AVT Marlin

Technical Manual

For CCD models with serial numbers: xx/yy-6zzzzzzz
and all CMOS models

V2.4.0

15 August 2008

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

ALLIED
Vision Technologies

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.

Trademarks

Unless stated otherwise, all trademarks appearing in this document of Allied Vision Technologies are brands protected by law.

Warranty

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.

Copyright

Allied Vision Technologies GmbH 08/2008

Managing Director: Mr. Frank Grube
Tax ID: DE 184383113

Support:

Taschenweg 2A
D-07646 Stadtroda, Germany
Tel.: +49 (0)36428 6770
Fax: +49 (0)36428 677-28
e-mail: info@alliedvisiontec.com

Contents

Contacting Allied Vision Technologies

Info

- **Technical information:**
  support@alliedvisiontec.com
  phone (for Germany): +49 (0)36428 677-270
  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 **MARLIN 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 1394b 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
0.9	18.12.2003	First issue
0.91	09.01.2004	Typos corrected, minor changes, spectral sensitivity of IR cut filter added
1.0	20.01.2004	Wording checked, MARLIN W90/270 added
1.1	07.09.2004	MARLIN F-131C added, added features to make manual compliant with firmware 2.05, wording checked, impulse diagrams corrected
1.2	08.10.2004	Manual compliant to firmware 2.06
1.3	23.02.2005	For MARLINS with serial numbers xx/yy-6zzzzzzz
1.31	12.04.2005	Color: firmware 20050321, CMOS included
1.4	24.08.2005	Added MARLIN F-146, all: class B compliant
2.0.0	10.03.2006	Added MARLIN F-201, manual compliant to firmware 3.03, added features secure image signature (SIS) and user profiles, minor corrections
2.1.0	10.04.2006	Time stamp changed
to be continued on next page		

Table 1: Document history

Version	Date	Remarks
	continued from last page	
2.2.0	26.02.2007	Minor corrections New formula for MARLIN F-131 (*Formula 11: Frame rate calculation MARLIN F-131 as function of AOI height and width* on page 165) MARLIN F-145C2: corrected resolutions, new color formats in Format_7 Mode_0 and Format_7 Mode_2 (*Table 58: Video fixed formats Marlin F-145B2 / F-145C2* on page 141) Improved Chapter Secure image signature (SIS) on page 225 Added exposure time formula for Trigger_Mode_1 Chapter *Exposure time (shutter) and offset* on page 120 Firmware update note corrected (Chapter *Firmware update* on page 236) Added Mono16 modi (Chapter *Video formats, modes and bandwidth* on page 137)
2.3.0	29.02.2008	Minor corrections Sensor tilting changed to sensor rotating in Chapter *Camera dimensions* on page 42 Added detailed description of BRIGHTNESS (800h) in Table 94: Feature control register on page 195 Added detailed description of WHITE-BALANCE (80Ch) in Table 94: Feature control register on page 195 et seq. Added new Format7_Mode4 for MARLIN F-131C in *Table 64: Video fixed formats Marlin F-131B / F-131C (NIR)* on page 147 et seq. New sensor IBIS5B (*Figure 14: Spectral sensitivity of Marlin F-131B (with IBIS5B as standard) / Marlin F-131B NIR (with IBIS5B NIR as standard) without cut filter and optics* on page 41, *Figure 15: Spectral sensitivity of Marlin F-131C without cut filter and optics* on page 41) Corrected data path bandwidth (CCD: 12 bit, ADC: 10 bit) in *Figure 32: Block diagram b/w camera* on page 65. Added Format_0 Mode_5 (640x480, Mono8) with 60 fps for MARLIN F-046B and MARLIN F-046C in *Table 54: Video formats Marlin F-046B / F-046C* on page 139
	to be continued on next page	

Table 1: Document history

Version	Date	Remarks
		continued from last page
2.4.0	15.08.08	Added Format_7 Mode_3 (full binning) in *Table 13: Specification MARLIN F-201B/C* on page 31 Corrected frame rate for Format_7 Mode_3 (full binning) in *Table 62: Video fixed formats Marlin F-201B / F-201C* on page 145ff. **Restructuring of Marlin Technical Manual:** • Added *Contacting Allied Vision Technologies* on page 8 • Added Chapter *Manual overview* on page 13 • Restructured Chapter *Marlin types and highlights* to Chapter *MARLIN cameras* on page 17. – Infos from *Marlin 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 *Marlin Instruction Leaflet* – Infos on CS-/C-Mounting moved to Hardware Installation Guide, Chapter *Changing filters safety instructions* – Infos on *System components* and *Environmental conditions* moved to *Marlin 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 137 • Binning / sub-sampling modes and color modes are only listed in Chapter *Video formats, modes and bandwidth* on page 137
		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]	• 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 65 • Revised Chapter *Controlling image capture* on page 113; added *Table 37: Trigger modi* on page 113 • Revised Chapter *Video formats, modes and bandwidth* on page 137 • Revised Chapter *How does bandwidth affect the frame rate?* on page 166 • Revised Chapter Configuration of the camera on page 171 • Revised Chapter *Firmware update* on page 236 • Added Chapter *Sensor position accuracy of AVT cameras* on page 237 • Revised Chapter *Index* on page 238 Changed provisions directive to 2004/108/EG in Chapter *Declarations of conformity* on page 18 New measurement of minimum exposure time and therefore also new offset values: – *Table 43: Camera-specific minimum exposure time* on page 121 – *Table 44: Camera-specific minimum exposure time* on page 121 – Chapter *Example Marlin F-033* on page 121 – *Figure 67: Data flow and timing after end of exposure* on page 124 – Chapter *Specifications* on page 21 Added cross-reference from **upload LUT** to **GPDATA_BUFFER** in Chapter *Loading an LUT into the camera* on page 83. Added cross-reference from **upload/download shading image** to **GPDATA_BUFFER** in: – Chapter *Loading a shading image out of the camera* on page 89 – Chapter *Loading a shading image into the camera* on page 90 Corrected: b/w and color Marlin cameras have IR cut filter (except Marlin F-131BNIR: ASG) in Chapter *Specifications* on page 21ff.
	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]	Added detailed level values of I/Os in Chapter *Camera I/O connector pin assignment* on page 49. Added little endian vs. big endian byte order in Chapter GPDATA_BUFFER on page 235 Added RoHS in Chapter *Declarations of conformity* on page 18 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 120 and in *Figure 67: Data flow and timing after end of exposure* on page 124. New photo of LED position in *Figure 24: Position of Status LEDs* on page 50

Table 1: Document history

Manual overview

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

- Chapter *Contacting Allied Vision Technologies* on page 8 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 *MARLIN 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 42 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 48 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 65 describes in detail IIDC conform as well as AVT-specific camera features.
- Chapter *Controlling image capture* on page 113 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 137 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 166 gives some considerations on bandwidth details.
- Chapter Configuration of the camera on page 171 lists standard and advanced register descriptions of all camera features.
- Chapter *How does bandwidth affect the frame rate?* on page 166 explains where to get information on firmware updates and explains the extended version number scheme of FPGA/µC.
- Chapter *Appendix* on page 237 lists the sensor position accuracy of AVT cameras.
- Chapter *Index* on page 238 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**.

Note

- This version of the **Technical Manual** applies to MARLINs, having serial numbers starting with 6 after the - e.g. Xx/yy-6zzzzzzz and all CMOS versions, regardless of S/N.
- For CCD MARLINs with different serial numbers the version 1.2 of the Technical Manual applies.

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.

MARLIN cameras

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

Entry-level model With the new Marlin, Allied Vision Technologies presents a whole series of attractive digital camera entry-level models of the FireWire™ type.

Price-performance These products offer an unequalled price-performance relationship and make the decision to switch from using analogue to digital technology easier than ever before.

Image applications Allied Vision Technologies can provide users with a range of products that meet almost all the requirements of a very wide range of image applications.

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 8-bit and 10-bit mode (CCD b/w only), the cameras ensure very high quality images under almost all circumstances. The Marlin is equipped with an asynchronous trigger shutter as well as true partial scan, and integrates numerous useful and intelligent smart features for image processing.

Declarations of conformity

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

Category Name	Model Name
Digital Camera (IEEE 1394)	MARLIN F-033B
	MARLIN F-033C
	MARLIN F-046B
	MARLIN F-046C
	MARLIN F-080B
	MARLIN F-080C
	MARLIN F-145B2
	MARLIN F-145C2
	MARLIN F-146B
	MARLIN F-146C
	MARLIN F-201B
	MARLIN F-201C
	MARLIN F-131B
	MARLIN F-131C

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

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

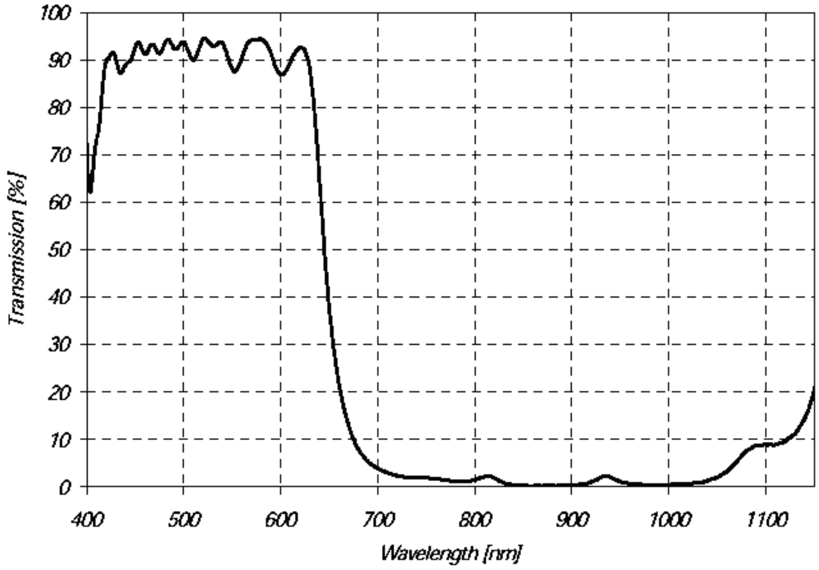


Figure 1: Spectral transmission of Jenofilt 217

Camera lenses

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

Focal length Marlin F-033/046/145/146	Distance = 0.5 m	Distance = 1 m
4.8 mm	0.5 m x 0.67 m	1.0 m x 1.33 m
8 mm	0.3 m x 0.4 m	0.6 m x 0.8 m
12 mm	0.195 m x 0.26 m	0.39 m x 0.58 m
16 mm	0.145 m x 0.19 m	0.29 m x 0.38 m
25 mm	9.1 cm x 12.1 cm	18.2 cm x 24.2 cm
35 mm	6.4 cm x 8.51 cm	12.8 cm x 17.02 cm
50 mm	4.4 cm x 5.85 cm	8.8 cm x 11.7 cm

Table 4: Focal length vs. field of view (Marlin F-033/046/145/146)

Focal length Marlin F-080	Distance = 0.5 m	Distance = 1 m
4.8 mm	0.375 m x 0.5 m	0.75 m x 1 m
8 mm	0.22 m x 0.29 m	0.44 m x 0.58 m
12 mm	0.145 m x 0.19 m	0.29 m x 0.38 m
16 mm	11 cm x 14.7 cm	22 cm x 29.4 cm
25 mm	6.9 cm x 9.2 cm	13.8c m x 18.4 cm
35 mm	4.8 cm x 6.4 cm	9.6 cm x 12.8 cm
50 mm	3.3 cm x 4.4 cm	6.6 cm x 8.8 cm

Table 5: Focal length vs. field of view (Marlin F-080)

Focal length Marlin F-131	Distance = 0.5 m	Distance = 1 m
4.8 mm	0.7 m x 0.93 m	1.4 m x 1.86 m
8 mm	0.4 m x 0.53 m	0.8 m x 1.06 m
12 mm	0.27 m x 0.36 m	0.54 m x 0.72 m
16 mm	0.2 m x 0.27 m	0.4 m x 0.54 m
25 mm	12.5 cm x 16.63 cm	25 cm x 33.25 cm
35 mm	8.8 cm x 11.7 cm	17.6 cm x 23.4 cm
50 mm	6 cm x 7.98 cm	12 cm x 15.96 cm

Table 6: Focal length vs. field of view (Marlin F-131)

Focal length Marlin F-201	Distance = 0.5 m	Distance = 1 m
4.8 mm	0.55 m x 0.74 m	1.1 m x 1.48 m
8 mm	0.33 m x 0.44 m	0.67 m x 0.89 m
12 mm	0.22 m x 0.29 m	0.43 m x 0.64 m
16 mm	0.161 m x 0.21 m	0.32 m x 0.42 m
25 mm	10.1 cm x 13.2 cm	20.2 cm x 26.9 cm
35 mm	7.1 cm x 9.4 cm	14.2 cm x 18.9 cm
50 mm	4.9 cm x 6.5 cm	9.8 cm x 13 cm

Table 7: Focal length vs. field of view (Marlin F-201)

Specifications

Note

For information on bit/pixel and byte/pixel for each color mode see Table 78: ByteDepth on page 166.

MARLIN F-033B/C

Feature	Specification
Image device	Type 1/2 (diag. 8 mm) progressive scan SONY CCD ICX-414AL/AQ with HAD microlens
Chip size	7.48 mm x 6.15 mm
Cell size	9.9 µm x 9.9 µm
Picture size (max.)	656 x 494 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm
ADC	12 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps; 7.5 fps; 15 fps; 30 fps; 60 fps Up to 73.06 fps in Format_7
Gain control	Manual: 0-24 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**32** µs ...67,108,864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 17 frames
Look-up tables	One, user-programmable (10 bit → 8 bit); default gamma (0.5)
Smart functions	Real-time shading correction, image sequencing, image mirror (L-R ↔ R-L), binning, serial port (IIDC V1.31), secure image signature (SIS), user profiles 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 V1.3

Table 8: Specification MARLIN F-033B/C

Feature	Specification
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Typical < 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); incl. connectors, without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+ 5 °C ... + 45 °C
Storage temperature	-10 °C ... + 60 °C
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w and color:** IR cut filter
Optional accessories	**b/w and color:** IR pass filter, protection glass
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 8: Specification MARLIN F-033B/C

Note

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

MARLIN F-046B/C

Feature	Specification
Image device	Type 1/2 (diag. 8 mm) progressive scan SONY CCD ICX-415AL/AQ with HAD microlens
Chip size	7.48 mm x 6.15 mm
Cell size	8.3 µm x 8.3 µm
Picture size (max.)	780 x 582 (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm
ADC	12 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps; 7.5 fps; 15 fps; 30 fps; up to 52.81 fps in Format_7
Gain control	Manual: 0-24 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**32** µs …67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 13 frames
Number of look-up tables	One, user-programmable (10 bit → 8 bit); gamma (0.5)
Smart functions	Real-time shading correction image sequencing, image mirror (L-R ↔ R-L), binning, secure image signature (SIS), user profiles 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 1394 IIDC V1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Less than 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+5 … +45 °Celsius
Storage temperature	-10 … +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w and color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass

Table 9: Specification MARLIN F-046B/C

Feature	Specification
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 9: Specification MARLIN F-046B/C

Note

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

MARLIN F-080B/C (-30 fps*)

* Variant: F-080-30 fps only

This variant offers higher speed at a slight expense in image quality.

Feature	Specification
Image device	Type 1/3 (diag. 6 mm) progressive scan SONY CCD ICX-204AL/AK with HAD microlens
Chip size	5.8 mm x 4.92 mm
Cell size	4.65 µm x 4.65 µm
Picture size (max.)	1032 x 778 (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm, CS-Mount on demand
ADC	12 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps; 7.5 fps; 15 fps; 30 fps*; up to 20.08 (30.13*) fps in Format_7
Gain control	Manual: 0-24 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**50** (**37***) µs … 67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 7 frames
Number of look-up tables	One, user-programmable (10 bit → 8 bit); gamma (0.5)
Smart functions	Real-time shading correction image sequencing, image mirror (L-R ↔ R-L), binning, secure image signature (SIS), user profiles 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 1394 IIDC V1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Less than 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+5 … +45 °Celsius
Storage temperature	-10 … +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)

Table 10: Specification MARLIN F-080B/C

Feature	Specification
Standard accessories	**b/w and color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 10: Specification MARLIN F-080B/C

Note

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

MARLIN F-145B2/C2

Feature	Specification
Image device	Type 1/2 (diag. 8 mm) progressive scan SONY CCD ICX-205AL/AK with HAD microlens
Chip size	7.6 mm x 6.2 mm
Cell size	4.65 µm x 4.65 µm
Picture size (max.)	1392 x 1040 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm
ADC	12 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps; 7.5 fps Up to 10 fps in Format_7
Gain control	Manual: 0-24 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**38** µs … 67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 3 frames
Number of look-up tables	One, user-programmable (10 bit → 8 bit); gamma (0.5)
Smart functions	Real-time shading correction image sequencing, image mirror (L-R ↔ R-L), binning, serial port (IIDC V1.31), secure image signature (SIS), user profiles 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 1394 IIDC V1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Less than 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+5 … +45 °Celsius
Storage temperature	-10 … +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w and color:** IR cut filter

Table 11: Specification MARLIN F-145B2/C2

Feature	Specification
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 11: Specification MARLIN F-145B2/C2

Note

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

MARLIN F-146B/C

Feature	Specification
Image device	Type 1/2 (diag. 8 mm) progressive scan SONY CCD ICX-267AL/AK with HAD microlens
Chip size	7.6 mm x 6.2 mm
Cell size	4.65 µm x 4.65 µm
Picture size (max.)	1392 x 1040 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm
ADC	12 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps, 7.5 fps, 15 fps Up to 17.4 fps in Format_7
Gain control	Manual: 0-24 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**46** µs … 67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 3 frames
Number of look-up tables	One, user-programmable (10 bit → 8 bit); gamma (0.5)
Smart functions	Real-time shading correction image sequencing, image mirror (L-R ↔ R-L), binning, secure image signature (SIS), user profiles 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 1394 IIDC V1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Less than 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+5 … +45 °Celsius
Storage temperature	-10 … +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w and color:** IR cut filter
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass

Table 12: Specification MARLIN F-146B/C

Feature	Specification
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 12: Specification MARLIN F-146B/C

Note

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

MARLIN F-201B/C

Feature	Specification
Image device	Type 1/1.8 (diag. 9 mm) progressive scan SONY CCD ICX274AL/AQ with HAD microlens
Chip size	8.5 mm x 6.8 mm
Cell size	4.40 µm x 4.40 µm
Picture size (max.)	1628 x 1236 (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm
ADC	12 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps; 7.5 fps Up to 12.5 fps in Format_7 Mode_0
Gain control	Manual: 0-24 dB (0.035 dB/step); auto gain (select. AOI)
Shutter speed	**59** µs … 67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 2 frames
Number of look-up tables	One, user-programmable (10 bit → 8 bit); gamma (0.5)
Smart functions	Real-time shading correction, image sequencing, image mirror (L-R ↔ R-L), binning, serial port (IIDC V1.31), secure image signature (SIS), user profiles 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 1394 IIDC V1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Less than 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+5 … +45 °Celsius
Storage temperature	-10 … +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)
Standard accessories	**b/w and color:** IR cut filter

Table 13: Specification MARLIN F-201B/C

Feature	Specification
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 13: Specification MARLIN F-201B/C

Note

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

MARLIN F-131B/C (NIR)

Feature	Specification
Image device	Type 2/3 (diag. 11 mm) global shutter FillFactory CMOS sensor IBIS5B/IBIS5B NIR
Chip size	8.6 mm x 6.9 mm
Cell size	6.7 µm x 6.7 µm
Picture size (max.)	1280 x 1024 pixels (Format_7 Mode_0)
Lens mount	C-Mount: 17.526 mm (in air); Ø 25.4 mm (32 tpi) mechanical flange back to filter distance: 8.2 mm
ADC	10 bit
Color modes	**Only color:** Raw8, RGB8, YUV422, YUV411
Frame rates	3.75 fps; 7.5 fps; 15 fps Up to 25 fps in Format_7
Gain control	Manual: 0- 16 dB (13 x 1.25 dB)
Shutter speed	10 µs … 67.108.864 µs (~67s); auto shutter (select. AOI)
External trigger shutter	Trigger_Mode_0, Trigger_Mode_1, advanced feature: Trigger_Mode_15 (bulk); image transfer by command; trigger delay
Internal FIFO memory	Up to 4 frames
Number of look-up tables	One, user-programmable (10 bit → 8 bit); separate gamma (0.5) LUT
Smart functions	Dark signal non uniformity (DSNU) correction, blemish correction, real-time shading correction; high dynamic range (HDR) mode, image mirror (L-R ↔ R-L), sub-sampling 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 1394 IIDC V1.3
Power requirements	DC 8 V - 36 V via IEEE 1394 cable or 12-pin HIROSE
Power consumption	Less than 3 watt (@ 12 V DC)
Dimensions	72 mm x 44 mm x 29 mm (L x W x H); without tripod and lens
Mass	<120 g (without lens)
Operating temperature	+5 … +45 °Celsius
Storage temperature	-10 … +60 °Celsius
Regulations	CE, FCC Class B, RoHS (2002/95/EC)

Table 14: Specification MARLIN F-131B/C (NIR)

Feature	Specification
Standard accessories	**b/w and color:** IR cut filter Marlin F-131BNIR only: ASG (protection glass)
Optional accessories	**b/w:** IR cut filter, IR pass filter **color:** protection glass
On request	Host adapter card, angled head, locking IEEE 1394 cable
Software packages	API (FirePackage, Direct FirePackage, Fire4Linux)

Table 14: Specification MARLIN F-131B/C (NIR)

