AVT Oscar

Technical Manual

V2.4.0

15 August 2008

Allied Vision Technologies GmbH
Taschenweg 2a
D-07646 Stadtroda / Germany

Legal notice

For customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential 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. However there is no guarantee that interferences will not occur in a particular installation. If the equipment does cause harmful interference to radio or television reception, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the distance between the equipment and the receiver.
- Use a different line outlet for the receiver.
- Consult a radio or TV technician for help.

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 B 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.

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The information provided by Allied Vision Technologies is supplied without any guarantees or warranty whatsoever, be it specific or implicit. Also excluded are all implicit warranties concerning the negotiability, the suitability for specific applications or the non-breaking of laws and patents. Even if we assume that the information supplied to us is accurate, errors and inaccuracy may still occur.

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Contents

Contacting Allied Vision Technologies

Info

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  phone (for USA): +1 978-225-2030
  outside Germany/USA: Please check the link for your local dealer.
  http://www.alliedvisiontec.com/partner.html
- **Ordering and commercial information:**
  customer-care@alliedvisiontec.com
  phone (for Germany): +49 (0)36428 677-230
  phone (for USA): +1 978-225-2030
  outside Germany/USA: Please check the link for your local dealer.
  http://www.alliedvisiontec.com/partner.html
  Please note order number/text given in the **AVT Modular Camera Concept**.

Introduction

This **OSCAR Technical Manual** describes in depth the technical specifications, dimensions, all camera features (IIDC standard and AVT smart features) and their registers, trigger features, all video and color formats, bandwidth and frame rate calculation.

For information on hardware installation, safety warnings, pin assignments on I/O connectors and 1394a connectors read the **Hardware Installation Guide**.

Note

Please read through this manual carefully.

We assume that you have read already the Hardware Installation Guide and that you have installed the hardware and software on your PC or laptop (FireWire card, cables).

Document history

Version	Date	Remarks
1.0	10.05.2005	First issue
1.1	25.08.2005	Oscar F-510C: firmware 1.05/3.00; minor corrections and clarifications
2.0.0	14.03.2006	Manual compliant to firmware 3.03, added feature user profiles, minor corrections
2.0.1	15.03.2006	All Oscar cameras are Class B compliant.
2.1.0	28.06.2006	New layout, manual compliant to firmware 3.04, RoHS conformity, minor corrections
2.1.1	18.09.2006	Corrected BAYER demosaicing interpolation formula (Chapter Color interpolation (BAYER demosaicing) on page 91) Minor corrections
2.2.0	26.10.2006	Added Format_7 binning modes for Oscar F-510C (Chapter Oscar F-510C on page 23, Chapter Binning (only Oscar F-510C) on page 84 and Chapter Video formats: Oscar F-510C on page 123) Minor corrections
to be continued on next page		

Table 1: Document history

Version	Date	Remarks
		continued from last page
2.3.0	23.02.2007	Minor corrections New offset and jitter values (Chapter Exposure time (shutter) and offset on page 111 and Figure 52: Data flow and timing after end of exposure on page 114) New jitter values at start of exposure, camera idle (Chapter Jitter at start of exposure on page 116)
2.3.1	23.03.2007	Minor corrections Note: binning only Oscar F-510C (Chapter Binning (only Oscar F-510C) on page 84)
2.4.0	15.08.08	Sensor tilting changed to rotation in Chapter Camera dimensions on page 29 Added detailed description of BRIGHTNESS (800h) in Table 78: Feature control error register on page 173 Added detailed description of WHITE-BALANCE (80Ch) in Table 78: Feature control error register on page 173 et seq. Corrected exposure time example in Chapter Exposure time (shutter) and offset on page 111 Added Chapter Sensor position accuracy of AVT cameras on page 203 Moved AVT Glossary from Appendix of OSCAR Technical Manual to AVT Website. Changed provisions directive to 2004/108/EG in Chapter Declarations of conformity on page 18 Added detailed level values of I/Os in Chapter Camera I/O pin assignment on page 36.
		to be continued on next page

Table 1: Document history

Version	Date	Remarks
continued from last page		
2.4.0 [continued]	15.08.08 [continued]	**Restructuring of Oscar Technical Manual:** • Added Contacting Allied Vision Technologies on page 8 • Added Chapter Manual overview on page 13 • Restructured Chapter *Oscar types and highlights* to Chapter OSCAR cameras on page 17. – Infos from *Oscar camera types* table moved to Chapter Specifications on page 21 – *Safety instructions* moved to *Hardware Installation Guide*, Chapter *Safety instructions* and *AVT camera cleaning instructions* – Environmental conditions moved to *Oscar Instruction Leaflet* – Infos on C-Mounting moved to *Hardware Installation Guide*, Chapter *Changing filters safety instructions* – Infos on *System components* and *Environmental conditions* moved to *Oscar Instruction Leaflet* – Infos on *IR cut filter* and *Lenses* moved to Chapter Filter and lenses on page 19 • Moved binning explanation from Chapter Specifications on page 21 to Chapter Video formats, modes and bandwidth on page 120 • Binning / sub-sampling modes and color modes are only listed in Chapter Video formats, modes and bandwidth on page 120 • Moved detailed description of the camera interfaces (FireWire, I/O connector), ordering numbers and operating instructions to the Hardware Installation Guide. • Revised Chapter Description of the data path on page 52 • Revised Chapter Controlling image capture on page 100; added Table 30: Trigger modi on page 100; User profiles are only described in Chapter User profiles on page 198 • Revised Chapter Video formats, modes and bandwidth on page 120
to be continued on next page		

Table 1: Document history

Version	Date	Remarks
		continued from last page
2.4.0 [continued]	15.08.08 [continued]	• Revised Chapter How does bandwidth affect the frame rate? on page 142 • Revised Chapter Configuration of the camera on page 145 • Revised Chapter Firmware update on page 202 • Added Chapter Sensor position accuracy of AVT cameras on page 203 • Revised Chapter Index on page 204 Added cross-reference from upload LUT to GPDATA_BUFFER in Chapter Loading an LUT into the camera on page 73. Added cross-reference from upload/download shading image to GPDATA_BUFFER in: – Chapter Loading a shading image out of the camera on page 81 – Chapter Loading a shading image into the camera on page 82 Added little endian vs. big endian byte order in Chapter GPDATA_BUFFER on page 201 Added RoHs in Chapter Declarations of conformity on page 18 Added descriptions of MaxImageSize in Chapter What is the real size of the shading image (MaxImageSize)? on page 79 Listed shutter speed with offset in Chapter Specifications on page 21ff. New measurement of IntEna signals, therefore new offsets in Chapter Exposure time (shutter) and offset on page 111 and in *Figure 52: Data flow and timing after end of exposure* on page 114. New photo of LED positions in Figure 13: Position of Status LEDs on page 37

Table 1: Document history

Manual overview

This **manual overview** describes each chapter of this manual shortly.

- Chapter Contacting Allied Vision Technologies on page 10 lists AVT contact data for both:
  - technical information / ordering
  - commercial information
- Chapter Introduction on page 9 (this chapter) gives you the document history, a manual overview and conventions used in this manual (styles and symbols). Furthermore you learn how to get more information on **how to install hardware (Hardware Installation Guide)**, available **AVT software** (incl. documentation) and where to get it.
- Chapter OSCAR cameras on page 17 gives you a short introduction to the STINGRAY cameras with their FireWire technology. Links are provided to data sheets and brochures on AVT website.
- Chapter Declarations of conformity on page 18 gives you information about conformity of AVT cameras.
- Chapter Filter and lenses on page 19 describes the IR cut filter and suitable camera lenses.
- Chapter Specifications on page 21 lists camera details and spectral sensitivity diagrams for each camera type.
- Chapter Camera dimensions on page 29 provides CAD drawings of standard housing (copper and GOF) models, tripod adapter, available angled head models, cross sections of CS-Mount and C-Mount.
- Chapter Camera interfaces on page 35 describes in detail the inputs/outputs of the cameras (incl. Trigger features). For a general description of the interfaces (FireWire and I/O connector) see **Hardware Installation Guide**.
- Chapter Description of the data path on page 52 describes in detail IIDC conform as well as AVT-specific camera features.
- Chapter Controlling image capture on page 100 describes trigger modi, exposure time, one-shot/multi-shot/ISO_Enable features. Additionally special AVT features are described: sequence mode and secure image signature (SIS).
- Chapter Video formats, modes and bandwidth on page 120 lists all available fixed and Format_7 modes (incl. color modes, frame rates, binning/sub-sampling, AOI=area of interest).
- Chapter How does bandwidth affect the frame rate? on page 142 gives some considerations on bandwidth details.
- Chapter Configuration of the camera on page 145 lists standard and advanced register descriptions of all camera features.
- Chapter Firmware update on page 202 explains where to get information on firmware updates and explains the extended version number scheme of FPGA/µC.

- Chapter Appendix on page 203 lists the sensor position accuracy of AVT cameras.
- Chapter Index on page 204 gives you quick access to all relevant data in this manual.

Conventions used in this manual

To give this manual an easily understood layout and to emphasize important information, the following typographical styles and symbols are used:

Styles

Style	Function	Example
Bold	Programs, inputs or highlighting important things	**bold**
Courier	Code listings etc.	`Input`
Upper case	Register	REGISTER
Italics	Modes, fields	*Mode*
Parentheses and/or blue	Links	(Link)

Table 2: Styles

Symbols

Note

This symbol highlights important information.

Caution

This symbol highlights important instructions. You have to follow these instructions to avoid malfunctions.

www

This symbol highlights URLs for further information. The URL itself is shown in blue Color.

Example:

http://www.alliedvisiontec.com

More information

For more information on hardware and software read the following:

- **Hardware Installation Guide** describes the hardware installation procedures for all 1394 AVT cameras (Dolphin, Oscar, Marlin, Guppy, Pike, Stingray). Additionally you get safety instructions and information about camera interfaces (IEEE1394a/b copper and GOF, I/O connectors, input and output).

Note

You find the **Hardware Installation Guide** on the product CD in the following directory:

products\cameras-general

www

All **software packages** (including **documentation** and **release notes**) provided by AVT can be downloaded at:

www.alliedvisiontec.com/avt-products/software.html

All software packages are also on AVT's product CD.

Before operation

We place the highest demands for quality on our cameras.

Target group This **Technical Manual** is the guide to detailed technical information of the camera and **is written for experts**.

Getting started For a quick guide how to get started read **Hardware Installation Guide** first.

Note

Please read through this manual carefully before operating the camera.

For information on **AVT accessories** and **AVT software** read **Hardware Installation Guide**.

Caution

Before operating any AVT camera read **safety instructions** and **ESD warnings** in **Hardware Installation Guide**.

Note

To demonstrate the properties of the camera, all examples in this manual are based on the **FirePackage** OHCI API software and the **SmartView** application.

www

These utilities can be obtained from Allied Vision Technologies (AVT). A free version of **SmartView** is available for download at:

www.alliedvisiontec.com

Note

The camera also works with all IIDC (formerly DCAM) compatible IEEE 1394 programs and image processing libraries.

OSCAR cameras

Oscar

With Oscar cameras, entry into the world of digital image processing is simpler and more **cost-effective** than ever before.

High image quality

With the new Oscar, Allied Vision Technologies presents a whole series of attractive digital camera models of the FireWire™ type. The multi-megapixel resolutions, image pre-processing functions, frame grabbing functions and robust industrial casings make them highly suitable for a wide range of different applications.

Price-performance

In this price class the Oscar sets new standards.

Image applications

Oscar cameras offer the perfect solution for applications in medical, microscopy and general digital image processing.

FireWire

The industry standard IEEE 1394 (FireWire or i.Link) facilitates the simplest computer compatibility and bidirectional data transfer using the plug-and-play process. Further development of the IEEE 1394 standard has already made 800 Mbit/second possible – and the FireWire roadmap is already envisaging 1600 Mbit/second, with 3.2 Gbit/second as the next step. Investment in this standard is therefore secure for the future; each further development takes into account compatibility with the preceding standard, and vice versa, meaning that IEEE 1394b is backward-compatible with IEEE 1394a. Your applications will grow as technical progress advances.

High quality images

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 Megapixel the cameras offer unrivalled solutions for many extreme high resolution applications.

The OSCAR family consists of the following models:

www

For further information on the highlights of OSCAR **types**, the OSCAR **family** and the whole range of **AVT FireWire cameras** read the data sheets and brochures on the website of Allied Vision Technologies:

www.alliedvisiontec.com

Declarations of conformity

Allied Vision Technologies declares under its sole responsibility that the following products

Category Name	Model Name
Digital camera (IEEE 1394)	OSCAR F-320C
	OSCAR F-510C
	OSCAR F-810C

Table 3: Model names

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

- FCC Class B
- CE (following the provisions of 2004/108/EG directive)
- RoHS (2002/95/EC)

Filter and lenses

IR cut filter: spectral transmission

The following illustration shows the spectral transmission of the IR cut filter:

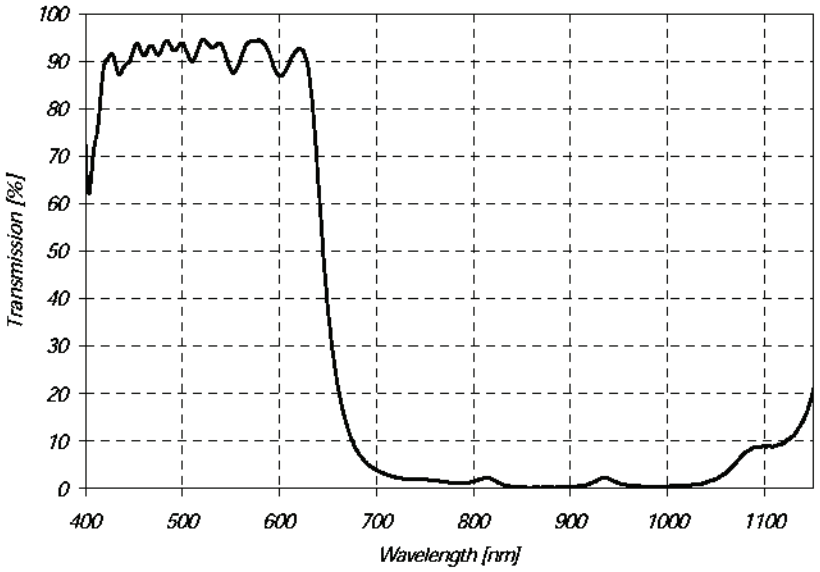


Figure 1: Spectral transmission of Jenofilt 217

Camera lenses

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

Note

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 length for type 1/1.8 sensor OSCAR F-320C	Distance = 0.5 m	Distance = 1 m
4.8 mm	740 mm x 549 mm	1488 mm x 1103 mm
8 mm	441 mm x 327 mm	890 mm x 660 mm
12 mm	292 mm x 216 mm	591 mm x 438 mm
16 mm	217 mm x 161 mm	441 mm x 327 mm
25 mm	136 mm x 101 mm	280 mm x 207 mm
35 mm	95 mm x 71 mm	198 mm x 147 mm
50 mm	65 mm x 48 mm	136 mm x 101 mm

Table 4: Focal length vs. field of view (OSCAR F-320C)

Focal length for type 2/3 sensor OSCAR F-510C/F-810C	Distance = 0.5 m	Distance = 1 m
4.8 mm	908 mm x 681 mm	1825 mm x 1368 mm
8 mm	541 mm x 406 mm	1091 mm x 818 mm
12 mm	358 mm x 268 mm	725 mm x 543 mm
16 mm	266 mm x 200 mm	541 mm x 406 mm
25 mm	167 mm x 125 mm	343 mm x 257 mm
35 mm	117 mm x 88 mm	243 mm x 182 mm
50 mm	79 mm x 59 mm	167 mm x 125 mm

Table 5: Focal length vs. field of view (OSCAR F-510C/F-810C)

Specifications

Note

Oscar cameras are always equipped with **color** sensors.

Note

For information on bit/pixel and byte/pixel for each color mode see Table 61: ByteDepth on page 142.

Oscar F-320C

Feature	Specification
Image device	Type 1/1.8 (diag. 8.93 mm) frame readout SONY CCD ICX-262AQ with HAD microlens
Chip size	8.10 mm x 6.64 mm
Cell Size	3.45 µm x 3.45 µm
Picture size (max.)	2080 x 1540 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) adjustable from 17.3 mm to 22.5 mm Mechanical flange back to filter distance: 10.5 mm (see Figure 9: Oscar C-Mount dimensions (standard filter) on page 33)
ADC	12 bit
Color modes	Mono8; Y8-green, Y8-red, Y8-blue; RAW8/16; RGB8; YUV4:2:2; YUV4:1:1
Frame rates	3.75 fps; 7.5 fps; 15 fps; 30 fps Up to 6.59 fps in Format_7 frame readout Up to 39.31 fps in Format_7 progressive
Gain control	Manual: 0-20 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**66** µs …67.108.864 µs (~67s); auto shutter (select. AOI)

Table 6: Specification Oscar F-320C

Feature	Specification
External trigger shutter	Trigger Mode_0, Trigger_Mode_1 (progressive scan, Format_7 Mode_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 tables	One, user programmable (12 bit → 8/12 bit); gamma (0.5)
Smart functions	Real time shading correction, High SNR mode (image summation), image mirror (L-R ↔ R-L), sub-sampling, user profiles AWB (auto white balance), color correction, hue, saturation, Two configurable inputs, two configurable outputs RS-232 port (serial port, IIDC V1.31)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s
Digital interface	IEEE 1394a IIDC v. 1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	3.6 watt (@ 12 V DC)
Dimensions	72.5 mm x 44 mm x 44 mm (L x W x H); without tripod and lens
Mass	<170 g (without lens and tripod)
Operating temperature	+5 ... +45 °Celsius
Storage temperature	-10 ... +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	IR cut filter
Optional accessories	Protection glass, locking IEEE 1394 cable
On request	Host adapter card, angled head
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 6: Specification Oscar F-320C

Note

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

Oscar F-510C

Feature	Specification
Image device	Type 2/3 (diag. 11 mm) frame readout SONY CCD ICX-282AQ with HAD microlens
Chip size	9.74 mm x 7.96 mm
Cell Size	3.4 µm x 3.4 µm
Picture size (max.)	2588 x 1958 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) adjustable from 17.3 mm to 22.5 mm Mechanical flange back to filter distance: 10.5 mm (see Figure 9: Oscar C-Mount dimensions (standard filter) on page 33)
ADC	12 bit
Color modes	Mono8; Y8-green, Y8-red, Y8-blue; RAW8/16; RGB8; YUV4:2:2; YUV4:1:1
Frame rates	1.875 fps; 3.75 fps; 7.5 fps Up to 3.8 fps in Format_7 frame readout Up to 7.59 fps in Format_7 progressive
Gain control	Manual: 0-20 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**94** µs …67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger Mode_0, Trigger_Mode_1 (progressive scan, Format_7 Mode_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 tables	One, user programmable (12 bit → 8/12 bit); gamma (0.5)
Smart functions	Real time shading correction, High SNR mode (image summation), image mirror (L-R ↔ R-L), sub-sampling, binning, user profiles AWB (auto white balance), color correction, hue, saturation, Two configurable inputs, two configurable outputs RS-232 port (serial port, IIDC V1.31)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s
Digital interface	IEEE 1394a IIDC v. 1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	3.6 watt (@ 12 V DC)
Dimensions	72.5 mm x 44 mm x 44 mm (L x W x H); without tripod and lens

Table 7: Specification Oscar F-510C

Feature	Specification
Mass	<170 g (without lens and tripod)
Operating temperature	+5 ... +45 °Celsius
Storage temperature	-10 ... +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	IR cut filter
Optional accessories	Protection glass, locking IEEE 1394 cable
On request	Host adapter card, angled head
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 7: Specification Oscar F-510C

Note

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

Oscar F-810C

Feature	Specification
Image device	Type 2/3 (diag. 11.07 mm) frame readout SONY CCD ICX-456AQ with HAD microlens
Chip size	9.79 mm x 7.93 mm
Cell size	2.7 µm x 2.7 µm
Picture size (max.)	3272 x 2469 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) adjustable from 17.3 mm to 22.5 mm Mechanical flange back to filter distance: 10.5 mm (see Figure 9: Oscar C-Mount dimensions (standard filter) on page 33)
ADC	12 bit
Color modes	Mono8; Y8-green, Y8-red, Y8-blue; Raw8/16; RGB8; YUV422; YUV411
Frame rates	3.75 fps; 7.5 fps Up to 3.15 fps in Format_7 frame readout Up to 8.88 fps in Format_7 progressive
Gain control	Manual: 0-20 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**118** µs …67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger Mode_0, Trigger_Mode_1 (progr. scan, Format_7 Mode_0); advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	64 MByte, optional up to 256 MByte
Look-up tables	One, user programmable (12 bit → 8/12 bit); gamma (0.5)
Smart functions	Real time shading correction, High SNR mode (image summation), image mirror (L-R ↔ R-L), sub-sampling, user profiles AWB (auto white balance), color correction, hue, saturation Two configurable inputs, two configurable outputs RS-232 port (serial port, IIDC V1.31)
Transfer rate	100 Mbit/s, 200 Mbit/s, 400 Mbit/s
Digital interface	IEEE 1394a IIDC v. 1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	3.6 watt (@ 12 V DC)
Dimensions	72.5 mm x 44 mm x 44 mm (L x W x H); without tripod and lens

Table 8: Specification Oscar F-810C

Feature	Specification
Mass	<170 g (without lens and tripod)
Operating temperature	+5 ... +45 °Celsius
Storage temperature	-10 ... +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	IR cut filter
Optional accessories	Protection glass, locking IEEE 1394 cable
On request	Host adapter card, angled head
Software packages	API (FirePackage, Active FirePackage, Fire4Linux)

