BYTE_PER_PACKET" is divisible by 4):

$$fps \approx \frac{BYTE\_PER\_PACKET}{AoiWidth \cdot AoiHeight \cdot ByteDepth \cdot 125\,\mu s}$$

Formula 12: Max. fps Calculation

ByteDepth based on the following values:

Mono8	=> 8 bits/pixel	= 1	byte per pixel
Mono16	=> 16 bits/pixel	= 2	bytes per pixel
YUV4:2:2	=> 16 bits/pixel	= 2	bytes per pixel
YUV4:1:1	=> 12 bits/pixel	= 1.5	bytes per pixel
RGB8	=> 24 bits/pixel	= 3	bytes per pixel

Example formula for the OF-810C camera:

RGB8, 3272 x 2469 pixel – 2 fps desired

$$BYTE\_PER\_PACKET = 2 \cdot 3272 \cdot 2469 \cdot 3 \cdot 125\mu s = 6004 > 4096$$

$$\Rightarrow fps_{reachable} \approx \frac{4096}{3272 \cdot 2469 \cdot 3 \cdot 125\mu s} = 1{,}35$$

Formula 13: Example max. fps calculation

11.1 Test images

The cameras have two test images.

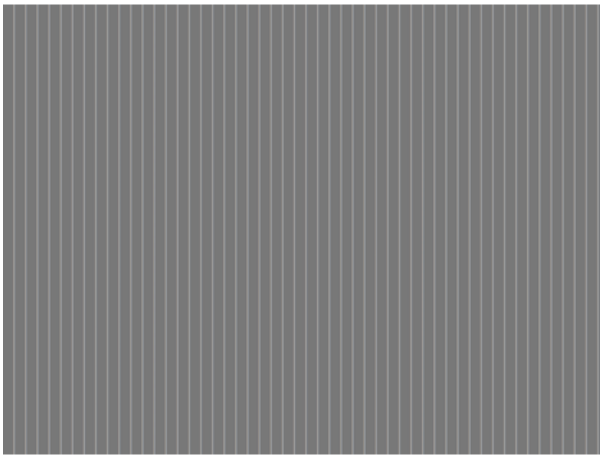


Figure 58: Test image 1

The second test image is in colors:

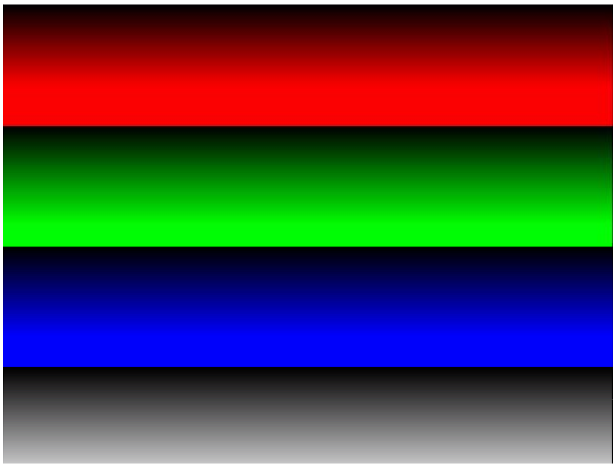


Figure 59: Test image 2

12 Configuration of the camera

All camera settings are made by writing specific values into the corresponding registers. This applies for both general operating states such as video formats and modes, exposure times, etc. and to all extended features of the camera that are turned on and off and controlled via corresponding registers.

12.1 Camera_Status_Register

The interoperability of cameras from different manufacturers is ensured by IIDC, formerly DCAM (Digital Camera Specification), published by the IEEE-1394 Trade Association.
IIDC is primarily concerned with setting memory addresses (e.g. CSR: Camera_Status_Register) and their meaning.

In principle all addresses in IEEE-1394 networks are 64 bits long.

The first 10 bits describe the Bus_Id, the next 6 bits the Node_Id.
Of the subsequent 48 bits, the first 16 are is always FFFFh, leaving the description for the Camera_Status_Register in the last 32 bits.

If in the following, mention is made of a CSR F0F00600h, this means in full:

Bus_Id, Node_Id, FFFF F0F00600h

Writing and reading to and from the register can be done with programs such as “FireView” or by other programs developed using an API library(e.g. FirePackage).

Every register is 32 bit (Big Endian) and implemented as follows:

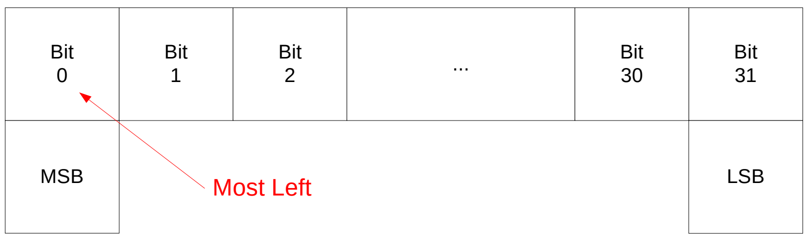
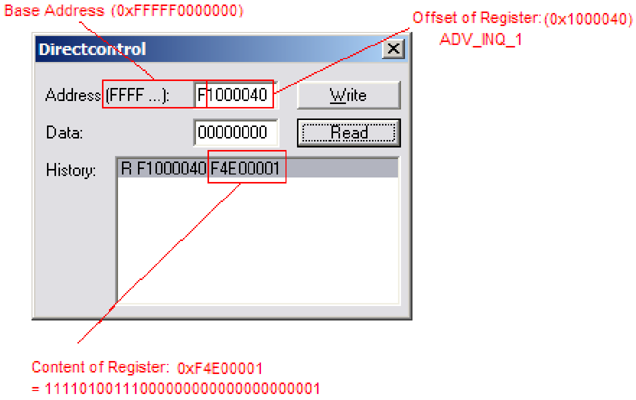


Figure 60: 32-bit register

This example requires that to enable *ISO_Enabled* mode (ISO_Enable / Free-Run) (bit 0 in register 614h), the value 80000000 h must be written into the corresponding register.



	MaxResolution	TimeBase	ExtdShutter	TestImage		Sequences			Lookup Tables	Shading	DeferredTrans					
Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1	1	1	1	0	1	0	0	1	1	1	0	0	0	0	0

																GP_Buffer
Bit	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Figure 61: Configuration of the camera

12.2 Configuration ROM

The information in the Configuration ROM is needed to identify the node, its capabilities and which drivers are required.

The base address for the “configuration ROM” for all registers is FFFF F0000000h.
The ConfigRom is divided into the

- Bus info block: providing critical information about the bus-related capabilities,
- Root directory: specifying the rest of the content and organization, such as:
    - Node unique ID leaf
    - Unit directory and
    - Unit dependant info.