Note

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

Spectral sensitivity

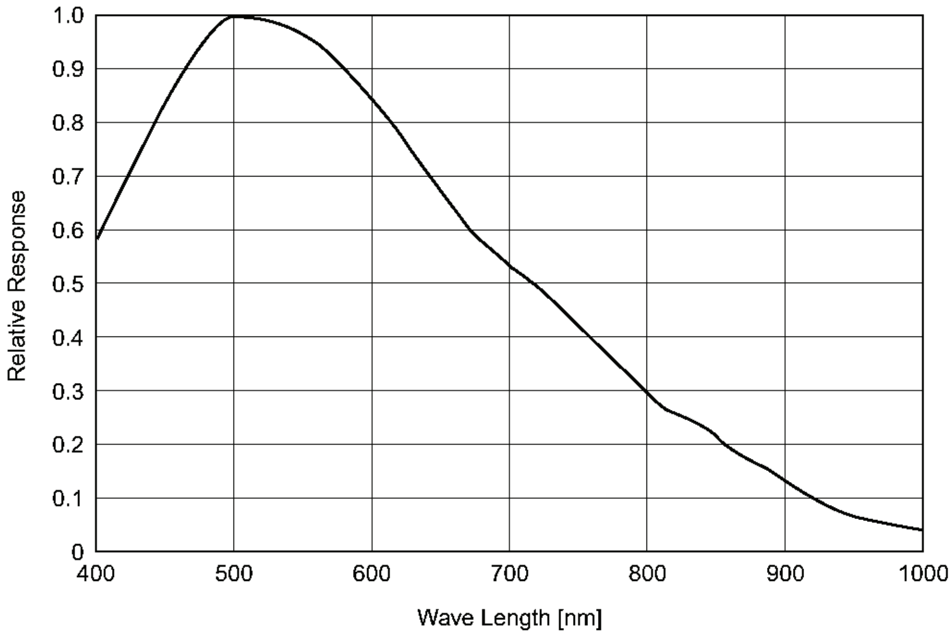


Figure 2: Spectral sensitivity of Marlin F-033B without cut filter and optics

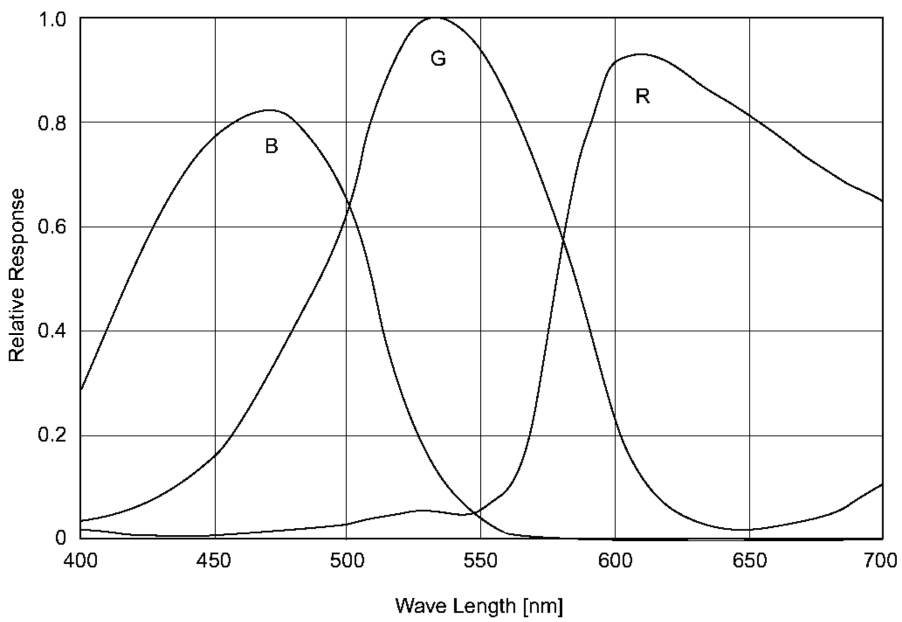


Figure 3: Spectral sensitivity of Marlin F-033C without cut filter and optics

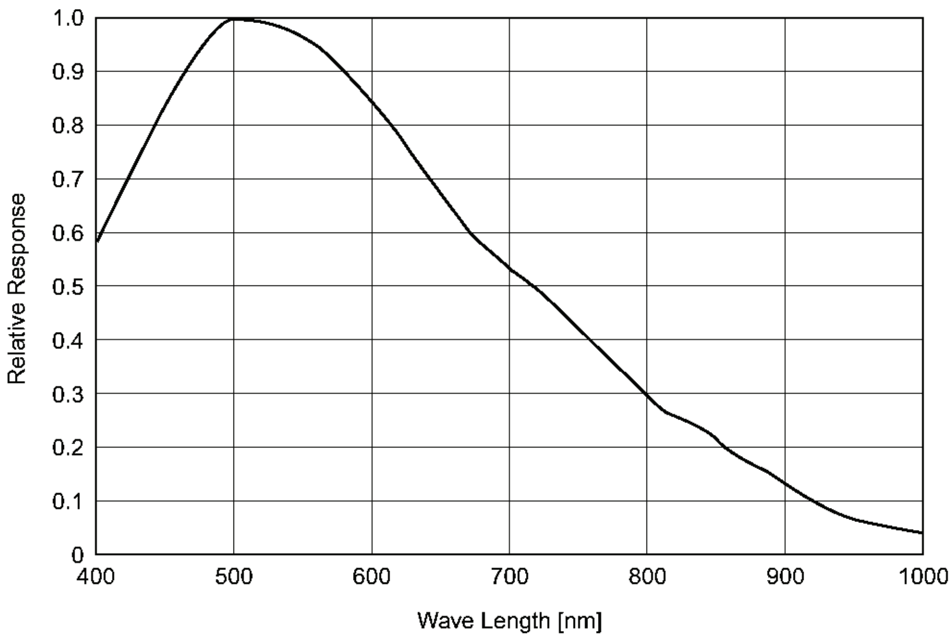


Figure 4: Spectral sensitivity of Marlin F-046B without cut filter and optics

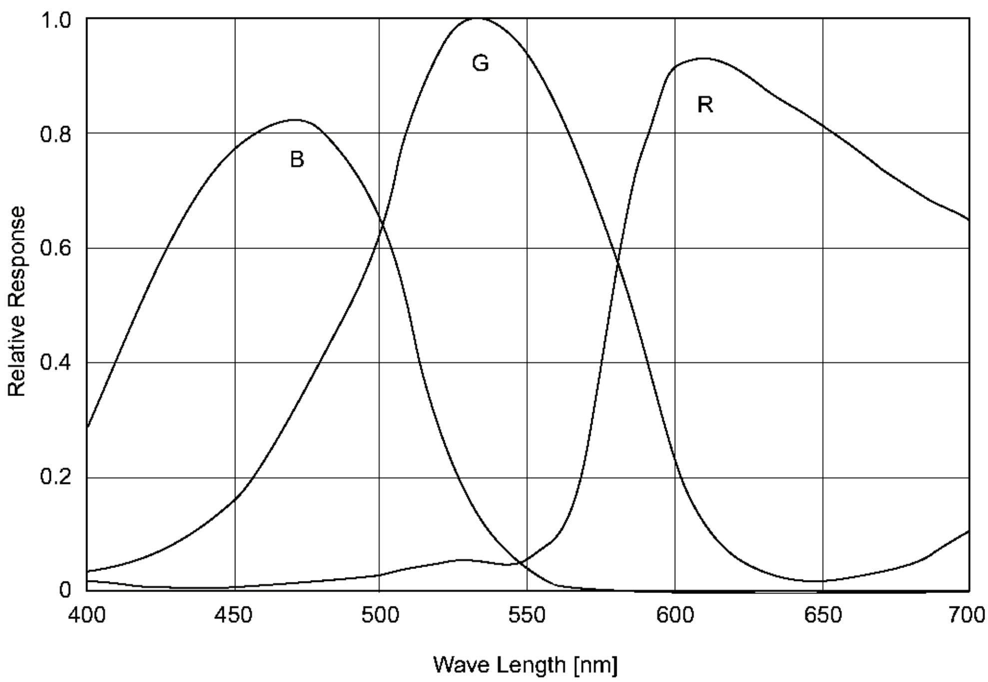


Figure 5: Spectral sensitivity of Marlin F-046C without cut filter and optics

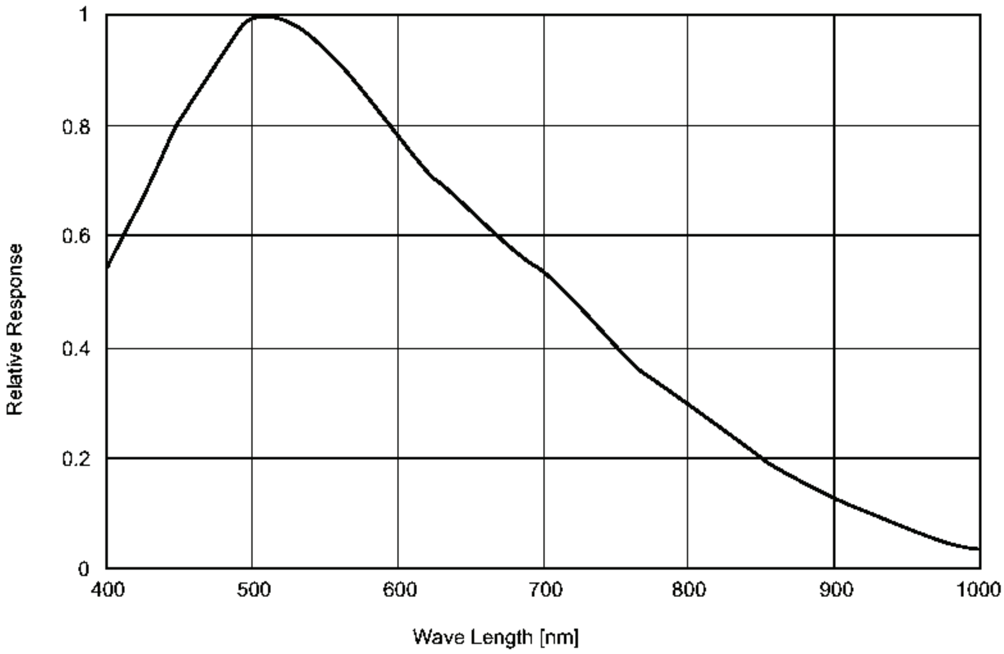


Figure 6: Spectral sensitivity of Marlin F-080B without cut filter and optics

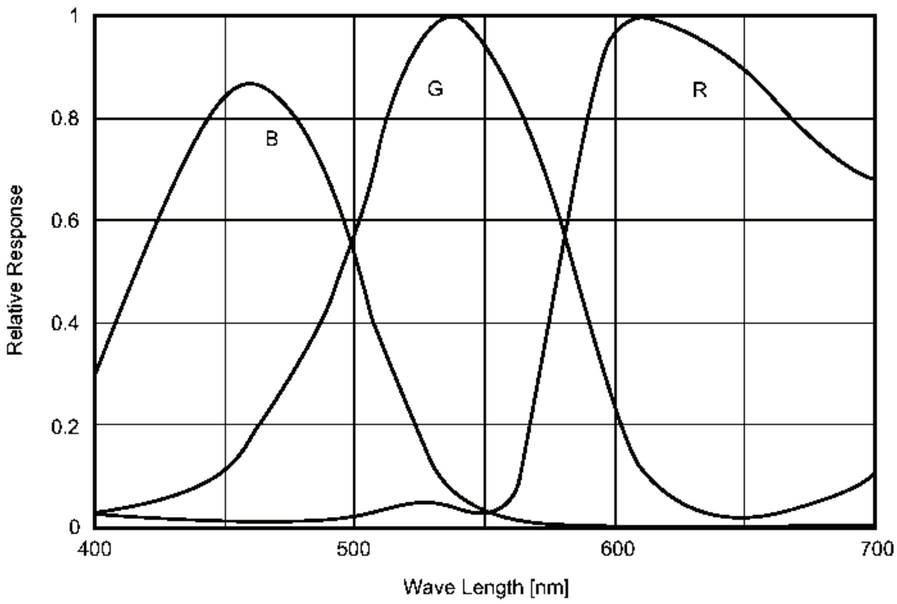


Figure 7: Spectral sensitivity of Marlin F-080C without cut filter and optics

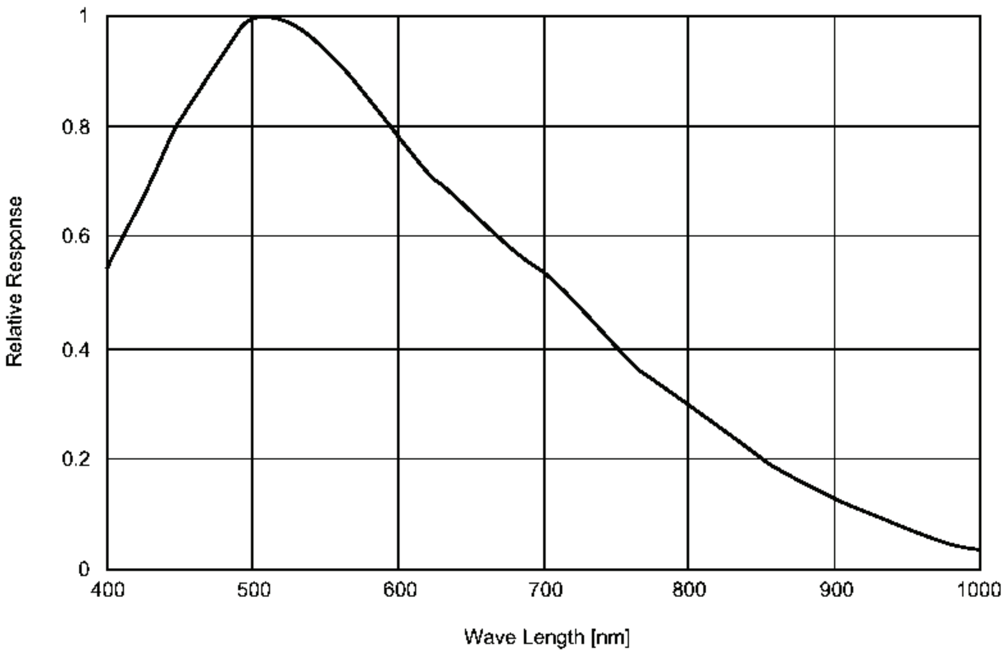


Figure 8: Spectral sensitivity of Marlin F-145B2 without cut filter and optics

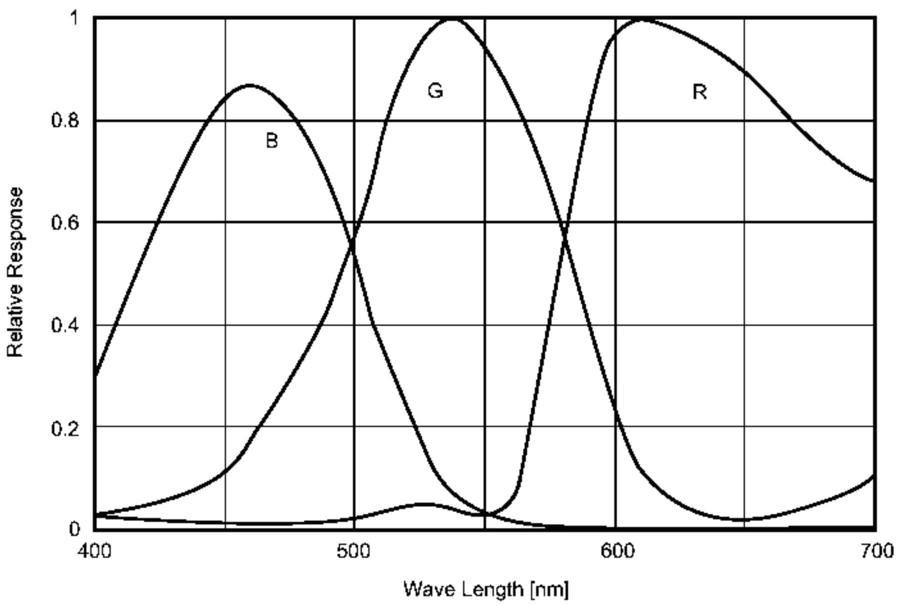


Figure 9: Spectral sensitivity of Marlin F-145C2 without cut filter and optics

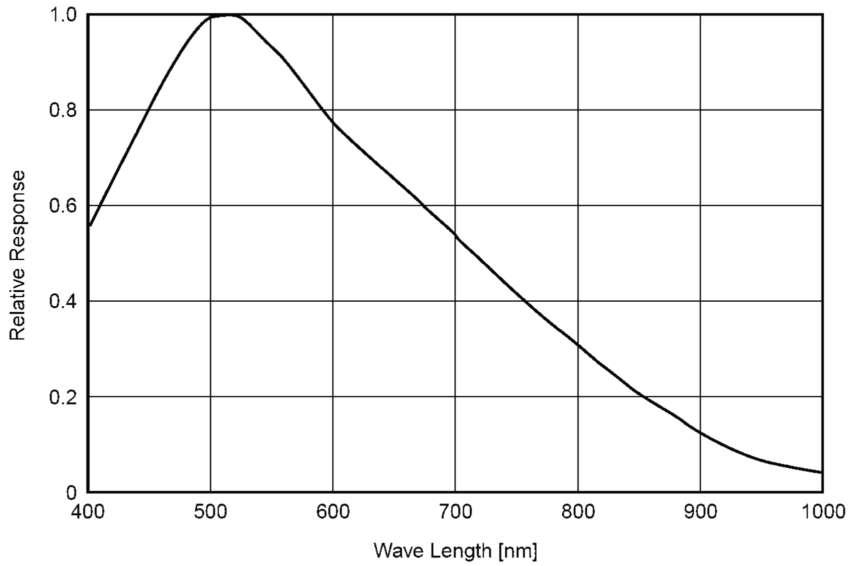


Figure 10: Spectral sensitivity of Marlin F-146B without cut filter and optics

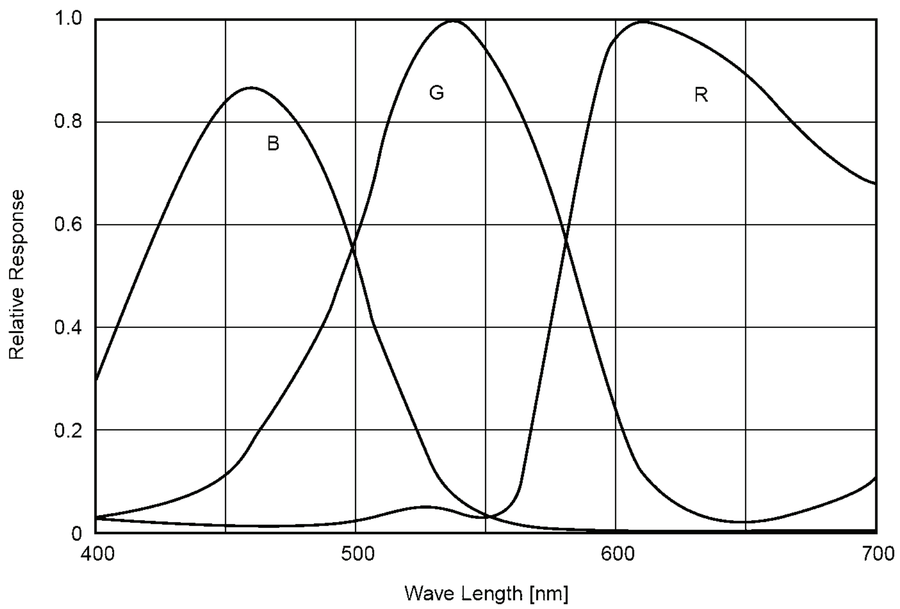


Figure 11: Spectral sensitivity of Marlin F-146C without cut filter and optics

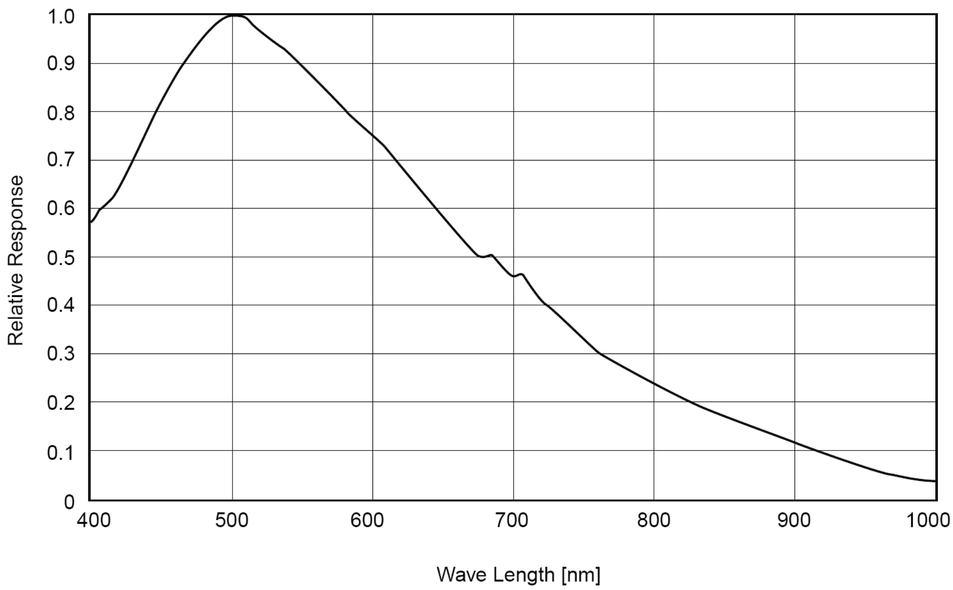


Figure 12: Spectral sensitivity of Marlin F-201B without cut filter and optics

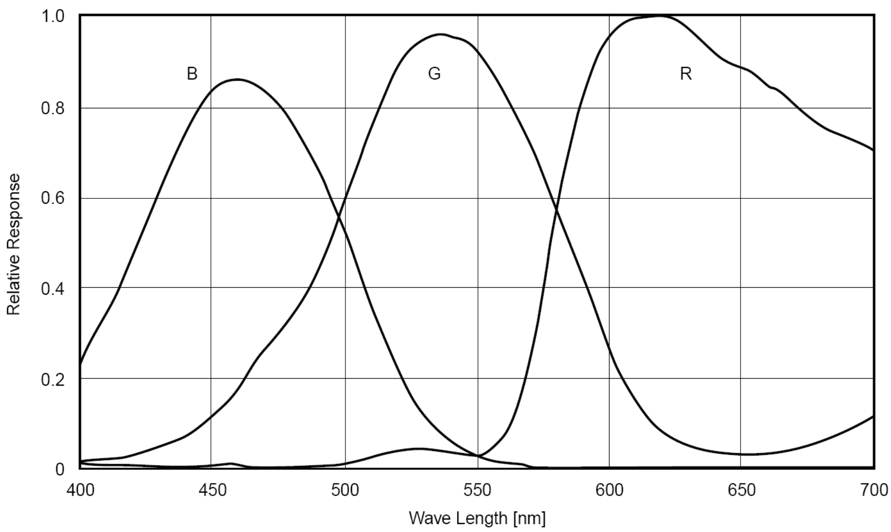


Figure 13: Spectral sensitivity of Marlin F-201C without cut filter and optics

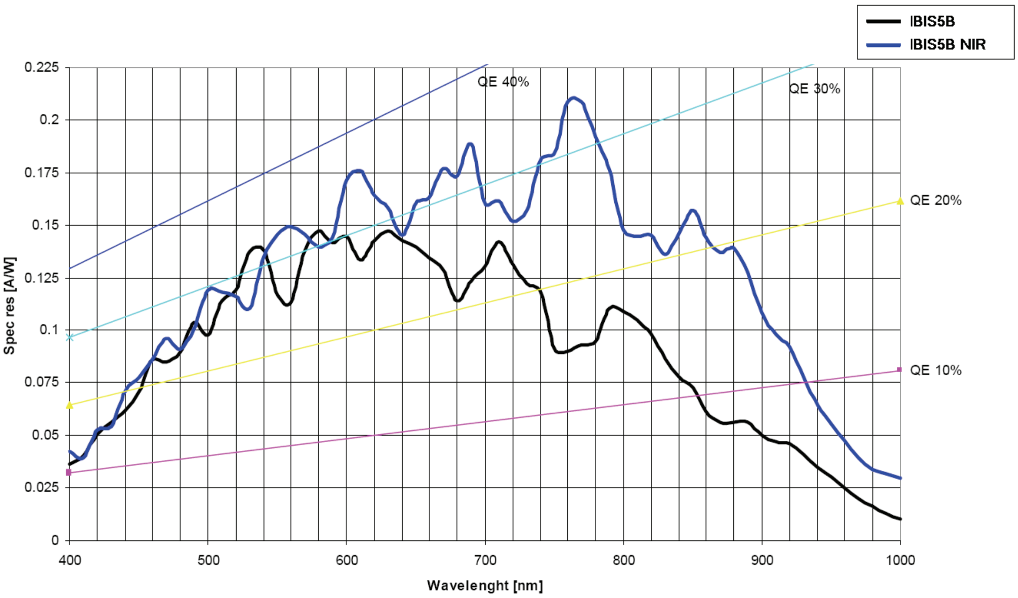


Figure 14: Spectral sensitivity of Marlin F-131B (with IBIS5B as standard) / Marlin F-131B NIR (with IBIS5B NIR as standard) without cut filter and optics