Table 8: Specification Oscar F-810C

Note

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

Spectral sensitivity

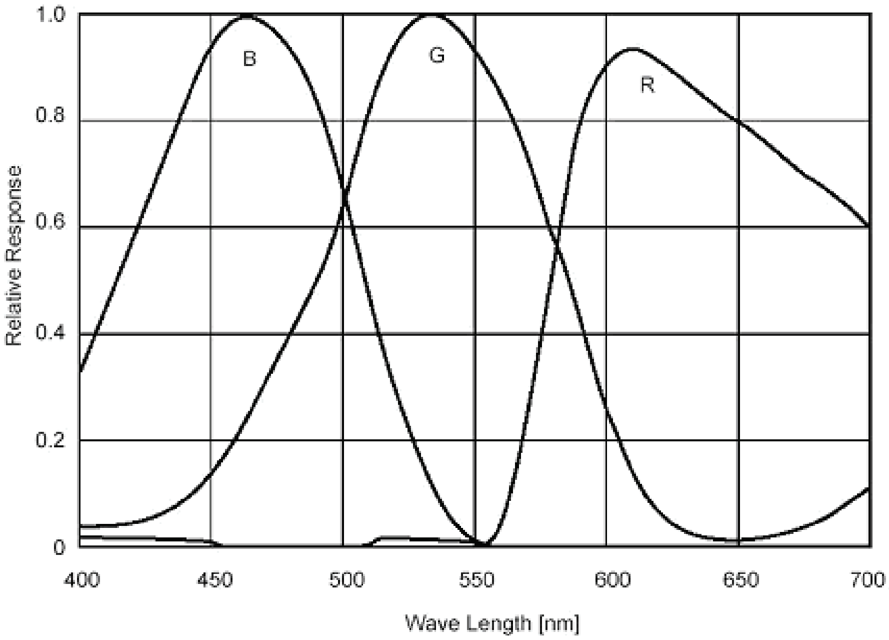


Figure 2: Spectral sensitivity of Oscar F-320C without cut filter and optics

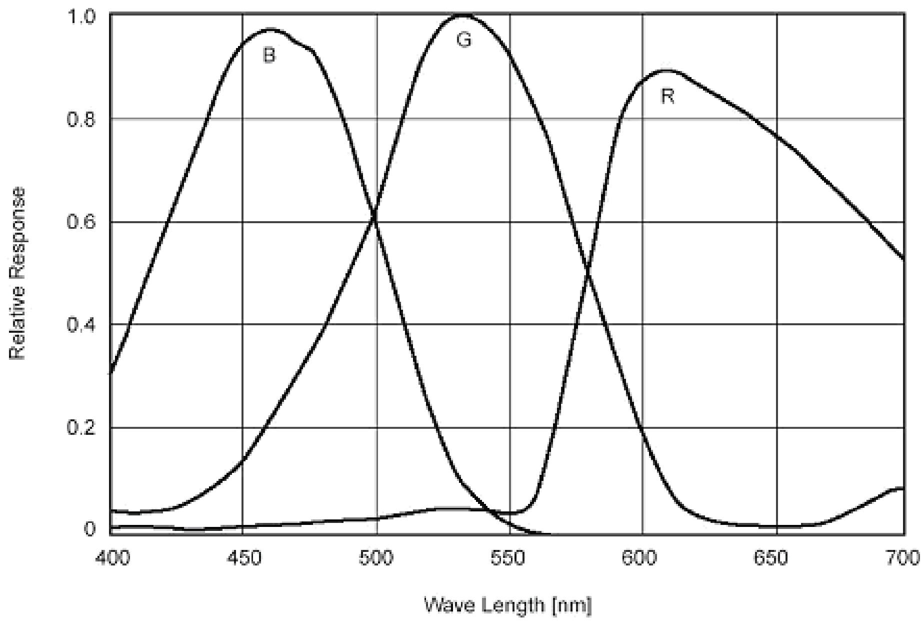


Figure 3: Spectral sensitivity of Oscar F-510C without cut filter and optics

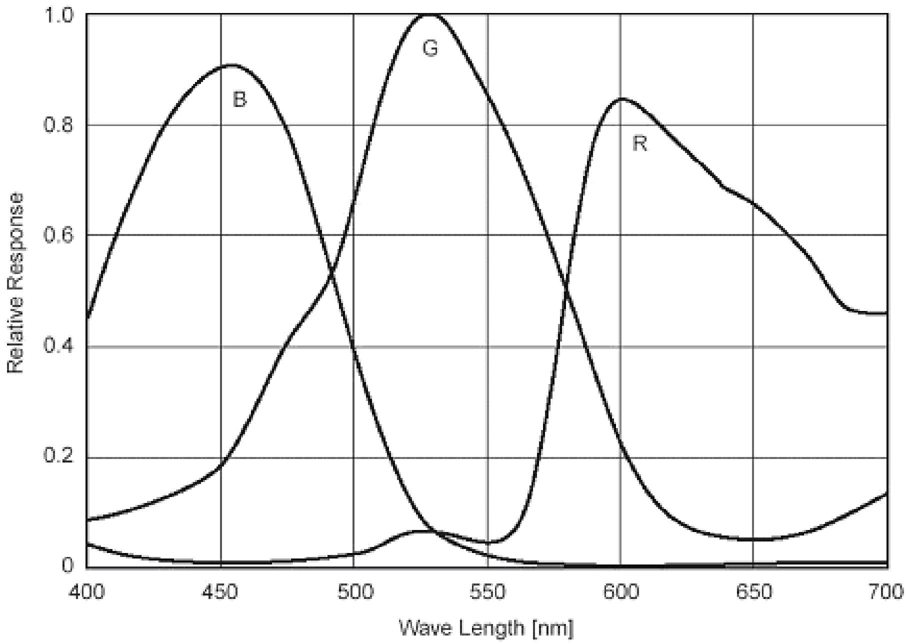


Figure 4: Spectral sensitivity of Oscar F-810C without cut filter and optics

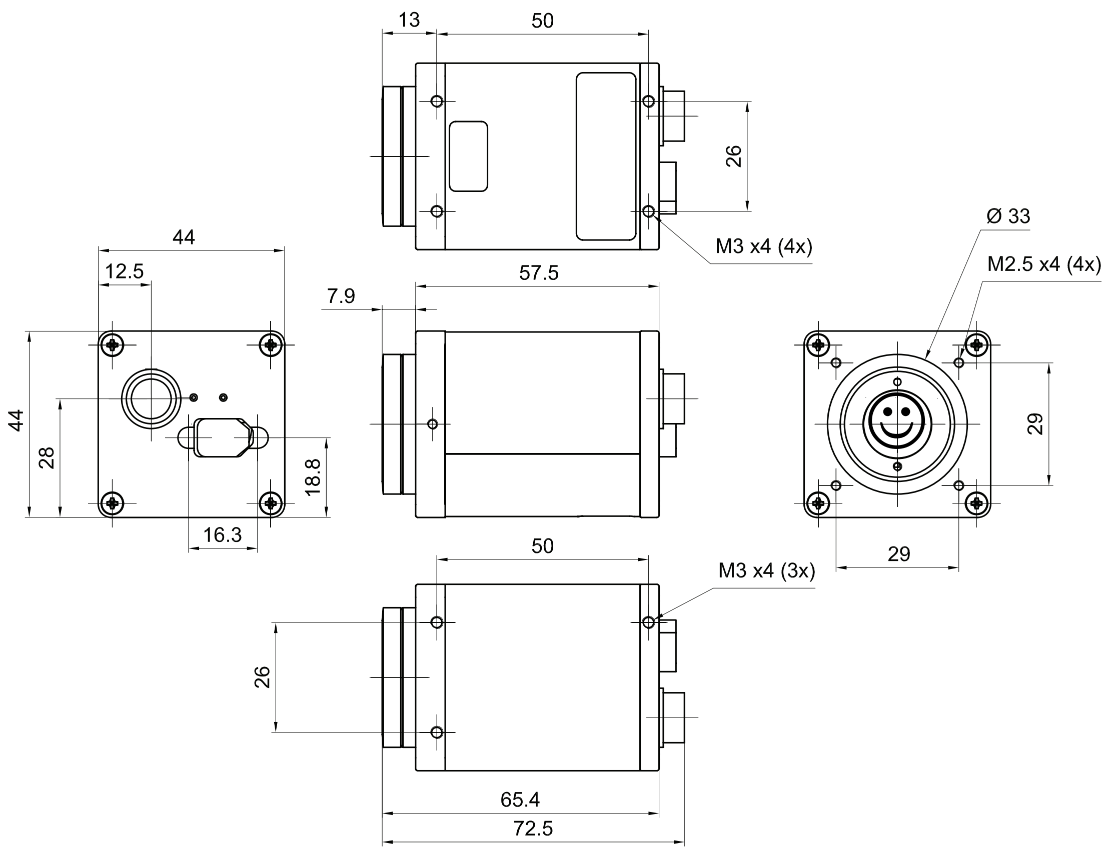
Camera dimensions

Note

For information on **sensor position accuracy:**

(sensor shift x/y, optical back focal length z and sensor rotation α) see Chapter Sensor position accuracy of AVT cameras on page 203.

Oscar standard housing



Body size: 72.5 mm x 44 mm x 44 mm (L x W x H)
Mass: 170 g (without lens)

Figure 5: Camera dimensions

Oscar W90

This version has the sensor tilted by 90 degrees clockwise, so that it views upwards.

Note

An additional specification is required for the rotation of the sensor.

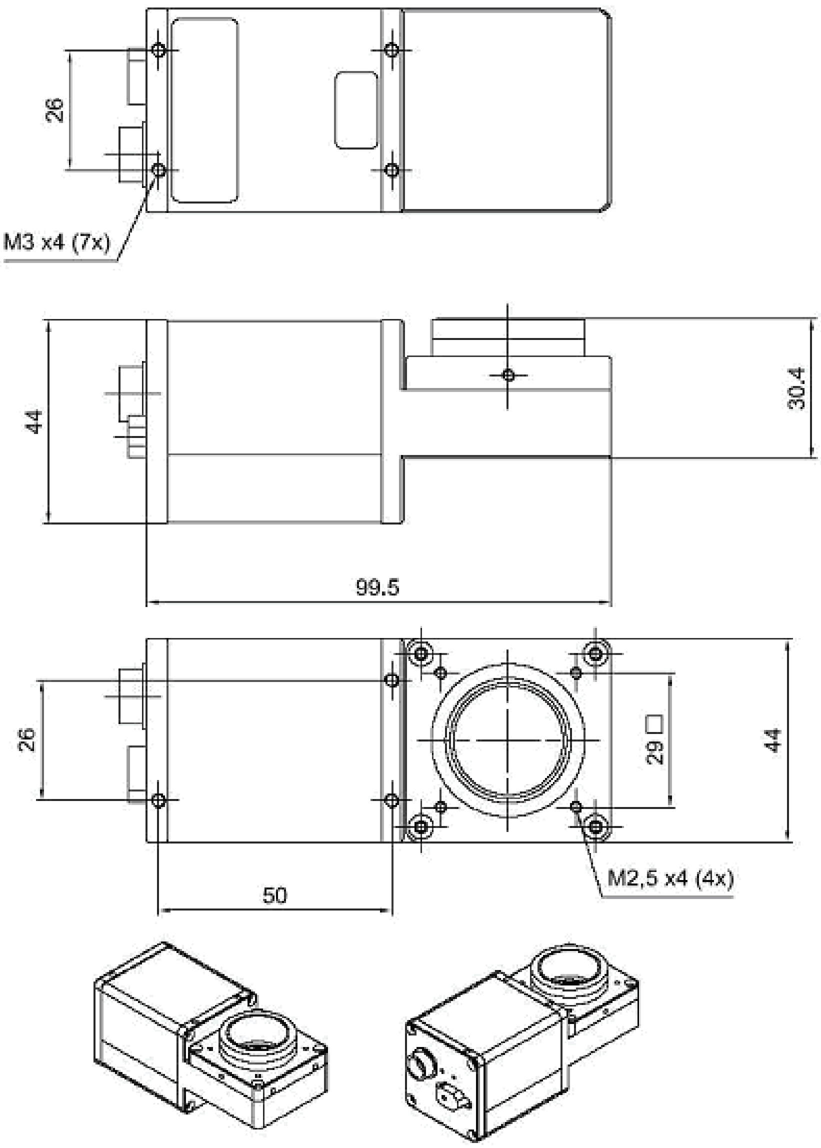


Figure 6: Oscar W90

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.

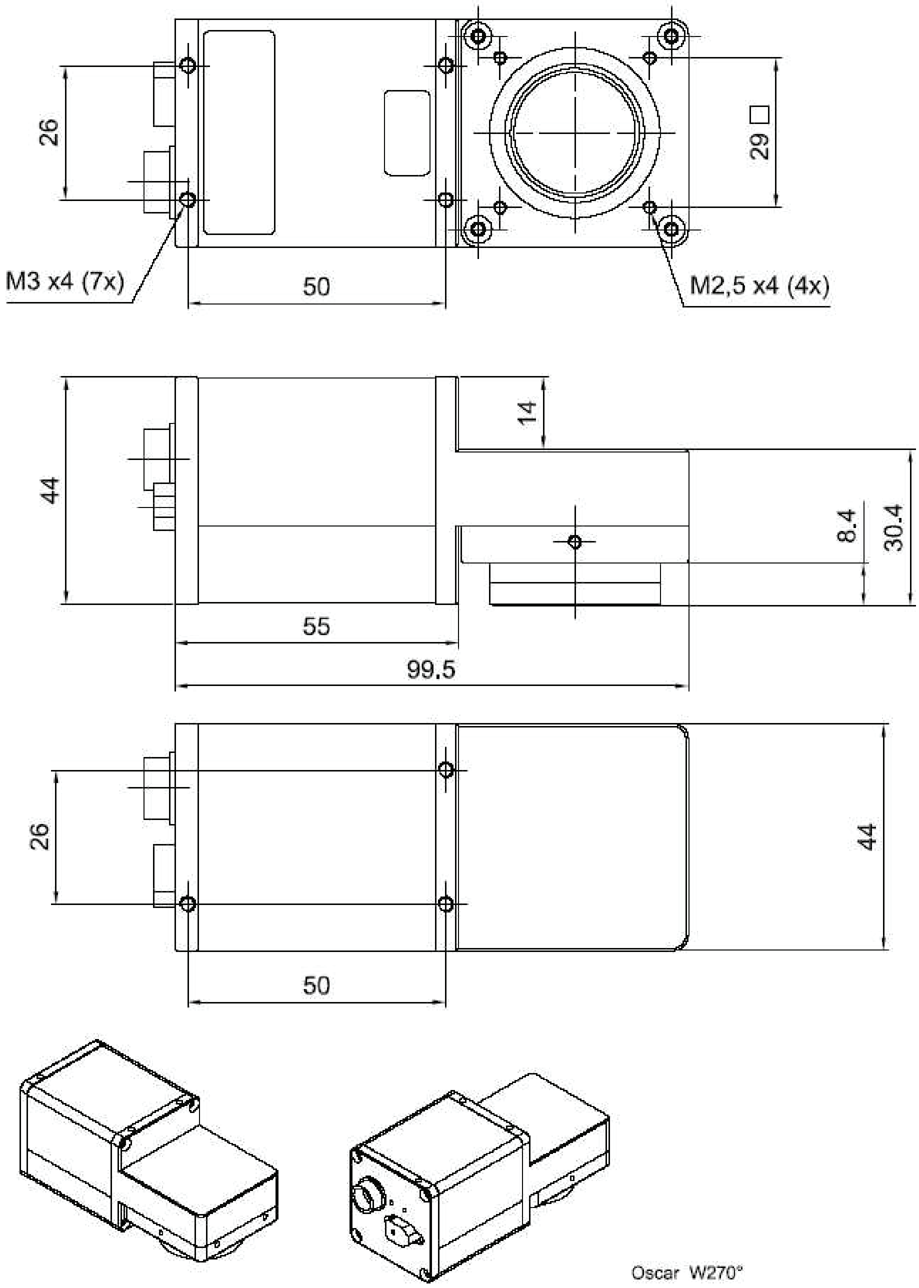


Figure 7: Oscar W270

Tripod adapter

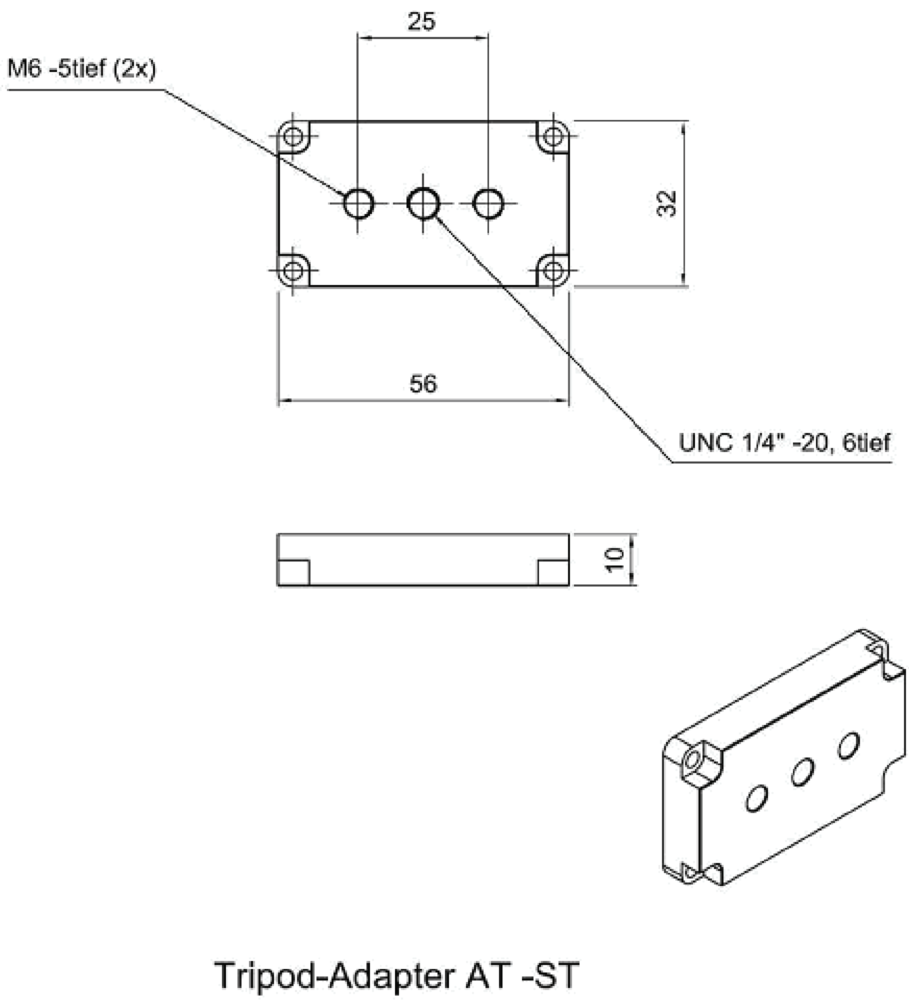


Figure 8: Tripod dimensions

Cross section: C-Mount (standard filter)

All Oscar cameras are equipped with standard filter.

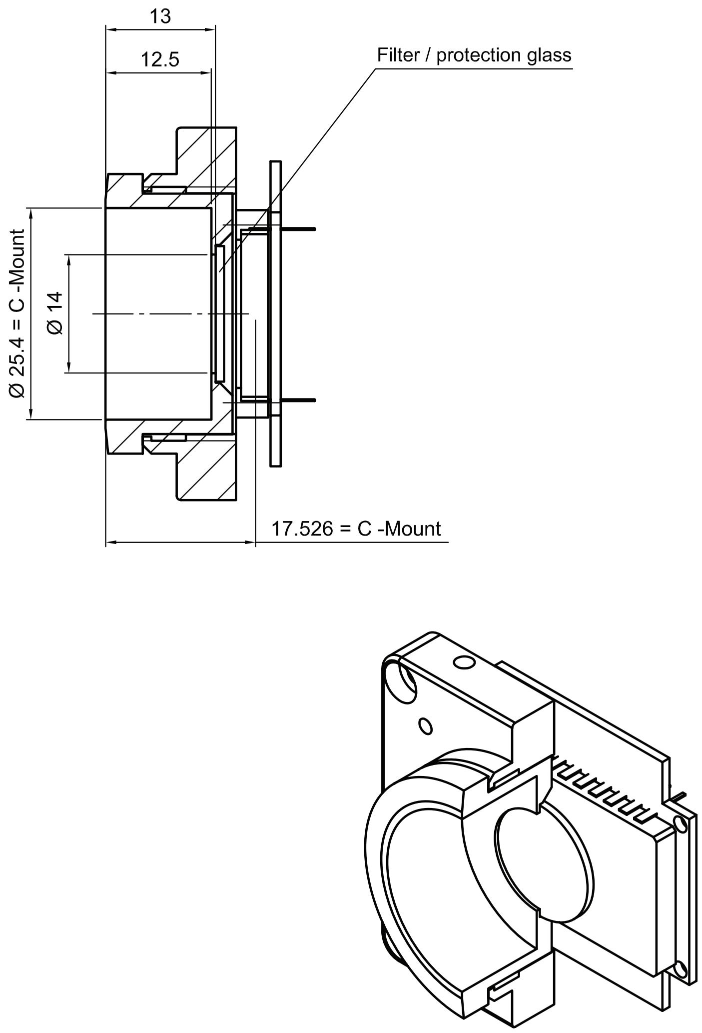


Figure 9: Oscar C-Mount dimensions (standard filter)

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, renewed adjustment may be required in the field.

Figure 10: Back focus adjustment

How to proceed:

1. Loosen screws (location as shown above by arrow) with an Allen key (1.3 x 50; Order#: K 9020411).
2. 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.
3. 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.
4. Once focus is achieved, tighten the two locking screws without applying excessive torque.

Camera interfaces

This chapter gives you detailed information on status LEDs, inputs and outputs, trigger features and transmission of data packets.

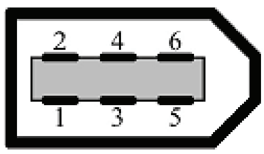
Note

For a detailed description of the **camera interfaces (FireWire, I/O connector), ordering numbers and operating instructions** see the **Hardware Installation Guide,** Chapter ***Camera interfaces***.

Read all **Notes** and **Cautions** in the **Hardware Installation Guide**, before using any interfaces.

IEEE 1394a port pin assignment

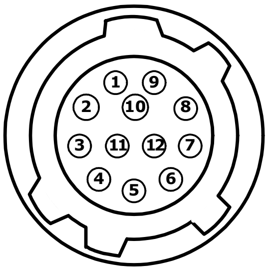
The IEEE 1394 plug is designed for industrial use and has the following pin assignment as per specification:



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

Figure 11: IEEE 1394a connector

Camera I/O pin assignment



Pin	Signal	Direction	Level	Description
1	External GND		GND for RS232 and ext. power	External ground for RS232 and external power
2	External Power		+8 ... +36 V DC	Power supply
3				
4	Camera In 1	In	U_{in}(high) = 2 V...U_{inVCC} U_{in}(low) = 0 V...0.8 V	Camera Input 1 (GPIn1) default: Trigger
5				
6	Camera Out 1	Out	Open emitter	Camera Output 1 (GPOut1) default: IntEna
7	Camera In GND	In	Common GND for inputs	Camera Common Input Ground (In GND)
8	RxD RS232	In	RS232	Terminal Receive Data
9	TxD RS232	Out	RS232	Terminal Transmit Data
10	Camera Out Power	In	Common VCC for outputs max. 36 V DC	Camera Output Power for digital outputs (OutVCC)
11	Camera In 2	In	U_{in}(high) = 2 V...U_{inVCC} U_{in}(low) = 0 V...0.8 V	Camera Input 2 (GPIn2) default: -
12	Camera Out 2	Out	Open emitter	Camera Output 2 (GPOut2) default: -

Figure 12: Camera I/O connector pin assignment

Note

GP = General Purpose

For a detailed description of the **I/O connector and its operating instructions** see the **Hardware Installation Guide**, Chapter *OSCAR input description*.

Read all **Notes** and **Cautions** in the **Hardware Installation Guide**, before using the I/O connector.

Status LEDs

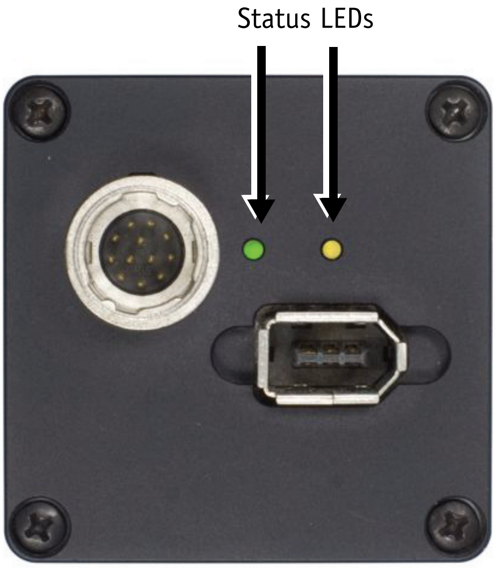


Figure 13: Position of Status LEDs

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:

State	Description
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 9: LED indication

Blink codes are used to signal warnings or error states:

Class S1 → **Error codes 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 10: 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

Control and video data signals

The inputs and outputs of the camera can be configured by software. The different modes are described below.

Inputs

Note

For a general description of the **inputs** and **warnings** see the **Hardware Installation Guide,** Chapter *OSCAR input description*.

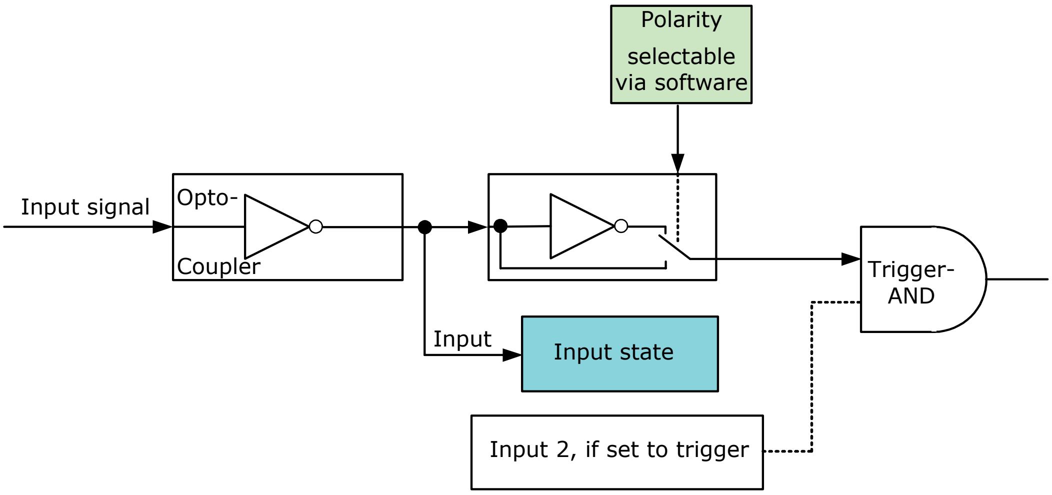


Figure 14: Input block diagram

Triggers

All inputs configured as triggers are linked by logical AND function. If two inputs are being used as triggers, a high signal at the output of the block 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.

Input/output pin control

All input and output signals running over the camera I/O connector 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]	Reserved
		Polarity	[7]	0: low active 1: high active
		---	[8..10]	Reserved
		InputMode	[11..15]	Mode see Table 12: Input routing on page 41
		---	[16..30]	Reserved
		PinState	[31]	RD: Current state of pin
0xF1000304	IO_INP_CTRL2	Same as IO_INP_CTRL1		

Table 11: Advanced register: **Input control**

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	
0x06..0x0F	Reserved	
0x10..0x1F	Reserved	

Table 12: Input routing

Note

If you set more than 1 input to function as a trigger input, all trigger inputs are ANDed.

Trigger delay

Oscar cameras feature various ways to delay image capture based on an external trigger.

With IIDC V1.31 there is a standard CSR at register F0F00534/834h to control a delay up to FFFh x 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]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature

Table 13: 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 Read: Status of the feature ON=1 OFF=0
		---	[7..19]	Reserved
		Value	[20..31]	Value

Table 14: Trigger Delay CSR

The cameras also have an advanced register which allows even more precise image capture delay 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]	Reserved
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	Reserved
		DelayTime	[11..31]	Delay time in µs

Table 15: Trigger delay advanced CSR

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

Note

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

Outputs

Note

For a general description of the **outputs** and **warnings** see the **Hardware Installation Guide**, Chapter *OSCAR output description*.

Output features are configured by software. Any signal can be placed on any output.

The main features of output signals are described below:

Signal	Description
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. This signal can be used to fire a **strobe flash.**
Fval (Frame valid) signal	This feature signals readout from the sensor. This signal Fval follows IntEna.
Busy signal	This signal appears when: • the exposure is being made or • the sensor is being read out or • data transmission is active. The camera is busy.

Table 16: Output signals

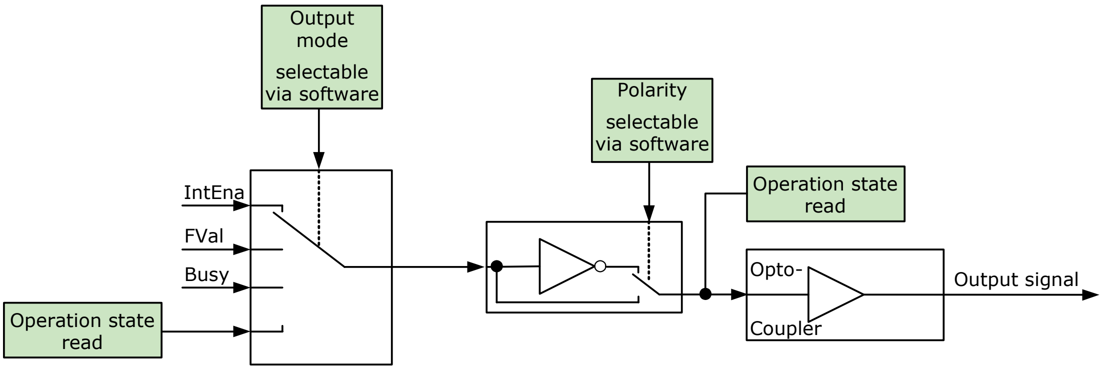


Figure 15: Output block diagram

IO_OUTP_CTRL 1-2

The outputs (Output mode, Polarity) 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. This allows for example 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]	Reserved
		Polarity	[7]	0: active low 1: active high (inverting)
		---	[8..10]	Reserved
		Output mode	[11..15]	Mode see Table 18: Output routing on page 47
		---	[16..30]	Reserved
		PinState	[31]	RD: Current state of pin WR: New state of pin
0xF1000324	IO_OUTP_CTRL2	Same as IO_OUTP_CTRL1		

Table 17: Advanced register: **Output control**

Output modes

ID	Mode	Default
0x00	Off	
0x01	Output state follows **PinState** bit	Using this mode, the Polarity bit has to be set to 0 (not inverted). This is necessary for an error free display of the output status.
0x02	Integration enable	Output 1
0x03	Reserved	
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 18: 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.