The base address of the camera control register is calculated as follows based on the camera-specific base address:

	Offset	0-7	8-15	16-23	24-31	
Bus info block	400h	04	24	45	EE	
	404h	31	33	39	34	…. ASCII for 1394
	408h	20	00	A0	00	…. Bus capabilities
	40Ch	00	0A	47	01	…. Node_Vendor_Id, Chip_id_hi
	410h	00	00	Serial number		…. Chip_id_lo
Root directory	414h	00	04	B7	85	
	418h	03	00	0A	47	
	41Ch	0C	00	83	C0	
	420h	8D	00	00	02	
	424h	D1	00	00	04	

According to IEEE1212, the root directory may have another length. The keys (e.g. 8D) point to the offset factors rather than the offset (e.g.420h) itself.

Table 55: Config Rom

The entry with key 8D in the root directory (420h in this case) provides the offset for the unique ID leaf node as follows: 420h + 000002 * 4 = 428h

	Offset	0-7	8-15	16-23	24-31
Node unique ID leaf	428h	00	02	CA	71
	42Ch	00	0A	47	01
	430h	00	00	Serial number	

The entry with key D1 in the root directory (424h in this case) provides the offset for the unit directory as follows: 424h + 000004 * 4 = 434h

	Offset	0-7	8-15	16-23	24-31
Unit directory	434h	00	03	93	7D
	438h	12	00	A0	2D
	43Ch	13	00	01	02
	440h	D4	00	00	01

The entry with key D4 in the unit directory (440h in this case) provides the offset for unit dependent info: 440h + 000001 * 4 = 444h

	Offset	0-7	8-15	16-23	24-31
	444h	00	03	7F	89

Unit dependent info	448h	40	3C	00	00
	44Ch	81	00	00	02
	450h	82	00	00	06

Table 56: ConfigRom cont.

And finally, the entry with key 40 (448h in this case) provides the offset for the camera control register:

FFFF F0000000h + 3C0000h * 4 = FFFF F0F00000h

The base address of the camera control register is thus
FFFF F0F00000h.

The offset entered in the table always refers to the base address of F0F00000h.

ⓘ This means that if you want to use the "DirectControl" program to read or write to a register, the following value must be entered in the *Address* field:

"F0F00000h + Offset"

12.3 Implemented registers

The following tables show how standard registers from IIDC v. 1.3 are implemented in the camera. Base address is F0F00000h. Differences and explanations can be found in the third column.

12.3.1 Camera initialize register

Offset	Name	Notes
000h	INITIALIZE	Assert MSB = 1 for Init.

Table 57: Camera initialize register

12.3.2 Inquiry register for video format

Offset	Name	Field	Bit	Description
100h	V_FORMAT_INQ	Format_0	[0]	Up to VGA (non compressed)
		Format_1	[1]	SVGA to XGA
		Format_2	[2]	SXGA to UXGA
		Format_3	[3..5]	Reserved
		Format_6	[6]	Still Image Format
		Format_7	[7]	Partial Image Fomat
		-	[8..31]	Reserved

Table 58: Format inquiry register

12.3.3 Inquiry register for video mode

Offset	Name	Field	Bit	Description
180h	V_MODE_INQ (Format_0)	Mode_0	[0]	160 x 120 YUV 4:4:4
		Mode _1	[1]	320 x 240 YUV 4:2:2
		Mode _2	[2]	640 x 480 YUV 4:1:1
		Mode _3	[3]	640 x 480 YUV 4:2:2
		Mode _4	[4]	640 x 480 RGB
		Mode _5	[5]	640 x 480 MONO8
		Mode _6	[6]	640 x 480 MONO16
		Mode _X	[7]	Reserved
		-	[8..31]	Reserved zero)
184h	V_MODE_INQ (Format_1)	Mode_0	[0]	800 x 600 YUV 4:2:2
		Mode _1	[1]	800 x 600 RGB
		Mode _2	[2]	800 x 600 MONO8
		Mode _3	[3]	1024 x 768 YUV 4:2:2
		Mode _4	[4]	1024 x 768 RGB

		Mode _5	[5]	1024 x 768 MONO8
		Mode _6	[6]	800 x 600 MONO16
		Mode _7	[7]	1024 x 768 MONO16
		-	[8..31]	Reserved (zero)
188h	V_MODE_INQ (Format_2)	Mode_0	[0]	1280 x 960 YUV 4:2:2
		Mode _1	[1]	1280 x 960 RGB
		Mode _2	[2]	1280 x 960 MONO8
		Mode _3	[3]	1600 x 1200 YUV 4:2:2
		Mode _4	[4]	1600 x 1200 RGB
		Mode _5	[5]	1600 x 1200 MONO8
		Mode _6	[6]	1280 x 960 MONO16
		Mode _7	[7]	1600 x 1200 MONO16
		-	[8..31]	Reserved (zero)
18Ch … 197h	Reserved for other V_MODE_INQ_x for Format_x.			always 0
198h	V_MODE_INQ_6 (Format_6)			always 0
19Ch	V_MODE_INQ (Format_7)	Mode_0	[0]	Format_7 Mode_0
		Mode _1	[1]	Format_7 Mode_1
		Mode _2	[2]	Format_7 Mode_2
		Mode _3	[3]	Format_7 Mode_3
		Mode _4	[4]	Format_7 Mode_4
		Mode _5	[5]	Format_7 Mode_5
		Mode _6	[6]	Format_7 Mode_6
		Mode _7	[7]	Format_7 Mode_7
		-	[8..31]	Reserved (zero)

Table 59: Video mode inquiry register

12.3.4 Inquiry register for video frame rate and base address

Offset	Name	Field	Bit	Description
200h	V_RATE_INQ (Format_0, Mode_0)	FrameRate_0	[0]	Reserved
		FrameRate _1	[1]	Reserved
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
204h	V_RATE_INQ (Format_0, Mode_1)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
208h	V_RATE_INQ (Format_0, Mode_2)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
20Ch	V_RATE_INQ (Format_0, Mode_3)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)

Offset	Name	Field	Bit	Description
210h	V_RATE_INQ (Format_0, Mode_4)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
214h	V_RATE_INQ (Format_0, Mode_5)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
218h	V_RATE_INQ (Format_0, Mode_6)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
21Ch … 21Fh	Reserved V_RATE_INQ_0_x (for other Mode_x of Format_0)			always 0
220h	V_RATE_INQ (Format_1, Mode_0)	FrameRate_0	[0]	Reserved
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)