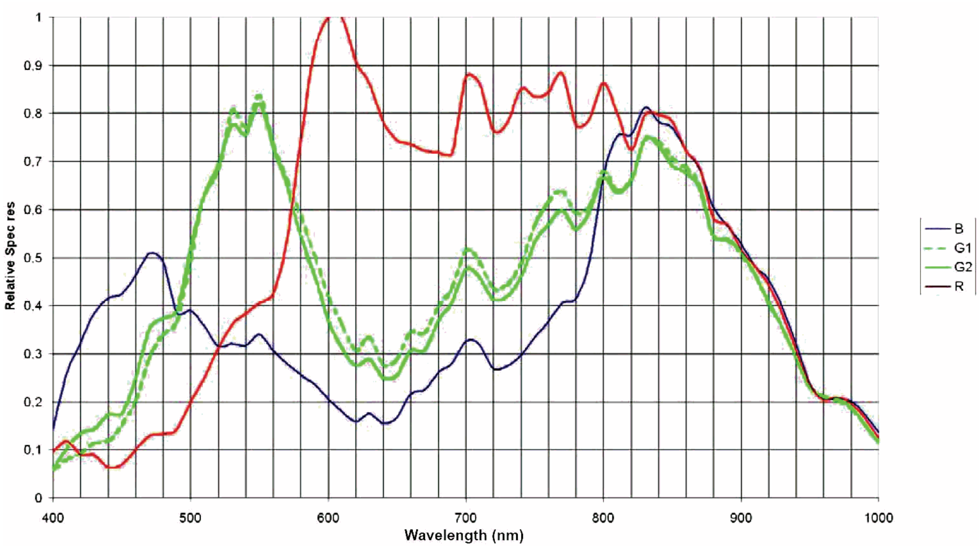


Figure 15: Spectral sensitivity of Marlin F-131C without cut filter and optics

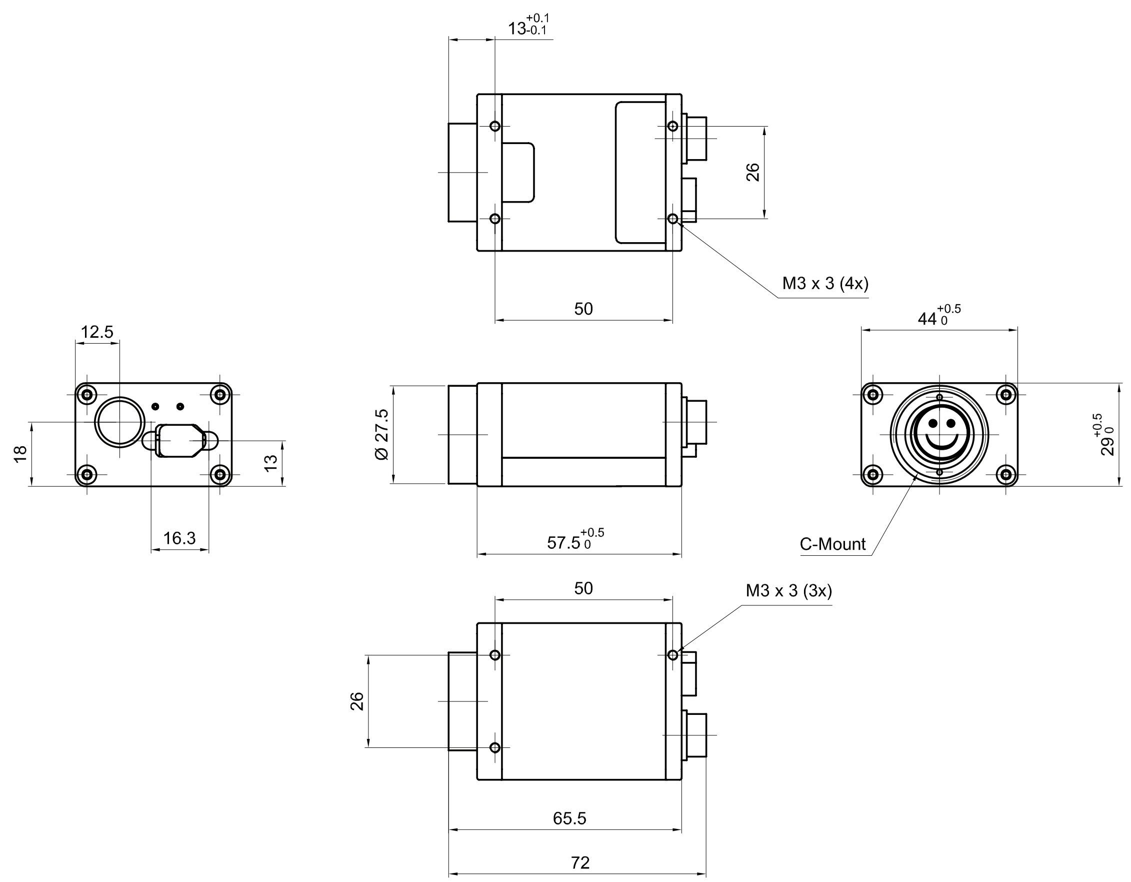
Camera dimensions

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 237.

MARLIN standard housing



Body size: 72 mm x 44 mm x 29 mm (L x W x H)
Mass: 120 g (without lens)

Figure 16: Camera dimensions

Tripod adapter

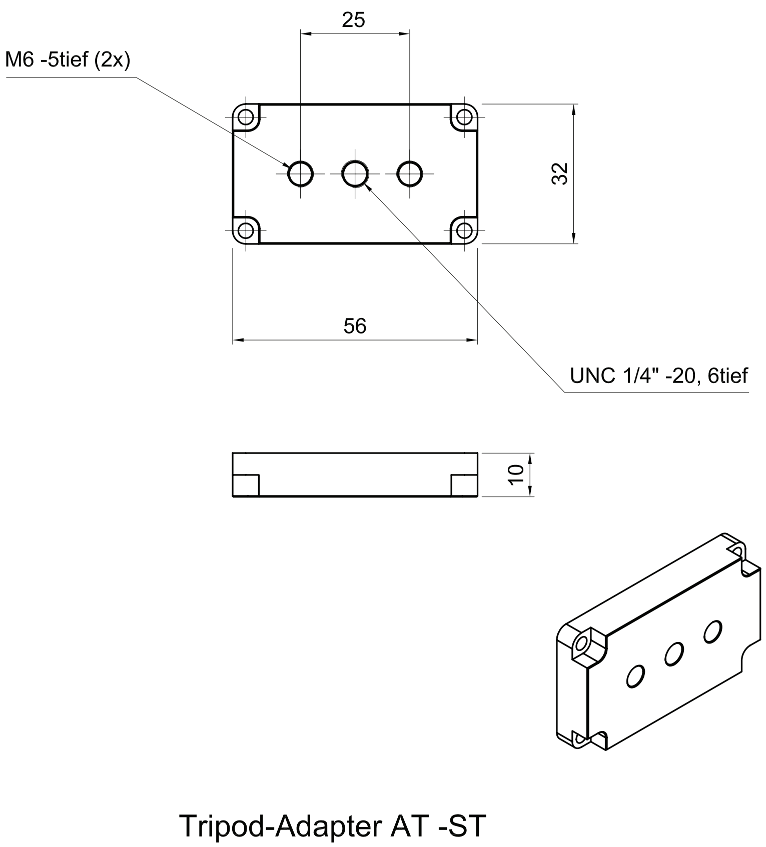


Figure 17: Tripod dimensions

MARLIN W90

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

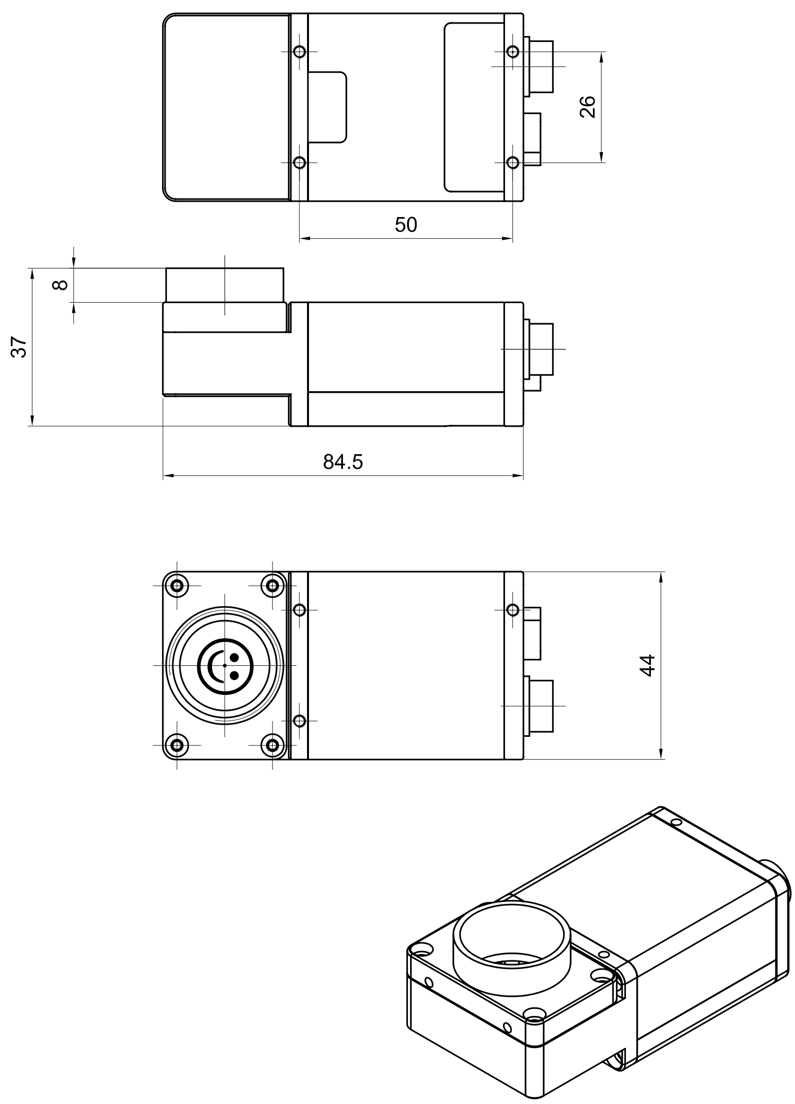


Figure 18: MARLIN W90

MARLIN W90 S90

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

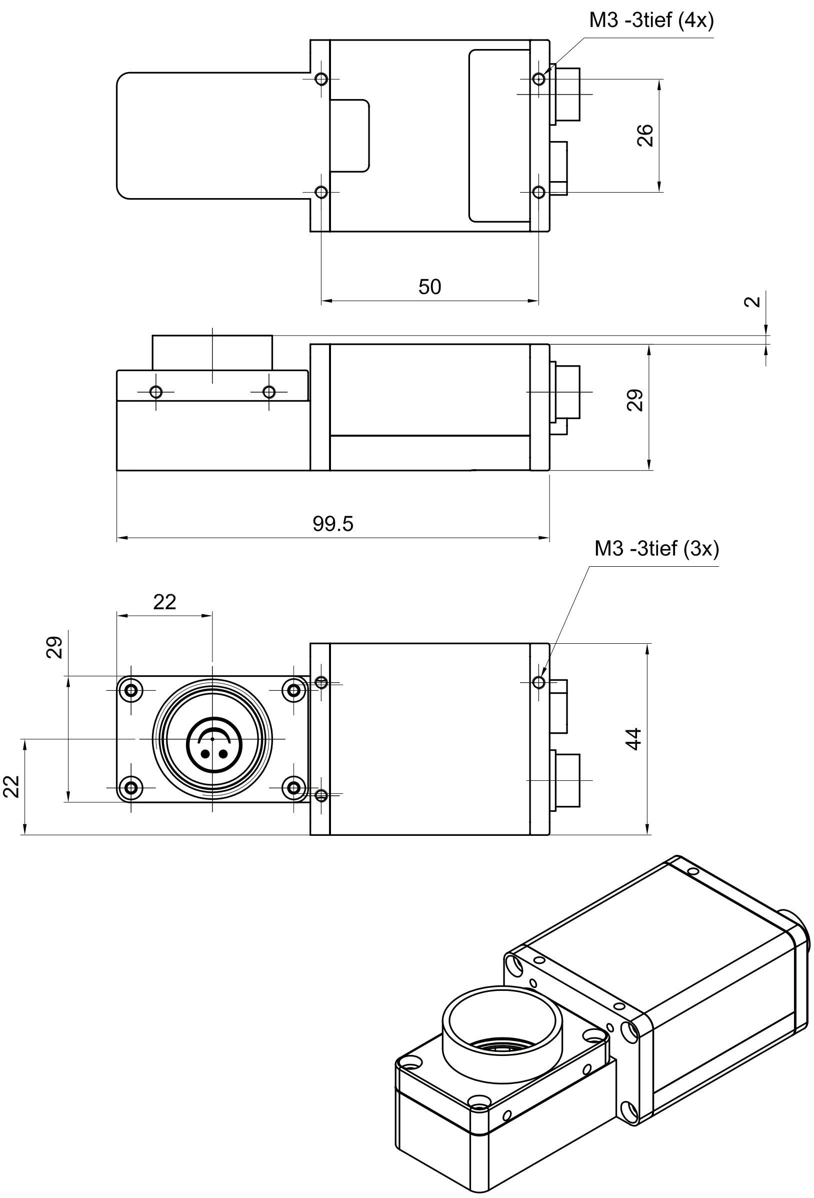


Figure 19: MARLIN W90 S90

MARLIN W270

This version has the sensor tilted by 270 degrees clockwise, so that it views downwards.

Consult your dealer, if you have inquiries for this version.

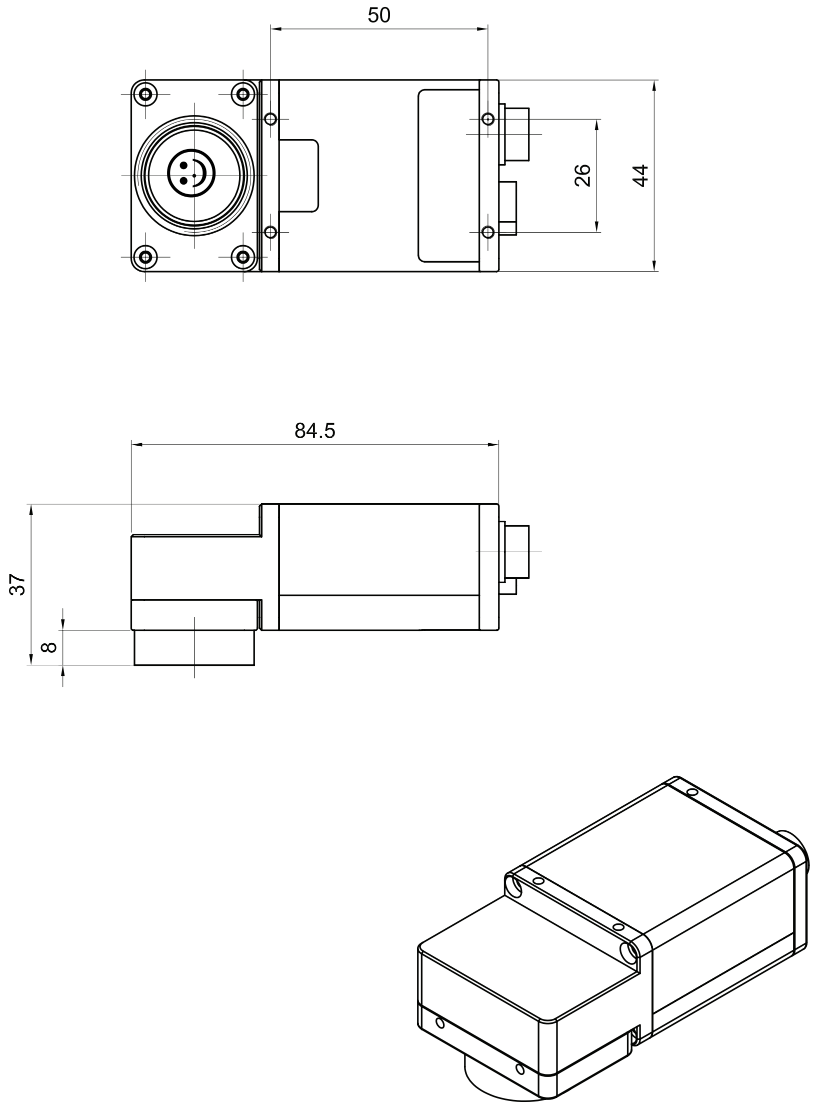


Figure 20: MARLIN W270

MARLIN W270 S90

This version has the sensor tilted by 270 degrees clockwise, so that it views downwards.

Additionally the sensor is tilted by 90 degrees clockwise.

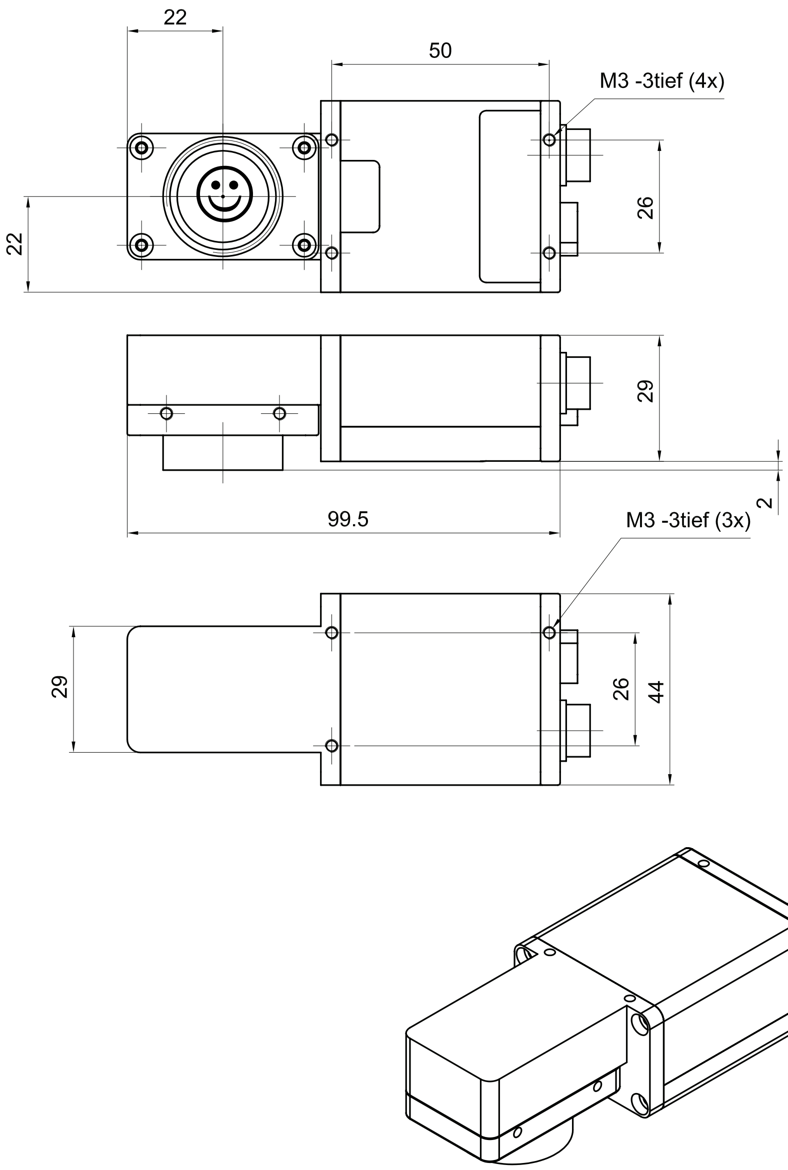


Figure 21: MARLIN W270 S90

Camera interfaces

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

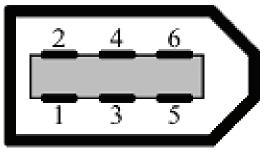
Note

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

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

IEEE 1394a port pin assignment

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



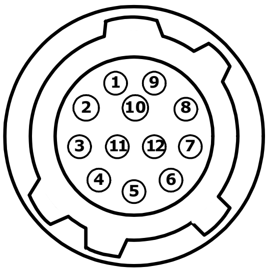
Pin	Signal
1	Cable power
2	Cable GND
3	TPB-
4	TPB+
5	TPA-
6	TPA+

Figure 22: IEEE 1394a connector

Note

Cables with latching connectors on one or both sides can be used and are available with various lengths of 4.5 m or up to 17.5 m. Ask your local dealer for more details.

Camera I/O connector 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 (CCD models only)		+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 collector	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 collector	Camera Output 2 (GPOut2) default: -

Figure 23: 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 *MARLIN input description***.