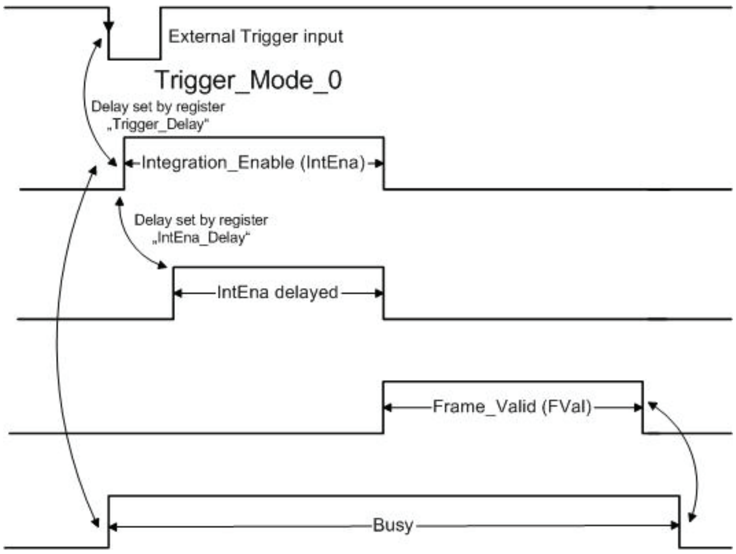


Figure 16: Output impulse diagram

Note

The signals can be inverted.

Note

- Note that **trigger delay** in fact 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 achievable maximum frequency is strongly dependent on individual software capabilities. As a rule of thumb, the camera itself will limit the toggle frequency to not more than 700 Hz.
- In **split shutter** mode the camera will issue two (Oscar F-810C: three) IntEnas and FrameValids but only one Busy, because it integrates the two (Oscar F-810C: three) fields separately.

Pixel data

Pixel data are transmitted as isochronous data packets in accordance with the 1394 interface described in IIDC V1.3. The first packet of a frame is identified by the **1** in the **sync bit** (sy) of the packet header.

sync bit

<table>
<tr><th colspan="2">0-7</th><th colspan="2">8-15</th><th colspan="2">16-23</th><th colspan="2">24-31</th></tr>
<tr><td colspan="4">data_length</td><td>tg</td><td>channel</td><td>tCode</td><td>sy</td></tr>
<tr><td colspan="8">header_CRC</td></tr>
<tr><td colspan="8">Video data payload</td></tr>
<tr><td colspan="8">data_CRC</td></tr>
</table>

Table 19: Isochronous data block packet format. Source: IIDC V1.3

Field	Description
data_length	Number of bytes in the data field
tg	**Tag field** shall be set to zero
channel	**Isochronous channel number**, as programmed in the iso_channel field of the cam_sta_ctrl register
tCode	**Transaction code** shall be set to the isochronous data block packet tCode
sy	**Synchronization value (sync bit)** This is one single bit. It indicates the start of a new frame. It shall be set to 0001h on the first isochronous data block of a frame, and shall be set to zero on all other isochronous blocks
Video data payload	Shall contain the digital video information

Table 20: Description of data block packet format

- The video data for each pixel are output in either 8-bit 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 V1.3)

<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)

Figure 17: YUV 4:2:2 and YUV 4:1:1 format: Source: IIDC V1.3

<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)

Figure 18: Y8 and Y16 format: Source: IIDC V1.3

<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

Figure 19: Data structure: Source: IIDC V1.3

Description of the data path

Block diagram of the cameras

The following diagram illustrates the data flow and the 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. For sensor data see Chapter Specifications on page 21.

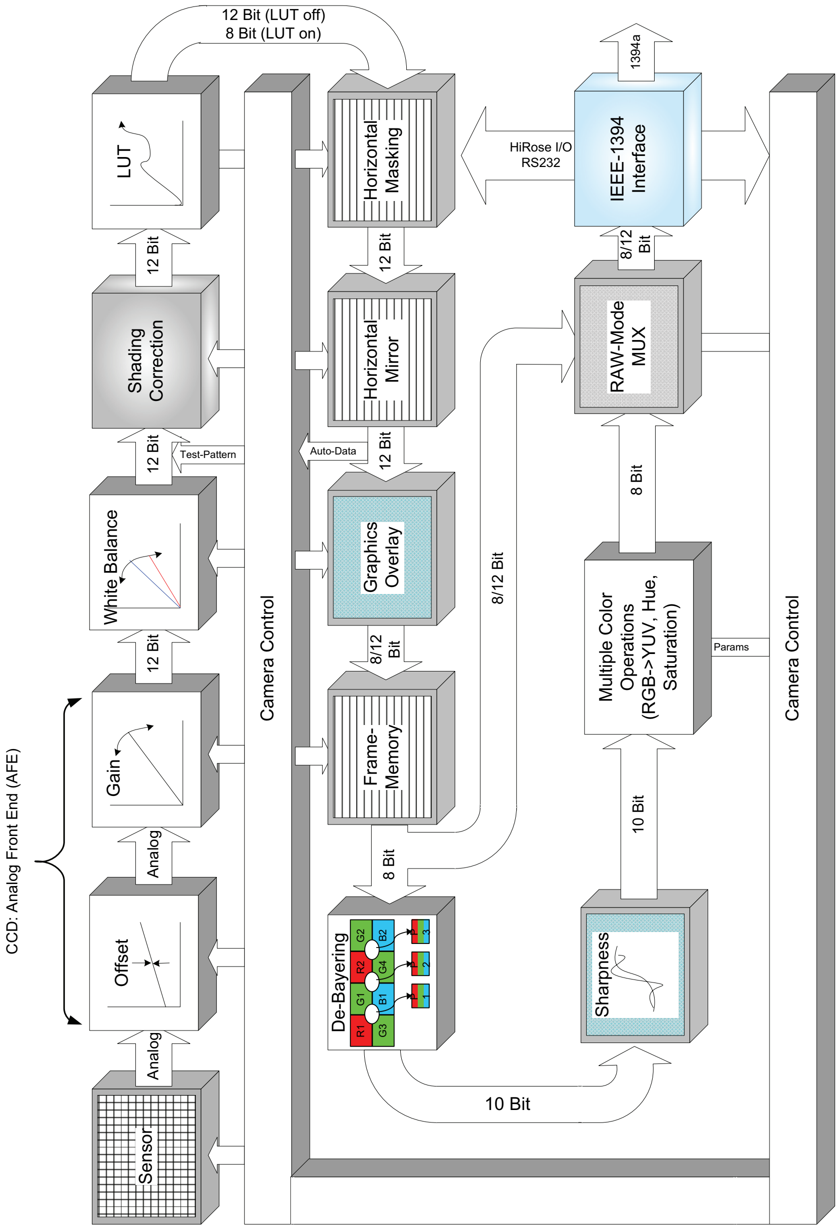


Figure 20: Block diagram Oscar cameras

Black and white output interpolation modes

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 luma 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 luma 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 luma.

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

Note

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

Read out modes 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 Oscar F-320C and Oscar F-510C have two field readouts, the Oscar F-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.

Oscar F-320C: ICX-262AQ readout scheme

The screenshot below, taken from the Oscar F-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.

Note

The high frame readout mode reads out 2 from 12 lines and thus achieves a remarkably high frame rate of nearly 40 fps.

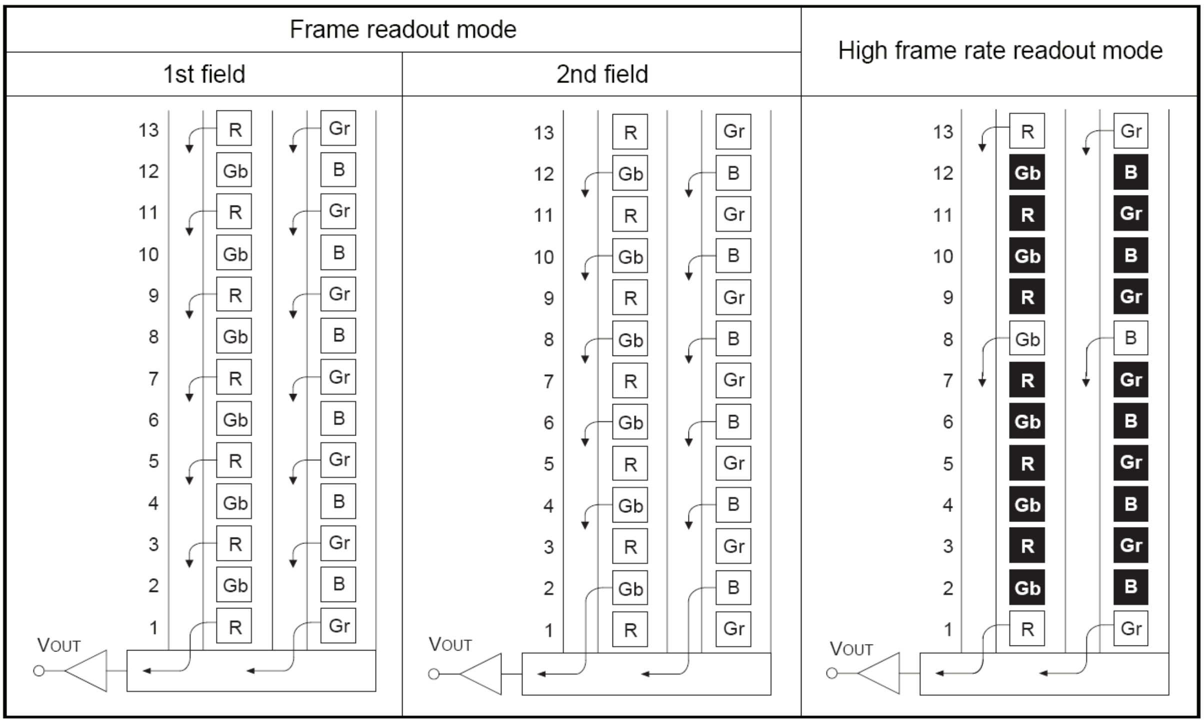


Figure 21: Oscar F-320C: Sony ICX-262AQ readout scheme

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.

Oscar F-510C: ICX-282AQ readout scheme

Oscar F-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 megapixel resolution.

The readout scheme of it is shown below:

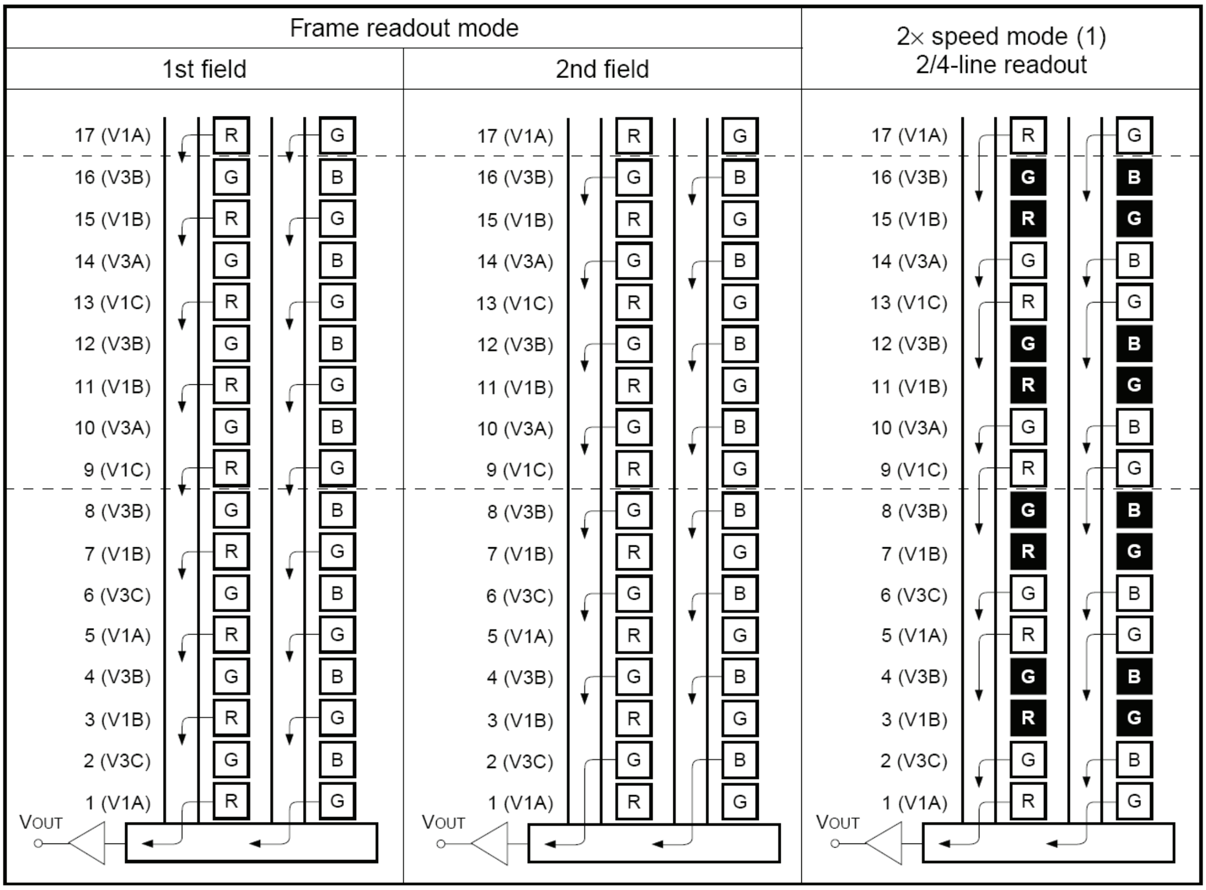


Figure 22: Oscar F-510C: Sony ICX-282AQ readout scheme

Oscar F-810C: ICX-456AQ readout scheme

Oscar F-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.

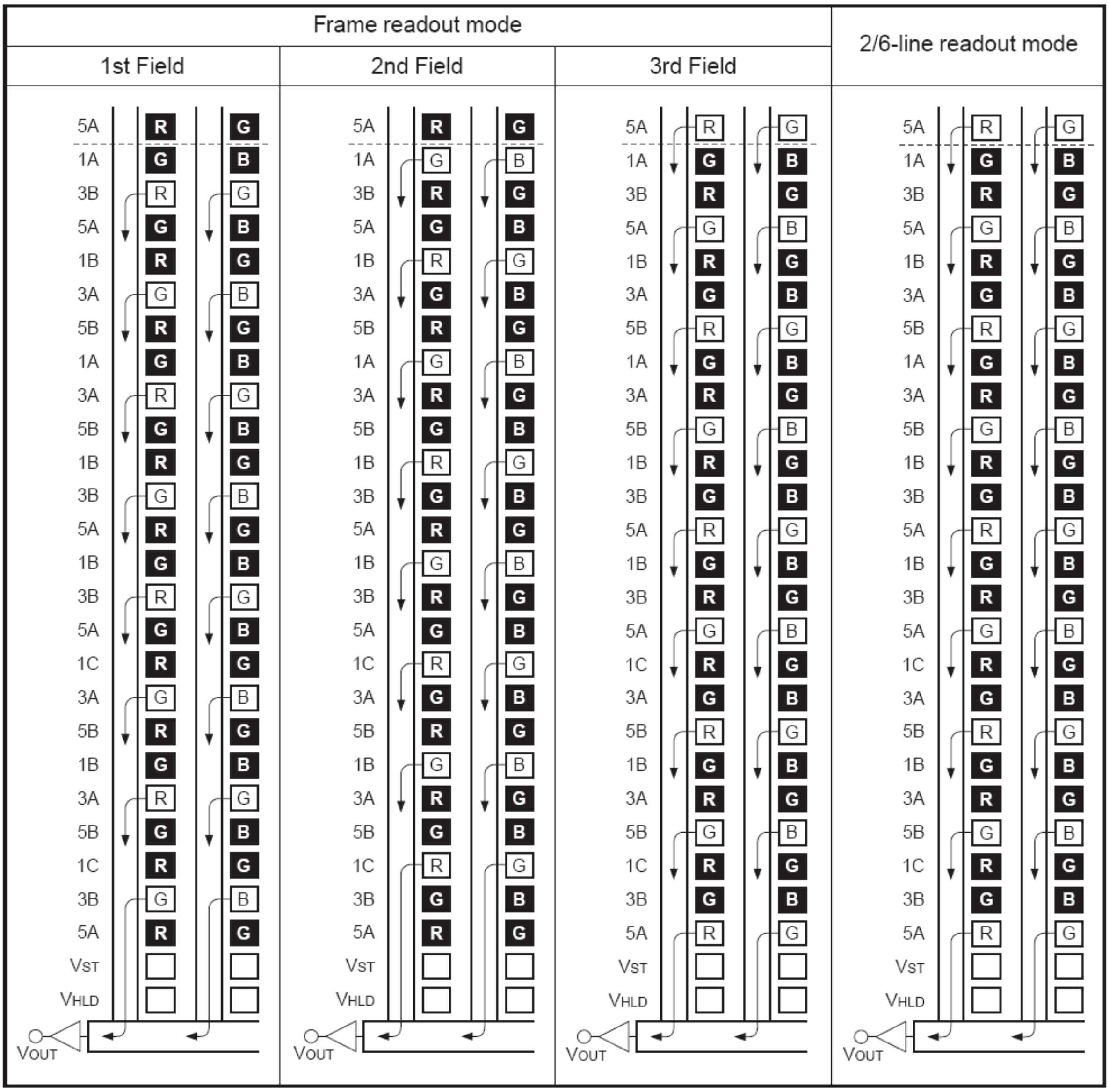


Figure 23: Oscar F-810C: Sony ICX-456AQ readout scheme

Frame readout implications

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.

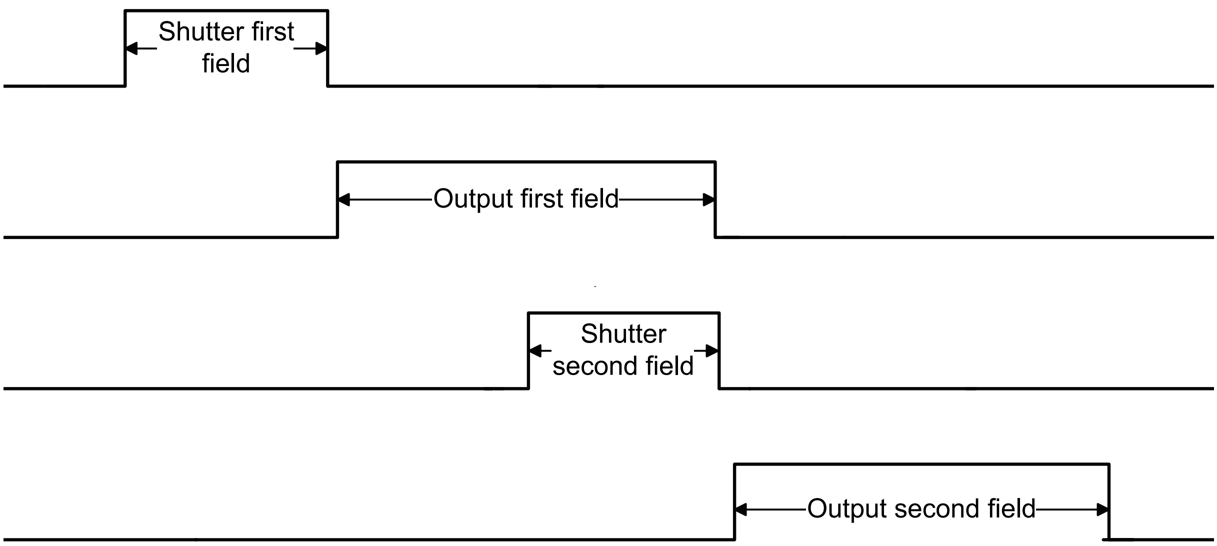


Figure 24: Split shutter

Note

Using this mode with moving objects introduces red/blue artefacts with the Oscar F-320C and Oscar F-510C, and jagged artefacts with the Oscar F-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 Oscar F-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 read-out time of the first field.

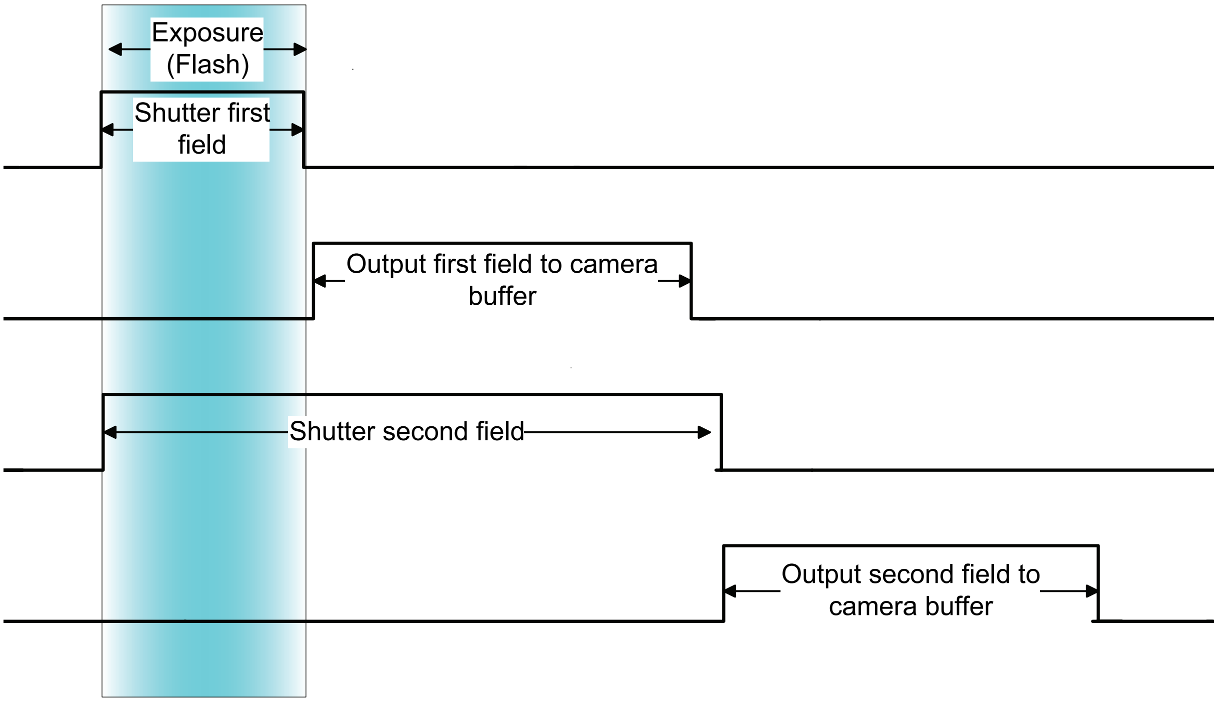


Figure 25: Joint shutter

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

Note

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

White balance

Oscar 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 +9.5 dB (in 512 steps) relative to the channel with highest output.

The following screenshot is taken from the data sheet of the AFE and illustrates the details:

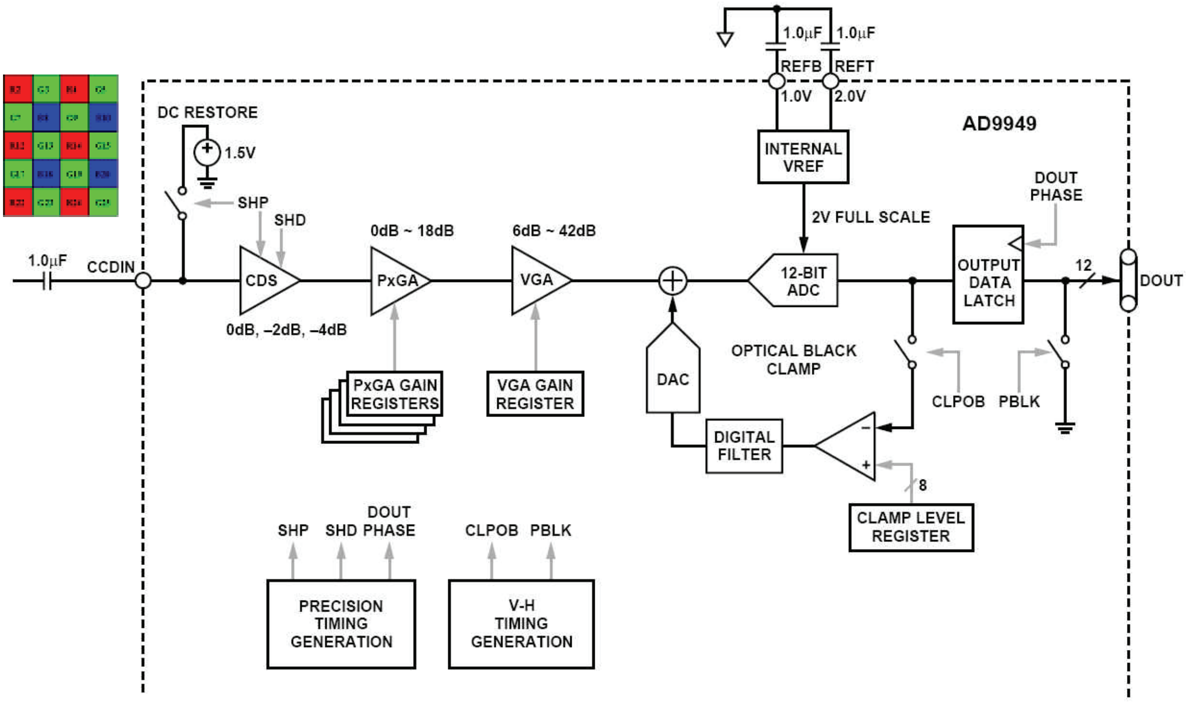


Figure 26: Block diagram of AFE (Source: Analog Devices)

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.

From the user's point of view, the white balance settings are made in register 80Ch of IIDC V1.3. This register is described in more detail below.

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 will be ignored.
		---	[2..4]	Reserved
		One_Push	[5]	Write 1: begin to work (self-cleared after operation) Read: 1: in operation 0: not in operation If A_M_Mode = 1, this bit will be ignored.
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current mode 0: MANUAL 1: AUTO
		U/B_Value	[8..19]	U/B 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.
		V/R_Value	[20..31]	V/R 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 21: 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.