Offset	Name	Field	Bit	Description
224h	V_RATE_INQ (Format_1, Mode_1)	FrameRate_0	[0]	Reserved
		FrameRate _1	[1]	Reserved
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
228h	V_RATE_INQ (Format_1, Mode_2)	FrameRate_0	[0]	Reserved
		FrameRate _1	[1]	Reserved
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
22Ch	V_RATE_INQ (Format_1, Mode_3)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
230h	V_RATE_INQ (Format_1, Mode_4)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
234h	V_RATE_INQ (Format_1, Mode_5)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps

Offset	Name	Field	Bit	Description
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
238h	V_RATE_INQ (Format_1, Mode_6)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	240 fps (v1.31)
		-	[8..31]	Reserved (zero)
23Ch	V_RATE_INQ (Format_1, Mode_7)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
240h	V_RATE_INQ (Format_2, Mode_0)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	Reserved
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
244h	V_RATE_INQ (Format_2, Mode_1)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	Reserved

		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
Offset	**Name**	**Field**	**Bit**	**Description**
248h	V_RATE_INQ (Format_2, Mode_2)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	120 fps (v1.31)
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
24Ch	V_RATE_INQ (Format_2, Mode_3)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	Reserved
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
250h	V_RATE_INQ (Format_2, Mode_4)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	Reserved
		FrameRate _6	[6]	Reserved
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
254h	V_RATE_INQ (Format_2, Mode_5)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	Reserved
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
258h	V_RATE_INQ (Format_2, Mode_6)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps

		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	Reserved
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved (zero)
Offset	**Name**	**Field**	**Bit**	**Description**
25Ch	V_RATE_INQ (Format_2, Mode_7)	FrameRate_0	[0]	1.875 fps
		FrameRate _1	[1]	3.75 fps
		FrameRate _2	[2]	7.5 fps
		FrameRate _3	[3]	15 fps
		FrameRate _4	[4]	30 fps
		FrameRate _5	[5]	60 fps
		FrameRate _6	[6]	Reserved
		FrameRate _7	[7]	Reserved
		-	[8..31]	Reserved
260h … 2BFh	Reserved V_RATE_INQ_y_x (for other Format_y, Mode_x)			
2C0h	V_REV_INQ_6_0 (Format_6, Mode0)			always 0
2C4h .. 2DFh	Reserved V_REV_INQ_6_x (for other Mode_x of Format_6)			always 0
2E0h	V-CSR_INQ_7_0		[0..31]	CSR_quadlet offset for Format_7 Mode_0
2E4h	V-CSR_INQ_7_1		[0..31]	CSR_quadlet offset for Format_7 Mode_1
2E8h	V-CSR_INQ_7_2		[0..31]	CSR_quadlet offset for Format_7 Mode_2
2ECh	V-CSR_INQ_7_3		[0..31]	CSR_quadlet offset for Format_7 Mode_3
2F0h	V-CSR_INQ_7_4		[0..31]	CSR_quadlet offset for Format_7 Mode_4
2F4h	V-CSR_INQ_7_5		[0..31]	CSR_quadlet offset for Format_7 Mode_5
2F8h	V-CSR_INQ_7_6		[0..31]	CSR_quadlet offset for Format_7 Mode_6
2FCh	V-CSR_INQ_7_7		[0..31]	CSR_quadlet offset for Format_7 Mode_7

Table 60: Frame rate inquiry register

12.3.5 Inquiry register for basic function

Offset	Name	Field	Bit	Description
400h	BASIC_FUNC_INQ	Advanced_Feature_Inq	[0]	Inquiry for advanced features (Vendor unique Features)
		Vmode_Error_Status_Inq	[1]	Inquiry for existence of Vmode_Error_Status register
		Feature_Control_Error_Status_Inq	[2]	Inquiry for existence of Feature_Control_Error_Status
		Opt_Func_CSR_Inq	[3]	Inquiry for Opt_Func_CSR
		-	[4..7]	
		1394b_mode_Capability	[8]	Inquiry for 1394b_mode_Capability
		-	[9..15]	Reserved
		Cam_Power_Cntl	[16]	Camera process power ON/OFF capability
		-	[17..18]	Reserved
		One_Shot_Inq	[19]	One Shot transmission capability
		Multi_Shot_Inq	[20]	Multi Shot transmission capability
		-	[21..27]	Reserved
		Memory_Channel	[28..31]	Maximum memory channel number (N) If 0000, no user memory available

Table 61: Basic function inquiry register

12.3.6 Inquiry register for feature presence

Offset	Name	Field	Bit	Description
404h	FEATURE_HI_INQ	Brightness	[0]	Brightness Control
		Auto_Exposure	[1]	Auto_Exposure Control
		Sharpness	[2]	Sharpness Control
		White_Balance	[3]	White_Balance Control
		Hue	[4]	Hue Control
		Saturation	[5]	Saturation Control
		Gamma	[6]	Gamma Control
		Shutter	[7]	Shutter Control
		Gain	[8]	Gain Control
		Iris	[9]	Iris Control
		Focus	[10]	Focus Control
		Temperature	[11]	Temperature Control
		Trigger	[12]	Trigger Control
		Trigger_Delay	[13]	Trigger_Delay Control

		White_Shading	[14]	White_Shading Control
		Frame_Rate	[15]	Frame_Rate Control
			[16..31]	Reserved
408h	FEATURE_LO_INQ	Zoom	[0]	Zoom Control
		Pan	[1]	Pan Control
		Tilt	[2]	Tilt Control
		Optical_Filter	[3]	Optical_Filter Control
			[4..15]	Reserved
		Capture_Size	[16]	Capture_Size for Format_6
		Capture_Quality	[17]	Capture_Quality for Format_6
			[16..31]	Reserved
40Ch	OPT_FUNCTION_INQ	-	[0]	Reserved
		PIO	[1]	Parallel Input/Output control
		SIO	[2]	Serial Input/Output control
		Strobe_out	[4..31]	Strobe signal output
410h .. 47Fh		Reserved		Address error on access

Offset	Name	Field	Bit	Description
480h	Advanced_Feature_Inq	Advanced_Feature_Quadlet_Offset	[0..31]	Quadlet offset of the advanced feature CSR's from the base address of initial register space (Vendor unique) This register is the offset for the Access_Control_Register and thus the base address for Advanced Features. Access_Control_Register does not prevent access to advanced features. In some programs it should still always be activated first. "Advanced Feature Set Unique Value" is 7ACh and CompanyID is A47h.