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

Status LEDs

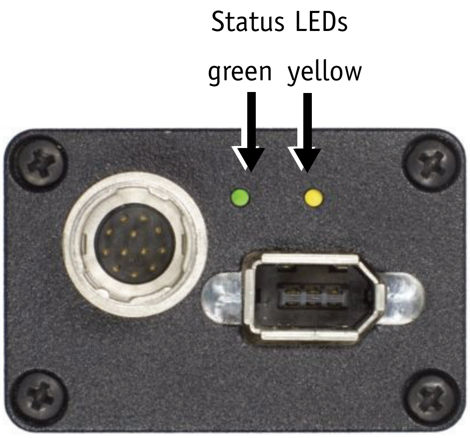


Figure 24: Position of Status LEDs

Status LED green

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

State	Description
Power/S2	LED off - power off LED on - power on

Table 15: LED indication: green

Status LED yellow

The following states are displayed via the yellow LED:

State	Description
Com/S1	Asynchronous and isochronous data transmission active (indicated asynchronously to transmission over the 1394 bus)

Table 16: LED indication: yellow

Blink codes are used to signal warnings or error states:

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

Table 17: 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 *MARLIN input description*.

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

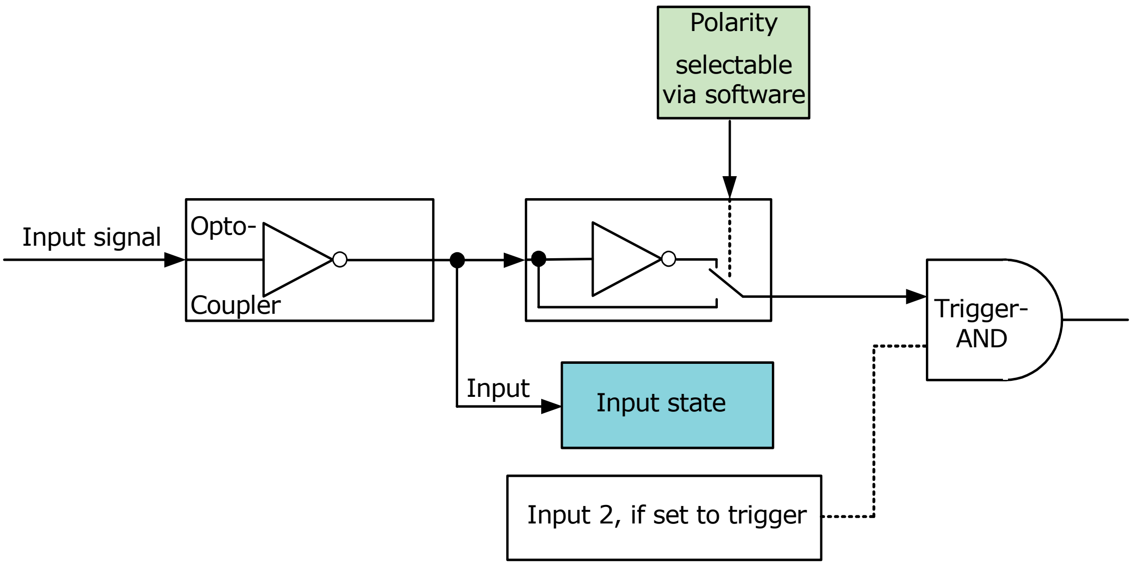


Figure 25: Input block diagram

Triggers

All inputs configured as triggers are linked by AND. 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.

Furthermore polarity of external triggering can be selected according to IIDC V1.3x register 0xF0F00830.

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]	
		Polarity	[7]	0: low active 1: high active
		---	[8..10]	Reserved
		InputMode	[11..15]	Mode see Table 19: Input routing on page 53
		---	[16..30]	Reserved
		PinState	[31]	RD: Current state of pin
0xF1000304	IO_INP_CTRL2	Same as IO_INP_CTRL1		

Table 18: 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 19: Input routing

Trigger delay

Since firmware version 2.03, 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 timebase value. The following table explains the inquiry register and the meaning of the various bits.

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

Table 20: Trigger delay inquiry register

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

Table 21: 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 22: 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

T

Note

For a general description of the **outputs** and **warnings** see the **Hardware Installation Guide**, Chapter *MARLIN 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 23: Output signals

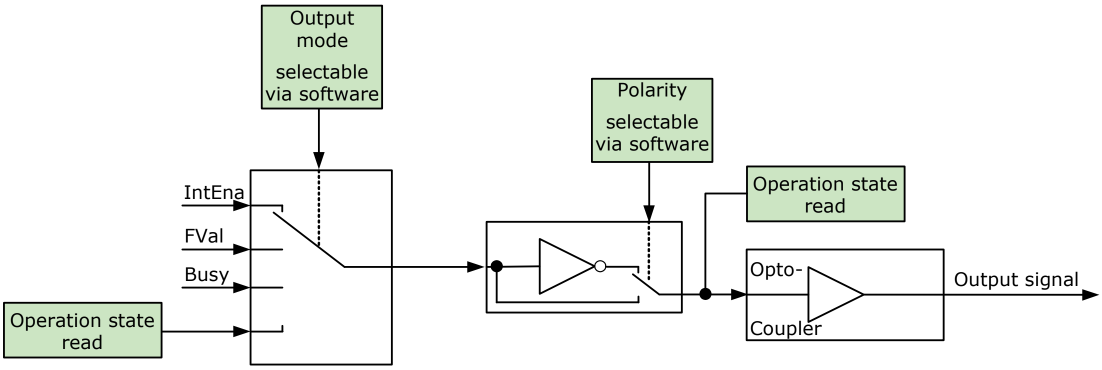


Figure 26: Output block diagram

IO_OUTP_CTRL 1-2

The outputs (Output mode, Polarity) are controlled via two advanced feature registers (see Table 24: Advanced register: Output control on page 58).

The **Polarity** field determines whether the output is inverted or not. The **output mode** can be viewed in the table below. The current status of the output can be queried and set via the **PinState**.

From firmware 2.03 onwards 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.

Note

Outputs in **Direct** Mode:

For correct functionality the **Polarity should always be set to 0** (SmartView: Trig/IO tab, Invert=No).

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: Signal not inverted 1: Signal inverted
		---	[8..10]	Reserved
		Output mode	[11..15]	Mode see Table 25: Output routing on page 59
		---	[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 24: 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 25: 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.

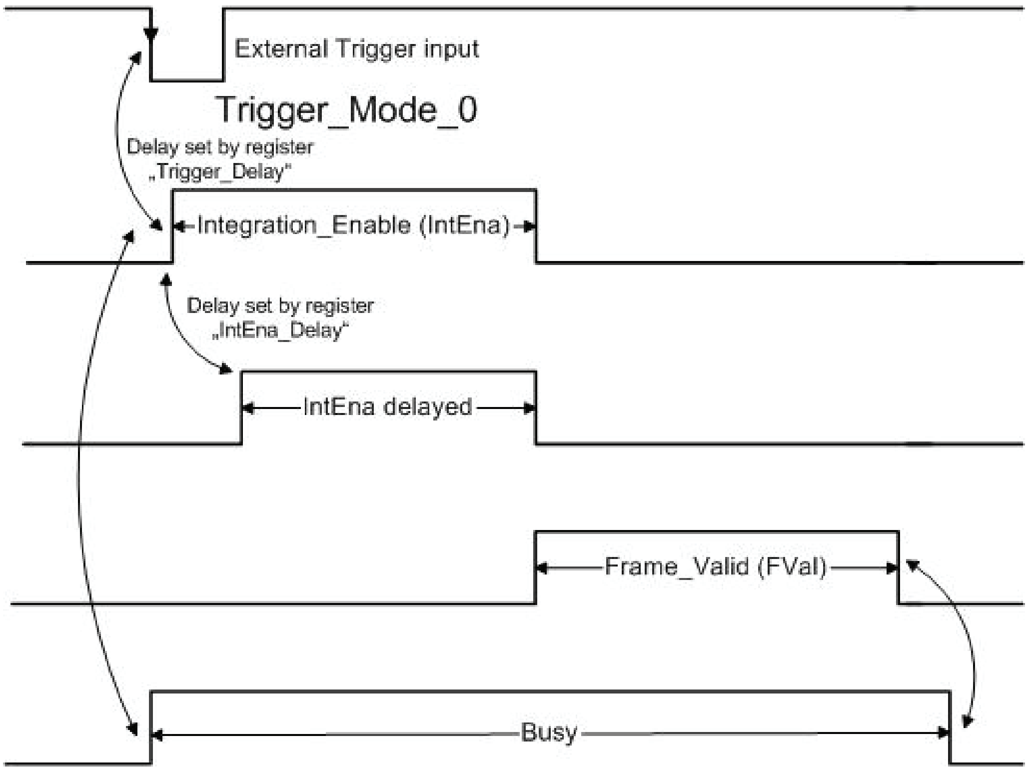


Figure 27: Output Impulse Diagram

Note

The signals can be inverted.

Caution

Firing a new trigger while **IntEna** is still active can result in **image corruption** due to double exposure occurring.

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.

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>

Figure 28: 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 26: Description of data block packet format

- The video data for each pixel are output in either 8-bit or 10-bit format.
- Each pixel has a range of 256 or 1024 shades of gray.
- The digital value 0 is black and 255 or 1023 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 specification)

<YUV (4: 2: 2) format >

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

<YUV (4: 1: 1) format >

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

Figure 29: YUV422 and YUV411 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 30: 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 31: Data structure: Source: IIDC V1.3

Description of the data path

Block diagrams of the cameras

The following diagrams illustrate the data flow and the bit resolution of image data after being read from the CCD or CMOS 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.

Black and white cameras

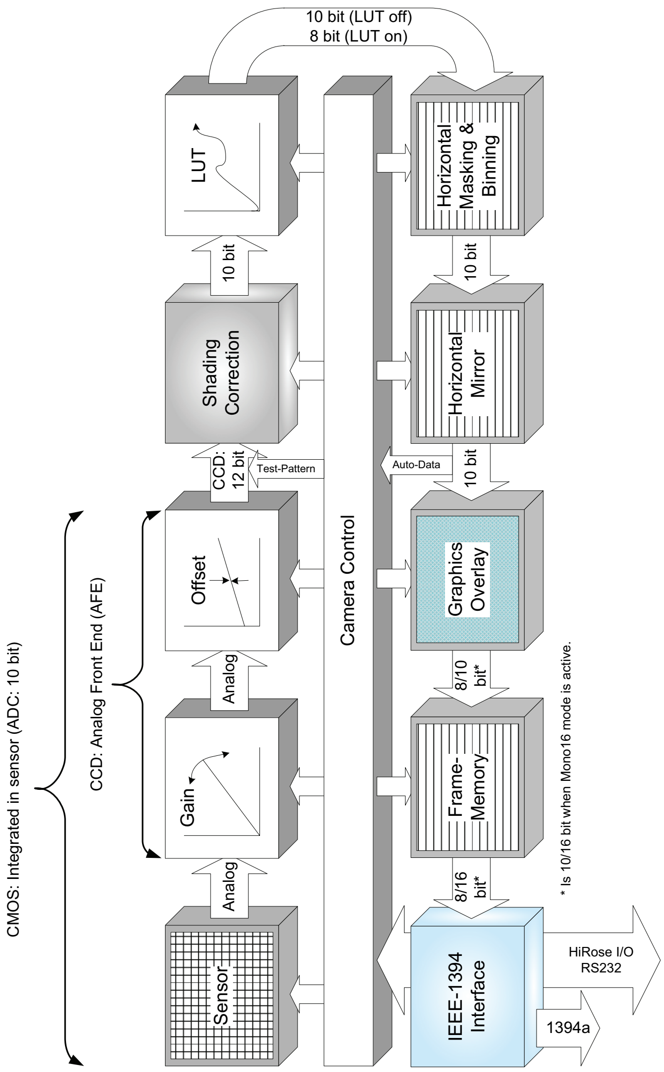


Figure 32: Block diagram b/w camera

Color cameras

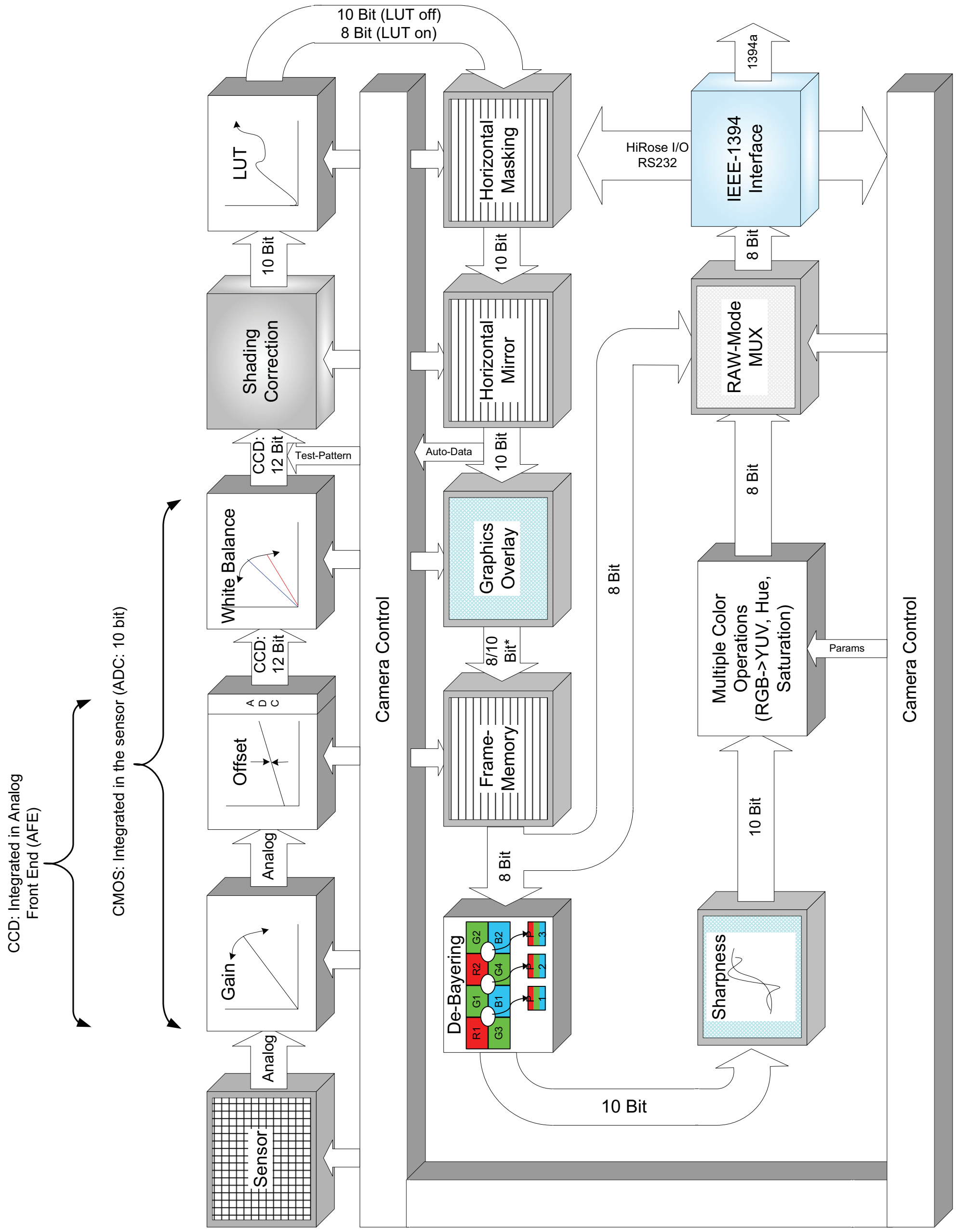


Figure 33: Block diagram color camera

IBIS5A multiple slope (High Dynamic Range mode)

The MARLIN F-131 sensor has a high dynamic range of about 60 dB. This can be extended to almost 100 dB by switching to a special mode.

This mode is called dual (in the case of rolling shutter) or multiple slope mode (in the case of global shutter).

The following diagram, taken from FillFactory's application notes, explains the functionality.

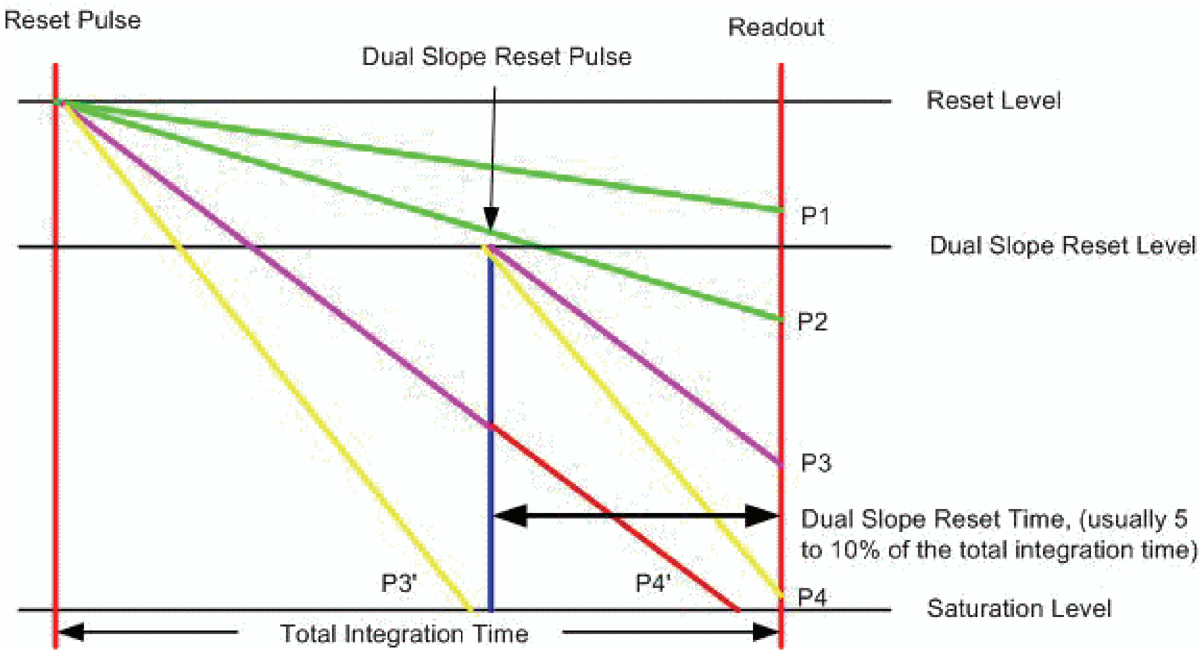


Figure 34: Multiple slope (high dynamic range) pixel charge as a function of time

The colored lines represent the analogue signal on the photo diode which decreases as a result of exposure. The slope is determined by the amount of light at each pixel (the more light, the steeper the slope). When the pixels reach the saturation level, the analogue signal will no longer change despite further light exposure. As shown in the diagram, without any dual or multiple slope pulse, pixels P3' and P4' reach saturation before the sample moment of the analogue values.

When dual slope is enabled, a second reset pulse will be given (blue line) at a certain time before the end of the integration time.

This dual slope reset pulse resets the analogue signal of the pixels below the dual slope reset level to this level. After the reset, the analogue signal starts to decrease with the same slope as before (pink P3 and yellow P4 lines).

This introduces a knee-point in the exposure function.

If the dual slope reset pulse is placed at the end of the integration time (90% for instance), the analogue signal which would have normally reached the saturation level is no longer saturated at read out. This effect increases the optical dynamic range of the sensor.

It is important to notice that pixel signals above the dual slope reset level will be left unaffected (green P1 and green P2).

MARLIN F-131 with three knee-points

The MARLIN F-131 offers up to three knee-points when in global shutter mode. This functionality is controlled via the following registers.

Register	Name	Field	Bit	Description
0xF1000280	HDR_CONTROL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Enable/disable HDR mode
		---	[7..19]	Reserved
		MaxKneePoints	[20..23]	R: Number of knee-points possible in this mode
		---	[24..27]	Reserved
		KneePoints	[28..31]	W: Number of active knee-points
0xF1000284	KNEEPOINT_1	---	[0..15]	Reserved
		Kneepoint1	[16..31]	R/W: Time in µs
0xF1000288	KNEEPOINT_2	---	[0..15]	Reserved
		Kneepoint2	[16..31]	R/W: Time in µs
0xF100028C	KNEEPOINT_3	---	[0..15]	Reserved
		Kneepoint3	[16..31]	R/W: Time in µs

Table 27: High dynamic range configuration register

Note

It is recommended that knee-points be adjusted to 10 %, 5 % and 2.5 % of the total exposure or shutter time being applied at the end of the exposure.

Example Adjust image so that the dark areas are well displayed. Calculate the used shutter time. Activate HDR mode.

Assuming shutter time to be 40 ms = 40,000 µs:

- Kneepoint_1 = 10 % * 40,000 µs = 4,000 µs = 0xFA0
- Kneepoint_2 = 5 % * 40,000 µs = 2,000 µs = 0x7D0
- Kneepoint_3 = 2.5 % * 40,000 µs = 1,000 µs = 0x3E8

The following needs to be written:

Name	Address	Write the following
HDR_CONTROL:	(Address: 0xF1000280)	0x02000003
KNEEPOINT_1:	(Address: 0xF1000284)	0x00000FA0
KNEEPOINT_2:	(Address: 0xF1000288)	0x000007D0
KNEEPOINT_3:	(Address: 0xF100028C)	0x000003E8

Table 28: Example: 3 knee-points

For further tuning, readjust KNEEPOINT_X but maintain ratio KNEEPOINT_1 > KNEEPOINT_2 > KNEEPOINT_3.

The figure below, taken from the sensor's data sheet, illustrates the nonlinear behavior of the photo response curve in dual slope mode.

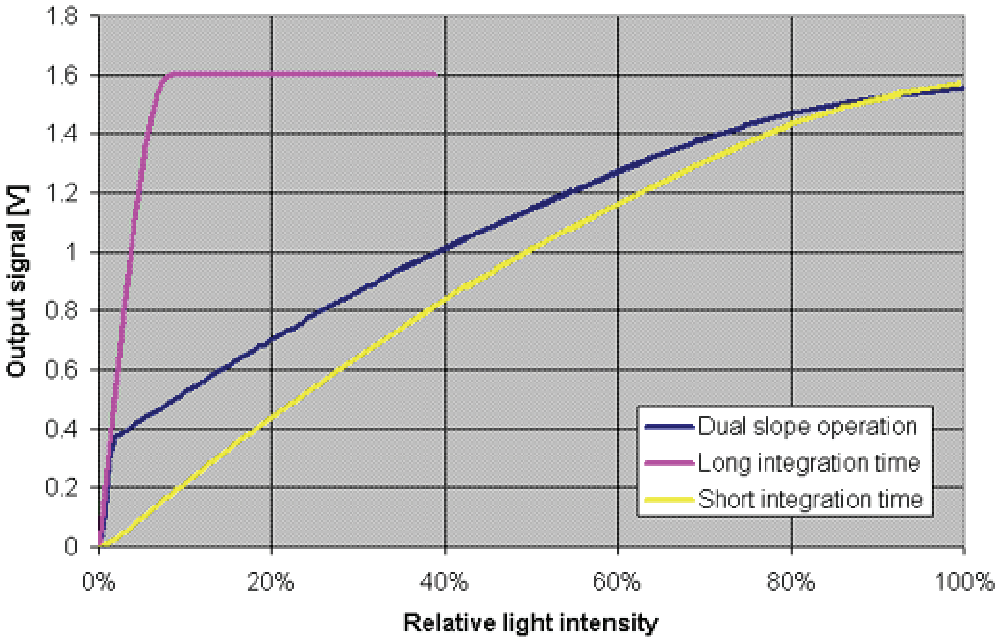


Figure 35: IBIS5A nonlinear photo response curve with two slopes

White balance

Marlin color cameras have both manual and automatic white balance. White balance is applied so that non-colored image parts are displayed non-colored.