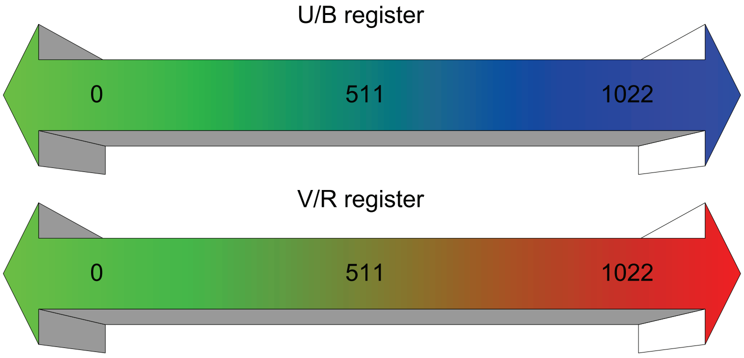


Figure 27: U/V slider range

One-push automatic white balance

Note

Configuration

To configure this feature in control and status register (CSR): See Chapter White balance register on page 60.

To activate one-push automatic white balance: Set one-push bit in the WHITE_BALANCE register.

The camera automatically generates frames, based on the current settings of all registers (GAIN, OFFSET, SHUTTER, etc.).

For white balance, in total **9** 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 current values for both the one-push and the automatic white balance.

This feature uses the assumption that the R-G-B component sums of the samples are equal; i.e., it assumes that the average of the sampled grid pixels is to be monochrome.

Note

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

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

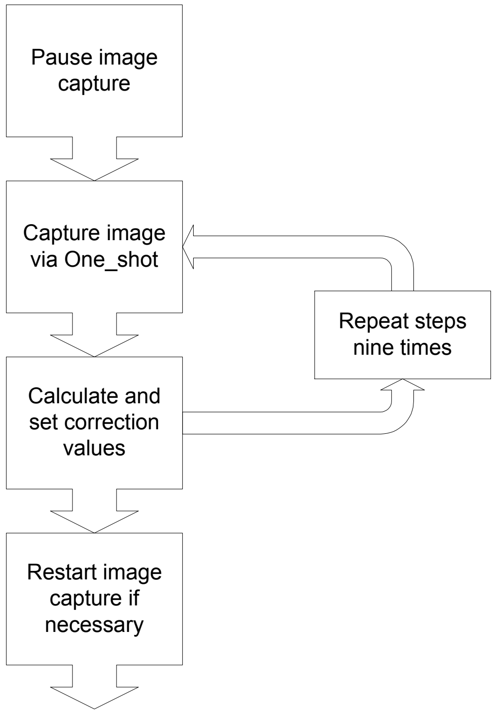


Figure 28: Auto white balance sequence

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

Automatic white balance

The auto white balance feature 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.

Note	Configuration
ⓘ	To set position and size of the control area (Auto_Function_AOI) in an advanced register: see Table 95: Advanced register: Autofunction AOI on page 193.

AUTOFNC_AOI affects the auto shutter, auto gain and auto white balance features and is independent of the Format_7 AOI settings. If this feature is switched off, the work-area position and size represent the current active image size.

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

The following drawing illustrates the AUTOFNC_AOI settings in greater detail.

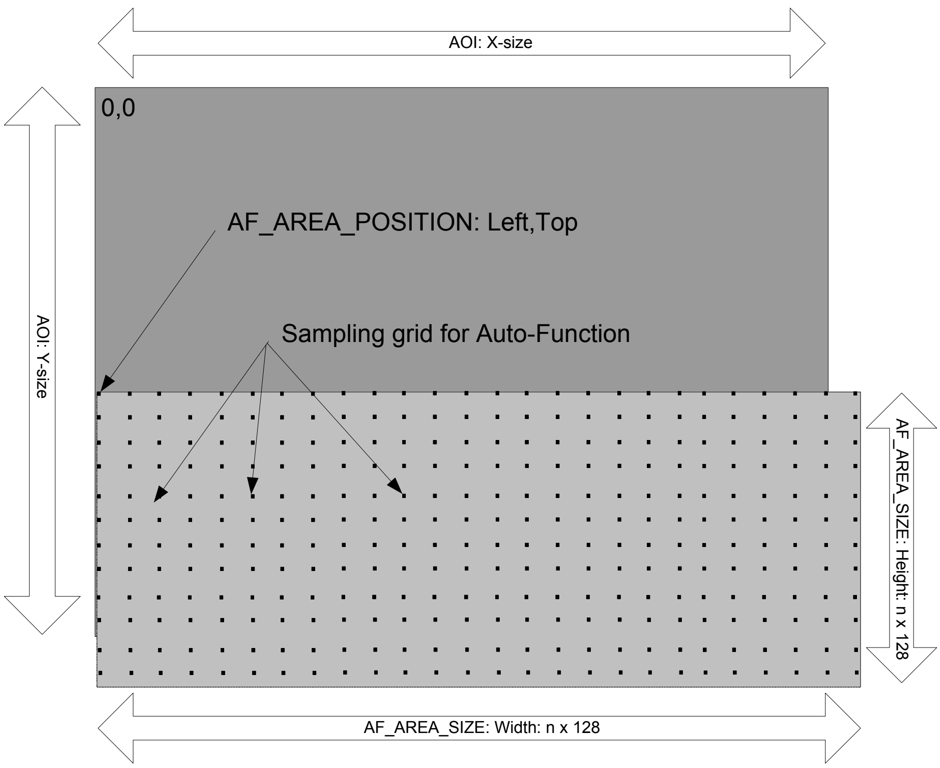


Figure 29: AUTOFNC_AOI positioning

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

Visualization of the AUTOFNC_AOI is carried out with the help of the graphics overlay function of the camera (see Chapter Block diagram of the cameras on page 52). This area is highlighted when the **Show work area** bit is set high.

Note

The algorithm will try to create an uncolored image when looking at an area that is completely colored with automatic white balance ON.

Manual gain

As shown in Figure 26: Block diagram of AFE (Source: Analog Devices) on page 59, 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 22: Manual gain range of the various Oscar types

The increment length is ~0.0351 dB/step.

Note

- 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 longer shutter settings.
- Generally all 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.

Auto gain

In combination with auto white balance, all Oscar cameras are equipped with **auto gain** feature.

When enabled auto gain adjusts the gain within the default gain limits or within the limits set in advanced register F1000370h in order to reach the brightness set in auto exposure register as reference.

Increasing the auto exposure value (aka target grey 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 tables show 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 Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current 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 23: CSR: **Gain**

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 star 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 24: CSR: **Auto Exposure**

Note

Configuration

To configure this feature in an advanced register: See Table 94: Advanced register: Auto gain control on page 192.

Note

- Values can only be changed within the limits of gain CSR.
- Changes in auto exposure register only have an effect when auto gain is active.
- Auto exposure limits are 50..205. (**SmartView→Ctrl1 tab: Target grey level**)

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 x Y + Offset

Note

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

The IIDC brightness register at offset 800h is used for this purpose.

The following table shows the BRIGHTNESS register.

Register	Name	Field	Bit	Description
0xF0F00800	BRIGHTNESS	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 Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current 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 25: CSR: **Brightness**

Auto shutter

In combination with auto white balance, Oscar cameras 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 in order to reach the reference brightness set in auto exposure register.

Note

Target grey level parameter in **SmartView** corresponds to **Auto_exposure** register 0xF0F00804 (IIDC).

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.

To configure this feature in control and status register (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 1: begin to work (self-cleared after operation) Read: 1: in operation 0: not in operation If A_M_Mode = 1, this bit will be ignored.
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		A_M_MODE	[7]	Write: set mode Read: read current 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: CSR: **Shutter**

Note

Configuration

To configure this feature in an advanced register: See Table 93: Advanced register: Auto shutter control on page 192.

Look-up table (LUT) and gamma function

The AVT Oscar camera provides one user-defined look-up 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 to be applied on the 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 = $(\text{Input})^{0.5}$

This gamma LUT is used with all Oscar models.

It is known as compensation for the nonlinear brightness response of many displays e.g. CRT monitors. The look-up table converts the incoming **12 bit** from the digitizer to outgoing **8 bit**.

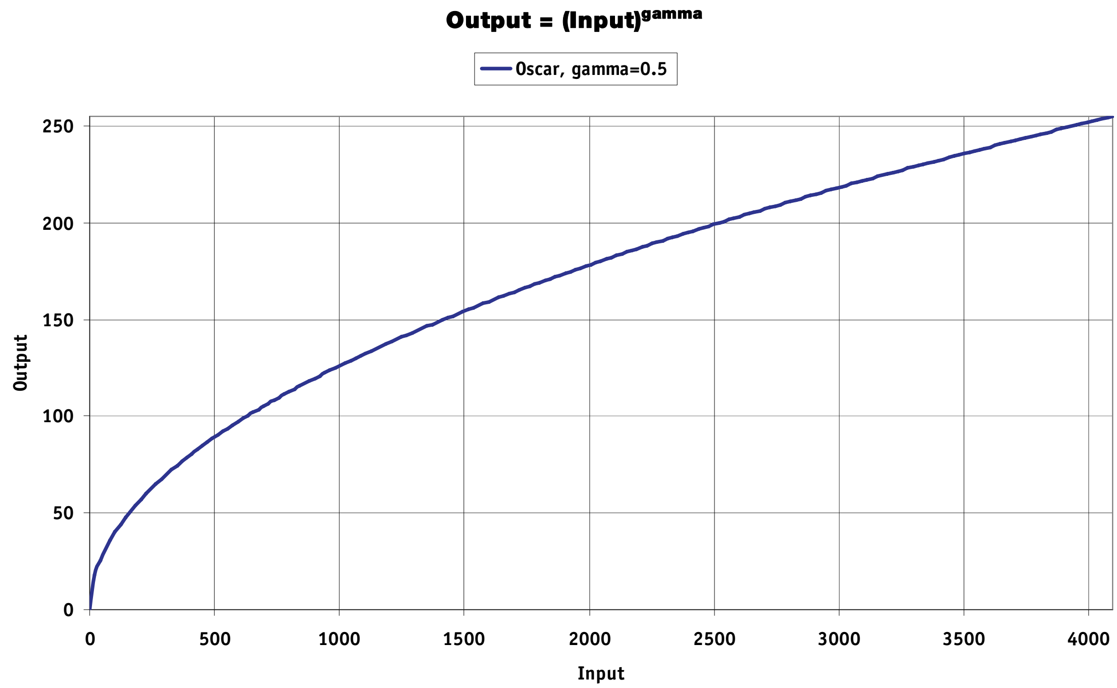


Figure 30: Gamma LUT

Note

- The input value is the most significant **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 LUT, it is not possible to use a different LUT when gamma correction is enabled.
- After overriding the LUT with a user defined content, gamma functionality is no longer available until the next full initialization of the camera.
- LUT content is volatile if you do not use the user profiles to save the LUT.

Loading an 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 kByte, and a complete LUT at 4026 x 8 bit is 4 kByte, programming can't take place in a one block write step because the size of an LUT is larger than GPDATA_BUFFER. Therefore input must be handled in several steps.The flow diagram below shows the sequence required to load data into the camera.

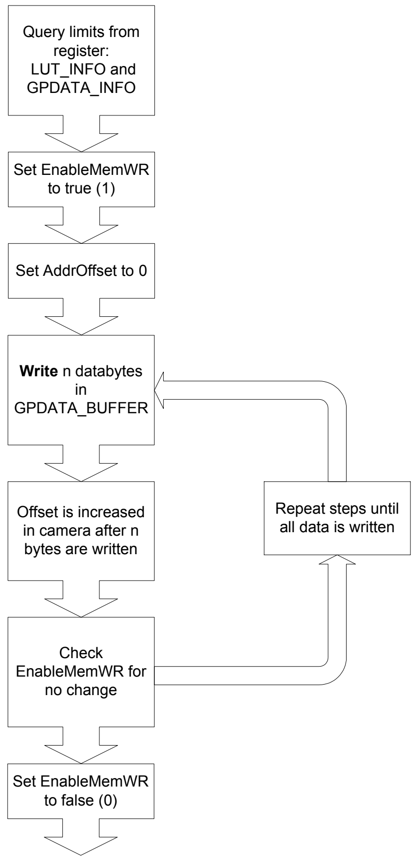


Figure 31: Loading an LUT

Note

Configuration

- To configure this feature in an advanced register: See Table 89: Advanced register: LUT on page 187.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 201.

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 allows correction data to be generated automatically in the camera itself.

Note

- Shading correction does not support the mirror function.
- If you use shading correction, don't change the mirror function.

The following pictures describe the process of automatic generation of correction data. The line profiles were created using MVTEC's **ActivVision Tools**.

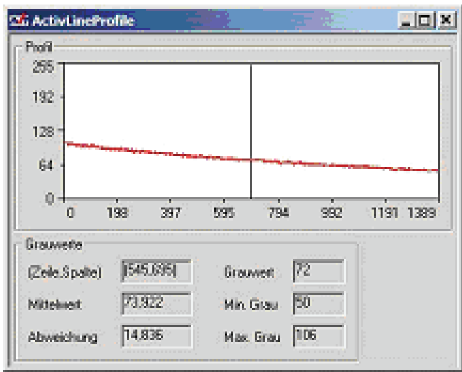


Figure 32: Shading correction: Source image with non-uniform illumination

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 are removed from the source image, therefore its not included in the shading image.

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 means that only the background must be visible and the brightest pixel has a gray value of less than 255 when automatic generation of shading data is started.

It may be necessary to use a neutral white reference, e.g. a piece of paper instead of the real image.

Algorithm

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

After this, a search is made for the brightest pixel in the mean value frame. The brightest pixel(s) remain unchanged. A factor is then calculated for each pixel to be multiplied by, 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 process depends on the number of frames to be calculated and on the resolution of the image.

Correction alone 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:

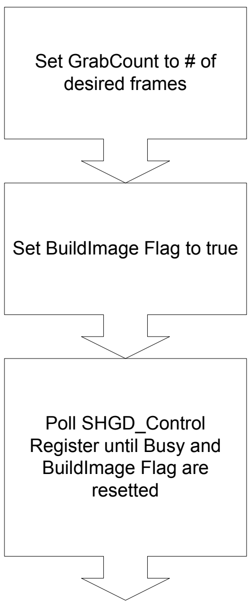


Figure 33: Automatic generation of a shading image

Note

Configuration

To configure this feature in an advanced register: See Table 90: Advanced register: Shading on page 188.

Note

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.

Note

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

Note

- The calculation of shading data is always carried out at the current resolution setting. If the AOI is later larger than the window in which correction data was calculated, none of the pixels lying outside are corrected.
- For Format_7 mode, it is advisable to generate the shading image in the largest displayable frame format. This ensures that any smaller AOIs 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.
- Changing binning modes involves the generation of new shading reference images due to a change in the image size.

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).

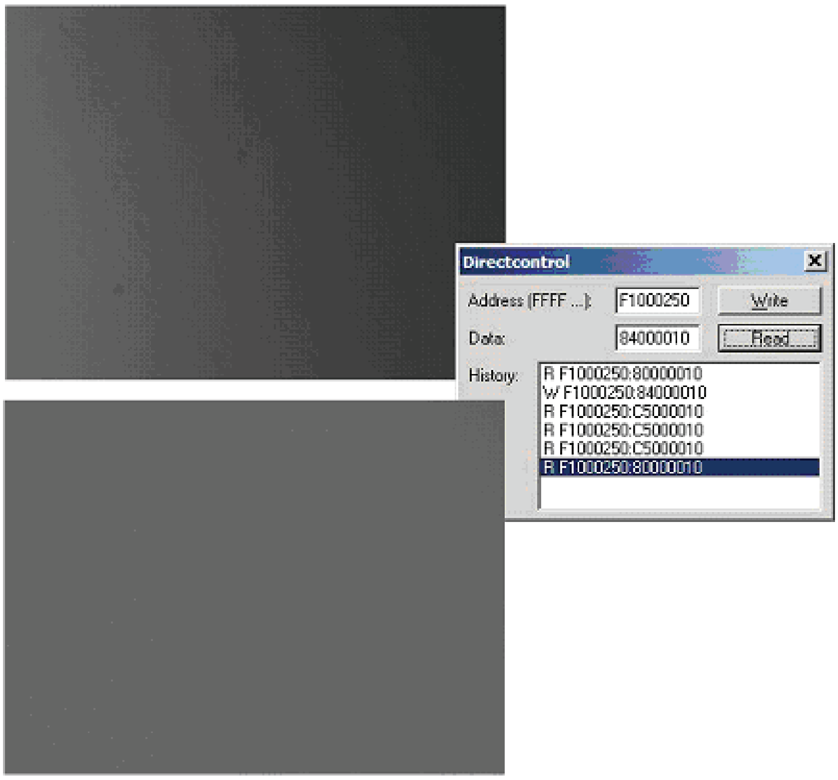


Figure 34: Generation of shading image

After the lens has been focused again, the image below will be seen, but now with a considerably more uniform gradient. This is also made apparent in the graph on the right.

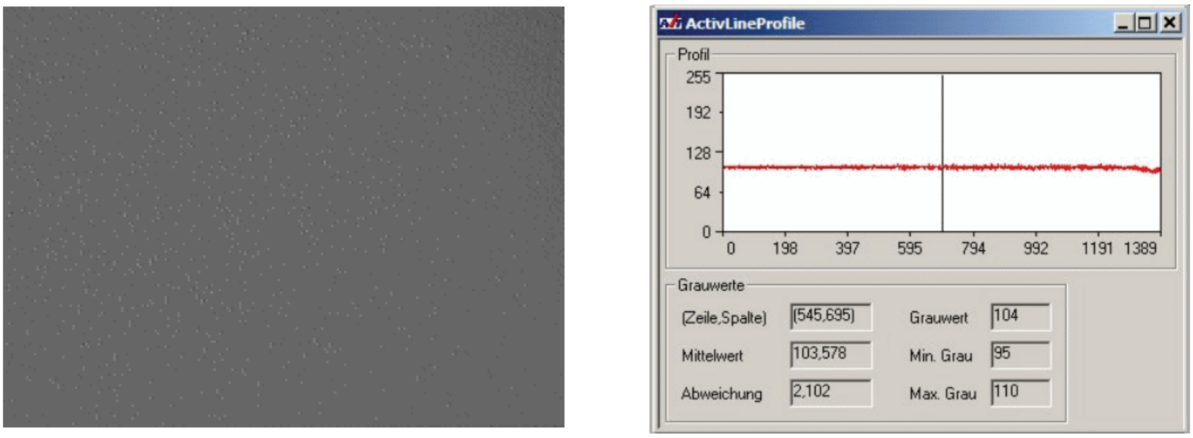


Figure 35: Example of shaded image

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.

What is the real size of the shading image (MaxImageSize)?

The register 0xF1000258 SHDG_INFO (MaxImageSize) delivers the sensor size but not the size of the shading image buffer.

Therefore: If you use this reported (but wrong) MaxImageSize then:

- A shading image which is too small will be uploaded/downloaded.
- The shading correction will only be applied on the first field.
- In Format_7 there will be a row-wise image error

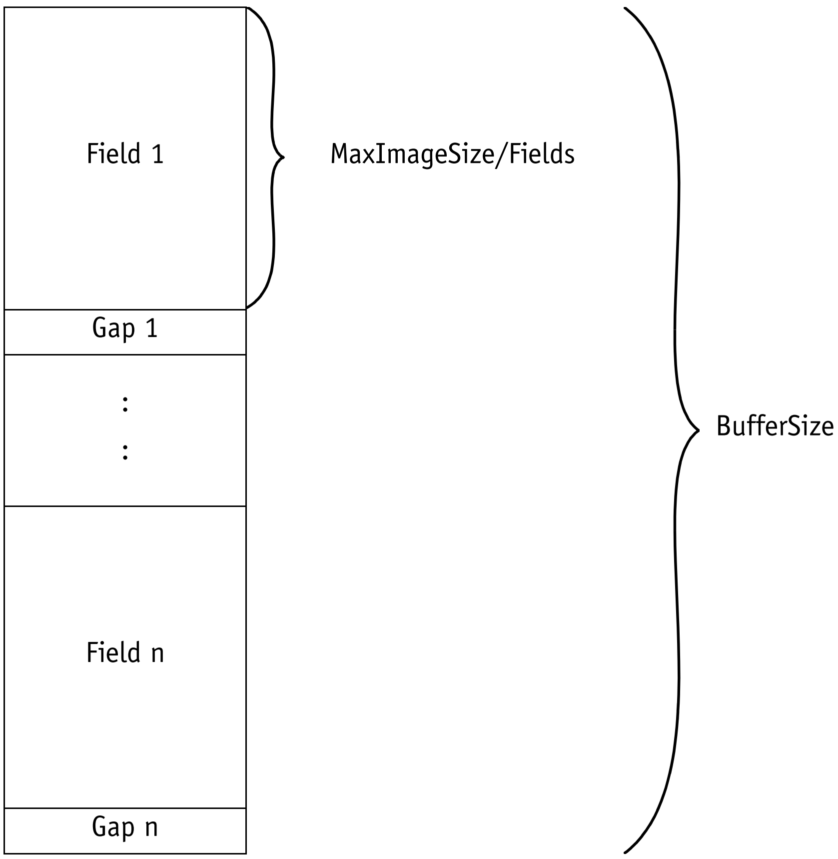
To avoid using a wrong MaxImageSize read the following notes:

The camera's internal buffer for the shading image is greater than the sensor image. Therefore the buffer is divided in N sections with:

n = 1...N

N: number of fields per frame

After each field there is a gap so you can see where each field ends and where the next field begins:



Camera model	N: number of fields per frame	BufferSize
Oscar F-320C	2	620000h
Oscar F-510C	2	A00000h
Oscar F-810C	3	FC0000h

Table 27: Number of fields and BufferSize

For uploading/downloading a shading image the last Gap n can be ignored. The size of a field is calculated from the MaxImageSize which is theoretically camera dependent (MaxImageSize < BufferSize).

This leads to the following formula:

$$\text{MaxImageSize} = \left(\frac{(N-1) \times \text{BufferSize} + \text{MaxImageSize}}{N}\right)$$

Formula 1: MaxImageSize

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:

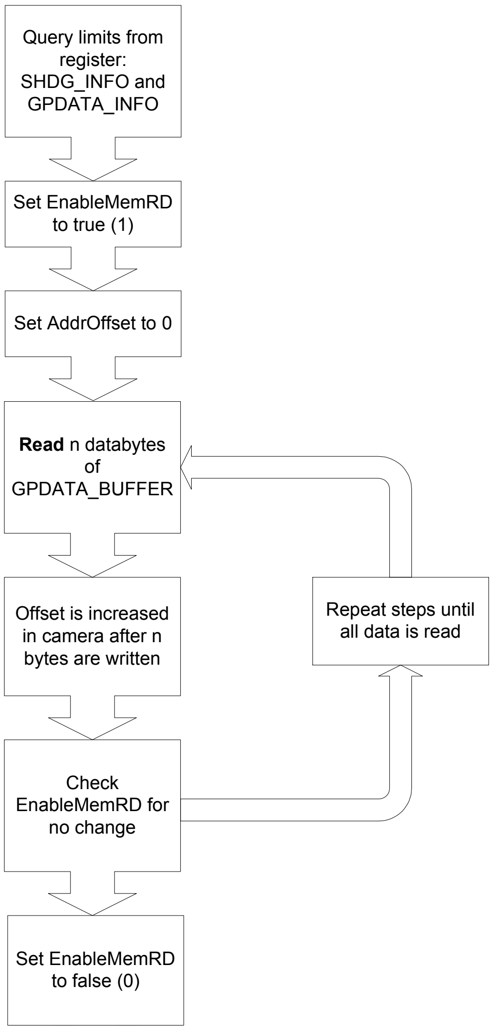


Figure 36: Uploading shading image to host

Note

Configuration

- To configure this feature in an advanced register: See Table 90: Advanced register: Shading on page 188.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 201.

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:

It is recommended that block writes are used to write a block of n bytes with one command into the GPDATA_BUFFER. With firmware 3.04 it is possible to write quadlets directly into the buffer, but this takes much more time.

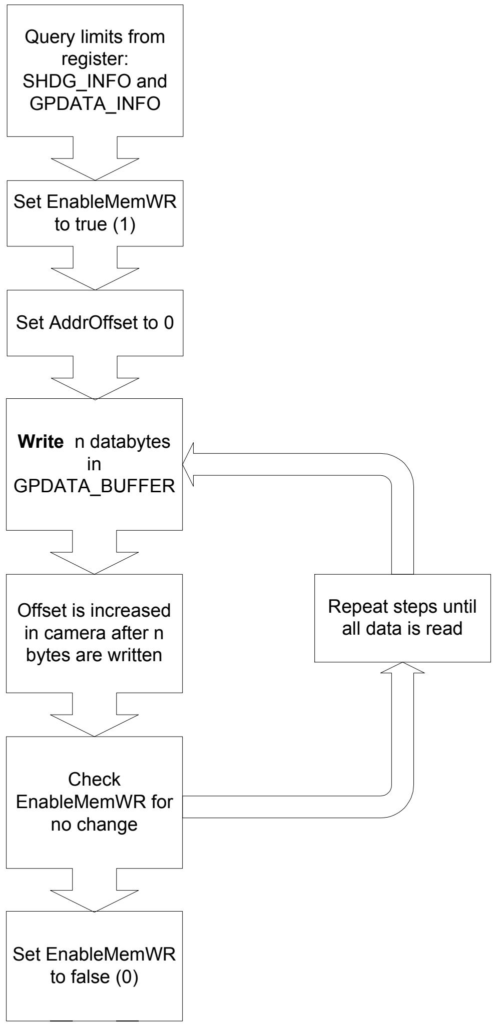


Figure 37: Loading the shading reference image

Note — **Configuration**

- To configure this feature in an advanced register: See Table 90: Advanced register: Shading on page 188.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 201.

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 to the current **FOV** center and can be combined with all image manipulation functions, like **binning**, **shading** and **DSNU**.

This function is especially useful when the camera is looking at objects with the help of a mirror or in certain microscopy applications.

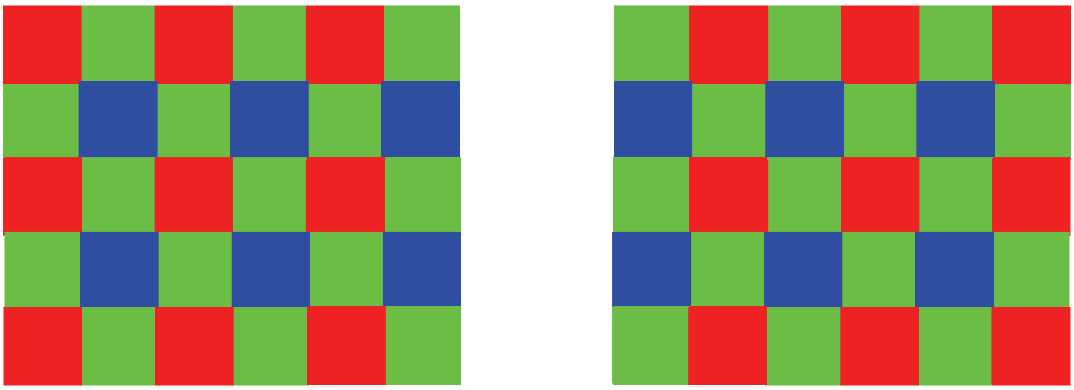
Note

Configuration

To configure this feature in an advanced register: See Table 99: Advanced register: Mirror on page 196.