484h	PIO_Control_CSR_Inq	PIO_Control_Quadlet_Offset	[0..31]	Quadlet offset of the PIO_Control CSR's from the base address of initial register space (Vendor unique)
488h	SIO_Control_CSR_Inq	SIO_Control_Quadlet_Offset	[0..31]	Quadlet offset of the SIO_Control CSR's from the base address of initial register space (Vendor unique)
48Ch	Strobe_Output_CSR_Inq	Strobe_Output_Quadlet_Offset	[0..31]	Quadlet offset of the Strobe_Output signal CSR's from the base address of initial register space (Vendor unique)

Table 62: Feature presence inquiry register

12.3.7 Inquiry register for feature elements

Register	Name	Field	Bit	Description
0xF0F00500	BRIGHTNESS_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		-	[2]	Reserved
		One_Push_Inq	[3]	One Push auto mode (Controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto Mode (Controlled automatically by the camera)
		Manual_Inq	[7]	Manual Mode (Controlled by user)
		Min_Value	[8..19]	Min. value for this feature
		Max_Value	[20..31]	Max. value for this feature
504h	AUTO_EXPOSURE_INQ	Same definition as Brightness_inq.		
508h	SHARPNESS_INQ	Same definition as Brightness_inq.		
50Ch	WHITE_BAL_INQ	Same definition as Brightness_inq.		
510h	HUE_INQ	Same definition as Brightness_inq.		
514h	SATURATION_INQ	Same definition as Brightness_inq.		
518h	GAMMA_INQ	Same definition as Brightness_inq.		
51Ch	SHUTTER_INQ	Same definition as Brightness_inq.		
520h	GAIN_INQ	Same definition as Brightness_inq.		
524h	IRIS_INQ	always 0		
528h	FOCUS_INQ	always 0		
52Ch	TEMPERATURE_INQ	Same definition as Brightness_inq.		

Offset	Name	Field	Bit	Description
530h	TRIGGER_INQ	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute value
		-	[2..3	Reserved
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Polarity_Inq	[6]	Capability of changing the polarity of the rigger input
			[7..15]	Reserved
		Trigger_Mode0_Inq	[16]	Presence of Trigger_Mode 0
		Trigger_Mode1_Inq	[17]	Presence of Trigger_Mode 1
		Trigger_Mode2_Inq	[18]	Presence of Trigger_Mode 2
		Trigger_Mode3_Inq	[19]	Presence of Trigger_Mode 3
			[20..31	Reserved
Offset	**Name**	**Field**	**Bit**	**Description**
534h	TRIGGER_DELAY_INQUIRY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Abs_Control_Inq	[1]	Capability of control with absolute

				value
		-	[2]	Reserved
		One_Push_Inq	[3]	One Push auto mode Controlled automatically by the camera once)
		Readout_Inq	[4]	Capability of reading out the value of this feature
		ON_OFF	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto Mode (Controlled automatically by the camera)
		Manual_Inq	[7]	Manual Mode (Controlled by user)
		Min_Value	[8..19]	Min. value for this feature
		Max_Value	[20..31]	Max. value for this feature
538..57Ch	Reserved for other FEATURE_HI_INQ			
580h	ZOOM_INQ	always 0		
584h	PAN_INQ	always 0		
588h	TILT_INQ	always 0		
58Ch	OPTICAL_FILTER_INQ	always 0		
590 .. 5BCh	Reserved for other FEATURE_LO_INQ	always 0		
5C0h	CAPTURE_SIZE_INQ	always 0		
5C4h	CAPTURE_QUALITY_INQ	always 0		
5C8h .. 5FCh	Reserved for other FEATURE_LO_INQ	always 0		
600h	CUR-V-Frm_RATE/Revision	Bits [0..2] for the frame rate		
604h	CUR-V-MODE	Bits [0..2] for the current video mode		
608h	CUR-V-FORMAT	Bits [0..2] for the current video format		
60Ch	ISO-Channel	Bits [0..3] for channel, [6..7] for ISO-speed		

610h	Camera_Power	always 0
614h	ISO_EN/Continuous_Shot	Bit 0: 1 for Cont. Shot; 0 for stop
618h	Memory_Save	always 0
61Ch	One_Shot, Multi_Shot, Count Number	See text
620h	Mem_Save_Ch	always 0
624	Cur_Mem_Ch	always 0
628h	Vmode_Error_Status	Error in combination of Format/Mode/ISO Speed: Bit(0): No error; Bit(0)=1: error

Table 63: Feature elements inquiry register

12.3.8 Inquiry register for absolute value CSR offset address

Offset	Name	Notes
700h	ABS_CSR_HI_INQ_0	always 0
704h	ABS_CSR_HI_INQ_1	always 0
708h	ABS_CSR_HI_INQ_2	always 0
70Ch	ABS_CSR_HI_INQ_3	always 0
710h	ABS_CSR_HI_INQ_4	always 0
714h	ABS_CSR_HI_INQ_5	always 0
718h	ABS_CSR_HI_INQ_6	always 0
71Ch	ABS_CSR_HI_INQ_7	always 0
720h	ABS_CSR_HI_INQ_8	always 0
724h	ABS_CSR_HI_INQ_9	always 0
728h	ABS_CSR_HI_INQ_10	always 0
72Ch	ABS_CSR_HI_INQ_11	always 0
730h	ABS_CSR_HI_INQ_12	always 0
734 .. 77Fh	Reserved	always 0
780h	ABS_CSR_LO_INQ_0	always 0
784h	ABS_CSR_LO_INQ_1	always 0
788h	ABS_CSR_LO_INQ_2	always 0
78Ch	ABS_CSR_LO_INQ_3	always 0
790h .. 7BFh	Reserved	always 0
7C0h	ABS_CSR_LO_INQ_16	always 0
7C4h	ABS_CSR_LO_INQ_17	always 0
7C8h .. 7FFh	Reserved	always 0

Table 64: Absolute value inquiry register

12.3.9 Status and control register for One_Push feature

The *OnePush* feature WHITE_BALANCE, is currently implemented. If this flag is set, the feature becomes immediately active even if no images are being inputted (see 8.3.1 One Push automatic white balance).