White balance does **not** use the so called PxGA® (Pixel Gain Amplifier) of the analog front end (AFE) but a digital representation in the FPGA in order to modify the gain of the two channels with lower output by +9.5 dB (in 106 steps) relative to the channel with highest output.

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

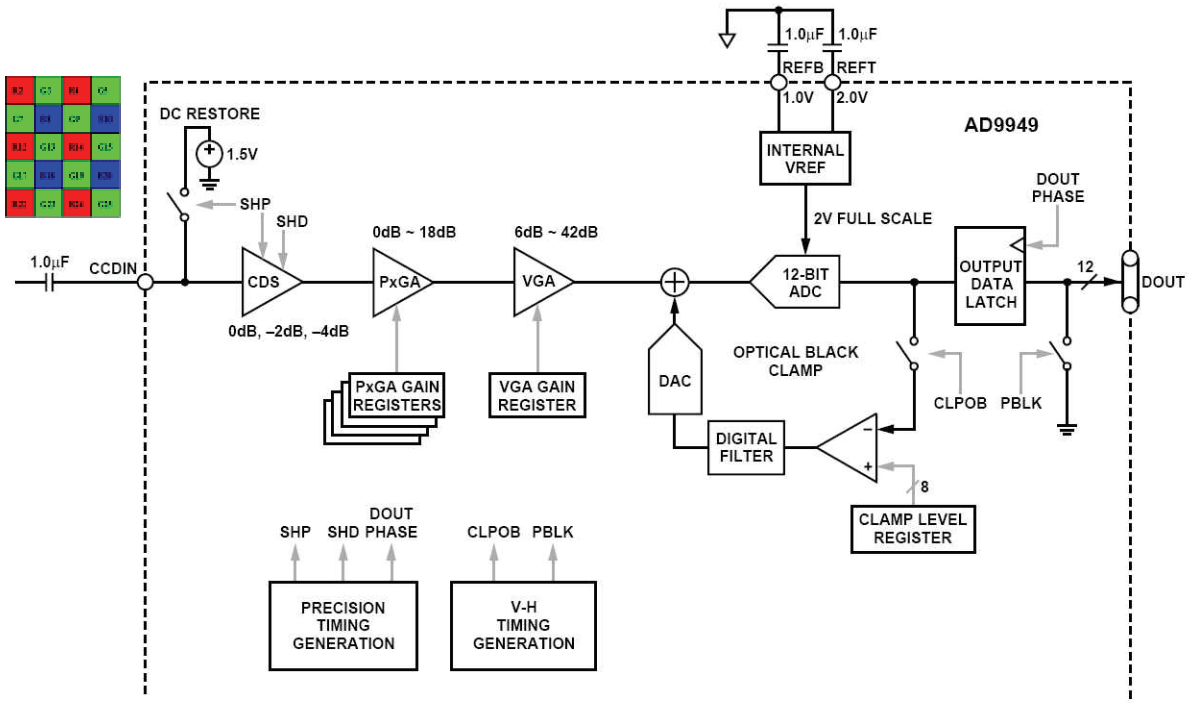


Figure 36: Block diagram of AFE (Source: Analog Devices)

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) then bypasses the PxGA before further amplification and digitization.

From the user's point, 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 29: 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.

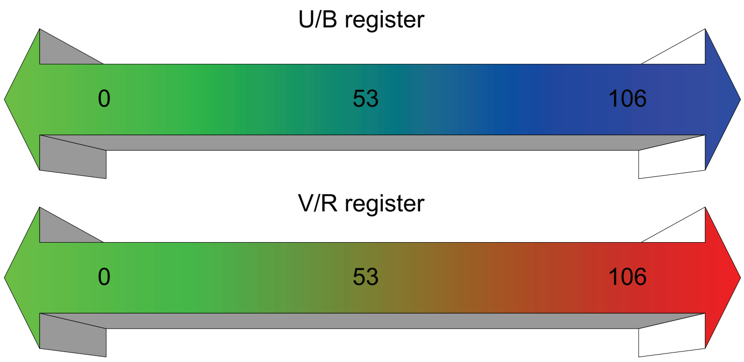


Figure 37: U/V slider range

One-push automatic white balance

Note

Configuration

To configure this feature in control and status register (CSR): See Table 29: White balance register on page 71.

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

For white balance, in total **6** 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 are used as actual 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 shall be 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 outputted on the 1394 bus. Any previously active image capture is restarted after the completion of white balance.

Automatic white balance can also be enabled by using an external trigger. However, if there is a pause of >10 seconds between capturing individual frames this process is aborted.

The following flow diagram illustrates the automatic white balance sequence.

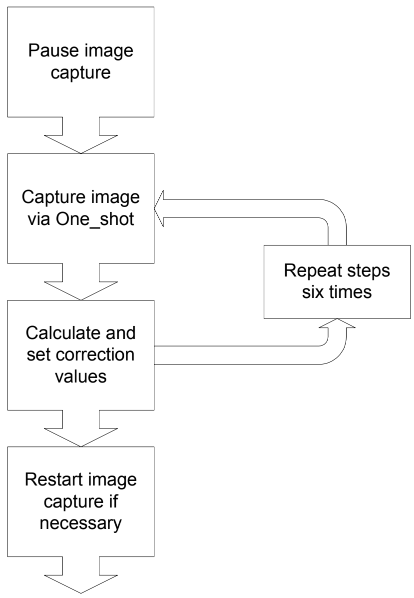


Figure 38: Automatic white balance sequence

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.

For the white balance algorithm a grid is used 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 117: Advanced register: Autofunction AOI on page 222.

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 follow the current active image size.

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.

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

The following drawing illustrates the AUTOFNC_AOI settings in greater detail.

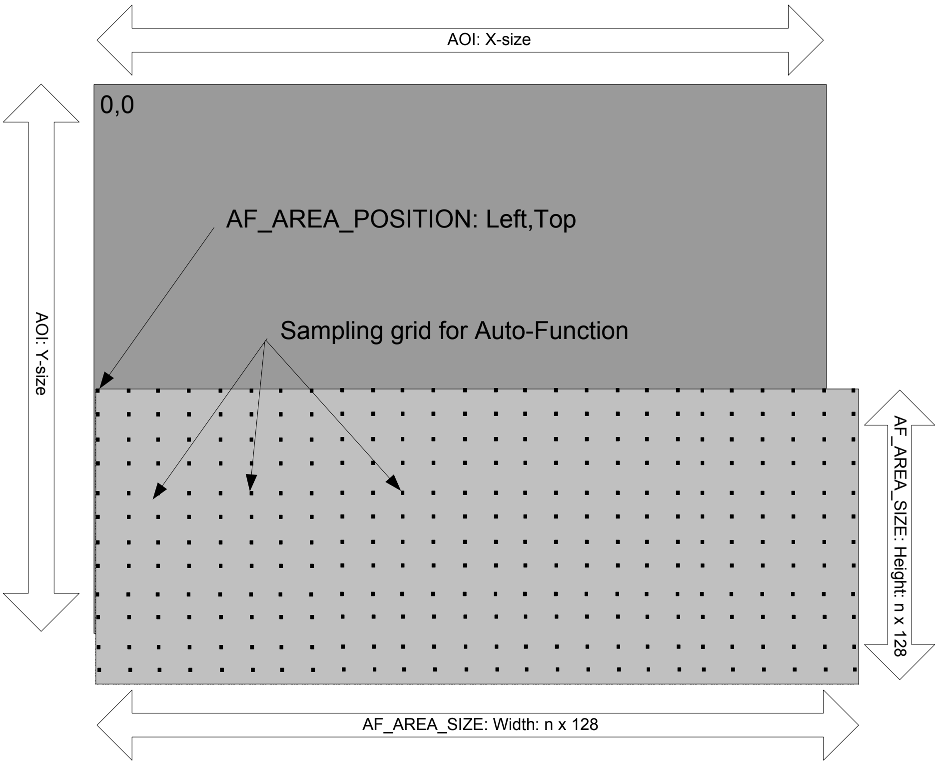


Figure 39: AUTOFNC_AOI positioning

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

Auto shutter

In combination with auto white balance, all Marlin CCD models and CMOS models are equipped with 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 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
		---	[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 30: CSR: **Shutter**

Note

Configuration

To configure this feature in an advanced register: See Table 115: Advanced register: Auto shutter control on page 221.

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

In combination with auto white balance, all Marlin CCD models are equipped with **auto gain** feature.

When enabled auto gain adjusts the gain within the default gain limits (see Table 33: Manual gain range of the various Marlin types on page 80) 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 table shows both the gain and auto exposure CSR.

Register	Name	Field	Bit	Description
0xF0F00820	GAIN	Presence_Inq	[0]	Presence of this feature: 0: N/A 1: Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the value field 1: Control with value in the absolute value CSR If this bit= 1 the value in the value field has to be ignored
		---	[2..4]	Reserved
		One_Push	[5]	Write: Set bit high to start Read: Status of the feature: Bit high: WIP Bit low: Ready
		ON_OFF	[6]	Write: ON or OFF this feature Read: read a status 0: OFF 1: ON
		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 31: 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 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 32: CSR: **Auto Exposure**

Note

Configuration

To configure this feature in an advanced register: See Table 116: Advanced register: Auto gain control on page 221.

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**)
- Auto gain is not possible with CMOS models due to coarse gain settings.

Manual gain

Marlin 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
Marlin CCD cameras	0 … 680	0 … 24 dB
Marlin CMOS camera	1 … 14	0 … 16 dB

Table 33: Manual gain range of the various Marlin types

The increment length is ~0.0354 dB/step for CCD models and 1.25 dB/step for CMOS.

Note

- Setting the gain does not change the offset (black value) for CCD models.
- A higher gain also produces greater image noise. This reduces image quality. For this reason, try first to increase the brightness, using the aperture of the camera optics and/or longer shutter settings.

Brightness (black level or offset)

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

CCD models: 0...+16 gray values (@ 8 bit)

Increments are in 1/16 LSB (@ 8 bit)

CMOS model: 0 … +127 (@ 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) for CCD models.
- Setting the gain changes the offset (black value) for CMOS models. This is due to the lack of black clamping circuitry in sensor.

The IIDC register brightness 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 34: CSR: **Brightness**

Look-up table (LUT) and gamma function

The AVT Marlin 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 apply it 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 = $(\text{Input})^{0.45}$

This is used with all Marlin CCD models.

It is known as compensation for the nonlinear brightness response of many displays e.g. CRT monitors. The look-up table converts the most significant 10 bits from the digitizer to 8 bits. The gamma function is controlled by the register F0F00818h by toggling bit 6.

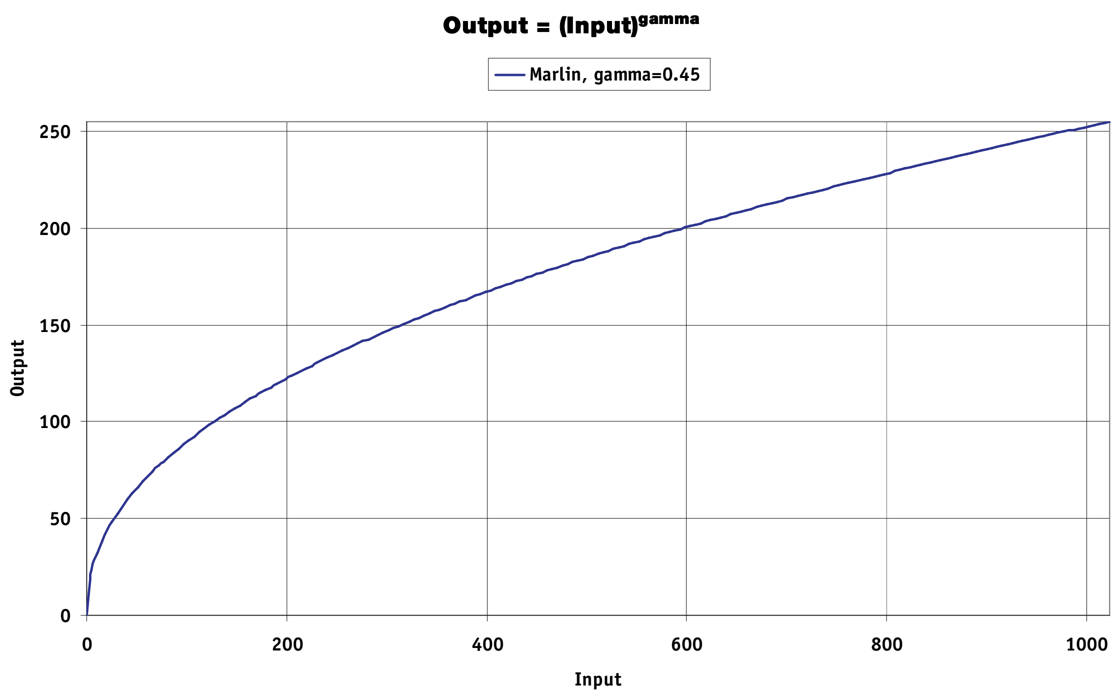


Figure 40: Gamma LUT

Note

- The input value is the most significant **10-bit** value from the digitizer. The gamma LUT of the CCD models outputs the most significant 8 bit as shown above.
- As gamma correction for the CCD models is also implemented via the look-up table, it is not possible to use a different LUT when gamma correction is enabled.
- With all CCD models, the user LUT will be overwritten when Gamma is enabled and vice versa.
- CMOS models have the gamma function built in the sensor, so that it won't be overwritten.
- LUT content is by default volatile, use **user set functionality** to store the LUT permanently in the camera.

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 kB, and a complete LUT at 1024 x 8 bit is 1 kB, programming can take place in a one block write step. The flow diagram below shows the sequence required to load data into the camera.

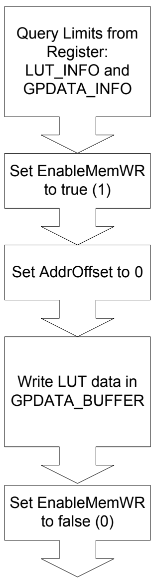


Figure 41: Loading an LUT

Note

Configuration

- To configure this feature in an advanced register: See Table 107: Advanced register: LUT on page 213.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 235.

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.

How to store shading image

After generating the shading image in the camera, it can be uploaded to the host computer for nonvolatile storage purposes.

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

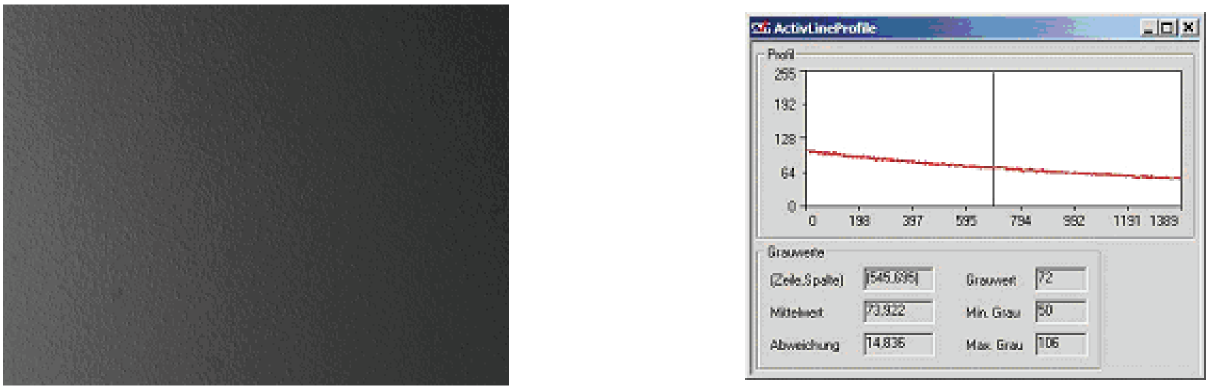


Figure 42: Shading correction: Source image with non-uniform illumination

- 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. 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.

Correction alone can compensate for shading by up to 50 % and relies on 10 bit pixel data to avoid the generation of missing codes.

How to proceed:

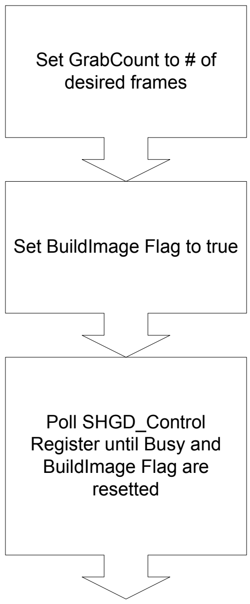


Figure 43: Automatic generation of a shading image

Note

Configuration

To configure this feature in an advanced register: See Table 108: Advanced register: Shading on page 214.

Note

- The maximum value of GRAB_COUNT depends on the type of camera and the number of frame buffers that exist. GRAB_COUNT is also automatically corrected to the power of two.
- The SHDG_CTRL register should not be queried at very short intervals. This is because each query delays the generation of the shading image. An optimal interval time is 500 ms.

The following pictures illustrate the sequence of commands for generating the shading image.

The correction sequence controlled 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).

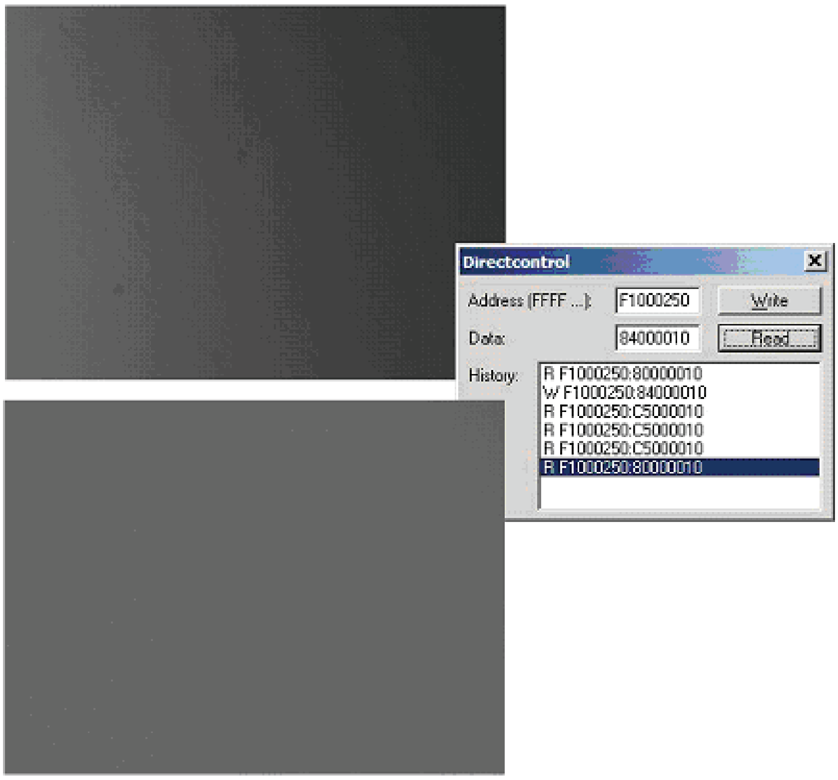


Figure 44: Generation of shading image

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.
- **CCD models only**: Shading correction can be combined with the Image mirror, binning and gamma functionality. Changing binning modes involve the generation of new shading reference images due to a change in the image size.
- **CMOS models only**: Using shading correction in combination with the gamma feature on the CMOS models may lead to improper results.

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.

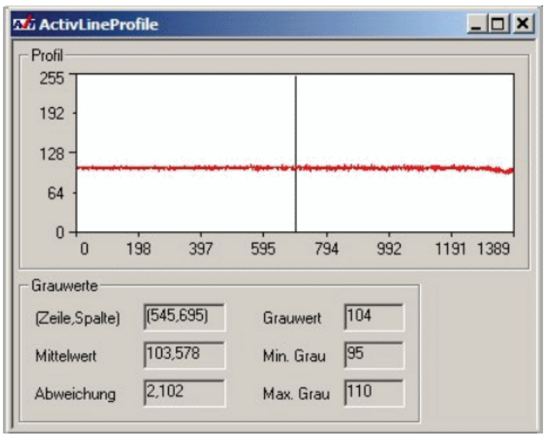


Figure 45: Example of shaded image

Loading a shading image out of the camera

GPDATA_BUFFER is used to load a shading image out of 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 reads are used to read a block of n bytes with one command out of the GPDATA_BUFFER. With firmware 3.03 it is possible to read quadlets directly out of the buffer, but this takes much more time.

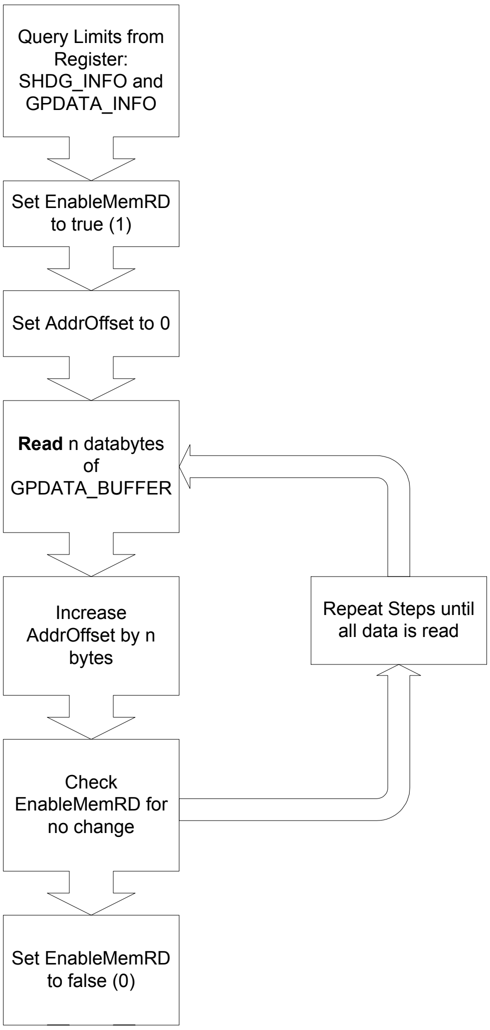


Figure 46: Uploading shading image to host

Note

Configuration

- To configure this feature in an advanced register: See Table 108: Advanced register: Shading on page 214.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 235.