Note

The use of the mirror function with color cameras and image output in RAW format has implications on the BAYER-ordering of the colors.



Mirror OFF: R-G-G-B (all Oscar cameras)   Mirror ON: G-R-B-G (all Oscar cameras)

Figure 38: Mirror and Bayer order

Note

During switchover one image may be temporarily corrupted.

Binning (only Oscar F-510C)

2 x Binning

Definition

Binning is the process of combining neighboring pixels while being read out from the CCD chip.

Note

Only **Oscar F-510C** has the binning feature.

Binning is used primarily for 3 reasons:

- a reduction in the number of pixels and thus the amount of data while retaining the original image area angle
- an increase in the frame rate (vertical binning and full binning only)
- a brighter image, also resulting in an improvement in the signal-to-noise ratio of the image

Signal-to-noise ratio (SNR) and **signal-to-noise separation** specify the quality of a signal with regard to its reproduction of intensities. The value signifies how high the ratio of noise is in regard to the maximum achievable signal intensity.

The higher this value, the better the signal quality. The unit of measurement used is generally known as the decibel (dB), a logarithmic power level. 6 dB is the signal level at approximately a factor of 2.

However, the advantages of increasing signal quality are accompanied by a reduction in resolution.

Only Format_7

Binning is possible only in video Format_7. The type of binning used depends on the video mode.

Note

Changing binning modes involves the generation of new shading reference images due to a change in the image size.

Types

In general, we distinguish between the following types of binning (H=horizontal, V=vertical):

- 2 x H-binning
- 2 x V-binning

Vertical binning

Vertical binning increases the light sensitivity of the camera by a factor of two by adding together the values of two adjoining vertical pixels output as a single pixel. At the same time this normally improves signal-to-noise separation by about 3 dB.

This reduces vertical resolution. The new resolution is approximately 1/2 of the original resolution.

Format_7 Mode_6

By default use **Format_7 Mode_6** for 2 x vertical binning.

This reduces vertical resolution, depending on the model.

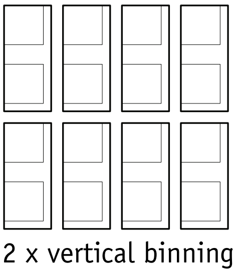


Figure 39: 2 x vertical binning

Note

Vertical resolution is reduced, but **signal-to noise ratio** (SNR) is increased by about 3 (2 x binning).

Note

If **vertical binning** is activated the image may appear to be over-exposed and may require correction.

Note

The image appears **vertically** compressed in this mode and no longer exhibits a true aspect ratio.

Horizontal binning

Definition

In **horizontal binning** adjacent horizontal pixels in a line are combined in pairs.

This means that in horizontal binning the light sensitivity of the camera is also increased by a factor of two (6 dB). Signal-to-noise separation improves by approx. 3 dB.

This reduces horizontal resolution. The new resolution is approximately 1/2 of the original resolution.

Format_7 Mode_5

By default use **Format_7 Mode_5** for 2 x horizontal binning.

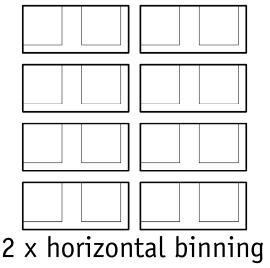


Figure 40: 2 x horizontal binning

Note

The image appears **horizontally** compressed in this mode and does no longer show true aspect ratio.

If **horizontal binning** is activated the image may appear to be over-exposed and must eventually be corrected.

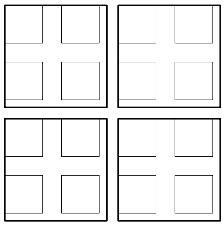
2 x full binning

If horizontal and vertical binning are combined, every 4 pixels are consolidated into a single pixel. At first two horizontal pixels are put together and then combined vertically.

Light sensitivity This increases light sensitivity by a total of a factor of 4 and at the same time signal-to-noise separation is improved by about 6 dB.

Resolution This reduces horizontal and vertical resolution. The new resolution is approximately 1/4 of the original resolution.

Format_7 Mode_7 By default use **Format_7 Mode_7** for 2 x full binning.



2 x full binning

Figure 41: 2 x full binning

Sub-sampling

What is sub-sampling?

Definition Sub-sampling is the process of skipping neighboring pixels (with the same color) while being read out from the CCD chip.

Which Oscar models have sub-sampling?

All Oscar models have this feature.

Description of sub-sampling

Sub-sampling is used primarily for the following reasons:

- A reduction in the number of pixels and thus the amount of 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 of Oscar F-320C and Oscar F-810C is always H+V sub-sampling mode. Oscar F-510C offers two additional special F_7 modes, with horizontal full resolution, but vertically read out progressive (thus sub-sampled). This is advantageous for applications relying on highest horizontal resolution.

Use progressive modes 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 Chapter Read out modes of the sensor on page 53.

2 out of 4 H+V sub-sampling

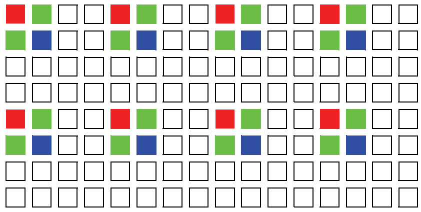


Figure 42: 2 out of 4 H+V sub-sampling (**color**)

Note

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

High SNR mode (High Signal Noise Ratio)

To configure this feature in an advanced register: See Table 101: Advanced register: High Signal Noise Ratio (HSNR) on page 197.

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 $\sqrt{2}$ (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.

Note

- The averaged image is output 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 (**Dy**namic **R**ange) enhancements.

Sharpness

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

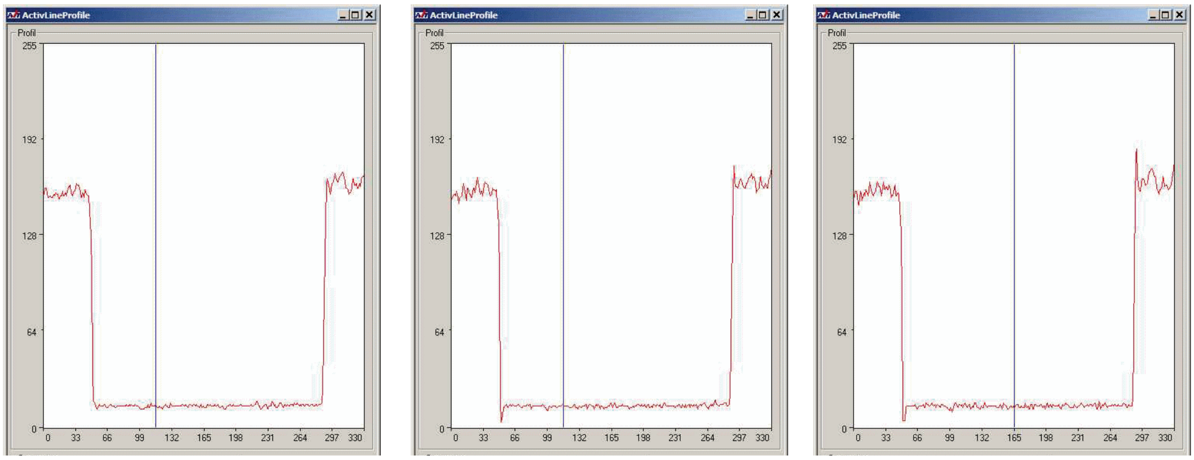


Figure 43: Sharpness: left: 0, middle: 1, right: 2

Note

Configuration

To configure this feature in feature control register: See Table 77: Feature control register on page 169.

Color interpolation

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

RAW mode is accessible via Color_Mode Mono8, RAW8 and via Format_7.

Note

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

Color interpolation (BAYER demosaicing)

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

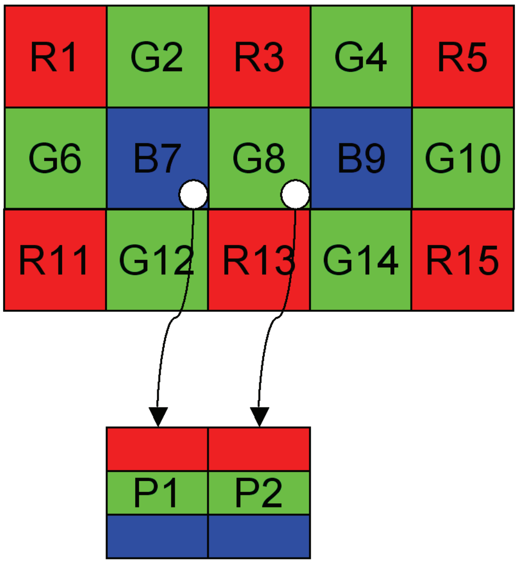


Figure 44: Bayer demosaicing (interpolation)

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

$$P1_{green} = \frac{G2 + G6 + G8 + G12}{4} \qquad P2_{green} = \frac{G4 + 2 \times G8 + G12}{4}$$

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

Formula 2: Bayer demosaicing interpolation formula

Color correction

Why color correction?

The spectral response of a CCD is different of those of an output device or the human eye. This is the reason for the fact that perfect color reproduction is not possible. In each Oscar camera there is a factory setting for the color correction coefficients, see Chapter GretagMacbeth ColorChecker on page 92.

Color correction is needed to eliminate the overlap in the color channels. This overlap is caused by the fact that:

- Blue light: is seen by the red and green pixels on the CCD
- Red light: is seen by the blue and green pixels on the CCD
- Green light: is seen by the red and blue pixels on the CCD

The color correction matrix subtracts out this overlap.

Color correction in AVT cameras

In AVT cameras the color correction is realized as an additional step in the process from the sensor data to color output.

Color correction is used to harmonize colors for the human eye. With other AVT (color) cameras so far, you had the opportunity to use it or to switch it off.

Color correction: formula

Color correction is performed on all color CCD models before YUV conversion and mapped via a matrix as follows.

$$
\begin{aligned}
red^* &= Crr \times red + Cgr \times green + Cbr \times blue \\
green^* &= Crg \times red + Cgg \times green + Cbg \times blue \\
blue^* &= Crb \times red + Cgb \times green + Cbb \times blue
\end{aligned}
$$

Formula 3: Color correction

GretagMacbeth ColorChecker

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

Note

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:

Register	Name	Description
0xF10003A0	COLOR_CORR	Write: 02000000h to switch color correction OFF Write: 00000000h to switch color correction ON (default)

Table 28: Color correction switch off in YUV mode

Color conversion (RGB → YUV)

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

$$\begin{aligned} Y &= 0.3 \times R + 0.59 \times G + 0.11 \times B \\ U &= -0.169 \times R - 0.33 \times G + 0.498 \times B + 128 \\ V &= 0.498 \times R - 0.420 \times G - 0.082 \times B + 128 \end{aligned}$$

Formula 4: RGB to YUV conversion

Note

- 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.

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 white balance. Use this setting to manipulate the color appearance after having done 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.

Note

Configuration

To configure this feature in feature control register: See Table 77: Feature control register on page 169.

Consider hue changes as a change in the angle of the vector, 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.

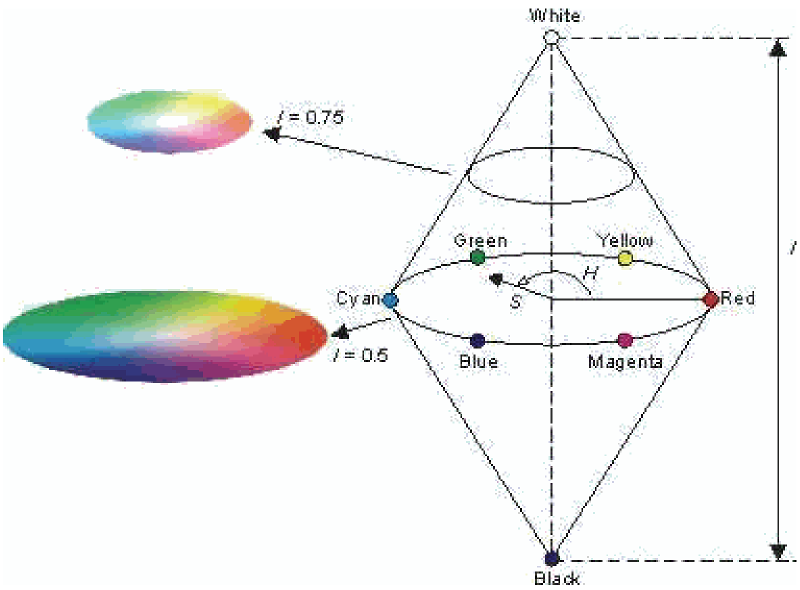


Figure 45: Hue and saturation explanation

Note

This transformation is not accessible from outside.

Serial interface

All Oscar cameras are equipped with the SIO (serial input/output) feature as described in IIDC V1.31. This means that the Oscar's serial interface which is used for firmware upgrades can also 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 serial interface data is put into a camera buffer and can be polled from here via simple read commands. Controlling registers enable the settings of baud rates and the check of buffer sizes and serial interface errors.

Note

- Hardware handshaking is not supported.
- Typical PC hardware does not usually support 230400 bps or more.

Base address for the function is: F0F02100h.

To configure this feature in access control register (CSR):

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 bit 8: 8 bit 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 bit 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.

Table 29: Serial input/output control and status register (SIO CSR)

Offset	Name	Field	Bit	Description
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 WR: 0: no error (to clear status) 1: Ignored
		FER	[13]	Receive data framing error Read: current status WR: 0: no error (to clear status) 1: Ignored
		PER	[14]	Receive data parity error Read: current status WR: 0: no error (to clear status) 1: Ignored
		---	[15..31]	Reserved

Table 29: Serial input/output control and status register (SIO CSR)

Offset	Name	Field	Bit	Description
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 RD: Number of bytes to be read from the receive FIFO WR: 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 character from receive buffer WR: Write character to transmit buffer
	SIO_DATA_REGISTER	CHAR_1	[8..15]	Character_1 RD: Read character from receive buffer+1 WR: Write character to transmit buffer+1
	SIO_DATA_REGISTER	CHAR_2	[16..23]	Character_2 RD: Read character from receive buffer+2 WR: Write character to transmit buffer+2
	SIO_DATA_REGISTER	CHAR_3	[24..31]	Character_3 RD: Read character from receive buffer+3 WR: Write character to transmit buffer+3

Table 29: Serial input/output control and status register (SIO CSR)

To read data:

1. Query RDRD flag (buffer ready?) and write the number of bytes the host wants to read to RBUF_CNT.
2. 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?).
3. Read received characters from SIO_DATA_REGISTER, beginning at char 0.
4. To input more characters, repeat from step 1.

To write data:

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

Note

- 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. Alternatively use SmartView to try out this feature.

Controlling image capture

Shutter modes 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.

Continuous mode In continuous modes the shutter is opened shortly before the vertical reset happens, thus acting in a frame-synchronous way.

External trigger 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 no image lag and with minimal image blur.

Camera I/O The external trigger is fed as a TTL signal through **Pin 4** of the camera I/O connector.

Trigger modi

Oscar cameras support IIDC conforming Trigger_Mode_0 and Trigger_Mode_1 (in progressive modes only) and special Trigger_Mode_15 (bulk trigger).

Trigger mode	also known as	Description
Trigger_Mode_0	Edge mode	Sets the shutter time according to the value set in the **shutter** (or extended shutter) **register**
Trigger_Mode_1	Level mode	Sets the shutter time according to the **active low time** of the pulse applied (or active high time in the case of an inverting input)
Trigger_Mode_15	Programmable mode	Is a **bulk trigger**, combining one external trigger event with continuous or one-shot or multi-shot internal trigger

Table 30: Trigger modi

Edge mode (Trigger_Mode_0)

Trigger_Mode_0 sets the shutter time according to the value set in the shutter (or extended shutter) register.

Level mode (Trigger_Mode_1)

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).

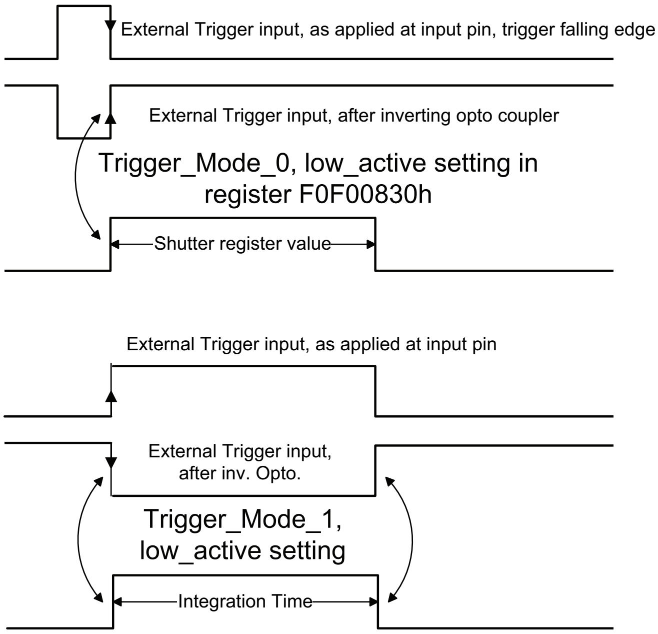


Figure 46: Trigger_Mode_0 and 1

Bulk trigger (Trigger_Mode_15)

Trigger_Mode_15 is a bulk trigger, combining one external trigger event with continuous or one-shot or multi-shot internal trigger.

It is an extension of 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.
- Grabbing an unlimited number of images after one external trigger (surveillance)

The figure below illustrates this mode.

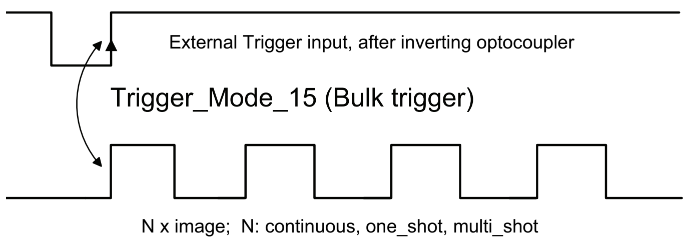


Figure 47: Trigger_Mode_15

The functionality is controlled via bit [6] and bitgroup [12-15] of the IIDC 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 Read: read a status 0: OFF 1: ON If this bit = 0, other fields will be read only.
		Trigger_Polarity	[7]	Select trigger polarity (Except for software trigger) If Polarity_Inq is 1: Write to change polarity of the trigger input. Read to get polarity of the trigger input. If Polarity_Inq is 0: Read only. 0: Low active input 1: High active input
		Trigger_Source	[8..10]	Select trigger source Set trigger source ID from trigger source ID_Inq.
		Trigger_Value	[11]	Trigger input raw signal value read only 0: Low 1: High
		Trigger_Mode	[12..15]	Trigger_Mode (Trigger_Mode_0..15)
		---	[16..19]	Reserved
		Parameter	[20..31]	Parameter for trigger function, if required (optional)

Table 31: Trigger_Mode_15 (Bulk trigger)

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 = continuous	Middle = one-shot	Right = multi-shot
Line #3 switches camera back to **continuous** mode. Only one image is grabbed precisely with the first external trigger. To repeat rewrite line three.	Line #3 toggles **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.	Line #3 toggles **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.

Table 32: Description: using Trigger_Mode_15: continuous, one-shot, multi-shot

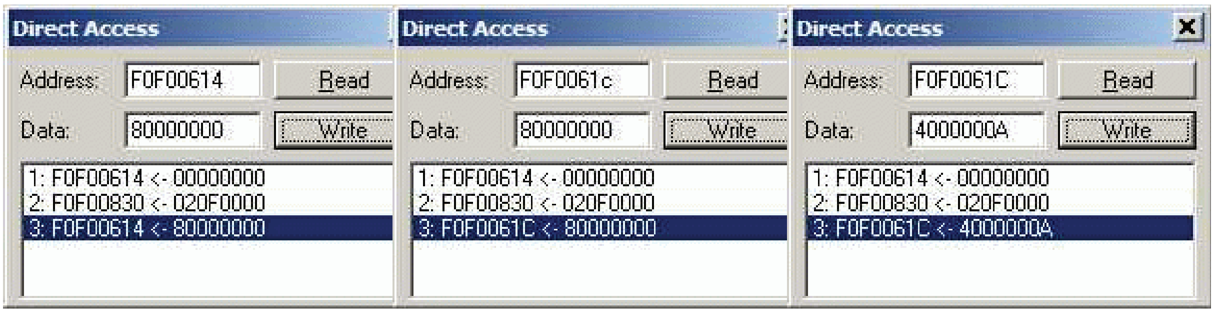


Figure 48: Using Trigger_Mode_15: Continuous, one-shot, multi-shot

Note

Shutter for the images is controlled by shutter register.

Trigger delay

As already mentioned earlier, the cameras feature various ways to delay image capture based on external trigger.

With IIDC V1.31 there is a standard CSR at Register F0F00534/834h to control a delay up to FFFh x time base value.

The following table explains the inquiry register and the meaning of the various bits.

Register	Name	Field	Bit	Description
0xF0F00534	TRIGGER_DLY_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]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature

Table 33: 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 Read: read a status 0: OFF 1: ON If this bit = 0, other fields will be read only.
		---	[7..19]	Reserved
		Value	[20..31]	Value If you write the value in OFF mode, this field will be ignored. If **ReadOut** capability is not available, then the read value will have no meaning.

Table 34: CSR: **trigger delay**

In addition, the cameras have an advanced register which allows even more precise delay of 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]	Reserved
		ON_OFF	[6]	Trigger delay on/off
		---	[7..10]	Reserved
		DelayTime	[11..31]	Delay time in µs

Table 35: Advanced CSR: **trigger delay**

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

Note

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

Shutter modes

Due to the frame readout (interlaced) modes 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.

Split shutter

The **split shutter** term results from the fact that two (Oscar F-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.

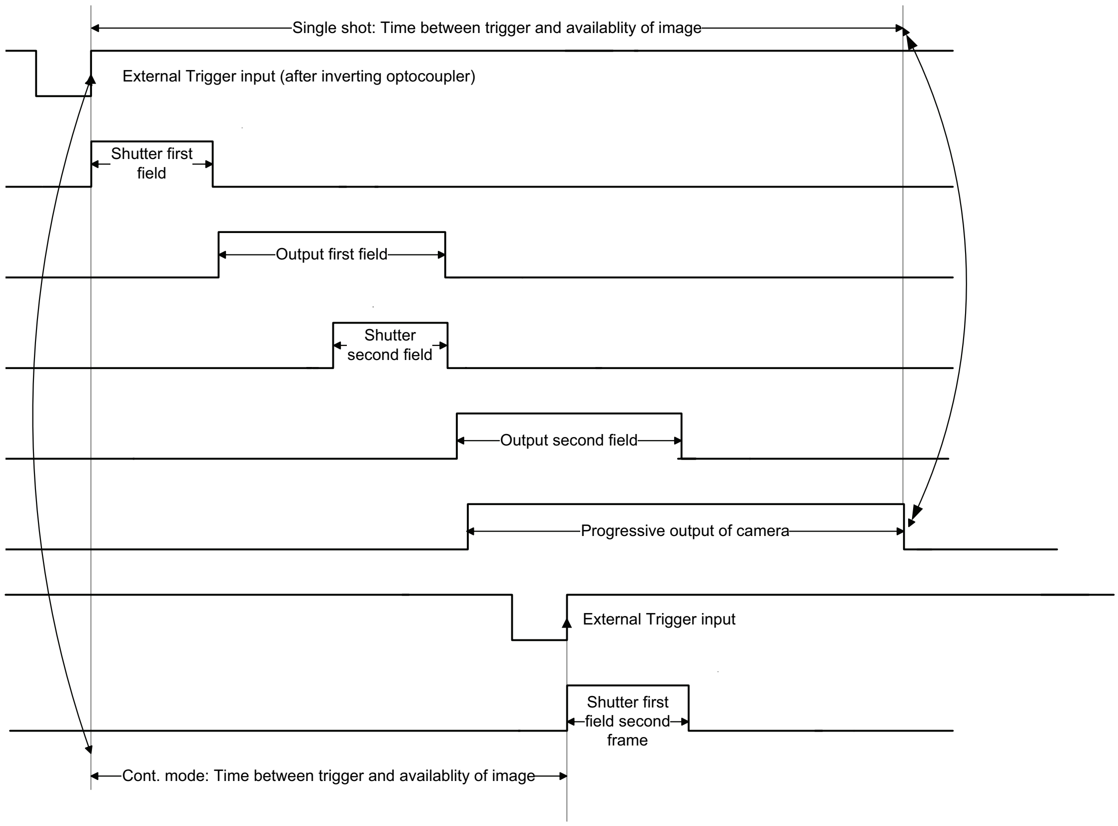


Figure 49: Split shutter

Note

- 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 (Oscar F-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.

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 diagram illustrates this mode.