Offset	Name	Notes
800h	BRIGHTNESS	See above
804h	AUTO-EXPOSURE	See above
808h	SHARPNESS	See above
80Ch	WHITE-BALANCE	See above always 0 for Mono
810h	HUE	See above always 0 for Mono
814h	SATURATION	See above always 0 for Mono
818h	GAMMA	See above
81Ch	SHUTTER	see Advanced Feature Timebase
820h	GAIN	See above
824h	IRIS	always 0
828h	FOCUS	always 0
82Ch	TEMPERATURE	always 0
830h	TRIGGER-MODE	Can be effected via Advanced Feature IO_INP_CTRLx.
834h .. 87C	Reserved for other FEATURE_HI	always 0
880h	Zoom	always 0
884h	PAN	always 0
888h	TILT	always 0
88Ch	OPTICAL_FILTER	always 0
890 .. 8BCh	Reserved for other FEATURE_LO	always 0
8C0h	CAPTURE-SIZE	always 0
8C4h	CAPTURE-QUALITY	always 0
8C8h .. 8FCh	Reserved for other FEATURE_LO	always 0

Table 65: Feature control register

12.3.10 Feature control error status register

Offset	Name	Notes
640h	Feature_Control_Error_Status_HI	always 0
644h	Feature_Control_Error_Status_LO	always 0

Table 66: Feature control error register

12.3.11 Video mode control and status registers for Format_7

The offset to the base address is in V-CSR_INQ_7_x. The offset 100h must be added for *Mode 1*, 200h for *Mode 2* 200h and 300h for *Mode 3*.

Offset	Name	Notes
000h	MAX_IMAGE_SIZE_INQ	Acc. to IIDC v. 1.3
004h	UNIT_SIZE_INQ	Acc. to IIDC v. 1.3
008h	IMAGE_POSITION	Acc. to IIDC v. 1.3
00Ch	IMAGE_SIZE	Acc. to IIDC v. 1.3
010h	COLOR_CODING_ID	See note
014h	COLOR_CODING_INQ	Acc. to IIDC v. 1.3
034h	PIXEL_NUMER_INQ	Acc. to IIDC v. 1.3
038h	TOTAL_BYTES_HI_INQ	Acc. to IIDC v. 1.3
03Ch	TOTAL_BYTES_LO_INQ	Acc. to IIDC v. 1.3
040h	PACKET_PARA_INQ	See note
044h	BYTE_PER_PACKET	Acc. to IIDC v. 1.3

Table 67: Format_7 control and status register

ⓘ For all modes in Format_7, *ErrorFlag_1* and *ErrorFlag_2* are refreshed on each access to the Format_7 Register.

ⓘ Contrary to IIDC DCAM v. 1.3, registers relevant to Format_7 are refreshed on each access. The "Setting_1" bit is automatically cleared after each access.

ⓘ When *ErrorFlag_1* or *ErrorFlag_2* are set and Format_7 is configured, no image capture is started.

ⓘ Contrary to IIDC v.1.3, COLOR_CODING_ID is set to a default value after an INITIALIZE or "reset".

ⓘ Contrary to IIDC DCAM v.1.3, the *UnitBytePerPacket* field is already filled in with a fixed value in the PACKET_PARA_INQ register.

12.4 Advanced features

The camera has a variety of extended features going beyond the possibilities described in IIDC v. 1.3. The following chapter summarizes all available advanced features in order of ascending register.
The following table gives an overview of all available registers:

Register	Register name	Remarks
0XF1000010	VERSION_INFO	
0XF1000040	ADV_INQ_1	
0XF1000044	ADV_INQ_3	
0XF1000200	MAX_RESOLUTION	
0XF1000208	TIMEBASE	
0XF100020C	EXTD_SHUTTER	
0XF1000210	TEST_IMAGE	
0XF1000220	SEQUENCE_CTRL	except MF131x and OSCAR
0XF1000224	SEQUENCE_PARAM	except MF131x and OSCAR
0XF1000240	LUT_CTRL	
0XF1000244	LUT_MEM_CTRL	
0XF1000248	LUT_INFO	
0XF1000250	SHDG_CTRL	
0XF1000254	SHDG_MEM_CTRL	
0XF1000258	SHDG_INFO	
0XF1000260	DEFERRED_TRANS	
0XF1000270	FRAMEINFO	
0XF1000274	FRAMECOUNTER	
0XF1000280	HDR_CONTROL	MF131x only
0XF1000284	KNEEPOINT_1	MF131x only
0XF1000288	KNEEPOINT_2	MF131x only
0XF100028C	KNEEPOINT_3	MF131x only
0XF1000290	DSNU_CONTROL	MF131B only; Firmware 2.02
0XF1000294	BLEMISH_CONTROL	MF131x only; Firmware 2.02
0XF1000300	IO_INP_CTRL1	
0XF1000304	IO_INP_CTRL2	
0XF1000308	IO_INP_CTRL3	Dolphin series only
0XF1000320	IO_OUTP_CTRL1	
0XF1000324	IO_OUTP_CTRL2	
0XF1000328	IO_OUTP_CTRL3	Dolphin series only
0XF1000340	IO_INTENA_DELAY	
0XF1000360	AUTOSHUTTER_CTRL	Marlin/Oscar series only
0XF1000364	AUTOSHUTTER_LO	Marlin/Oscar series only
0XF1000368	AUTOSHUTTER_HI	Marlin/Oscar series only
0XF1000370	AUTOGAIN_CTRL	Marlin/Oscar series only
0XF1000390	AUTOFNC_AOI	Marlin/Oscar series only
0XF10003A0	COLOR_CORR	Marlin/Oscar series only

0XF1000400	TRIGGER_DELAY	
0XF1000410	MIRROR_IMAGE	Marlin/Oscar series only
0XF1000414	MNR	
0XF1000510	SOFT_RESET	
0XF1000520	HIGH_SNR	Oscar only
0XF1000FFC	GPDATA_INFO	
0XF1001000	GPDATA_BUFFER	

Table 68: Advanced Registers Summary

Advanced features should always be activated before accessing them.

ⓘ Currently all registers can be accessed without being activated. This makes it easier to operate the camera using “Directcontrol”.

ⓘ AVT reserves the right to require activation in future versions of the software.

12.4.1 Version information inquiry

The presence of each of the following features can be queried by the “0” bit of the corresponding register.