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 3.03 it is possible to write quadlets directly into the buffer, but this takes much more time.

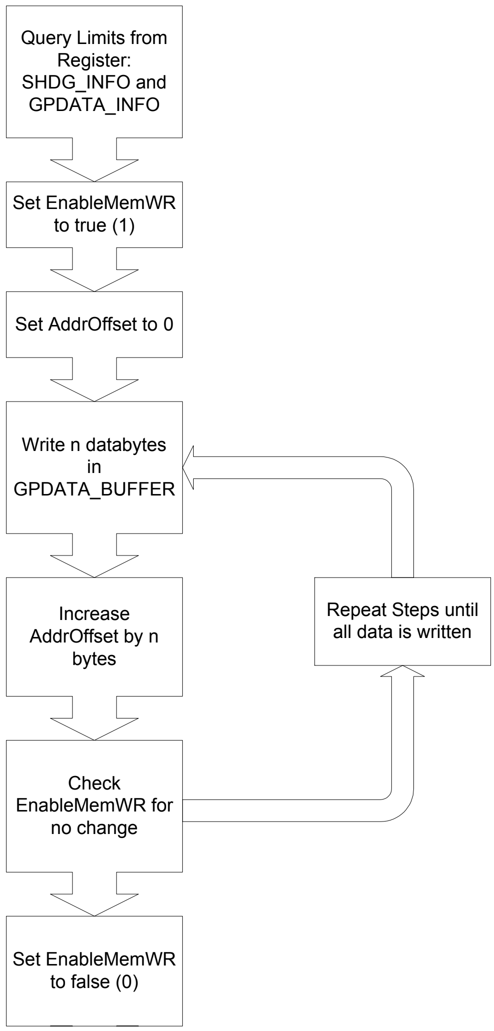


Figure 47: Loading the shading reference image

Note

Configuration

- To configure this feature in an advanced register: See Table 108: Advanced register: Shading on page 214.
- For information on GPDATA_BUFFER: See Chapter GPDATA_BUFFER on page 235.

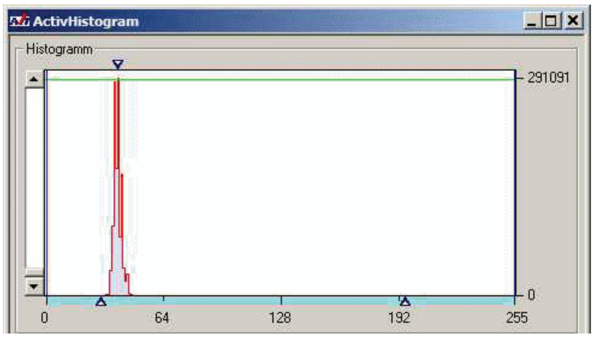
DSNU & blemish correction (MARLIN F-131B only)

In order to further reduce the **dark signal non uniformity** (DSNU) of the CMOS sensor to levels similar to CCD sensors, the MARLIN F-131B is equipped with a special **DSNU reduction function**, extending the shading correction.

The DSNU function applies an additive correction to every pixel in order to equalize the dark level of the pixels. This function also enables correction of single and double blemished pixels by replacing them with their neighborhood pixels. DSNU and blemish pixel correction are generated simultaneously but can be switched on/off separately.

The following screenshots demonstrate how it works:

On the left picture (without correction) it can be seen that over the complete field of view there is a certain spread of the histogram, indicating non uniform dark pixels and blemished pixel(s) with brightness around 192(Δ). With pure DSNU correction the spread is considerably smaller.



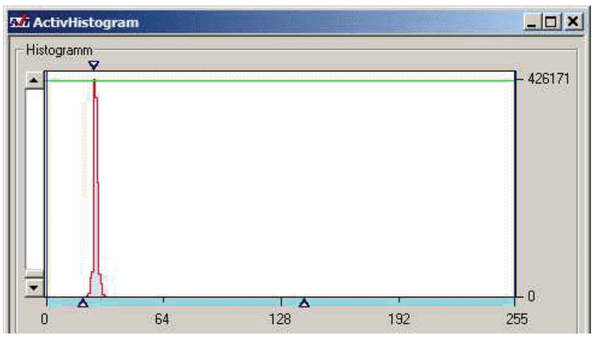


Figure 48: Effect of DSNU correction

The table below shows the advanced register map, required to control this functionality.

Note — **Configuration**

To configure this feature in an advanced register:

- See Table 112: Advanced register: DSNU on page 218.
- Table 113: Advanced register: Blemish on page 219

Having generated the correction data it is possible to separately control the blemish pixel correction with the help of the following register:

The effect of the additional blemish correction can be demonstrated with the next screenshot. Not only is the spread now smaller, there are also no pixels above a considerably lower grey level (Δ at. app. 96 in this case).

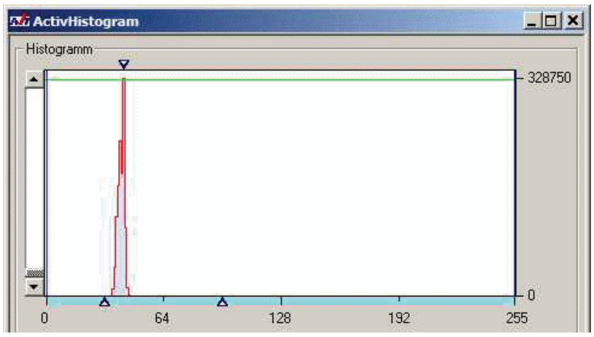


Figure 49: Histogram with blemish correction

Note

- For maximum efficiency, perform a new DSNU correction every time the shutter, gain or offset settings are changed. Generate the image by closing the lens to eliminate image information.
- DSNU correction feature is not available for the Marlin F-131C. The **FPN** correction in former releases of the Marlin F-131 worked different and is replaced by the DSNU correction.
- The use of DSNU correction should be accompanied with shading correction for both low level as well as high level corrected pixels.
- DSNU and blemish correction are volatile.

Horizontal mirror function

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

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

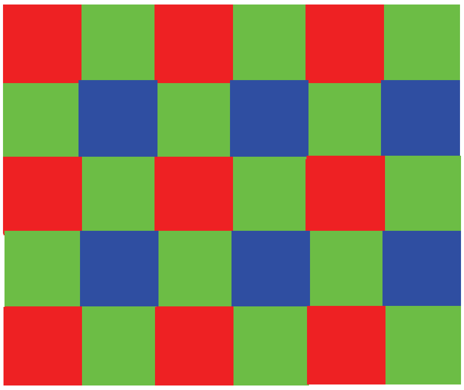
Note

Configuration

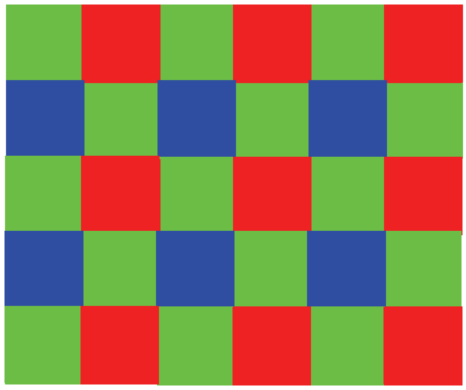
To configure this feature in an advanced register: See Table 121: Advanced register: Mirror on page 224.

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 Marlin color cameras)



Mirror ON: G-R-B-G (all Marlin color cameras)

Figure 50: Mirror and Bayer order

Note

During switchover one image may be temporarily corrupted.

Binning (only Marlin CCD b/w models)

2 x binning

Definition

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

Note

Only **Marlin CCD equipped b/w cameras** have this 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 only)
- 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 wanted signal intensity expected.

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 involve 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

and the full binning modes:

- 2 x full binning (a combination of 2 x H-binning and 2 x V-binning)

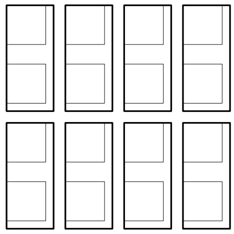
Vertical binning

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 2 dB.

Format_7 Mode_2

By default use **Format_7 Mode_2** for 2 x vertical binning.

This reduces vertical resolution, depending on the model.



2 x vertical binning

Figure 51: 2 x vertical binning

Note

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

2 x horizontal binning: 2 pixel signals from 2 horizontal neighboring pixels are combined.

Light sensitivity

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**. Horizontal resolution is lowered, depending on the model.

Horizontal resolution

Horizontal resolution is lowered, depending on the model.

Format_7 Mode_1

By default and without further remapping use **Format_7 Mode_1** for 2 x horizontal binning.

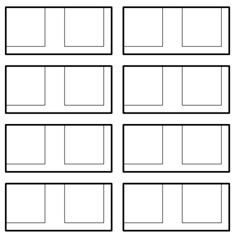


Figure 52: 2 x horizontal binning

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 is reduced, depending on the model.

Resolution Resolution is reduced, depending on the model.

Format_7 Mode_3 By default use **Format_7 Mode_3** for 2 x full binning.

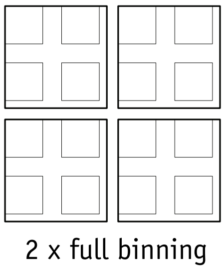


Figure 53: 2 x full binning

Sub-sampling (MARLIN F-131B/C, MARLIN F-146C and MARLIN F-201C)

What is sub-sampling?

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

Which Marlin models have sub-sampling?

- All CMOS equipped Marlin models, both color and b/w have this feature (FW > 2.03).
- The CCD models Marlin F-146C and Marlin F-201C are also equipped with this mode, acting as a preview mode. Because it is realized digitally there is no further speed increase.

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 and image brightness
- CMOS: an increase in the frame rate.

Similar to binning mode the cameras support horizontal, vertical and h+v sub-sampling mode.

Have a look at the following table to check availability of the different sub-sampling modes (h=horizontal, v=vertical).

Camera model	Sub-sampling h	Sub-sampling v	Subsampling h+v
MF-131B/C	Format_7 Mode_1	Format_7 Mode_2	Format_7 Mode_3
MF-146C	not available	not available	Format_7 Mode_2
MF-201C	not available	not available	Format_7 Mode_2

Table 35: Sub-sampling modes MF-131B/C, MF-146C and MF-201C

Format_7 Mode_1 Only Marlin F-131B/C: By default use **Format_7 Mode_1** for

- b/w cameras: 1 out of 2 horizontal sub-sampling
- color cameras: 2 out of 4 horizontal sub-sampling

The different sub-sampling patterns are shown below.

1 out of 2

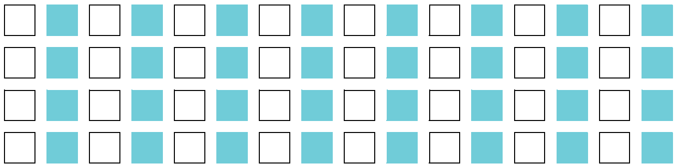


Figure 54: Horizontal sub-sampling 1 out of 2 (**b/w**)

2 out of 4

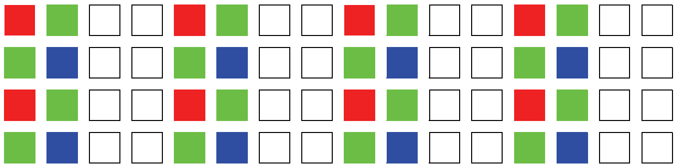


Figure 55: Horizontal sub-sampling 2 out of 4 (**color**)

Note

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

Format_7 Mode_2 Only MF-131B/C: By default use **Format_7 Mode_2** for

- **b/w** cameras: 1 out of 2 vertical sub-sampling
- **color** cameras: 2 out of 4 vertical sub-sampling

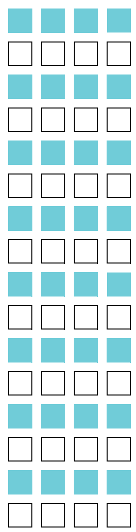


Figure 56: Vertical sub-sampling (**b/w**)

2 out of 4

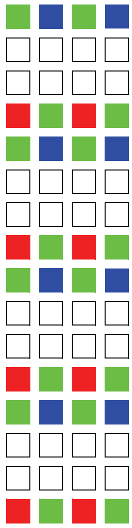


Figure 57: Vertical sub-sampling (**color**)

Note

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

Format_7 Mode_3

By default use **Format_7 Mode_3** for

- only Marlin F-131B: 1 out of 2 H+V sub-sampling
- only Marlin F-131C/146C/201C): 2 out of 4 H+V sub-sampling

1 out of 2 H+V sub-sampling (only Marlin F-131B)

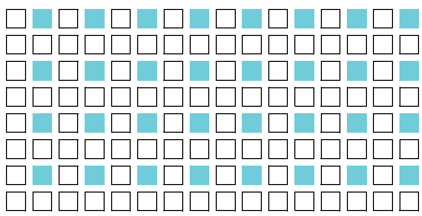


Figure 58: 1 out of 2 H+V sub-sampling (**b/w**)

2 out of 4 H+V sub-sampling (only Marlin F-131C/146C/201C)

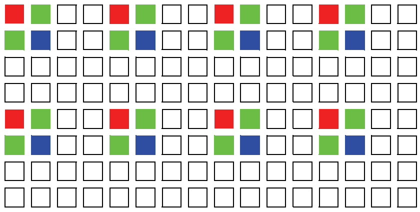


Figure 59: 2 out of 4 H+V sub-sampling (**color**)

Note

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

Parameter update timing

MARLIN cameras show the following timing behavior:

- Frame rate or transfer rate is always constant (precondition: shutter < transfer time)
- The delay from shutter update until the change takes place: up to 3 frames. Figure 60: MARLIN update timing on page 103 demonstrates this behavior. It shows that the camera receives a shutter update command while the sensor is currently integrating (Sync is low) with shutter setting 400. The camera continues to integrate and this image is output with the next FVal. The shutter change command becomes effective with the next falling edge of sync and finally the image taken with shutter 200 is output with a considerable delay.
- Parameters that are sent to the camera faster than the max. frame rate per second are stored in a FIFO and are activated in consecutive images.

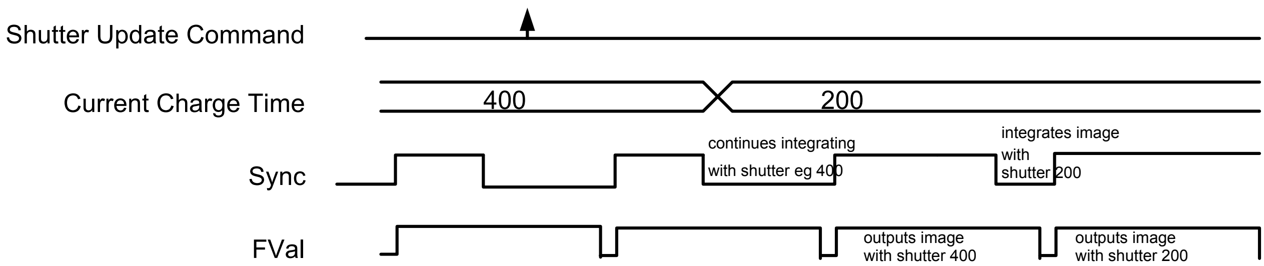


Figure 60: MARLIN update timing

Principally a Marlin camera is not able to recognize how many parameter the user will change. Due to the fact that communication between host and camera is asynchronous, it may happen that one part of parameter changes is done in image n+1 and the other part is done in image n+2.

Sharpness

All Marlin color 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.

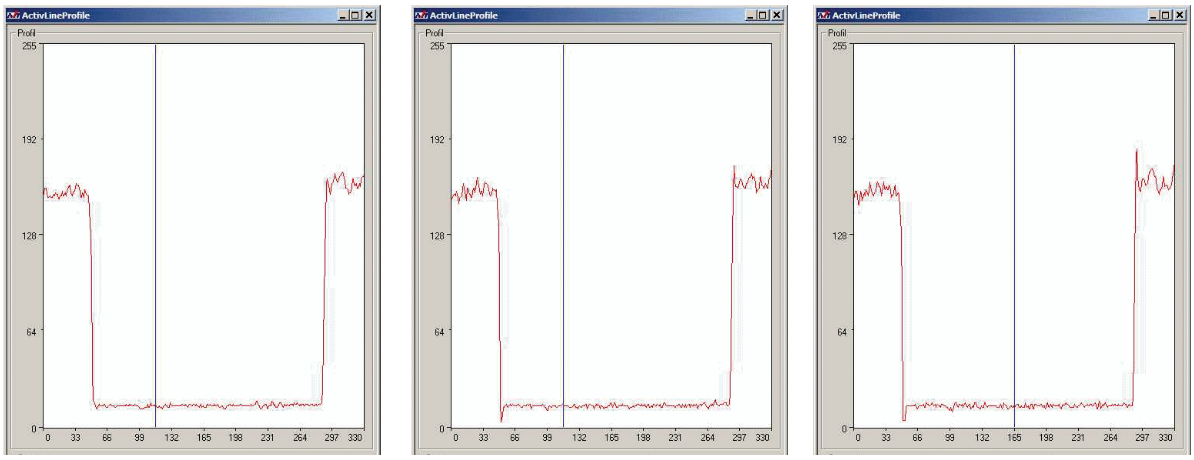


Figure 61: Sharpness: left: 0, middle: 1, right: 2

Note

Configuration

To configure this feature in feature control register: See Table 94: Feature control register on page 195.

Color interpolation and correction

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

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

RAW mode is primarily used to

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

RAW-mode is accessible via Color_Mode Mono8, RAW8 and via Format_7 Mode_1.

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. Only two lines are needed for this interpolation:

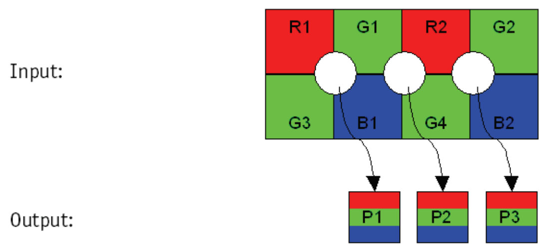


Figure 62: Bayer demosaicing (interpolation)

$$P1_{red} = R1 \qquad P2_{red} = R2 \qquad P3_{red} = R2$$

$$P1_{green} = \frac{G1 + G3}{2} \qquad P2_{green} = \frac{G1 + G4}{2} \qquad P3_{green} = \frac{G2 + G4}{2}$$

$$P1_{blue} = B1 \qquad P2_{blue} = B1 \qquad P3_{blue} = B2$$

Note

On the color camera, a wrongly colored border of one or two pixel wide forms on the left and right image borders. This is also a consequence of BAYER demosaicing as the image width displayed on the color camera is **not** scaled down.

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 Marlin camera there is a factory setting for the color correction coefficients, see Chapter GretagMacbeth ColorChecker on page 106.

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 Marlin (color) cameras you can use it or switch it off.

Color correction: formula

Color correction is performed on all Marlin color 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 1: 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 mode (RAW image transport).

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

Note

Configuration

To configure this feature in an advanced register: See Table 119: Advanced register: Color correction on page 223.

Color-correction coefficients cannot be changed.

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 2: 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 for 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

Marlin CCD color models are equipped with **hue** and **saturation** registers.

The **hue register** at offset 810h allows to change the color of objects without changing the white balance by +/- 40 steps (+/- 10°) from the nominal perception. Use this setting to manipulate the color appearance after having done the white balance.

The **saturation register** at offset 814h allows to change 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 94: Feature control register on page 195.

Serial interface

With FW > 2.03, all Marlin cameras are equipped with the SIO (serial input/output) feature as described in IIDC V1.31. This means that the Marlin's serial interface which is used for firmware upgrades can further be used as a general RS232 interface.

Data written to a specific address in the IEEE 1394 address range will be sent through the serial interface. Incoming data of the serial interface is put in a camera buffer and can be polled via simple read commands from this buffer. Controlling registers enable the settings of baud rates and the check of buffer sizes and serial interface errors.

Note

- 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 bits WR: Set stop bit RD: Get stop bit setting 0: 1 1: 1.5 2: 2
		---	[20..23]	Reserved
		Buffer_Size_Inq	[24..31]	Buffer Size (RD only) This field indicates the maximum size of receive/transmit data buffer If this value=1, Buffer_Status_Control and SIO_Data_Register Char 1-3 should be ignored.

Table 36: 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 36: 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 WR: Number of bytes to be read from the receive FIFO RD: Number of bytes left for readout from the receive FIFO
		---	[16..31]	Reserved
00Ch	TRANSMIT_BUFFER_ STATUS_CONTRL	TBUF_ST	[0..7]	SIO output buffer status RD: Space left in TX buffer WR: Ignored
		TBUF_CNT	[8..15]	SIO output buffer control RD: Number of bytes written to transmit FIFO WR: Number of bytes to transmit
		---	[16..31]	Reserved
010h .. 0FFh		---		Reserved
100h	SIO_DATA_REGISTER	CHAR_0	[0..7]	Character_0 RD: Read 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 36: 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 (host wanted to read more data 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 shutter**; meaning that all pixels 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.

CMOS sensors For CMOS sensors, a global shutter is not common. Normally a rolling curtain shutter is used to shorten the exposure or integration time. The curtain's width defines the integration time and the curtain sweeps with the frame readout time over the image. Although this is appropriate for still images, image distortion will be created with moving objects, because the upper image part is scanned earlier than the lower image part. For this reason the MARLIN F-131 features a non pipelined global shutter only. A side effect of this type of global shutter is that the integration or shutter time is added to the readout time, thus affecting the frame rates to be achieved.

Trigger modi

Marlin cameras support IIDC conforming Trigger_Mode_0 and Trigger_Mode_1 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 37: Trigger modi

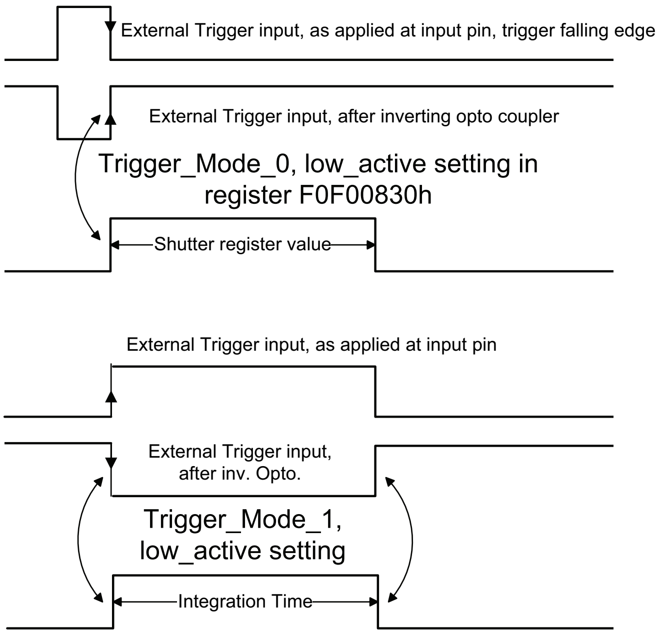


Figure 63: Trigger_mode_0 and 1

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 to the IIDC trigger modes. One external trigger event can be used to trigger a multitude of internal image intakes.