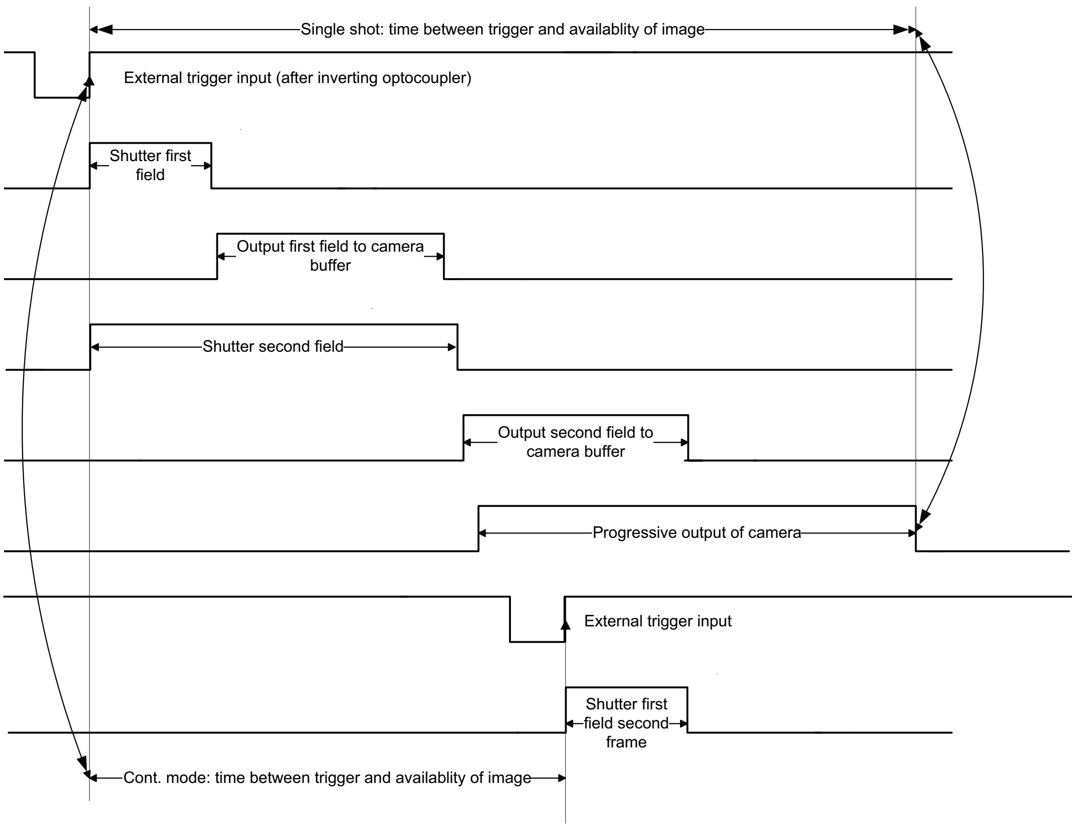


Figure 50: Joint shutter mode

Note

- 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 (Oscar F-810C) fields before the progressive output of the camera can start.

Exposure time (shutter) and offset

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

Shutter register value x time base + 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 Table 85: Advanced register: Time base on page 184). The default value here is set to 20 µs.

A camera-specific offset is also added to this value. It is different for the camera models:

Exposure time offset

Camera model	Offset interlaced	Offset progressive
Oscar F-320C	**46** µs	**57** µs
Oscar F-510C	**74** µs	**83** µs
Oscar F-810C	**98** µs	**98** µs

Table 36: Camera-specific offset

Example: Oscar F-510C

Camera	Register value	Timebase
Oscar F-510C in interlaced (frame readout) mode	100	20 µs

Table 37: Register value and time base for Oscar F-510C

100 x 20 µs + **74** µs = 2074 µs exposure time

The minimum adjustable exposure time set by register is **20** µs.
→ The real minimum exposure time of an Oscar F-510C is then
20 µs + **74** µs = 94 µs in frame readout mode.

Note

Generally all 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.

Extended shutter

The exposure time for long-term integration of up to 67 seconds can be extended via the advanced register: EXTENDED_SHUTTER

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

Table 38: Advanced register: **extended shutter**

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

Note

- 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 also may increase some unwanted effects, such as noise and pixel-to-pixel non-uniformity. Depending on the application, these effects may limit the longest usable integration time.
- Changes in this register have immediate effect, even when the camera is transmitting.
- Extended shutter becomes inactive after writing to a format/mode/frame rate register.

One-shot

Oscar cameras can record an image by setting the **one-shot 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 Chapter ISO_Enable / free-run on page 115), this flag is ignored.

If **one-shot mode** is combined with the external trigger, the **one-shot** 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, **one-shot** can be cancelled by clearing the bit.

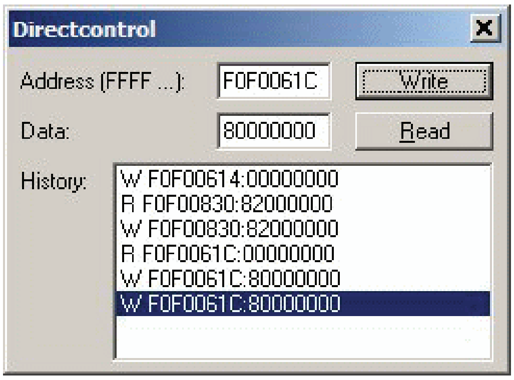


Figure 51: One-shot control

One-shot command on the bus starting exposure

The following sections describe the time response of the camera using a single frame (one-shot) 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.

Feature	Value
One-shot → microcontroller sync	≤ 250 µs (processing time in the microcontroller)
µC-Sync/ExSync → integration start	8 µs

Table 39: Values for one-shot

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.

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:

500 µs ± 62.5 µs

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

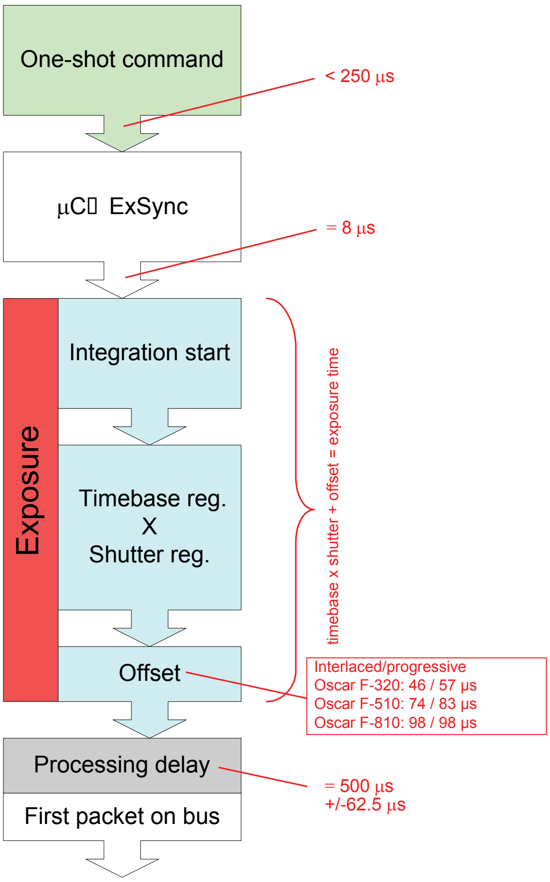


Figure 52: Data flow and timing after end of exposure

Multi-shot

Setting **multi-shot** 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 (see Chapter ISO_Enable / free-run on page 115), this flag is ignored and deleted automatically once all the images have been recorded.

If **multi-shot** 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 helpful in combination with the so-called **deferred mode** to limit the number of grabbed images to the FIFO size.

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 (free-run)**. The camera captures an infinite series of images. This operation can be quit by deleting the **0** bit.

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 Chapter Jitter at start of exposure on page 116.

The following screenshot shows an example of broadcast commands sent with the Firedemo example of FirePackage (version 1V51 or newer):

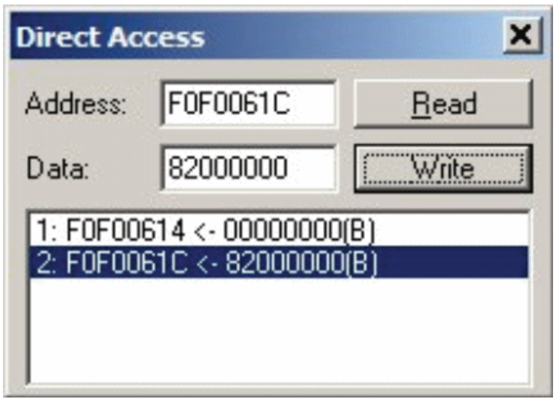


Figure 53: Broadcast one-shot

- 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, which forces all connected cameras to simultaneously grab one image.

Jitter at start of exposure

The following chapter discusses the latency time which exists for all Oscar cameras when either a hardware or software trigger is generated, until the actual image exposure starts.

Owing to the well-known fact that an **Interline Transfer CCD** sensor has both a light sensitive area and a separate storage area, it is common to interleave image exposure of a new frame and output that of the previous one. It makes continuous image flow possible, even with an external trigger.

The uncertain time delay before the start of exposure depends on the state of the sensor. A distinction is made as follows:

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

In this case the camera must not change horizontal timing so that the trigger event is synchronized with the current horizontal clock. This introduces a maximum 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
Oscar F-320C	± 3.35 µs	± 98 µs
Oscar F-510C	± 6.00 µs	± 134 µs
Oscar F-810C	± 7.85 µs	± 128 µs

Table 40: Jitter at exposure start

Note

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

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 order of events can be paused or delayed by using the **deferred image transport** feature.

Oscar cameras, by standard, are equipped with 32 MB RAM (Oscar F-810C: 64 MB 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 (standard)	# frames (256 MB)
Oscar F-320C	3 frames (32 MB)	31 frames (256 MB)
Oscar F-510C	2 frames (32 MB)	23 frames (256 MB)
Oscar F-810C	3 frames (64 MB)	15 frames (256 MB)

Table 41: 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 available bus bandwidth, DMA- and ISO-channels into account.

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]	Reserved
		SendImage	[5]	Send NumOfImages now (auto reset)
		HoldImg	[6]	Enable/disable deferred transport mode
		FastCapture	[7]	Enable/disable fast capture mode
		---	[8..15]	Reserved
		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 42: Advanced register: **Deferred image transport**

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.

Note

- Pay attention to the maximum number of images that can be stored in FIFO. If you capture more images 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. Read out one image less than maximum buffer size in this case.

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

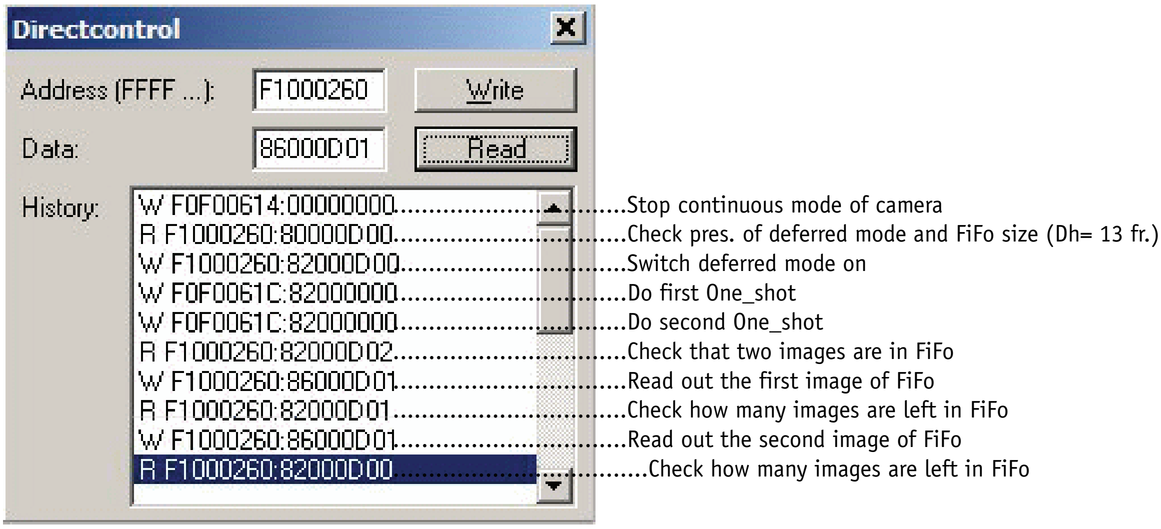


Figure 54: Example of controlling deferred mode

FastCapture

This mode can be activated only in Format_7.

- If **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.
- If **FastCapture** is set 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 need to be recorded at the highest sensor speed but the output can be at a lower frame frequency to save bandwidth.

Video formats, modes and bandwidth

The different Oscar models support different video formats, modes and frame rates.

These formats and modes are standardized in the IIDC (formerly DCAM) specification.

Resolutions in Format_0, Format_1 and Format_2, which are smaller than the generic sensor resolution, are generated symmetrically from the center of the sensor and without binning.

Different color processing modes in Format_7 are accessed via Color_Coding_ID register, as listed for Oscar F-510C.

Binning modes are only available in Format_7 for Oscar F-510C:

- Format_7 Mode_5: horizontal binning (H-binning)
- Format_7 Mode_6: vertical binning (V-binning)
- Format_7 Mode_7: horizontal and vertical binning (H+V binning)

Note

- The maximum frame rates can only be achieved with shutter settings lower than 1/framerate. This means that with default shutter time of 40 ms, a camera will not achieve frame rates higher than 25 frames/s. In order to achieve higher frame rates, please reduce the shutter time proportionally.
- **The following tables assume that bus speed is 400 Mbit/s.** With lower bus speeds (e.g. 200 or 100 Mbit/s) not all frame rates may be achieved.
- For information on bit/pixel and byte/pixel for each color mode see Table 92: ByteDepth on page 215.

Note

H-binning means horizontal binning.

V-binning means vertical binning.

Full binning (H+V) means horizontal + vertical binning

2 x binning means: 2 neighboring pixels are combined.

- **Binning increases signal-to-noise ratio** (SNR), but decreases resolution.

Video formats: Oscar F-320C

Format	Mode	Resolution	Color mode	60 fps	30 fps [4]	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	MONO8						
	6	640 x 480	MONO16						

Table 43: Video fixed formats Oscar F-320C (centered progressive preview mode)

Format	Mode	Resolution	Color mode	Frame rate / fps	Description
7	0	2080 x 1540	Mono8 [2]	6.59	frame readout, joint shutter
			YUV411	6.59	
			YUV422	5.11	
			RGB8	3.41	
			Raw8 [1]	6.59	
			Raw16 [1]	5.11	
			Y8red, Y8green, Y8blue [3]	6.59	
7	1	2080 x 1540	Mono8 [2]	6.59	frame readout, split shutter
			YUV411	6.59	
			YUV422	5.11	
			RGB8	3.41	
			Raw8 [1]	6.59	
			Raw16 [1]	5.11	
			Y8red, Y8green, Y8blue [3]	6.59	

Table 44: Video Format_7 formats Oscar F-320C

Format	Mode	Resolution	Color mode	Frame rate / fps	Description
7	2	344 x 254	Mono8 [2]	39.31 [4]	progressive preview mode sub-sampling
			YUV411	39.31 [4]	
			YUV422	39.31 [4]	
			RGB8	39.51 [4]	
			Raw8 [1]	39.31 [4]	
			Raw16 [1]	39.31 [4]	
			Y8red, Y8green, Y8blue [3]	39.31 [4]	

Table 44: Video Format_7 formats Oscar F-320C

[1] Camera outputs RAW image which needs to be converted outside of camera.
[2] Camera outputs interpolated B/W image using luma interpolation formula.
[3] Camera outputs interpolated B/W image using one of the R-G-B color planes.
[4] Only achievable with shutter settings that don't exceed 1/framerate.

Video formats: Oscar F-510C

Format	Mode	Resolution	Color mode	60 fps	30 fps [4]	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[2]	x[2]	
	3	1024 x 768	YUV422				x	x	
	4	1024 x 768	RGB8				x	x	
	5	1024 x 768	MONO8						
	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	MONO8				x[2]	x[2]	x[2]
	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						

Table 45: Video fixed formats Oscar F-510C (progressive)

[1] Camera outputs RAW image which needs to be converted outside of camera.
[2] Camera outputs interpolated B/W image using luma interpolation formula.
[3] Camera outputs interpolated B/W image using one of the R-G-B color planes.
[4] Only achievable with shutter settings that don't exceed 1/framerate.

Format	Mode	Resolution	Color mode	Frame rate / fps	Description
7	0	2588 x 1958	Mono8 [2]	3.80	frame readout joint shutter
			YUV411	3.80	
			YUV422	3.23	
			RGB8	2.15	
			Raw8 [1]	3.80	
			Raw16 [1]	3.23	
			Y8red, Y8green, Y8blue [3]	3.80	
7	1	2588 x 1958	Mono8 [2]	3.80	frame readout split shutter
			YUV411	3.80	
			YUV422	3.23	
			RGB8	2.15	
			Raw8 [1]	3.80	
			Raw16 [1]	3.23	
			Y8red, Y8green, Y8blue [3]	3.80	
7	2	1288 x 978	Mono8 [2]	7.59	progressive, centered sub-sampling
			YUV411	7.58	
			YUV422	7.59	
			RGB8	7.59	
			Raw8 [1]	7.59	
			Raw16 [1]	7.59	
			Y8red, Y8green, Y8blue [3]	7.59	
7	3	2576 x 978	Mono8 [2]	7.59	progressive scan v-sub-sampling
			YUV411	7.59	
			YUV422	6.50	
			RGB8	4.33	
			Raw8 [1]	7.59	
			Raw16 [1]	6.50	
			Y8red, Y8green, Y8blue [3]	7.59	

Table 46: Video Format_7 formats Oscar F-510C

Format	Mode	Resolution	Color mode	Frame rate / fps	Description
7	4	2576 x 1958	Mono8 [2]	3.87	progressive scan V-line-doubling
			YUV411	3.87	
			YUV422	3.25	
			RGB8	2.16	
			Raw8 [1]	3.87	
			Raw16 [1]	3.25	
			Y8red, Y8green, Y8blue [3]	3.87	
7	5	1292 x 1958	Mono8 [2]	3.79	interlaced, split shutter 2 x H-binning
			YUV411	3.80	
			YUV422	3.80	
			RGB8	3.80	
			Raw8 [1]	3.79	
			Raw16 [1]	3.80	
			Y8red, Y8green, Y8blue [3]	3.79	
7	6	2588 x 978	Mono8 [2]	6.98	interlaced, split shutter 2 x V-binning
			YUV411	6.99	
			YUV422	6.47	
			RGB8	4.31	
			Raw8 [1]	6.98	
			Raw16 [1]	6.47	
			Y8red, Y8green, Y8blue [3]	6.98	
7	7	1292 x 978	Mono8 [2]	6.98	interlaced, split shutter 2 x H+V binning
			YUV411	6.98	
			YUV422	6.98	
			RGB8	6.99	
			Raw8 [1]	6.98	
			Raw16 [1]	6.98	
			Y8red, Y8green, Y8blue [3]	6.98	

Table 46: Video Format_7 formats Oscar F-510C

[1] Camera outputs RAW image which needs to be converted outside of camera.
[2] Camera outputs interpolated B/W image using luma interpolation formula.
[3] Camera outputs interpolated B/W image using one of the R-G-B color planes.
[4] Only achievable with shutter settings that don't exceed 1/framerate.

The different color modes in Format_7 modes are controlled via the COLOR_CODING_ID register in combination with COLOR_CODING_INQ register.

Offset	Name	Field	Bit	Notes
F0F08010h	FORMAT_7_MODE_0 COLOR_CODING_ID	Coding_ID	[0..7]	Color coding ID from COLOR_CODING_INQ register
F0F08014h	F_7M_0 COLOR_CODING_INQ	Mono8	[0]	ID=0
		YUV 411	[1]	ID=1
		YUV 422	[2]	ID=2
		RGB8	[4]	ID=4
		RAW8	[9]	ID=9
		RAW16	[10]	ID=10
F0F08024h		Y8red	[0]	ID=128
		Y8green	[1]	ID=129
		Y8blue	[2]	ID=130
F0F09010h	F_7M_1 COLOR_CODING_ID			Same for Mode_1
F0F09014h	F_7M_1 COLOR_CODING_INQ			Same for Mode_1
F0F0A010h	F_7M_2 COLOR_CODING_ID			Same for Mode_2
F0F0A014h	F_7M_2 COLOR_CODING_INQ			Same for Mode_2
F0F0B010h	F_7M_3 COLOR_CODING_ID			Same for Mode_3
F0F0B014h	F_7M_3 COLOR_CODING_INQ			Same for Mode_3
F0F0C010h	F_7M_4 COLOR_CODING_ID			Same for Mode_4
F0F0C014h	F_7M_4 COLOR_CODING_INQ			Same for Mode_4

Table 47: Color coding inquiry and IDs

Video formats: Oscar F-810C

Format	Mode	Resolution	Color mode	60 fps	30 fps [4]	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	MONO8				x[2]	x[2]	
	6	800 x 600	MONO16						
	7	1024 x 768	MONO16						

Table 48: Fixed video formats Oscar F-810C (frame readout, centered)

[1] Camera outputs RAW image which needs to be converted outside of camera.
[2] Camera outputs interpolated B/W image using luma interpolation formula.
[3] Camera outputs interpolated B/W image using one of the R-G-B color planes.
[4] Only achievable with shutter settings that don't exceed 1/framerate.

Format	Mode	Resolution	Color mode	Frame rate / fps	Description
7	0	3272 x 2469	Mono8 [2]	3.15	frame readout joint shutter
			YUV411	2.70	
			YUV422	2.03	
			RGB8	1.35	
			Raw8 [1]	3.15	
			Raw16 [1]	2.03	
			Y8red, Y8green, Y8blue [3]	3.15	
7	1	3272 x 2469	Mono8 [2]	3.15	frame readout split shutter
			YUV411	2.70	
			YUV422	2.03	
			RGB8	1.35	
			Raw8 [2]	3.15	
			Raw16 [1]	2.03	
			Y8red, Y8green, Y8blue [3]	3.15	

Table 49: Format_7 video formats Oscar F-810C

Format	Mode	Resolution	Color mode	Frame rate / fps	Description
7	2	1088 x 822	Mono8 [2]	8.86	progressive scan sub-sampling
			YUV411	8.88	
			YUV422	8.88	
			RGB8	8.88	
			Raw8 [1]	8.86	
			Raw16 [1]	8.88	
			Y8red, Y8green, Y8blue [3]	8.86	

Table 49: Format_7 video formats Oscar F-810C

[1] Camera outputs RAW image which needs to be converted outside of camera.
[2] Camera outputs interpolated B/W image using luma interpolation formula.
[3] Camera outputs interpolated B/W image using one of the R-G-B color planes.
[4] Only achievable with shutter settings that don't exceed 1/framerate.

Area of interest (AOI)

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 limiting the image to a section when reading it out from the camera. At a lower vertical resolution the sensor can be read out faster and thus the frame rate is increased.

Note

The setting of AOIs is supported only in video Format_7.

While the size of the image read out for most other video formats and modes is fixed by the IIDC specification, thereby 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 = AOI) he is interested in to determine the size and thus the highest possible frame rate.

Setting the AOI is done in the IMAGE_POSITION and IMAGE_SIZE registers.

Note

Pay attention to the increments entering 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.

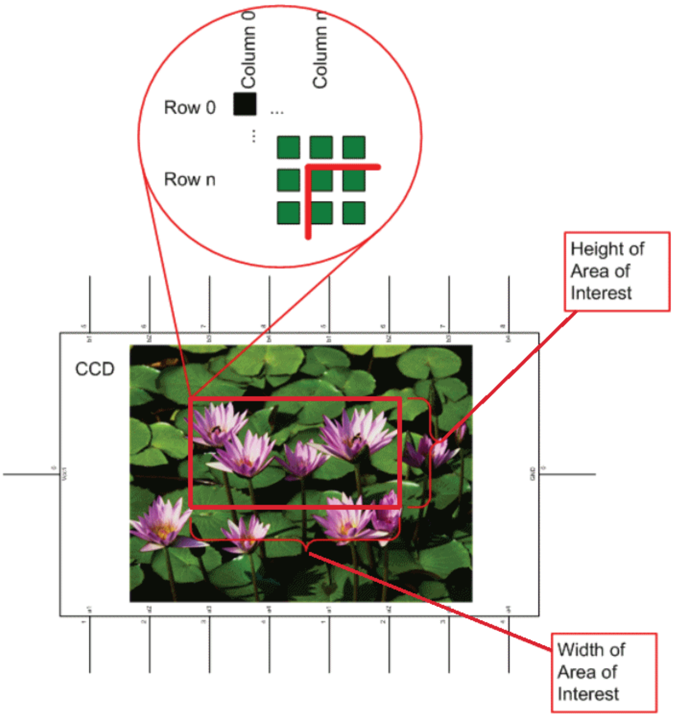


Figure 55: Area of Interest (AOI)

Note

- 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	Oscar F-320C	Oscar F-510C	Oscar F-810C F_7 Mode_0/1	Oscar F-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 50: AOI increments for different camera models and Format_7 modes

In addition to the Area of Interest, some 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.

Read the next chapter for more details.

Frame rates

An IEEE 1394 camera requires bandwidth to transport images.

The IEEE 1394a bus has very large bandwidth of at least 32 MByte/s for transferring (isochronously) image data. Per cycle up to 4096 bytes (or around 1000 quadlets = 4 bytes @ 400 Mbit/s) can thus be transmitted.

Note

All bandwidth data is calculated with:

1 MByte = 1024 kByte

Depending on the video format settings and the configured frame rate, the camera requires a certain percentage of maximum available bandwidth. Clearly the bigger the image and the higher the frame rate, there is more data to be transmitted.

The following tables indicate the volume of data in various formats and modes to be sent within one cycle (125 µs) at 400 Mbit/s of bandwidth.

The tables are divided into three formats:

Format	Resolution	Max. video format
Format_0	up to VGA	640 x 480
Format_1	up to XGA	1024 x 768
Format_2	up to UXGA	1600 x 1200

Table 51: Overview fixed formats

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 160 p40q
	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 52: 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, which arrives every 16.6 ms from the camera. Again no data need to be stored temporarily.

Thus around 64% of the available bandwidth (at S400) is used.

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

Table 53: Format_1

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

Table 54: Format_2

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

Note

- If the cameras are operated with an external trigger the maximum trigger frequency may not exceed the highest continuous frame rate, so preventing 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 V1.3.

Frame rates Format_7

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

Note

- Different values apply for the different sensors.
- Frame rates may be further limited by longer shutter times and/or bandwidth limitation from the IEEE 1394 bus.

Frame rates may be further limited by bandwidth limitation from the IEEE 1394 bus.

Details are described in the next chapters:

- Max. frame rate of CCD (theoretical formula)
- Diagram of frame rates as function of AOI by constant width: the curves describe RAW8, RAW12/YUV411, RAW16/YUV422, RGB8 and max. frame rate of CCD
- Table with max. frame rates as function of AOI by constant width

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

$$\mathrm{framerate}_{In} = \mathrm{framerate}_{CCD} = \frac{1}{T_{ChargeTrans} + T_{Dummy} + T_{Dump} + T_{Scan}}$$

Formula 5: Frame rate calculation

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

Note

- The time to transfer the storage to the vertical shift register (charge transfer time)
- The time to shift out the dummy lines
- The time to dump the lines outside the AOI
- The time to shift out the lines of the AOI (scanning time)

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

Details are described in the next chapter.