Register	Name	Field	Bit	Description
F1000010	VERSION_INFO1	µC type ID	[0..15]	Reserved
		µC version	[16..31]	Bcd-coded vers.#
F1000014			[0..31]	Reserved
F1000018	VERSION_INFO3	Camera type ID	[0..15]	See below
		FPGA version	[16..31]	Bcd-coded vers.#
F100001C			[0..31]	Reserved

Table 69: Version information register

This register holds information about the node_hw_version, the node_sw_version and the node_spec_ID (camera type). µC version and FPGA version are bcd-coded, which means that e.g. firmware version 0.85 is read as 0x0085.
The FPGA type ID identifies the camera type with the help of the following list:

ID	camera type	ID	camera type
1	F145b	21	M2F033B
2	F145c	22	M2F033C
3	F201b	23	M2F046B
4	F201c	24	M2F046C
5	F145b-1	25	M2F080B
6	F145c-1	26	M2F080C
7	F201b-1	27	M2F145B2
8	F201c-1	28	M2F145C2
9	MF033B		
10	MF033C	31	M2F145B2-15fps
11	MF046B	32	M2F145C2-15fps
12	MF046C		
13	MF080B	38	OF320C
14	MF080C	40	OF510C
15	MF145B2	42	OF810C
16	MF145C2		
17	MF131B	43	M2F080B-30fps
18	MF131C	44	M2F080C-30fps
19	MF145B2-15fps		
20	MF145C2-15fps		

Table 70: Camera type ID list

12.4.2 Advanced feature inquiry

Register	Name	Field	Bit	Description
0xF1000040	ADV_INQ_1	MaxResolution	[0]	
		TimeBase	[1]	
		ExtdShutter	[2]	
		TestImage	[3]	
		FrameInfo	[4]	
		Sequences	[5]	
		VersionInfo	[6]	
		-	[7]	
		Lookup Tables	[8]	
		Shading	[9]	
		DeferredTrans	[10]	
		HDR mode	[11]	MF-131B/C only
		DSNU	[12]	MF-131B only
		Blemish correction	[13]	
		TriggerDelay	[14]	
		Misc. features	[15]	
		Soft Reset	[16]	
		High SNR	[17]	Oscar only
		Color Correction	[18]	
		-	[19..30]	
		GP_Buffer	[31]	
0xF1000044	ADV_INQ_2	Input_1	[0]	
		Input_2	[1]	
		-	[2]	
		-	[3..7]	
		Output_1	[8]	
		Output_2	[9]	
		-	[10]	
		-	[11..15]	
		IntEnaDelay	[16]	
		-	[17]	
		-	[18..31]	
0xF1000048	ADV_INQ_3	-	[0..31]	
0xF100004C	ADV_INQ_4	-	[0..31]	

Table 71: Advanced feature inquiry register

12.4.3 MaxResolution

This register indicates the highest resolution for the sensor and is read-only.
This register normally outputs the MAX_IMAGE_SIZE_INQ Format_7 Mode_0 value.

Register	Name	Field	Bit	Description
0xF1000200	MAX_RESOLUTION	MaxHeight	[0..15]	Sensor height (rd only)
		MaxWidth	[16..31]	Sensor width (rd only)

Table 72: Max. resolution inquiry register

12.4.4 Timebase

Corresponding to IIDC, exposure time is set via a 12-bit value in the corresponding register (SHUTTER_INQ [51Ch] and SHUTTER [81Ch]).
This means that a value in the range of 1 to 4095 can be entered.

Oscar cameras use a time-base which is multiplied by the shutter register value. This multiplier is configured as the time base via the TIMEBASE register.

Register	Name	Field	Bit	Description
0xF1000208	TIMEBASE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..27]	
		Timebase_ID	[28..31]	

Table 73: Timebase configuration register

IDs 0-9 are in bits 28 to 31. Refer to the following table for code. Default time-base is 20µs.

This means that the integration time can be changed in 20 µs increments with the shutter control.

ⓘ Time-base can only be changed when the camera is in idle state and becomes active only after setting the shutter value.

ID	Timebase			ID	Timebase	
0	1	µs		5	50	µs
1	2	µs		6	100	µs
2	5	µs		7	200	µs
3	10	µs		8	500	µs
4	20	µs		9	1000	µs

Table 74: Timbease ID

ⓘ The ABSOLUTE VALUE CSR register, introduced in IIDC v. 1.3, is not implemented.

12.4.5 Extended shutter

The exposure time for long-term integration of up to 67 sec can be entered with µs- precision via the EXTENDED_SHUTTER register.

Register	Name	Field	Bit	Description
0xF100020C	EXTD_SHUTTER	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1.. 5]	
		ExpTime	[6..31]	Exposure time in µs

Table 75: Extended shutter configuration register

The longest exposure time, 3FFFFFFh, corresponds to 67.11 sec.

- Exposure times entered via the 81Ch register are mirrored in the extended register, but not vice versa.
- Changes in this register have immediate effect, even when camera is transmitting.
- Extended shutter becomes inactive after writing to a format/mode/framerate register.
- Extended shutter setting will therefore be overwritten by the normal timebase/shutter setting after Stop/Start of FireView or FireDemo.

12.4.6 Test images

Bits 8-14 indicate which test images are saved. Setting bits “28-31” activates or deactivates existing test images.

Register	Name	Field	Bit	Description
0xF1000210	TEST_IMAGE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7	
		Image_Inq_1	[8]	Presence of test image 1 0: N/A 1: Available
		Image_Inq_2	[9]	Presence of test image 2 0: N/A 1: Available
		Image_Inq_3	[10]	Presence of test image 3 0: N/A 1: Available
		Image_Inq_4	[11]	Presence of test image 4 0: N/A 1: Available
		Image_Inq_5	[12]	Presence of test image 5 0: N/A 1: Available
		Image_Inq_6	[13]	Presence of test image 6 0: N/A 1: Available
		Image_Inq_7	[14]	Presence of test image 7 0: N/A 1: Available
		---	[15..27]	
		TestImage_ID	[28..31]	0: No test image active 1: Image 1 active 2: Image 2 active ...

Table 76: Test image configuration register

12.4.7 Lookup tables (LUT)

The LUT_CTRL register activates this feature and enables certain LUTs. The LUT_INFO register indicates how many LUTs the camera can store and the maximum size of the individual LUTs.

Register	Name	Field	Bit	Description
0xF1000240	LUT_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	-
		ON_OFF	[6]	Enable/Disable this feature
		---	[7..25]	-
		LutNo	[26..31]	Use lookup table with number LutNo
0xF1000244	LUT_MEM_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	
		EnableMemWR	[5]	Enable write access
		---	[6..7]	
		AccessLutNo	[8..15]	
		AddrOffset	[16..31]	
0xF1000248	LUT_INFO	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7]	
		NumOfLuts	[8..15]	Max. # of lookup tables
		MaxLutSize	[16..31]	Max. lookup table size

Table 77: LUT control register

12.4.8 Shading correction

Owing to technical circumstances and optical effects and lighting, non-homogeneities may occur in the images.

As these effects are not normally desired, they should be eliminated as far as possible in subsequent image processing. The camera has automatic shading correction to do this.

Providing a shading image is present in the camera, the *on/off* bit can be used to enable shading correction.

The “on/off” and “ShowImage” bits must be set for saved shading images to be displayed.

ⓘ Always make sure that the shading image is saved at the highest resolution of the camera. If a lower resolution is chosen and *ShowImage* is set to “true”, the image will not be displayed correctly.