This is especially useful for:

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

The next image details this mode.

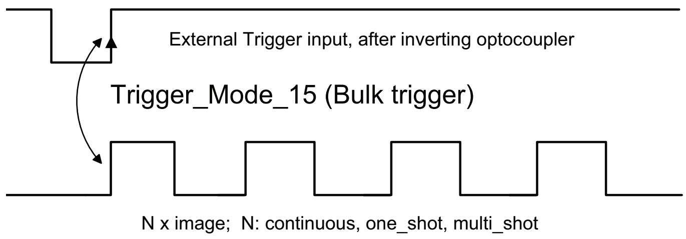


Figure 64: Trigger_Mode_15

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 38: Trigger_Mode_15 (Bulk trigger)

The screenshots below illustrate the use of Trigger_Mode_15 on a register level:

- Line #1switches continuous mode off, leaving viewer in listen mode.
- Line #2 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 39: Description: using Trigger_Mode_15: continuous, one-shot, multi-shot

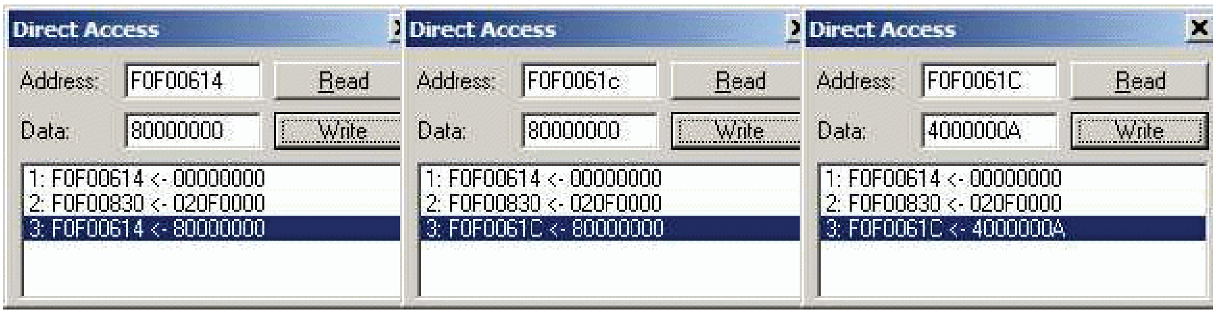


Figure 65: Using Trigger_Mode_15: Continuous, one-shot, multi-shot

Note

Shutter for the images is controlled by shutter register.

Trigger delay

As already mentioned earlier, since firmware version 2.03, Marlin 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 timebase 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 40: 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 41: CSR: **trigger delay**

Trigger delay advanced register

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

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 42: Advanced CSR: **trigger delay**

The advanced register allows to delay the start of the integration 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.

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 timebase + offset

- The exposure (shutter) time for Trigger_Mode_1 is based on the following formula:

  Length of active pulse + offset

Note

- Trigger_Mode_1: Do not make the pulse shorter than 20 µs, because this will not shorten the exposure time any further.
- Trigger_Mode_1: If you start exposure while the sensor is being read out, there will be an additional jitter for the exposure time (the jitter values are the same as in Table 48: Jitter at exposure start (no binning, no sub-sampling) on page 127).

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 103: Timebase ID on page 209). 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	Exposure time offset
Marlin F-033	12 µs
Marlin F-046	12 µs
Marlin F-080	30 µs
Marlin F-080-30fps	17 µs
Marlin F-145	26 µs
Marlin F-146	26 µs
Marlin F-201	39 µs
Marlin F-131	< 1 µs

Table 43: Camera-specific minimum exposure time

Minimum exposure time

Camera model	Minimum exposure time	Effective min. exp. time = Min. exp. time + offset
Marlin F-033	20 µs	20 µs + 12 µs = 32 µs
Marlin F-046	20 µs	20 µs + 12 µs = 32 µs
Marlin F-080	20 µs	20 µs + 30 µs = 50 µs
Marlin F-080-30fps	20 µs	20 µs + 17 µs = 37 µs
Marlin F-145	12 µs	12 µs + 26 µs = 38 µs
Marlin F-146	20 µs	20 µs + 26 µs = 46 µs
Marlin F-201	20 µs	20 µs + 39 µs = 59 µs
Marlin F-131	10 µs	10 µs + 0 µs = 10 µs

Table 44: Camera-specific minimum exposure time

Example Marlin F-033

Camera	Register value	Timebase
Marlin F-033	100	20 µs

Table 45: Register value and Timebase for **Marlin F-033**

register value x time base + offset = exposure time

100 x 20 µs + 12 µs = 2012 µs exposure time

The minimum adjustable exposure time set by register is 20 µs. → The real minimum exposure time of a Marlin F-033 is then:
20 µs + 12 µs = 32 µs

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 46: Advanced register: **extended shutter**

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

The lowest possible value of **ExpTime** is camera-specific (see Table 44: Camera-specific minimum exposure time on page 121).

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 may also increase some unwanted effects such as noise and pixel-to-pixel non-uniformity. Depending on the application, these effects may limit the longest 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

Marlin 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 125), 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.

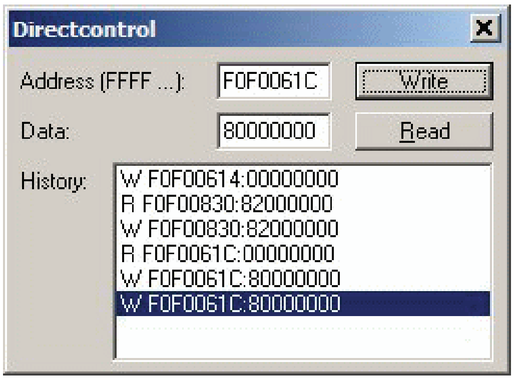


Figure 66: One_shot control

One-shot command on the bus to start of 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 47: 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 or CMOS 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).

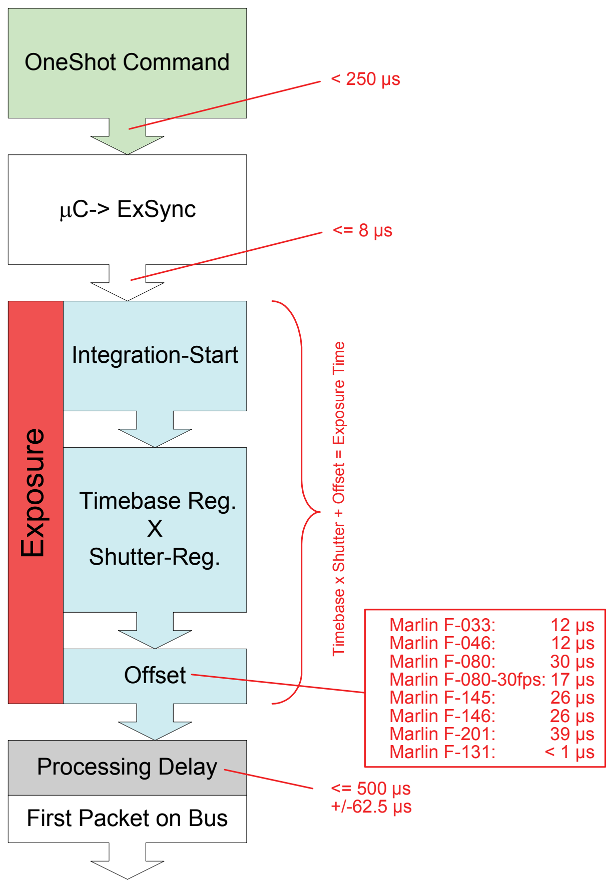


Figure 67: Data flow and timing after end of exposure

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 125), 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 126.

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

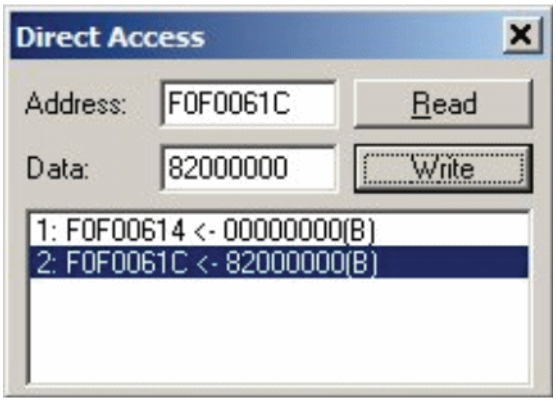


Figure 68: Broadcast one-shot

- 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 CCD models 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.

CMOS This is different to the way the **CMOS sensor of the Marlin F-131** works: the image sensitive area is also the storage area, which means that it cannot be used for the integration of the new frame until it has been read out.

Continuous image flow is thus only possible with the so-called rolling shutter.

Asynchronous image acquisition only makes sense with the global shutter; leading to a non-interleaving exposure - readout - exposure sequence. For every exposure cycle the sensor is completely reset so that the camera needs to be idle.

CCD For the CCDs the uncertainty 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 max. uncertainty which is equivalent to the line time. The line time depends on the sensor used and therefore can vary from model to model.

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

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

Model	Camera idle	Camera busy
Marlin F-033	33.33 ns	27.03 µs
Marlin F-046	33.33 ns	32.17 µs
Marlin F-080	50 ns	63.50 µs
Marlin F-131	25 ns	Not applicable
Marlin F-145	50 ns	92.25 µs
Marlin F-146	30 ns	54.78 µs
Marlin F-201	30 ns	64.5 µs

Table 48: Jitter at exposure start (no binning, no sub-sampling)

Note

- Jitter at the beginning of an exposure has no effect on the length of exposure, i.e. it is always constant.
- By default, the Marlin F-131, the CMOS sensor uses global shutter, so it cannot be re-triggered until the previous image has been read out.

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.

Deferred image transport

As all Marlin cameras are equipped with built in image memory, this order of events can be paused or delayed by using the **deferred image transport** feature.

Marlin cameras are equipped with 8 MB of RAM. The table below shows how many frames can be stored by each model. The memory operates according to the FIFO (first in, first out) principle. This makes addressing for individual images unnecessary.

Model	Memory Size
Marlin F-033	17 frames
Marlin F-046	13 frames
Marlin F-080	7 frames
Marlin F-131	4 frames
Marlin F-145	3 frames
Marlin F-146	3 frames
Marlin F-201	2 frames

Table 49: FIFO memory size

Deferred image transport is especially useful for multi-camera applications:

Assuming several cameras acquire images concurrently. These are stored in the built-in image memory of every camera. Until this memory is full, the limiting factor of available bus bandwidth, DMA- or ISO-channel is overcome.

Note

Configuration

To configure this feature in an advanced register: See Table 109: Advanced register: Deferred image transport on page 215.

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 max. buffer size in this case.

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

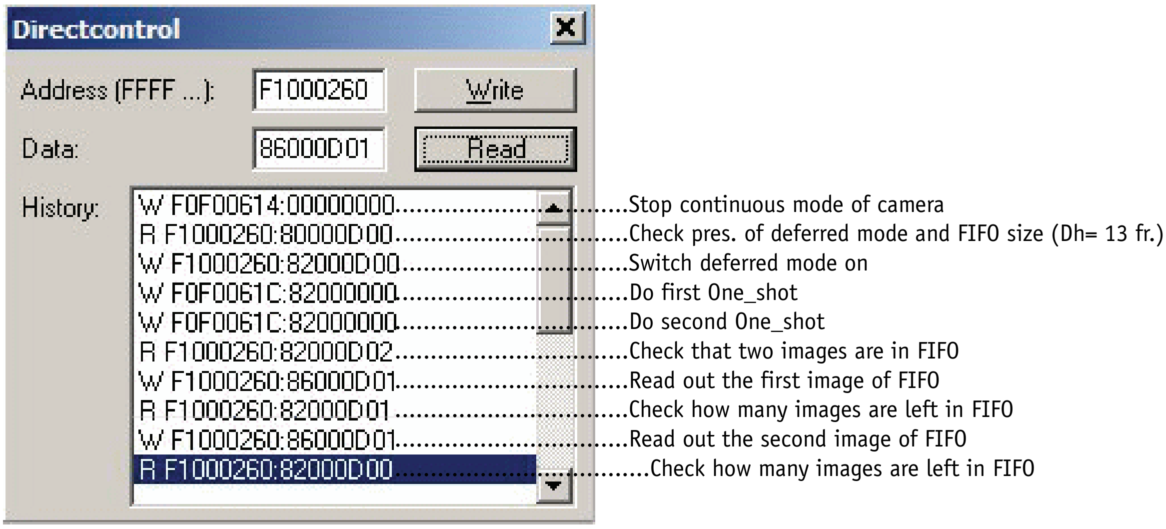


Figure 69: Example: Controlling deferred mode

FastCapture

Note This mode can be activated only in Format_7.

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

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

Sequence mode

Generally all AVT Marlin 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 while the camera is running. An uncertainty of one or two images remains because normally the host does not know (especially with external trigger) when the next image will arrive.

Sequence mode is a different concept where the camera holds a set of different image parameters for a sequence of images. The parameter set is stored volatile in the camera for each image to be recorded. This sequence of parameter sets is simply called a sequence. The advantage is that the camera can easily synchronize this parameter set with the images so that no uncertainty can occur. All CCD model AVT Marlin cameras support 32 different sequence parameters.

Examples For a sequence of images, each image can be recorded with a different shutter or gain to obtain different brightness effects.

The image area (AOI) of a sequence of images can automatically be modified, thus creating a panning or sequential split screen effect.

The following registers can be modified to affect the individual steps of the sequence.

Mode	this registers can be modified...
All modes	Cur_V_Mode, Cur_V_Format, ISO_Channel, ISO_Speed, Brightness, White_Balance (color cameras only), Shutter, Gain, look-up table, TestImage
Fixed modes only	Cur_V_Frm_Rate
Format_7 only	Image_Position, Image_Size, Color_Coding_ID, Byte_Per_Packet

Table 50: Registers to be modified within a sequence

Note

Sequence mode requires not only **FW 3.03** but also special care if changing image size, Color_Coding_ID and frame rate related parameters. This is because these changes not only affect settings in the camera but also require corresponding settings in the receiving software in the PC.

Caution

Incorrect handling may lead to **image corruption** or **loss of subsequent images**.

Please ask for detailed support if you want to use this feature.

How is sequence mode implemented?

There is a FIFO (first in first out) memory for each of the IIDC v. 1.3 registers listed above. The depth of each FIFO is fixed to 32(dez) complete sets. Functionality is controlled by the following advanced registers.

Register	Name	Field	Bit	Description
0xF1000220	SEQUENCE_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	Reserved
		AutoRewind	[5]	
		ON_OFF	[6]	Enable/disable this feature
		---	[7..15]	Reserved
		MaxLength	[16..23]	Max possible length of a sequence (read only)
		SeqLength	[24..31]	Length of the sequence (32 dez for all CCD models)

Table 51: Advanced register: **Sequence mode**

Register	Name	Field	Bit	Description
0xF1000224	SEQUENCE_PARAM	---	[0..4]	Reserved
		ApplyParameters	[5]	Apply settings to selected image of sequence; auto-reset
		IncImageNo	[6]	Increment ImageNo after ApplyParameters has finished
		---	[7..23]	Reserved
		ImageNo	[24..31]	Number of image within a sequence

Table 51: Advanced register: **Sequence mode**

The following flow diagram shows how to set up a sequence:

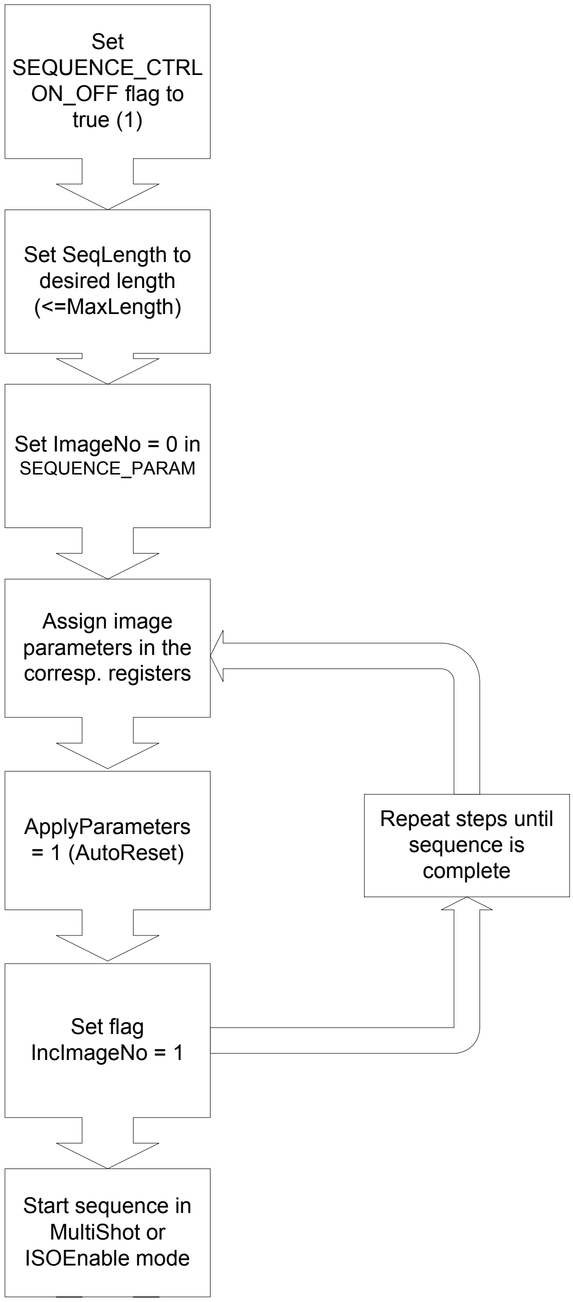


Figure 70: Sequence mode flow diagram

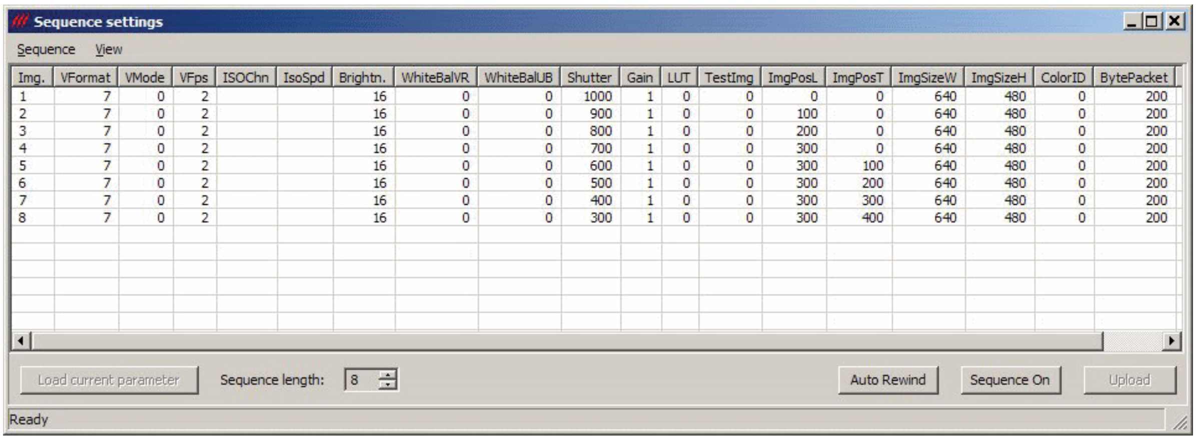
During sequencing, the camera obtains the required parameters, image by image, from the corresponding FIFOs (e.g. information for exposure time).

Points to pay attention to when working with a sequence

Note

- If more images are recorded than defined in **SeqLength**, the settings for the last image remain in effect.
- If **sequence** mode is cancelled, the camera can use the FIFO for other tasks. For this reason, a sequence must be loaded back into the camera after **sequence** mode has been cancelled.
- To repeat the sequence, stop the camera and send the **multi-shot** or **IsoEnable** command again. Each of these two commands resets the sequence.
- Using **single-shot** mode in combination with a sequence does not make sense, because **single-shot** mode restarts the sequence every time.
- The sequence may not be active when setting the AutoRewind flag. For this reason it is important to set the flag before the **multi-shot** or **IsoEnable** commands.
- If the sequence is used with the **deferred transport** feature, the number of images entered in **Seq_Length** may not be exceeded.

The following screenshot shows an example of a sequence for eight different image settings. It uses the **AVT Firetool program** as graphical representation. Please note the changes in the shutter time; that creates descending image brightness, and the change in the image position; which creates a panning effect.



Img.	VFormat	VMode	VFps	ISOChn	IsoSpd	Brightn.	WhiteBalVR	WhiteBalUB	Shutter	Gain	LUT	TestImg	ImgPosL	ImgPosT	ImgSizeW	ImgSizeH	ColorID	BytePacket
1	7	0	2			16	0	0	1000	1	0	0	0	0	640	480	0	200
2	7	0	2			16	0	0	900	1	0	0	100	0	640	480	0	200
3	7	0	2			16	0	0	800	1	0	0	200	0	640	480	0	200
4	7	0	2			16	0	0	700	1	0	0	300	0	640	480	0	200
5	7	0	2			16	0	0	600	1	0	0	300	100	640	480	0	200
6	7	0	2			16	0	0	500	1	0	0	300	200	640	480	0	200
7	7	0	2			16	0	0	400	1	0	0	300	300	640	480	0	200
8	7	0	2			16	0	0	300	1	0	0	300	400	640	480	0	200

Figure 71: Example of sequence mode settings with AVT Firetool

Changing the parameters within a sequence

To change the parameter set for one image, it is not necessary to modify the settings for the entire sequence. The image can simply be selected via the **ImageNo** field and it is then possible to change the corresponding IIDC V1.3 registers.

Points to pay attention to when changing the parameters

Note

- If the **ApplyParameters** flag is used when setting the parameters, all not-configured values are set to default values. As changing a sequence normally affects only the value of a specific register, and all other registers should not be changed, the **ApplyParameters** flag may not be used here.
- The values stored for individual images can no longer be read.
- If the camera is switched into **sequence mode**, the changes to the IIDC V1.3 registers for the image specified in **ImageNo** take immediate effect.
- Sequence mode requires firmware 3.03 and special care if changing image size and frame rate related parameters. This is because these changes not only affect settings in the camera but also require corresponding settings in the receiving software in the PC (e.g. FirePackage).