Oscar F-320C: AOI frame rates

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

Oscar F-320C: progressive scan mode

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

$$\text{frame rate} = \frac{1}{T_{ChargeTrans} + T_{Dummy} + T_{Dump} + T_{Scan}}$$

$$\text{frame rate} = \frac{1}{290\mu s + (257 - AOI\_HEIGHT) \times 6.8\mu s + AOI\_HEIGHT \times 98\mu s}$$

Formula 6: Frame rate calculation progressive scan mode **Oscar F-320C**

AOI height	T_{frame} / s	Frame rate / 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 55: Frame rates progressive **Oscar F-320C**

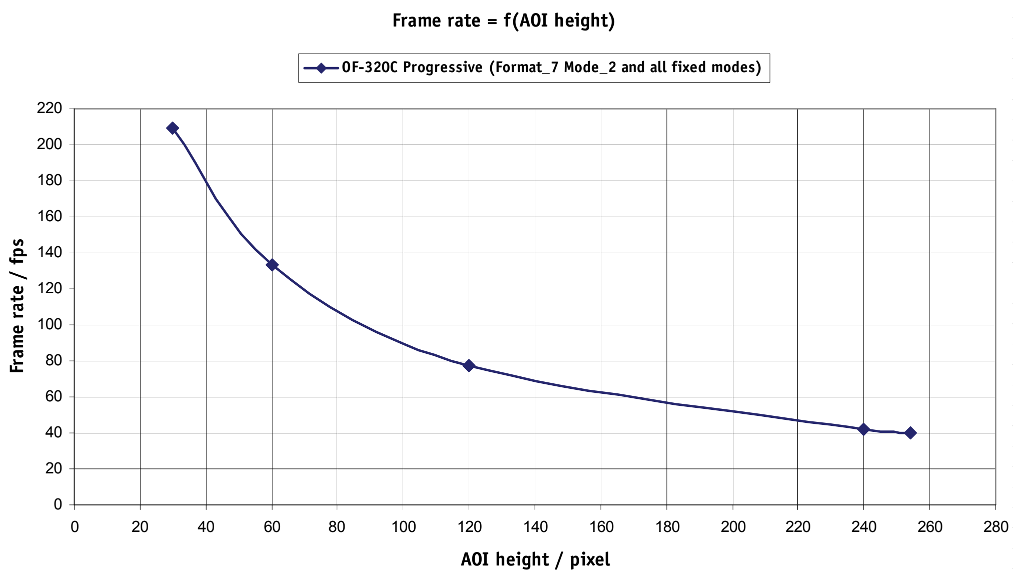


Figure 56: Graph of frames rates in progressive scan mode **Oscar F-320C**

Oscar F-320C: interlaced mode

For interlaced mode, the following formula applies:

$$\text{frame rate} = \frac{1}{T_{ChargeTrans} + T_{Dummy} + T_{Dump} + T_{Scan}}$$

$$\text{frame rate} = \frac{1}{580\mu s + (1542 - AOI\_HEIGHT) \times 6.8\mu s + AOI\_HEIGHT \times 98\mu s}$$

Formula 7: Frame rate calculation **interlaced** mode **Oscar F-320C**

AOI height	T_{frame} / s	Frame rate / 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 56: Frame rates **interlaced** mode **Oscar F-320C**

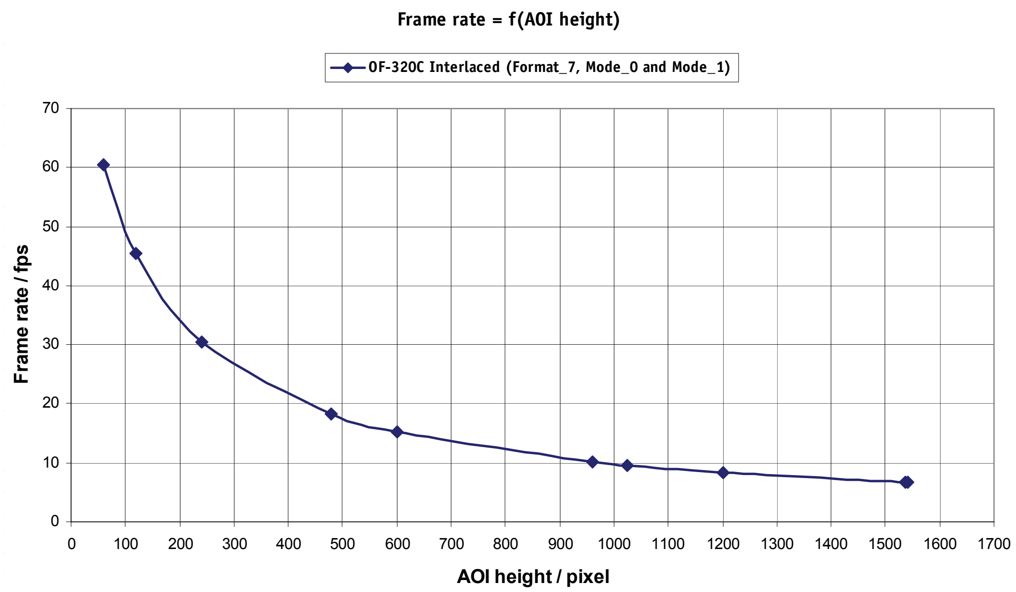


Figure 57: Graph of frame rates **interlaced** mode **Oscar F-320C**

Oscar F-510C: AOI frame rates

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

Oscar F-510C: progressive scan mode

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

$$\text{frame rate} = \frac{1}{T_{ChargeTrans} + T_{Dummy} + T_{Dump} + T_{Scan}}$$

$$\text{frame rate} = \frac{1}{230\mu s + (1038 - AOI\_HEIGHT) \times 4.9\mu s + AOI\_HEIGHT \times 134\mu s}$$

Formula 8: Frame rate calculation **progressive** scan mode **Oscar F-510C**

AOI height	T_{frame} / s	Frame rate / 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 57: Frame rates **progressive** scan **Oscar F-510C**

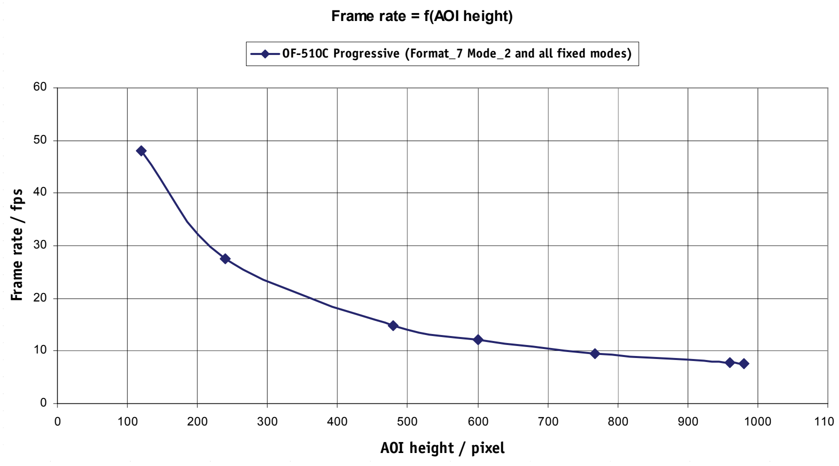


Figure 58: Graph of frame rate in **progressive** scan mode **Oscar F-510C**

Oscar F-510C: interlaced modes

For all interlaced modes (i.e. Format_7 Mode_0 and Mode_1), the following formula applies:

$$\text{frame rate} = \frac{1}{2 \times \left(233\mu s + \left(987 - \frac{AOI\_HEIGHT}{2}\right) \times 4.9\mu s + \frac{AOI\_HEIGHT}{2} \times 134\mu s\right)}$$

Formula 9: Frame rate calculation **interlaced** modes **Oscar F-510C**

AOI height	T_{frame} / s	Frame rate / 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 58: Frame rates **interlaced** modes **Oscar F-510C**

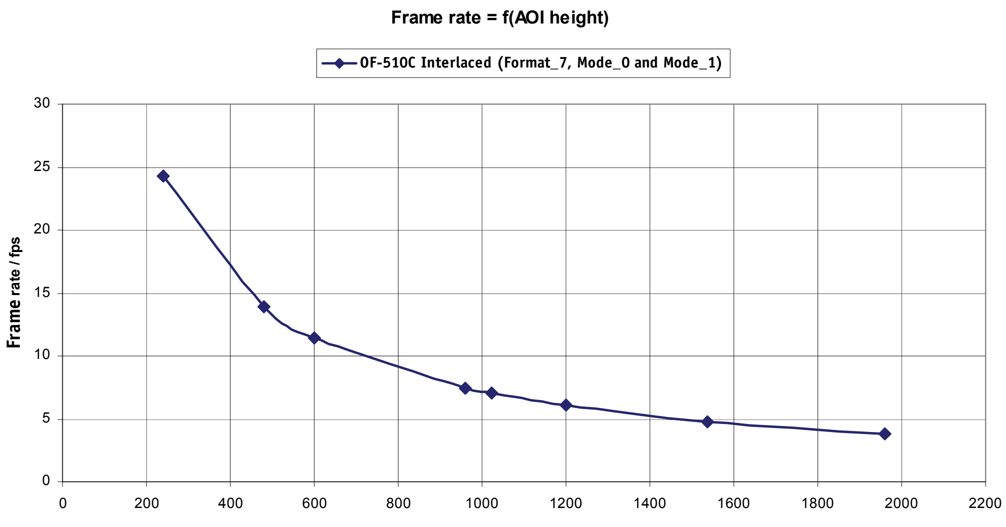


Figure 59: Graph of frame rates **interlaced** mode **Oscar F-510C**

Oscar F-810C: AOI frame rates

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

Oscar F-810C: progressive scan mode

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

$$\text{frame rate} = \frac{1}{T_{ChargeTrans} + T_{Dummy} + T_{Dump} + T_{Scan}}$$

$$\text{frame rate} = \frac{1}{276\mu s + (1246 - AO\_HEIGHT) \times 16\mu s + AOI\_HEIGHT \times 128\mu s}$$

Formula 10: Frame rate calculation **progressive** scan mode **Oscar F-810C**

The table details the frame rates for representative image heights.

AOI height	T_{frame} / s	Frame rate / 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 59: Frame rates **progressive** scan mode **Oscar F-810C**

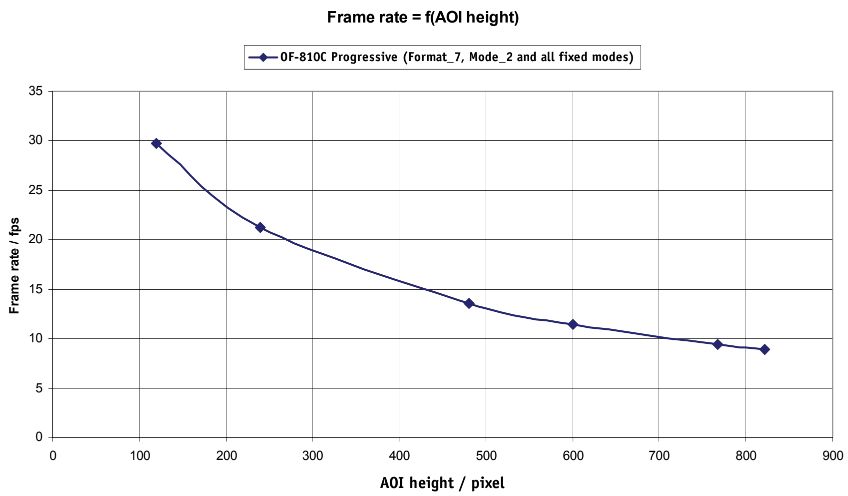


Figure 60: Graph of frame rate in **progressive** scan mode **Oscar F-810C**

Oscar F-810C: interlaced modes

For all interlaced modes (i.e. Format_7 Mode_0 and Mode_1), the following formula applies:

$$\text{frame rate} = \frac{1}{3 \times \left(291\mu s + \left(831 - \frac{\text{AOI\_HEIGHT}}{3}\right) \times 16\mu s + \frac{\text{AOI\_HEIGHT}}{3} \times 128\mu s\right)}$$

Formula 11: Frame rate calculation **interlaced** modes **Oscar F-810C**

AOI height	T_{frame} / s	Frame rate / 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 60: Frame rates **interlaced** modes **Oscar F-810C**

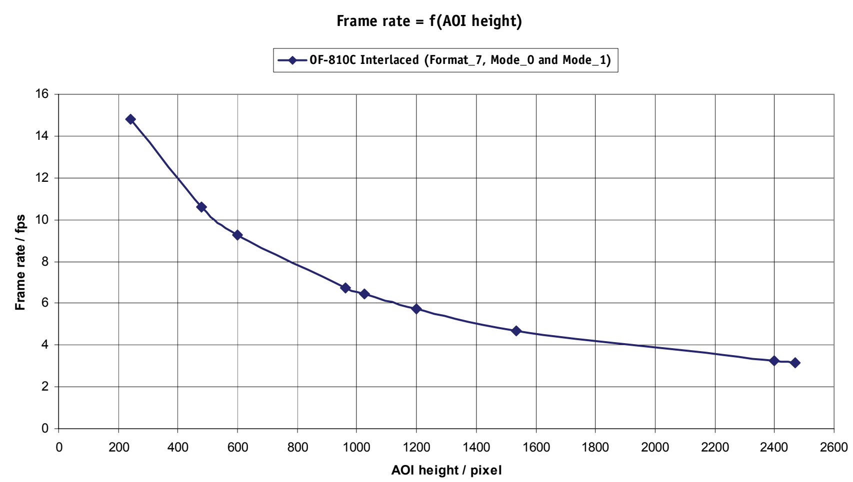


Figure 61: Graph of frame rate in **interlaced** mode **Oscar F-810C**

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 Mbit/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.

$$\text{BYTE\_PER\_PACKET} = \text{Framerate} \times \text{AOIWidth} \times \text{AOIHeight} \times \text{ByteDepth} \times 125\mu s$$

Formula 12: Byte_per_Packet calculation (only Format_7)

If the value for **BYTE_PER_PACKET** is greater than 4096 (the maximum data payload), the sought-after frame rate cannot be attained.

The attainable frame rate can be calculated using this formula:

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

$$\text{frame rate} \approx \frac{\text{BYTE\_PER\_PACKET}}{\text{AOIWidth} \times \text{AOIHeight} \times \text{ByteDepth} \times 125\mu s}$$

Formula 13: Maximum frame rate calculation

ByteDepth is based on the following values:

Mode	bit/pixel	byte per pixel
Mono8	8	1
Mono16	16	2
YUV4:2:2	16	2
YUV4:1:1	12	1.5
RGB8	24	3

Table 61: ByteDepth

Example formula for the Oscar F-810C camera

RGB8, 3272 x 2496 pixel, 2 fps desired

$$\text{BYTE\_PER\_PACKET} = 2 \times 3272 \times 2469 \times 3 \times 125\mu s = 6004 > 4096$$

$$\Rightarrow \text{framerate}_{\text{reachable}} \approx \frac{4096}{3272 \times 2469 \times 3 \times 125\mu s} = 1.35$$

Formula 14: Example maximum frame rate calculation

Test images

Loading test images

FirePackage	Fire4Linux
1. Start **SmartView**.	1. Start **cc1394** viewer.
2. Click the **Edit settings** button. 	2. In **Adjustments** menu click on **Picture Control**.
3. Click **Adv1** tab.	3. Click **Main** tab.
4. In combo box **Test images** choose **Image 1** or another test image.	4. Activate Test image check box **on**.
	5. In combo box **Test images** choose **Image 1** or another test image.

Table 62: Loading test images in different viewers

Oscar cameras have two test images.

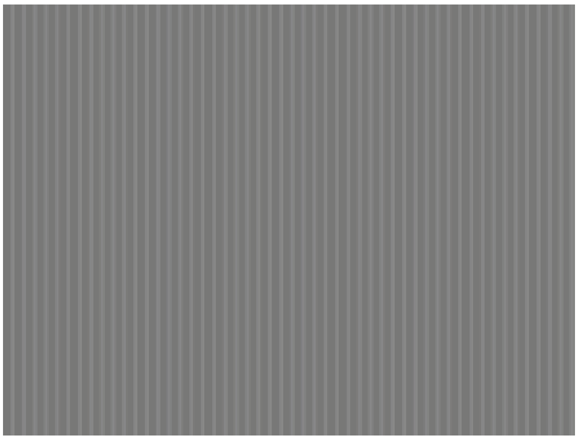


Figure 62: Test image 1

The second image is in colors:

Figure 63: Test image 2

Configuration of the camera

All camera settings are made by writing specific values into the corresponding registers.

This applies to:
- values for general operating states such as video formats and modes, exposure times, etc.
- extended features of the camera that are turned on and off and controlled via corresponding registers (so-called advanced registers).

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 bit long.

The first 10 bit describe the Bus_Id, the next 6 bit the Node_Id.

Of the subsequent 48 bit, the first 16 bit are always FFFFh, leaving the description for the Camera_Status_Register in the last 32 bit.

If a CSR F0F00600h is mentioned below 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 that are developed using an API library (e.g. **FirePackage**).

Every register is 32 bit (big endian) and implemented as follows (MSB = Most Significant Bit; LSB = Least Significant Bit):

Far left

Bit 0	Bit 1	Bit 2	...	Bit 30	Bit 31
MSB					LSB

Table 63: 32-bit register

Example

This requires, for example, that to enable **ISO_Enabled mode** (see Chapter ISO_Enable / free-run on page 115), (bit 0 in register 614h), the value 80000000 h must be written in the corresponding register.

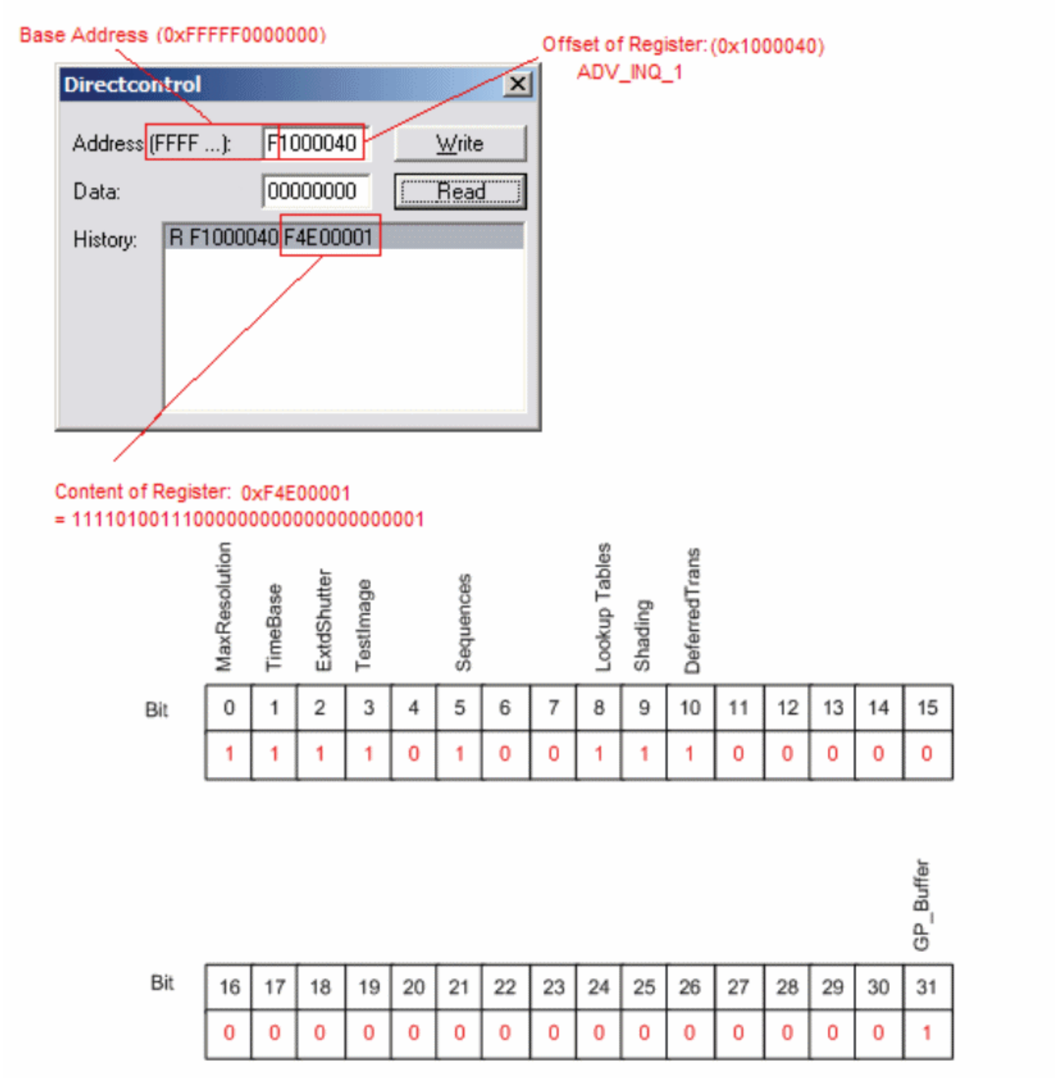


Figure 64: Configuration of the camera

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.

Note

If you want to use the **DirectControl** program to read or write to a register, enter the following value in the Address field:

F0F00000h + Offset

The **configuration ROM** is divided into

- Bus info block: providing critical information about bus-related capabilities
- Root directory: specifying the rest of the content and organization, such as:
  - Node unique ID leaf
  - Unit directory
  - 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	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.
	418h	03	00	0A	47	
	41Ch	0C	00	83	C0	
	420h	8D	00	00	02	
	424h	D1	00	00	04	

Table 64: Configuration ROM

The entry with key 8D in the root directory (420h in this case) provides the offset for the Node unique ID leaf.

To compute the effective start address of the node unique ID leaf:

To compute the effective start address of the node unique ID leaf	
currAddr	= node unique ID leaf address
destAddr	= address of directory entry
addrOffset	= value of directory entry
destAddr	= currAddr + (4 x addrOffset)
	= 420h + (4 x 000002h)
	= 428h

Table 65: Computing effective start address

420h + 000002h x 4 = 428h

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

Table 66: Configuration ROM

The entry with key D1 in the root directory (424h in this case) provides the offset for the unit directory as follows:

424h + 000004h x 4 = 434h

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

Table 67: Configuration ROM

The entry with key D4 in the unit directory (440h in this case) provides the offset for unit dependent info:

440h + 000001h * 4 = 444h

	Offset	0-7	8-15	16-23	24-31	
──────►	444h	00	03	7F	89	....unit_dep_info_length, CRC
Unit dependent info	448h	40	3C	00	00	....command_regs_base
	44Ch	81	00	00	02	....vender_name_leaf
	450h	82	00	00	06	....model_name_leaf

Table 68: Configuration ROM

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

FFFF F0000000h + 3C0000h x 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.

Implemented registers (IIDC V1.3)

The following tables show how standard registers from IIDC V1.3 are implemented in the camera.

- Base address is F0F00000h
- Differences and explanations can be found in the **Description** column.

Camera initialize register

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

Table 69: **Camera initialize** register

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 Format
		---	[8..31]	Reserved

Table 70: **Format** inquiry register

Inquiry register for video mode

Offset	Name	Field	Bit	Description	Color mode
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	

Table 71: **Video mode** inquiry register

Offset	Name	Field	Bit	Description	Color mode
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 71: **Video mode** inquiry register

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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC V1.31)
		---	[8..31]	Reserved (zero)

Table 72: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC V1.31)
		---	[8..31]	Reserved (zero)
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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC V1.31)
		---	[8..31]	Reserved (zero)

Table 72: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC V1.31)
		---	[8..31]	Reserved (zero)

Table 72: **Frame rate** inquiry register

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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC V1.31)
		---	[8..31]	Reserved (zero)

Table 72: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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
		FrameRate_3	[3]	15 fps
		FrameRate_4	[4]	30 fps
		FrameRate_5	[5]	60 fps
		FrameRate_6	[6]	120 fps (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC 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 (IIDC V1.31)
		FrameRate_7	[7]	240 fps (IIDC V1.31)
		---	[8..31]	Reserved (zero)

Table 72: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
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 (IIDC 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)

Table 72: **Frame rate** inquiry register

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 (IIDC 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)

Table 72: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
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)
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, Mode_0)			Always 0
2C4h .. 2DFh	Reserved V_REV_INQ_6_x (for other Mode_x of Format_6)			Always 0

Table 72: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
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 72: **Frame rate** inquiry register

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]	Reserved
		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 73: Basic function inquiry register

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

Table 74: **Feature presence** inquiry register

Offset	Name	Field	Bit	Description
410h .. 47Fh	Reserved			Address error on access
480h	Advanced_Feature_Inq	Advanced_Feature_Quadlet_Offset	[0..31]	Quadlet offset of the advanced feature CSRs 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 CSRs 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 CSRs from the base address of initial register space (vendor unique)

Table 74: **Feature presence** inquiry register

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]	Minimum value for this feature
		Max_Value	[20..31]	Maximum 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.		

Table 75: **Feature elements** inquiry register

Register	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 trigger 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
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]	Minimum value for this feature
		Max_Value	[20..31]	Maximum value for this feature
538 .. 57Ch	Reserved for other FEATURE_HI_INQ			

Table 75: **Feature elements** inquiry register

Register	Name	Field	Bit	Description
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	Bit [0..2] for the frame rate		
604h	CUR-V-MODE	Bit [0..2] for the current video mode		
608h	CUR-V-FORMAT	Bit [0..2] for the current video format		
60Ch	ISO-Channel	Bit [0..3] for channel, [6..7] for ISO speed		
610h	Camera_Power	Always 0		
614h	ISO_EN/Continuous_Shot	Bit 0: 1 for continuous shot; 0 for stop		
618h	Memory_Save	Always 0		
61Ch	One_Shot, Multi_Shot, Count Number	See Chapter One-shot on page 113 See Chapter Multi-shot on page 115		
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 75: **Feature elements** inquiry register

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 76: **Absolute value** inquiry register

Status and control register for one-push

The **one-push** feature WHITE_BALANCE, is currently implemented. If this flag is set, the feature becomes immediately active, even if no images are being input (see Chapter One-push automatic white balance on page 61).

Offset	Name	Field	Bit	Description
800h	BRIGHTNESS	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, value in the **Value** field is ignored.
		---	[2-4]	Reserved
		One_Push	[5]	Write 1: begin to work (Self cleared after operation) Read: Value=1 in operation Value=0 not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF, 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode Read: read a current mode 0: Manual 1: Auto
		---	[8-19]	Reserved
		Value	[20-31]	Value. Write the value in Auto mode, this field is ignored. If **ReadOut** capability is not available, read value has no meaning.