Register	Name	Field	Bit	Description
0xF1000250	SHDG_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		BuildError	[1]	tbd
		---	[2..3]	
		ShowImage	[4]	Show shading data as image
		BuildImage	[5]	Build a new ShadingImage
		ON_OFF	[6]	Shading On/Off
		Busy	[7]	Build in progress
		---	[8..23]	
		GrabCount	[24..31]	Number of images
0xF1000254	SHDG_MEM_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	
		EnableMemWR	[5]	Enable write access
		EnableMemRD	[6]	Enable read access
		---	[7]	
		AddrOffset	[8..31]	In bytes
0xF1000258	SHDG_INFO	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7]	
		MaxImageSize	[8..31]	Max. ShadingImage size (Bytes)

Table 78: Shading control register

12.4.9 Deferred image transport

Using the register, the sequence of recording and the transfer of the images can be paused. Setting “HoldImg” prevents transfer of the image. The images are stored in *ImageFIFO*.

The images indicated by *NumOfImages* are sent by setting the “SendImage” bit.

When “FastCapture” is set (in Format_7 only), images are recorded at the highest possible frame rate.

Register	Name	Field	Bit	Description
0xF1000260	DEFERRED_TRANS	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	
		SendImage	[5]	Send NumOfImages now (auto reset)
		HoldImg	[6]	Enable/Disable deferred transport mode
		FastCapture	[7]	Enable/disable fast capture mode
		---	[8..15]	
		FiFoSize	[16..23]	Size of FiFo in number of images (read only)
		NumOfImages	[24..31]	W: Number of images to send R: Number of images in buffer

Table 79: Deferred image configuration register

12.4.10 Frame information

This register can be used to double check the number of images received by the host computer against the number of images which were transmitted by the camera. The camera increments this counter with every FrameValid signal.

Register	Name	Field	Bit	Description
0xF1000270	FRAMEINFO	Presence_Inq	[0]	Indicates presence of this feature (read only)
		ResetFrameCnt	[1]	Reset frame counter
		---	[2..31]	
0xF1000274	FRAMECOUNTER	FrameCounter	[0..31]	Number of captured frames since last reset

Table 80: Frame information register

12.4.11 Input/output pin control

All input and output signals running over the HiRose plug are controlled by this register.

Register	Name	Field	Bit	Description
0xF1000300	IO_INP_CTRL1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..6]	
		Polarity	[7]	0: low active, 1: high active
		---	[8..10]	
		InputMode	[11..15]	Mode
		---	[16..30]	
		PinState	[31]	RD: Current state of pin
0xF1000304	IO_INP_CTRL2	Same as IO_INP_CTRL1		

Table 81: Input control configuration register

IO_INP_CTRL 1-2

The *Polarity* flag determines whether the input is low active (0) or high active (1). The *input mode* can be seen in the following table. The *PinState* flag is used to query the current status of the input.

For inputs, the *PinState* bit refers to the inverted output side of the optical coupler. This means that an open input sets the *PinState* bit to “1”.

ID	Mode	Default
0x00	Off	
0x01	Reserved	
0x02	Trigger input	Input 1
0x03	Reserved	
0x04	Reserved	
0x05	tbd (SPI external DCLK)	
0x06..0x0F	Reserved	
0x10..0x1F	Reserved	

Table 82: Input routing

Trigger

If more than one input is being operated in *trigger mode*, these inputs are logically linked by AND.

IO_OUTP_CTRL 1-2

The *Polarity* flag determines whether the output is low active (0) or high active (1). The *output mode* can be seen in the following table. The current status of the output can be queried and set via the *PinState* flag.

Register	Name	Field	Bit	Description
0xF1000320	IO_OUTP_CTRL1	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..6]	-
		Polarity	[7]	0: low active, 1: high active
		---	[8..10]	
		Output mode	[11..15]	Mode
		---	[16..30]	
		PinState	[31]	RD: Current state of pin WR: New state of pin
0xF1000324	IO_OUTP_CTRL2	Same as IO_OUTP_CTRL1		

Table 83: Output control configuration register

Output mode

ID	Mode	Default
0x00	Off	
0x01	Output state follows 'PinState' bit	
0x02	Integration enable	Output 1
0x03	reserved	
0x04	tbd (SPI internal DCLK)	
0x05	tbd (SPI external DCLK)	
0x06	FrameValid	
0x07	Busy	
0x08	Follow corresponding input (Inp1 → Out1, Inp2 → Out2, …)	Output 2
0x09..0x0F	reserved	
0x10..0x1F	reserved	

Table 84: Output ID

The "Polarity" setting refers to the input side of the inverting optical coupler output. "PinState 0" switches off the output transistor and produces high level over the resistor.

12.4.12 Delayed Integration enable

A delay time between initiating exposure on the sensor and the activation edge of the IntEna signal can be set using this register. The *on/off* flag activates/deactivates integration delay. The time can be set in µs in *DelayTime*.

ⓘ Please note that only one edge is delayed.

ⓘ If *IntEna_Out* is used to control an exposure, it is possible to have a variation in brightness or to precisely time a flash.

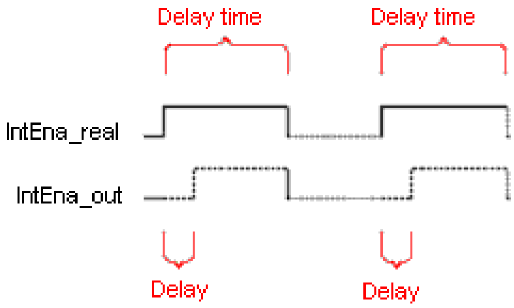


Figure 62: Delayed integration timing

Register	Name	Field	Bit	Description
0xF1000340	IO_INTENA_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	
		ON_OFF	[6]	Enable/Disable integration enable delay
		---	[7..11]	
		DELAY_TIME	[12..31]	Delay time in µs

Table 85: Delayed integration configuration register

12.4.13 Auto shutter

The table below illustrates the advanced register for auto shutter control. Purpose of this register is to limit the range within which the auto shutter is working.

Register	Name	Field	Bit	Description
0xF1000360	AUTOSHUTTER_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
			[1..31]	-
0xF1000364	AUTOSHUTTER_LO	Min Value	[0..31]	Min value
0xF1000368	AUTOSHUTTER_HI	Max Value	[0..31]	Max value

TableTable 86: Auto shutter ctrl. advanced register

12.4.14 Auto gain

The table below illustrates the advanced auto gain control register.

Register	Name	Field	Bit	Description
0xF1000370	AUTOGAIN_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
			[1..3]	-
	MAXVALUE	Max Value	[4..15]	Max value
		-	[16..19]	-
	MAXVALUE	Min value	[20..31]	Min value

Table 87: Advanced register for auto gain control

12.4.15 Auto function AOI

AUTOFNC_AOI affects the auto shutter, auto gain and auto white balance features and is independent of the Format7 AOI settings. If this feature is switched off, the work area position and size follow the current active image size.
As a reference it uses a grid of at least 300 samples equally spread over the area of interest or a fraction of it. The position and size of the control area (Auto_Function_AOI) can be set via the following advanced registers.

Register	Name	Field	Bit	Description
0xF1000390	AUTOFNC_AOI	Presence_Inq	[0]	Indicates presence of this feature (read only)
			[1..3]	-
		ShowWorkArea	[4]	Show work area
			[5]	-
		ON_OFF	[6]	Enable/Disable AOI
			[7..31]	-
0xF1000394	AF_AREA_POSITION	Left	[0..15]	work area position
		Top	[16..31]	
0xF1000398	AF_AREA_SIZE	Width	[0..15]	work area size
		Height	[16..31]	

Table 88: Advanced registe: AUTOFNC_AOI

The possible increment of the work area position and size is 128 pixel. The camera automatically adjusts your settings to allowed values. The AOI can be highlighted by setting both the Show work area bit and Enable/Disable AOI to high.

12.4.16 Color correction

Color correction can also be switched off in YUV mode with the help of the following register.

Register	Name	Field	Bit	Description
0xF10003A0	COLOR_CORR	Oscar C-type CCD cameras only: Write: 02000000h to switch Color correction OFF Write: 00000000h to switch Color correction ON (Default)		

Table 89: Color correction

12.4.17 Trigger delay

Register	Name	Field	Bit	Description
0xF1000400	TRIGGER_DELAY	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	-
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	-
		DelayTime	[11..31]	Delay time in µs

Table 90: Trigger Delay Advanced CSR

The advanced register allows to delay the start of the integration by max. 2^{21} µs, which is max. 2.1s after a trigger edge was detected.

12.4.18 Mirror

All Oscar cameras are equipped with an electronic mirror function, which mirrors pixels from the left side of the image to the right side and vice versa. The mirror is centered to the actual FOV center and can be combined with all image manipulation functions, like binning, shading and DSNU.

Register	Name	Field	Bit	Description
0xF1000410	MIRROR_CONTROL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		-	[1..5]	
		-	[6]	ON/OFF this feature: HIGH for ON, default :OFF
		-	[7..31]	

Table 91: Mirror control register

12.4.19 GPDATA_BUFFER

GPDATA_BUFFER is a register that regulates the exchange of data between camera and host for programming the LUT and the upload/download of the shading image.

GPDATA_INFO Buffer size query
GPDATA_BUFFER indicates the actual storage range

Register	Name	Field	Bit	Description
0xF1000FFC	GPDATA_INFO	---	[0..15]	
		BufferSize	[16..31]	Size of GPDATA_BUFFER (byte)
0xF1001000	GPDATA_BUFFER			
…				
0xF10017FC				

Table 92: GPData buffer register

ⓘ GPDATA_BUFFER can only be used by one function at a time.

12.4.20 Soft Reset

Register	Name	Field	Bit	Description
0xF1000510	SOFT_RESET	Presence Inquiry	[0]	Read only
			[1..5]	Reserved
		Reset	[6]	Initiate reset
			[7..19]	Reserved
	DELAY		[20..31]	Delay reset in 10ms steps

Table 93: Soft reset

The SOFT_RESET feature is similar to the INITIALIZE register, with the following differences:

- 1 or more bus reset will occur
- the FPGA will be rebooted

The reset can be delayed by setting the Delay to a value unequal to 0 – the delay is defined in 10ms steps.

ⓘ Once the SOFT_RESET is issued the camera will continue to respond to read or write requests, however will not process these requests!

12.4.21 High SNR mode

Register	Name	Field	Bit	Description
0xF1000520	HIGH_SNR	Presence Inquiry	[0]	Read only
			[1..5]	Reserved
		On_off	[6]	On/off
			[7..22]	Reserved
		GrabCount	[23..31]	Number of images

Table 94: High SNR mode

In this mode the camera grabs and averages a set number of images and outputs one image with the same bit depth. This means that the camera will output an 8 bit averaged image when an 8-bit image format is selected.

Because of the fact that normally uncorrelated (photon-, amplifier-) noise dominates over correlated noise (fixed pattern noise), adding two images will double (6 dB) the gray levels but only increase the noise levels by √2 (3 dB).
This enhances both the dynamic range as well as the signal to noise ratio.
Consequently adding 256 8-bit images will lead to a potential signal-to -noise enhancement of 24 dB.

ⓘ The averaged image is outputted at a lower frame rate being exactly the fraction: fps/number of images.

ⓘ The camera must be in idle before turning this feature on.

ⓘ The potential SNR enhancement may be lower when using more than 8-bit original bit depth.

ⓘ Select 16-bit image format in order to take advantage of the full potential SNR and DnR (dynamic Range) enhancements.

13 Firmware update

Firmware updates are possible without opening the camera.

You need:

- Programming cable E 1000666
- Software “AVTCamProg”
- PC or laptop with serial Interface (RS 232)
- Documentation for firmware update

Please contact your local dealer for further information.

14 Declarations of conformity

Allied Vision Technologies GmbH · Taschenweg 2a · 07646 Stadtroda

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Zertifiziert nach DIN ISO 9001
Zertifikat EN 1994 - 08

DECLARATION OF CONFIRMITY

We

Allied Vision Technologies GmbH
Taschenweg 2a
07646 Stadtroda
Germany

declare under our sole responsibility that the product

Category Name:	**Digital Color Camera (IEEE 1394)**
Model Name:	**OSCAR F-320C**

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN 55022; EN 55024; EN 61000; FCC Class B

Following the provisions of 89/336/EEC directive(s), amended by Directive 91/263 EEC, 92/31/EEC and 93/68/EEC

Stadtroda, February 14th, 2005

Allied Vision Technologies GmbH

Frank Grube
Managing Director

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We

Allied Vision Technologies GmbH
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07646 Stadtroda
Germany

declare under our sole responsibility that the product

Category Name:	**Digital Color Camera (IEEE 1394)**
Model Name:	**OSCAR F-510C**

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN 55022; EN 55024; EN 61000; FCC Class B

Following the provisions of 89/336/EEC directive(s), amended by Directive 91/263 EEC, 92/31/EEC and 93/68/EEC

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declare under our sole responsibility that the product

Category Name:	**Digital Color Camera (IEEE 1394)**
Model Name:	**OSCAR F-810C**

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN 55022; EN 55024; EN 61000; FCC Class B

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