Table 77: **Feature** control register

Offset	Name	Field	Bit	Description
804h	AUTO-EXPOSURE			See above Note: **Target grey level** parameter in SmartView corresponds to Auto_exposure register 0xF0F00804 (IIDC).
808h	SHARPNESS			See above

Table 77: **Feature** control register

Offset	Name	Field	Bit	Description
80Ch	WHITE-BALANCE	Presence_Inq	[0]	Presence of this feature 0: N/A 1: Available Always 0 for Mono
		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, value in the Value field is ignored.
		---	[2-4]	Reserved
		One_Push	[5]	Write '1': begin to work (Self cleared after operation) Read: Value='1' in operation Value='0' not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature, Read: read a status 0: OFF 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode Read: read a current mode 0: Manual 1: Auto
		U_Value / B_Value	[8-19]	U value / B value Write the value in AUTO mode, this field is ignored. If **ReadOut** capability is not available, read value has no meaning.
		V_Value / R_Value	[20-31]	V value / R value Write the value in AUTO mode, this field is ignored. If **ReadOut** capability is not available, read value has no meaning.

Table 77: **Feature** control register

Offset	Name	Field	Bit	Description
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 time base See Table 26: CSR: Shutter on page 70
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 77: **Feature** control register

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 78: **Feature control** error register

Video mode control and status registers for Format_7

Note

Color_Coding_ID and Inq is important for the various (above standard) color modes of the OSCAR cameras and is explained in Chapter Video formats, modes and bandwidth on page 120.

Quadlet offset Format_7 Mode_0

The quadlet offset to the base address for **Format_7 Mode_0**, which can be read out at F0F002E0h (according to Table 72: Frame rate inquiry register on page 153) gives 003C2000h.

4 x 3C2000h = F08000h so that the base address for the latter (Table 79: Format_7 control and status register on page 173) equals to F0000000h + F08000h = F0F08000h.

Quadlet offset Format_7 Mode_1

The quadlet offset to the base address for **Format_7 Mode_1**, which can be read out at F0F002E4h (according to Table 72: Frame rate inquiry register on page 153) gives 003C2400h.

4 x 003C2400h = F09000h so that the base address for the latter (Table 79: Format_7 control and status register on page 173) equals to F0000000h + F09000h = F0F09000h.

Format_7 control and status register (CSR)

Offset	Name	Notes
000h	MAX_IMAGE_SIZE_INQ	According to IIDC V1.3
004h	UNIT_SIZE_INQ	According to IIDC V1.3
008h	IMAGE_POSITION	According to IIDC V1.3

Table 79: **Format_7** control and status register

Offset	Name	Notes
00Ch	IMAGE_SIZE	According to IIDC V1.3
010h	COLOR_CODING_ID	See note
014h	COLOR_CODING_INQ	According to IIDC V1.3
034h	PIXEL_NUMER_INQ	According to IIDC V1.3
038h	TOTAL_BYTES_HI_INQ	According to IIDC V1.3
03Ch	TOTAL_BYTES_LO_INQ	According to IIDC V1.3
040h	PACKET_PARA_INQ	See note
044h	BYTE_PER_PACKET	According to IIDC V1.3

Table 79: **Format_7** control and status register

Note

- For all modes in Format_7, **ErrorFlag_1** and **ErrorFlag_2** are refreshed on each access to the Format_7 register.
- Contrary to IIDC V1.3, 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 V1.3, the **UnitBytePerPacket** field is already filled in with a fixed value in the PACKET_PARA_INQ register.

Advanced features (AVT-specific)

The camera has a variety of extended features going beyond the possibilities described in IIDC V1.3. The following chapter summarizes all available advanced features in ascending register order.

Note

This chapter is a **reference guide for advanced registers** and does not explain the advanced features itself. For detailed description of the theoretical background see

- Chapter Description of the data path on page 52
- Links given in the table below

Advanced registers summary

The following table gives an overview of **all available advanced registers**:

Register	Register name	Description
0XF1000010	VERSION_INFO	See Table 81: Advanced register: Version information on page 177
0XF1000040	ADV_INQ_1	See Table 83: Advanced register: Advanced feature inquiry on page 182
0XF1000044	ADV_INQ_2	
0XF1000200	MAX_RESOLUTION	See Table 84: Advanced register: Maximum resolution inquiry on page 183
0XF1000208	TIMEBASE	See Table 85: Advanced register: Time base on page 184
0XF100020C	EXTD_SHUTTER	See Table 87: Advanced register: Extended shutter on page 185
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	see FRMCNT_STAMP

Table 80: Advanced registers summary

Register	Register name	Description
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 CCD type color cameras only
0XF1000400	TRIGGER_DELAY	
0XF1000410	MIRROR_IMAGE	Marlin/Oscar series only
0XF1000414	MNR	
0XF1000510	SOFT_RESET	
0XF1000520	HIGH_SNR	OSCAR only
0XF1000550	USER_PROFILE	
0XF1000600	TIMESTAMP	aka secure image signature (SIS) Marlin series only
0XF1000610	FRMCNT_STAMP	Marlin series only
0XF1000620	TRGCNT_STAMP	Marlin series only
0XF1000FFC	GPDATA_INFO	
0XF1001000	GPDATA_BUFFER	

Table 80: Advanced registers summary

Note

Always activate advanced features before accessing them.

Note

- Currently all registers can be written 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.

Version information register

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

Register	Name	Field	Bit	Description
0xF1000010	VERSION_INFO1	µC type ID	[0..15]	Reserved
		µC version	[16..31]	Bcd-coded version number
0xF1000014			[0..31]	Reserved
0xF1000018	VERSION_INFO3	Camera type ID	[0..15]	See below
		FPGA version	[16..31]	Bcd-coded version number
0xF100001C			[0..31]	Reserved

Table 81: Advanced register: **Version information**

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 (= camera type ID) identifies the camera type with the help of the following list:

ID (decimal)	Camera type
1	F145b
2	F145c
3	F201b
4	F201c
5	F145b-1

Table 82: Camera type ID list

ID (decimal)	Camera type
6	F145c-1
7	F201b-1
8	F201c-1
9	MF033B
10	MF033C
11	MF046B
12	MF046C
13	MF080B
14	MF080C
15	MF145B2
16	MF145C2
17	MF131B
18	MF131C
19	MF145B2-15fps
20	MF145C2-15fps
21	M2F033B
22	M2F033C
23	M2F046B
24	M2F046C
25	M2F080B
26	M2F080C
27	M2F145B2
28	M2F145C2
31	M2F145B2-15fps
32	M2F145C2-15fps
38	OF320C
40	OF510C
42	OF810C
43	M2F080B-30fps
44	M2F080C-30fps
45	M2F145B2-ASM
46	MM2F145C2-ASM

Table 82: Camera type ID list

ID (decimal)	Camera type
47	M2F201B
48	M2F201C
49	M2F146B
50	M2F146C
101	PIKE F-032B
102	PIKE F-032C
103	PIKE F-100B
104	PIKE F-100C
105	PIKE F-145B
106	PIKE F-145C
107	PIKE F-210B
108	PIKE F-210C
109	-
110	-
111	PIKE F-421B
112	PIKE F-421C
201	GUPPY F-033B
202	GUPPY F-033C
203	GUPPY F-036B
204	GUPPY F-036C
205	GUPPY F-046B
206	GUPPY F-046C
207	GUPPY F-080B
208	GUPPY F-080C
209	-
210	-
211	-
212	-
213	GUPPY F-033B BL (board level)
214	GUPPY F-033C BL (board level)
215	GUPPY F-025B
216	GUPPY F-025C
217	GUPPY F-029B

Table 82: Camera type ID list

ID (decimal)	Camera type
218	GUPPY F-029C
219	GUPPY F-038B
220	GUPPY F-038C
221	GUPPY F-038B NIR
222	GUPPY F-038C NIR
223	GUPPY F-044B NIR
224	GUPPY F-044C NIR
225	GUPPY F-080B BL (board level)
226	GUPPY F-080C BL (board level)
227	GUPPY F-044B
228	GUPPY F-044C
401	STINGRAY F-033B (BL)
402	STINGRAY F-033C (BL)
403	---
404	---
405	STINGRAY F-046B (BL)
406	STINGRAY F-046C (BL)
407	STINGRAY F-080B (BL)
408	STINGRAY F-080C (BL)
413	STINGRAY F-145B (BL)
414	STINGRAY F-145C (BL)
415	STINGRAY F-146B (BL)
416	STINGRAY F-146C (BL)
417	STINGRAY F-201B (BL)
418	STINGRAY F-201C (BL)

Table 82: Camera type ID list

Advanced feature inquiry

This register indicates with a named bit if a feature is present or not. If a feature is marked as not present the associated register space might not be available and read/write errors may occur.

Note

Ignore unnamed bits in the following table: these bits might be set or not.

Register	Name	Field	Bit	Description
0xF1000040	ADV_INQ_1	MaxResolution	[0]	
		TimeBase	[1]	
		ExtdShutter	[2]	
		TestImage	[3]	
		FrameInfo	[4]	
		Sequences	[5]	
		VersionInfo	[6]	
		---	[7]	Reserved
		Look-up tables	[8]	
		Shading	[9]	
		DeferredTrans	[10]	
		HDR mode	[11]	Marlin F-131B/C only
		DSNU	[12]	Marlin F-131B only
		Blemish correction	[13]	Marlin F-131B only
		TriggerDelay	[14]	
		Misc. features	[15]	
		Soft Reset	[16]	
		High SNR	[17]	Oscar only
		Color Correction	[18]	
		User profiles	[19]	
		---	[20..21]	Reserved
		TimeStamp	[22]	Marlin only
		FrmCntStamp	[23]	Marlin only
		TrgCntStamp	[24]	Marlin only
		---	[25..30]	Reserved
		GP_Buffer	[31]	

Table 83: Advanced register: **Advanced feature** inquiry

Register	Name	Field	Bit	Description
0xF1000044	ADV_INQ_2	Input_1	[0]	
		Input_2	[1]	
		---	[2]	Reserved
		---	[3..7]	Reserved
		Output_1	[8]	
		Output_2	[9]	
		---	[10]	Reserved
		---	[11..15]	Reserved
		IntEnaDelay	[16]	
		---	[17]	Reserved
		---	[18..31]	Reserved
0xF1000048	ADV_INQ_3	---	[0..31]	Reserved
0xF100004C	ADV_INQ_4	---	[0..31]	Reserved

Table 83: Advanced register: **Advanced feature** inquiry

Maximum resolution

This register indicates the highest resolution for the sensor and is read-only.

Note

This register normally outputs the MAX_IMAGE_SIZE_INQ Format_7 Mode_0 value.

This is the value given in the specifications tables under **Picture size (max.)** in Chapter Specifications on page 21.

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

Table 84: Advanced register: **Maximum resolution** inquiry

Time base

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 you can enter a value in the range of 1 to 4095.

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]	Reserved
		Timebase_ID	[28..31]	See Table 86: Time base ID on page 184

Table 85: Advanced register: **Time base**

The time base IDs 0-9 are in bits 28 to 31. See Table 86: Time base ID on page 184.

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

Note

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

ID	Time base in µs	
0	1	
1	2	
2	5	
3	10	
4	**20**	**default value**
5	50	
6	100	
7	200	

Table 86: Time base ID

ID	Time base in µs
8	500
9	1000

Table 86: Time base ID

Note

The ABSOLUTE VALUE CSR register, introduced in IIDC V1.3, is not implemented.

Extended shutter

The exposure time for long-term integration of up to 67 seconds 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]	Reserved
		ExpTime	[6..31]	Exposure time in µs

Table 87: Advanced register: **Extended shutter**

The minimum allowed exposure time depends on the camera model. To determine this value write **1** to the **ExpTime** field and read back the minimum allowed exposure time.

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

Note

- 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 / frame rate register.
- Extended shutter setting will thus be overwritten by the normal time base/shutter setting after Stop/Start of FireView or FireDemo.

Test images

Bit [8] to [14] indicate which test images are saved. Setting bit [28] to [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]	Reserved
		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]	Reserved
		TestImage_ID	[28..31]	0: No test image active 1: Image 1 active 2: Image 2 active ...

Table 88: Advanced register: **Test image**

Look-up tables (LUT)

Load the look-up tables to be used into the camera and choose the look-up table number via the **LutNo** field. Now you can activate the chosen LUT via the LUT_CTRL register.

The LUT_INFO register indicates how many LUTs the camera can store and the maximum size of the individual LUTs.

The possible values for **LutNo** are 0..n-1, whereas n can be determined by reading the field **NumOfLuts** of the LUT_INFO register.

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

Table 89: Advanced register: **LUT**

Shading correction

Owing to technical circumstances, the interaction of recorded objects with one another, optical effects and lighting non-homogeneities may occur in the images.

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

Provided that 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.

Note

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]	Could not built shading image
		---	[2..3]	Reserved
		ShowImage	[4]	Show shading data as image
		BuildImage	[5]	Build a new shading image
		ON_OFF	[6]	Shading on/off
		Busy	[7]	Build in progress
		---	[8..23]	Reserved
		GrabCount	[24..31]	Number of images
0xF1000254	SHDG_MEM_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	Reserved
		EnableMemWR	[5]	Enable write access
		EnableMemRD	[6]	Enable read access
		---	[7]	Reserved
		AddrOffset	[8..31]	In bytes

Table 90: Advanced register: **Shading**

Register	Name	Field	Bit	Description
0xF1000258	SHDG_INFO	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7]	Reserved
		MaxImageSize	[8..31]	Maximum shading image size (in bytes)

Table 90: Advanced register: **Shading**

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. This is a mirror of the frame counter information found at 0xF1000610.

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

Table 91: Advanced register: **Frame information**

The **FrameCounter** is incremented when an image is read out of the sensor.

The **FrameCounter** does not indicate whether an image was sent over the IEEE 1394 bus or not.

Input/output pin control

Note

- See Chapter Input/output pin control on page 40
- See Chapter IO_INP_CTRL 1-2 on page 41
- See Chapter IO_OUTP_CTRL 1-2 on page 46
- See Chapter Output modes on page 47

Delayed Integration Enable (IntEna)

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**.

Note

- 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.

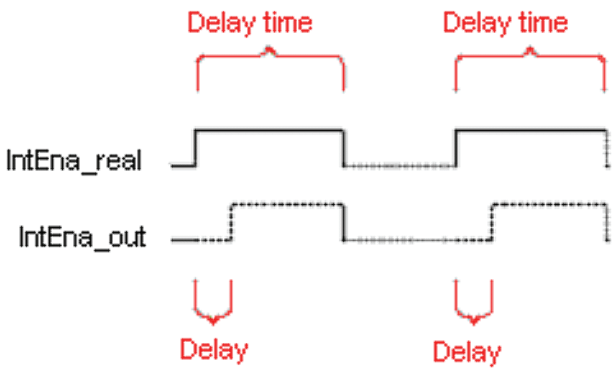


Figure 65: Delayed integration timing

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

Table 92: Advanced register: **Delayed Integration Enable (IntEna)**

Auto shutter control

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

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

Table 93: Advanced register: **Auto shutter control**

Note

- 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 (**SmartView→Ctrl1 tab: Target grey level**)

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 gain first for the same purpose.

Auto gain control

The table below illustrates the advanced register for **auto gain control**.

Register	Name	Field	Bit	Description
0xF1000370	AUTOGAIN_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..3]	Reserved
		MaxValue	[4..15]	Maximum value
		---	[16..19]	Reserved
		MinValue	[20..31]	Minimum value

Table 94: Advanced register: **Auto gain control**

MinValue and **MaxValue** limits the range the auto gain feature is allowed to use for the regulation process. Both values are initialized with the minimum and maximum value defined in the standard GAIN_INQ register.

Changing the **auto gain range** might not affect the regulation, if the regulation is in a stable condition and no other condition affecting the image brightness is changed.

If both auto gain and auto shutter are enabled and if the gain is at its lower boundary and shutter regulation is in progress, decreasing the lower auto gain boundary has no effect on auto gain/shutter regulation as long as auto shutter regulation is active.

Both values can only be changed within the range defined by the standard GAIN_INQ register.

Autofunction AOI

The table below illustrates the advanced register for **autofunction AOI**.

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

Table 95: Advanced register: **Autofunction AOI**

The possible increment of this work area position and size is 128 pixels. The camera automatically adjusts the settings to permitted values:

Region	Permitted values
Left, top	0, 128, 256, 384, 512, 768, 1024...
Width, height	128, 256, 384, 512, 768, 1024...

Table 96: Permitted values for AF_AREA_SIZE

Due to the fact that the active image size might not be divisible 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 pixel the camera accepts a maximum of 640 x 512 pixel 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 autofunction AOI is placed at the bottom of the image.

Note

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.

Color correction

To switch off color correction in YUV mode: see bit [6]

Register	Name	Field	Bit	Description
0xF10003A0	COLOR_CORR	ON_OFF	[6]	Color correction on/off default: on Write: 02000000h to switch color correction **OFF** Write: 00000000h to switch color correction **ON**

Table 97: Advanced register: **Color correction**

Trigger delay

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

Table 98: Advanced register: **Trigger delay**

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

Mirror image

The table below illustrates the advanced register for **Mirror image**.

Register	Name	Field	Bit	Description
0xF1000410	MIRROR_IMAGE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Mirror image on/off 1: on 0: off Default: off
		---	[7..31]	Reserved

Table 99: Advanced register: **Mirror**

Soft Reset

Register	Name	Field	Bit	Description
0xF1000510	SOFT_RESET	Presence Inquiry	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		Reset	[6]	Initiate reset
		---	[7..19]	Reserved
		Delay	[20..31]	Delay reset in 10 ms steps

Table 100: Advanced register: **Soft reset**

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

- 1 or more bus resets 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 10 ms steps.

Note

When SOFT_RESET has been defined, the camera will respond to further read or write requests, but will not process them.

High SNR mode (High Signal Noise Ratio)

With **High SNR** mode enabled the camera internally grabs **GrabCount** images and outputs a single averaged image.

Register	Name	Field	Bit	Description
0xF1000520	HIGH_SNR	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	High SNR mode on/off
		---	[7..22]	Reserved
		GrabCount	[23..31]	Number of images

Table 101: Advanced register: **High Signal Noise Ratio (HSNR)**

User profiles

Definition Within the IIDC specification **user profiles** are called **memory channels**. Often they are called **user sets**. In fact these are different expressions for the following: storing camera settings into a non-volatile memory inside the camera.

From firmware 3.04 onwards, Oscar cameras can store up to three user profiles (plus the factory default) in the camera in a non-volatile memory.

User profiles can be programmed with the following advanced feature register:

Register	Name	Field	Bit	Description
0xF1000550	USER_PROFILE	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..7]	Reserved
		SaveProfile	[8]	Save settings to profile
		RestoreProfile	[9]	Load settings from profile
		SetDefaultID	[10]	Set profile ID as default
		---	[11..19]	Reserved
		ErrorCode	[20..23]	Error code See Table 103: User profile: Error codes on page 199
		---	[24..27]	Reserved
		ProfileID	[28..31]	ProfileID (memory channel)

Table 102: Advanced register: **User profiles**

In general this advanced register is a wrapper around the standard memory channel registers with some extensions. In order to query the number of available user profiles please check the **Memory_Channel** field of the **BASIC_FUNC_INQ** register at offset **0x400** (see IIDC V1.3x for more details).

The **ProfileID** is equivalent to the memory channel number and specifies the profile number to store settings to or to restore settings from. In any case profile #0 is the hard-coded factory profile and cannot be overwritten.

After an initialization command, startup or reset of the camera, the **ProfileID** also indicates which profile was loaded on startup, reset or initialization.

Note

- The default profile is the profile that is loaded on power-up or an INITIALIZE command.
- A save or load operation delays the response of the camera until the operation is completed. At a time only one operation can be performed.

Store To store the current camera settings into a profile:

1. Write the desired **ProfileID** with the **SaveProfile** flag set.
2. Read back the register and check the **ErrorCode** field

Restore To restore the settings from a previous stored profile:

1. Write the desired **ProfileID** with the **RestoreProfile** flag set.
2. Read back the register and check the **ErrorCode** field.

Set default To set the default profile to be loaded on startup, reset or initialization:

1. Write the desired **ProfileID** with the **SetDefaultID** flag set.
2. Read back the register and check the **ErrorCode** field.

Factory default To go back to the factory default profile:

1. Select **ProfileID = 0** and toggle the **SetDefaultID** flag set.
2. Read back the register and check the **ErrorCode** field.

Error codes

Error code #	Description
0x00	No error
0x01	Profile data corrupted
0x02	Camera not idle during restore operation
0x03	Feature not available (feature not present)
0x04	Profile doesn’t exist
0x05	ProfileID out of range
0x06	Restoring the default profile failed
0x07	Loading LUT data failed
0x08	Storing LUT data failed

Table 103: User profile: **Error codes**

Reset of error codes

The **ErrorCode** field is set to zero on the next write access.

To reset the ErrorCode manually:

1. Write 00000000h to the **USER_PROFILE** register.

Stored settings

The following table shows the settings stored inside a profile:

Advanced registers
TIMEBASE
EXTD_SHUTTER
IO_INP_CTRL
IO_OUTP_CTRL
IO_INTENA_DELAY
AUTOSHUTTER_LO
AUTOSHUTTER_HI
AUTOGAIN_CTRL
AUTOFNC_AOI
COLOR_CORR
TRIGGER_DELAY
MIRROR_IMAGE
HIGH_SNR
LUT_CTRL
LUT_DATA

Table 104: User profile: stored settings

The user can specify which one will be loaded upon startup of the camera.

This frees the user software from having to restore camera settings, that differ from default, after every startup. This can be especially helpful if third party software is used which may not give easy access to certain advanced features or may not provide efficient commands for quick writing of data blocks (e.g. for a LUT) into the camera.

Note

- A profile save operation automatically disables capturing of images.
- A profile save or restore operation is an uninterruptable (atomic) operation: The write response (of the asynchronous write cycle) will be sent after completion of the operation.
- Restoring a profile will not overwrite other settings than listed above.
- If a restore operation fails or the specified profile does not exist, all registers will be overwritten with the hard-coded factory defaults (profile #0).
- Data written to this register is not reflected in the standard memory channel registers.

GPDATA_BUFFER

GPDATA_BUFFER is a general purpose register that regulates the exchange of data between camera and host for:

- writing look-up tables (LUTs) into the camera
- uploading/downloading 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]	Reserved
		BufferSize	[16..31]	Size of GPDATA_BUFFER (byte)
0xF1001000 … 0xF10017FC	GPDATA_BUFFER			

Table 105: Advanced register: **GPData buffer**

Note

- Read the BufferSize before using.
- GPDATA_BUFFER can be used by only one function at a time.

Little endian vs. big endian byte order

- Read/WriteBlock accesses to GPDATA_BUFFER are recommended, to read or write more than 4 byte data. This increases the transfer speed compared to accessing every single quadlet.
- The big endian byte order of the 1394 bus is unlike the little endian byte order of common operating systems (Intel PC). Each quadlet of the local buffer, containing the LUT data or shading image for instance, has to be swapped bytewise from little endian byte order to big endian byte order before writing on the bus.

Bit depth	little endian ⇨ big endian	Description
8 bit	L0 L1 L2 L3 ⇨ L3 L2 L1 L0	L: low byte
16 bit	L0 H0 L1 H1 ⇨ H1 L1 H0 L0	H: high byte

Table 106: Swapped first quadlet at address offset 0

Firmware update

Firmware updates can be carried out 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.

Note

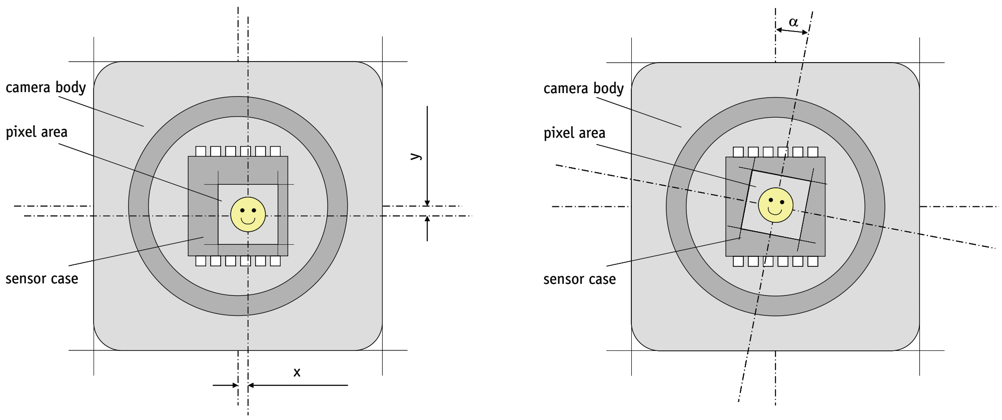
Only Oscar F-810C: cameras with a serial number **SN 50675733** (or higher) or with production date 26 April 2005 (or later) can be updated with microcontroller firmware 3.04/ FPGA firmware 1.06. (Cameras must have a FIFO memory of 64 MB. SmartView **Adv 1** tab → **FIFO size** must be 3.)

Note

Older versions have to be updated at the AVT factory.

Appendix

Sensor position accuracy of AVT cameras



AVT Guppy Series

Method of Positioning:	Automated mechanical alignment of sensor into camera front module. (lens mount front flange)		
Reference points:	Sensor: Center of pixel area (photo sensitive cells). Camera: Center of camera front flange (outer case edges).		
Accuracy:	x/y:	+/- 0.25mm	(Sensor shift)
	z:	+50 / -100µm	(for SN > 84254727, optical back focal length)
		+0 / -100µm	(for SN > 252138124, optical back focal length)
	α:	+/- 1°	(Sensor rotation)

AVT Marlin, Oscar, Dolphin, Pike, Stingray

Method of Positioning:	Optical alignment of photo sensitive sensor area into camera front module. (lens mount front flange)		
Reference points:	Sensor: Center of pixel area (photo sensitive cells). Camera: Center of camera front flange (outer case edges).		
Accuracy:	x/y:	+/- 0.1mm	(Sensor shift)
	z:	+0 / -50µm	(Optical back focal length)
	α:	+/- 0.5°	(Sensor rotation)

Note: x/y - tolerances between c-Mount hole and pixel area may be higher.

Figure 66: AVT sensor position accuracy

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