Caution

- Incorrect handling may lead to **image corruption** or **loss of subsequent images**.
- **Please ask for detailed support if you want to use this feature.**

Secure image signature (SIS)

SIS: Definition

Secure image signature (SIS) is the synonym for data, which is inserted into an image to improve or check image integrity.

With the new firmware V3.03, all CCD Marlin models can insert

- Time stamp (1394 bus cycle time at the beginning of integration)
- Trigger counter (external trigger seen only)
- Frame counter (frames read out of the sensor)

into a selectable line position within the image. Furthermore the trigger counter and the frame counter are available as advanced registers to be read out directly.

SIS: Scenarios

The following scenarios benefit from this feature:

- Assuming camera runs in **continuous mode**, the check of monotonically changing bus cycle time is a simple test that no image was skipped or lost in the camera or subsequently in the image processing chain.
- In (synchronized) **multi-camera applications**, the time stamp can be used to identify those images, shot at the same moment in time.
- The cross-check of the frame counter of the camera against the frame counter of the host system also identifies any **skipped or lost images** during transmission.
- The cross-check of the trigger counter against the frame counter in the camera can identify a **trigger overrun** in the camera.

Note

- **FirePackage** offers additional and independent checks to be performed for the purpose of image integrity. Details can be found in the respective documentation.

The handling of the SIS feature is fully described in the Chapter Secure image signature (SIS) on page 225.

Video formats, modes and bandwidth

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

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

Resolutions smaller than the generic sensor resolution are generated from the center of the sensor and without 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.

Note

H-binning means horizontal binning.

V-binning means vertical binning.

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

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

MARLIN F-033B/ MARLIN F-033C

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422						
	2	640 x 480	YUV411	x	x	x	x	x	
	3	640 x 480	YUV422		x	x	x	x	
	4	640 x 480	RGB8		x	x	x	x	
	5	640 x 480	Mono8	x x*	x x*	x x*	x x*	x x*	
	6	640 x 480	Mono16		x	x	x	x	

Table 52: Video fixed formats Marlin F-033B / F-033C

*: Color camera outputs RAW image, which needs to be converted outside of camera.

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes
7	0	656 x 494 656 x 492	Mono8 Mono16 YUV411 YUV422 RGB8 Mono8 (RAW8)	73.06 fps 50.16 fps 66.95 fps 50.47 fps 33.68 fps 73.73 fps
	1	328 x 494 656 x 494	Mono8 Mono16 Mono8 (RAW8)	73.06 fps H-binning 73.06 fps H-binning 73.06 fps Raw Bayer pattern
	2	656 x 246	Mono8 Mono16	128.00 fps V-binning 100.63 fps V-binning
	3	328 x 246	Mono8	128.00 fps H+V binning

Table 53: Video Format_7 default modes Marlin F-033B / F-033C

MARLIN F-046B/ MARLIN F-046C

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422		x	x	x	x	x
	2	640 x 480	YUV411		x	x	x	x	
	3	640 x 480	YUV422		x	x	x	x	
	4	640 x 480	RGB8		x	x	x	x	
	5	640 x 480	Mono8	x x*	x x*	x x*	x x*	x x*	
	6	640 x 480	Mono16		x	x	x	x	

Table 54: Video formats Marlin F-046B / F-046C

*: Color camera outputs RAW image, which needs to be converted outside of camera.

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes
7	0	780 x 582	Mono8 Mono16	52.81 fps 35.96 fps
		780 x 580	YUV411 YUV422 RGB8 Mono8 (RAW8)	48.05 fps 36.12 fps 24.06 fps 52.81 fps
	1	388 x 582	Mono8 Mono16	52.81 fps H-binning 52.81 fps H-binning
		780 x 582	Mono8 (RAW8)	52.81 fps Raw Bayer pattern
	2	780 x 290	Mono8 Mono16	92.49 fps V-binning 71.75 fps V-binning
	3	388 x 290	Mono8 Mono16	92.49 fps H+V binning 92.49 fps H+V binning

Table 55: Video Format_7 default modes Marlin F-046B / F-046C

MARLIN F-080B/ MARLIN F-080C (-30 fps)

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422						
	2	640 x 480	YUV411		x	x	x	x	
	3	640 x 480	YUV422		x	x	x	x	
	4	640 x 480	RGB8		x	x	x	x	
	5	640 x 480	Mono8		x x*	x x*	x x*	x x*	
	6	640 x 480	Mono16		x	x	x	x	
1	0	800 x 600	YUV422		x	x	x	x	
	1	800 x 600	RGB8			x	x	x	
	2	800 x 600	Mono8		x x*	x x*	x x*	x x*	
	3	1024 x 768	YUV422			x	x	x	
	4	1024 x 768	RGB8				x	x	
	5	1024 x 768	Mono8		x	x x*	x x*	x x*	
	6	800 x 600	Mono16		x	x	x	x	
	7	1024 x 768	Mono16			x	x	x	

Table 56: Video fixed formats Marlin F-080B / F-080C (-30 fps)

*: Color camera outputs RAW image, which needs to be converted outside of camera.

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes
7	0	1032 x 778 1032 x 776	Mono8 Mono16 YUV411 YUV422 RGB8 Mono8 (RAW8)	20.08 fps (30.13 fps**) 20.08 fps (20.33 fps**) 20.08 fps (27.16 fps**) 20.13 fps (20.38 fps**) 13.57 fps (13.57 fps**) 20.08 fps (30.13 fps**)
	1	516 x 778 1032 x 778	Mono8 Mono16 Mono8 (RAW8)	20.03 fps (30.13 fps**) H-binning 20.08 fps (30.13 fps**) H-binning 20.13 fps (30.13 fps**) Raw Bayer pattern
	2	1032 x 388	Mono8 Mono16	35.48 fps (53.16 fps**) V-binning 35.48 fps (40.17 fps**) V-binning
	3	516 x 388	Mono8 Mono16	35.48 fps (53.16 fps**) H+V binning 35.48 fps (53.16 fps**) H+V binning

Table 57: Video Format_7 default modes Marlin F-080B / F-080C (-30 fps)

30 fps column applying to this variant only. ** applying to 30 fps variant only

MARLIN F-145B2/ MARLIN F-145C2

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422						
	2	640 x 480	YUV411			x	x	x	
	3	640 x 480	YUV422			x	x	x	
	4	640 x 480	RGB8			x	x	x	
	5	640 x 480	Mono8			x x*	x x*	x x*	
	6	640 x 480	Mono16			x	x	x	
1	0	800 x 600	YUV422			x	x	x	
	1	800 x 600	RGB8			x	x		
	2	800 x 600	Mono8			x x*	x x*		
	3	1024 x 768	YUV422				x	x	
	4	1024 x 768	RGB8				x	x	
	5	1024 x 768	Mono8				x x*	x x*	
	6	800 x 600	Mono16			x	x		
	7	1024 x 768	Mono16				x	x	
2	0	1280 x 960	YUV422				x	x	x
	1	1280 x 960	RGB8				x	x	x
	2	1280 x 960	Mono8				x x*	x x*	x x*
	3	1600 x 1200	YUV422						
	4	1600 x 1200	RGB8						
	5	1600 x 1200	Mono8						
	6	1280 x 960	Mono16				x	x	x
	7	1600 x 1200	Mono16						

Table 58: Video fixed formats Marlin F-145B2 / F-145C2

*: Color camera outputs RAW image, which needs to be converted outside of camera.

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes	
7	0	1392 x 1040	Mono8 Mono16	10 fps 10 fps	
		1392 x 1038	YUV411 YUV422 RGB8 RAW8	10 fps 10 fps 7.5 fps 10 fps	
	1	696 x 1040	Mono8 Mono16	10 fps 10 fps	H-binning H-binning
		1392 x 1040	Mono8 (RAW)	10 fps	Raw Bayer pattern
	2	1392 x 520	Mono8 Mono16	17 fps 17 fps	V-binning V-binning
		696 x 518	YUV411 YUV422 RGB8 RAW8	10 fps 10 fps 10 fps 10 fps	H+V sub-sampling H+V sub-sampling H+V sub-sampling H+V sub-sampling
	3	696 x 520	Mono8	17 fps	H+V binning

Table 59: Video Format_7 default modes Marlin F-145B / F-145C

Owing to color interpolation, the maximum height is 1036 pixels in YUV modes and the first and last pixel columns contain no image information.

MARLIN F-146B / MARLIN F-146C

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422		x	x	x	x	
	2	640 x 480	YUV411		x	x	x	x	
	3	640 x 480	YUV422		x	x	x	x	
	4	640 x 480	RGB8		x	x	x	x	
	5	640 x 480	Mono8		x	x x*	x x*	x x*	
	6	640 x 480	Mono16		x	x	x	x	
1	0	800 x 600	YUV422			x	x	x	
	1	800 x 600	RGB8			x	x		
	2	800 x 600	Mono8			x x*	x x*		
	3	1024 x 768	YUV422			x	x	x	
	4	1024 x 768	RGB8				x	x	
	5	1024 x 768	Mono8			x x*	x x*	x x*	
	6	800 x 600	Mono16			x	x		
	7	1024 x 768	Mono16			x	x	x	
2	0	1280 x 960	YUV422				x	x	x
	1	1280 x 960	RGB8				x	x	x
	2	1280 x 960	Mono8			x x*	x x*	x x*	x x*
	3	1600 x 1200	YUV422						
	4	1600 x 1200	RGB8						
	5	1600 x 1200	Mono8						
	6	1280 x 960	Mono16				x	x	x
	7	1600 x 1200	Mono16						

Table 60: Video fixed formats Marlin F-146B / F-146C

*: Color camera outputs RAW image, which needs to be converted outside of camera.

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes
7	0	1392 x 1040	Mono8 Mono16	17.43 fps 11.32 fps
		1392 x 1038	YUV411 YUV422 RGB8 RAW8	15.1 fps 11.3 fps 7.55 fps 17.47 fps
	1	696 x 1040	Mono8 Mono16	17.43 fps H-binning 17.43 fps H-binning
		1392 x 1040	Mono8 (RAW)	17.43 fps
	2	1392 x 520	Mono16	22.6 fps V-binning
		696 x 518	YUV411 YUV422 RGB8 RAW8	17.51 fps H+V sub-sampling 17.47 fps H+V sub-sampling 17.51 fps H+V sub-sampling 17.47 fps H+V sub-sampling
	3	696 x 520	Mono8 Mono16	28.57 fps H+V binning 28.57 fps H+V binning

Table 61: Video Format_7 default modes Marlin F-146B / F-146C

Owing to color interpolation, the maximum height is 1038 pixels in YUV modes and the first and last one or two pixel columns contain incorrect color information.

In Format_7 maximum frame rates are given. Precise lowering is possible with lower packet size setting.

MARLIN F-201B / MARLIN F-201C

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422		x	x	x	x	
	2	640 x 480	YUV411			x	x	x	
	3	640 x 480	YUV422			x	x	x	
	4	640 x 480	RGB8			x	x	x	
	5	640 x 480	Mono8			x x*	x x*	x x*	
	6	640 x 480	Mono16			x	x	x	
1	0	800 x 600	YUV422			x	x	x	
	1	800 x 600	RGB8			x	x		
	2	800 x 600	Mono8			x x*	x x*		
	3	1024 x 768	YUV422			x	x	x	
	4	1024 x 768	RGB8				x	x	
	5	1024 x 768	Mono8			x x*	x x*	x x*	
	6	800 x 600	Mono16			x	x		
	7	1024 x 768	Mono16				x	x	
2	0	1280 x 960	YUV422				x	x	x
	1	1280 x 960	RGB8				x	x	x
	2	1280 x 960	Mono8			x x*	x x*	x x*	x x*
	3	1600 x 1200	YUV422				x x*	x x*	x x*
	4	1600 x 1200	RGB8						
	5	1600 x 1200	Mono8				x x*	x x*	x x*
	6	1280 x 960	Mono16				x	x	
	7	1600 x 1200	Mono16						

Table 62: Video fixed formats Marlin F-201B / F-201C

*: Color camera outputs RAW image, which needs to be converted outside of camera.

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes
7	0	1628 x 1236	Mono8 Mono16	12.48 fps 8.14 fps
		1628 x 1234	YUV411 YUV422 RGB8 RAW8	10.87 fps 8.15 fps 5.43 fps 12.52 fps
	1	812 x 1236	Mono8 Mono16	12.48 fps H-binning 12.48 fps H-binning
		1628 x 1236	Mono8 (RAW)	12.48 fps
	2	1628 x 618	Mono8 Mono16	22.35 fps V-binning 16.26 fps V-binning
		812 x 616	YUV411 YUV422 RGB8 RAW8	12.54 fps H+V sub-sampling 12.54 fps H+V sub-sampling 12.54 fps H+V sub-sampling 12.54 fps H+V sub-sampling
	3	812 x 618	Mono8 Mono16	12.47 fps H+V binning 12.47 fps H+V binning

Table 63: Video Format_7 default modes Marlin F-201B / F-201C

MARLIN F-131B (NIR)/ MARLIN F-131C

Format	Mode	Resolution	Color mode	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
0	0	160 x 120	YUV444						
	1	320 x 240	YUV422			x	x	x	
	2	640 x 480	YUV411			x	x	x	
	3	640 x 480	YUV422			x	x	x	
	4	640 x 480	RGB						
	5	640 x 480	Mono8		x**	x	x	x	
	6	640 x 480	Mono16						
1	0	800 x 600	YUV422			x	x	x	
	1	800 x 600	RGB						
	2	800 x 600	Mono8		x***	x	x	x	
	3	1024 x 768	YUV422			x	x	x	
	4	1024 x 768	RGB						
	5	1024 x 768	Mono8			x	x	x	
	6	800 x 600	Mono16						
	7	1024 x 768	Mono16						
2	0	1280 x 960	YUV422				x	x	x
	1	1280 x 960	RGB						
	2	1280 x 960	Mono8			x	x	x	x
	3	1600 x 1200	YUV422						
	4	1600 x 1200	RGB						
	5	1600 x 1200	Mono8						
	6	1280 x 960	Mono16						
	7	1600 x 1200	Mono16						

Table 64: Video fixed formats Marlin F-131B / F-131C (NIR)

Format	Mode	Resolution	Color mode	Maximal S400 frame rates for Format_7 modes
7	0	1280 x 1024 1280 x 1020	Mono8 YUV411 YUV422	25 fps* 17 fps* 12 fps*
	1	640 x 1024 640 x 1020	Mono8 YUV411 YUV422	48 fps* H-sub-sampling 33 fps* 25 fps*
	2	1280 x 512 1280 x 508	Mono8 YUV411 YUV422	50 fps* V-sub-sampling 33 fps* 25 fps*
	3	640 x 512 640 x 508	Mono8 YUV411 YUV422	94 fps* H+V sub-sampling 64 fps* 50 fps*
	4	1280 x 1024	Mono8	25 fps*

Table 65: Video Format_7 default modes Marlin F-131B / Marlin F-131C (NIR)

*: Color camera outputs RAW image, which needs to be converted outside of camera.

*: With minimum shutter; increasing shutter will decrease max. frame frequency proportionally due to global shutter principle.

**: With shutter ≤ 23 ms only

***: With shutter ≤ 18ms only.

Note

Generally full resolution mono frame rates are achievable only with shutter settings which fulfil the equation:

Shutter ≤ 1/fps- 40ms

Area of interest (AOI)

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

However, often only a certain section of the entire image is of interest. The amount of data to be transferred can be decreased by 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.

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

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

Note

For more information see Table 96: Format_7 control and status register on page 199.

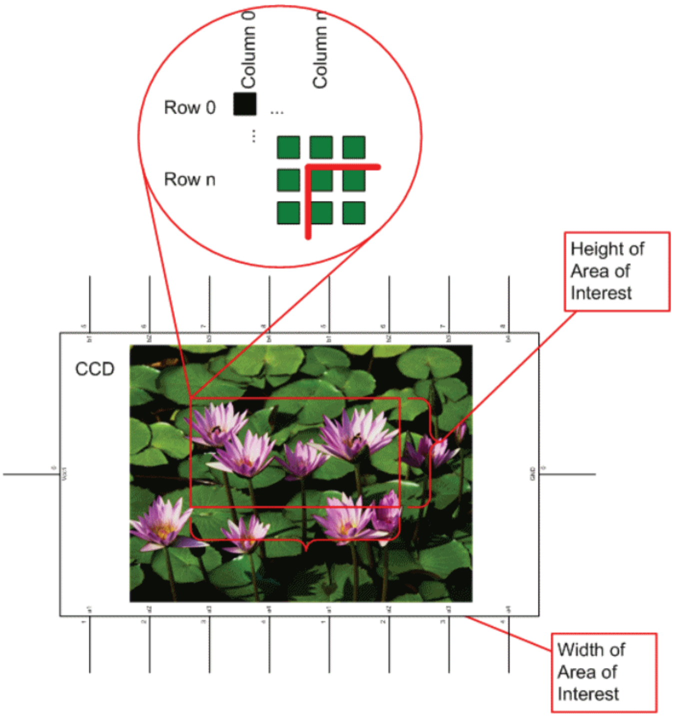


Figure 72: Area of Interest (AOI)

Note

- The left position + width and the upper position + height may not exceed the maximum resolution of the sensor.
- The coordinates for width and height must be divisible by 4.

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.

Autofunction AOI

Use this feature to select the image area (work area) on which the following autofunctions work:

- Auto shutter
- Auto gain
- Auto white balance

In the following screenshot you can see an example of the autofunction AOI:

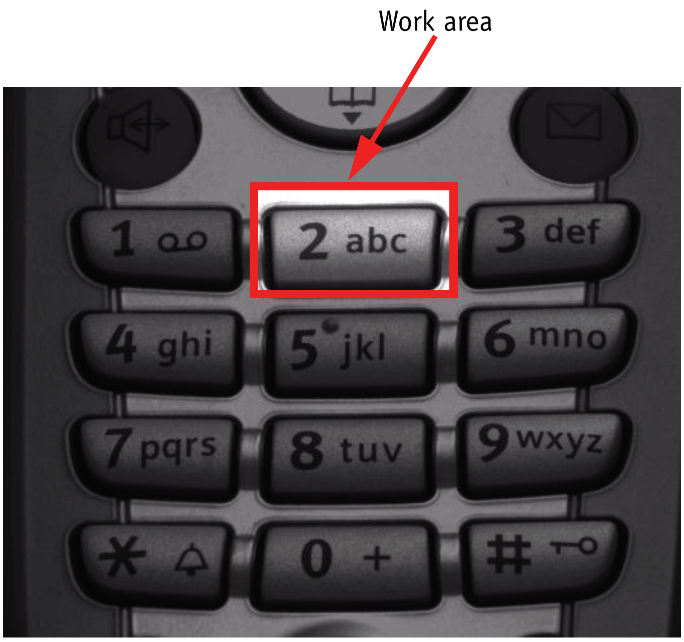


Figure 73: Example of autofunction AOI (*Show work area* is on)

Note

Autofunction AOI is independent from Format_7 AOI settings.

If you switch off autofunction AOI, work area position and work area size follow the current active image size.

To switch off autofunctions, carry out following actions in the order shown:

1. Uncheck **Show AOI** check box (SmartView **Ctrl2** tab).
2. Uncheck **Enable** check box (SmartView **Ctrl2** tab).
Switch off Auto modi (e.g. **Shutter** and/or **Gain**) (SmartView **Ctrl2** tab).

As a reference it uses a grid of at least 300 sample points equally spread over the AOI.

Note

To configure this feature in an advanced register see Table 117: Advanced register: Autofunction AOI on page 222.

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 66: 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 YUV444 24 bit/pixel		1/2H 80p 60q	1/4H 40p 30q	1/8H 20p 15q	
	1	320 x 240 YUV422 16 bit/pixel		1H 320p 160q	1/2H 160p 80q	1/4H 80p 40q	1/8H 40p 20q
	2	640 x 480 YUV411 12 bit/pixel		2H 1280p 480q	1H 640p 240q	1/2H 320p 120q	1/4H 160p 60q
	3	640 x 480 YUV422 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 67: 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, so that 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 is used.

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
1	0	800 x 600 YUV422 16 bit/pixel		5/2H 2000p 1000q	5/4H 1000p 500q	5/8H 500p 250q	6/16H 250p 125q	
	1	800 x 600 RGB 24 bit/pixel			5/4H 1000p 750q	5/8H 500p 375q		
	2	800 x 600 Y (Mono8) 8 bit/pixel	5H 4000p 1000q	5/2H 2000p 500q	5/4H 1000p 250q	5/8H 500p 125q		
	3	1024 x 768 YUV422 16 bit/pixel			3/2H 1536p 768q	3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q
	4	1024 x 768 RGB 24 bit/pixel				3/4H 768p 576q	3/8H 384p 288q	3/16H 192p 144q
	5	1024 x 768 Y (Mono8) 8 bit/pixel		3H 3072p 768q	3/2H 1536p 384q	3/4H 768p 192q	3/8H 384p 96q	3/16H 192p 48q
	6	800 x 600 (Mono16) 16 bit/pixel		5/2H 2000p 1000q	5/4H 1000p 500q	5/8H 500p 250q	5/16H 250p 125q	
	7	1024 x 768 Y (Mono16) 16 bit/pixel			3/2H 1536p 768q	3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q

Table 68: Format_1

Format	Mode	Resolution	60 fps	30 fps	15 fps	7.5 fps	3.75 fps	1.875 fps
2	0	1280 x 960 YUV422 16 bit/pixel			1H 1280p 640q	1/2H 640p 320q	1/4H 320p 160q	
	1	1280 x 960 RGB 24 bit/pixel				1H 1280p 960q	1/2H 640p 480q	1/4H 320p 240q
	2	1280 x 960 Y (Mono8) 8 bit/pixel			2H 2560p 640q	1H 1280p 320q	1/2H 640p 160q	1/4H 320p 80q
	3	1600 x 1200 YUV422 16 bit/pixel				5/4H 2000p 1000q	5/8H 1000p 500q	5/16H 500p 250q
	4	1600 x 1200 RGB 24 bit/pixel					5/8H 1000p 750q	5/16 500p 375q
	5	1600 x 1200 Y (Mono8) 8 bit/pixel			5/2H 4000p 1000q	5/4H 2000p 500q	5/8H 1000p 250q	5/16H 500p 125q
	6	1280 x 960 Y (Mono16) 16 bit/pixel				1H 1280p 640q	1/2H 640p 320q	1/4H 320p 160q
	7	1600 x 1200 Y (Mono16) 16 bit/pixel				5/4H 2000p 1000q	5/8H 1000p 500q	5/16H 500p 250q

Table 69: 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 a MF-145B2 @ 7.5 fps has to send 1280 pixels or 1 line of video per cycle. The camera thus 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 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.

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

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

Formula 3: 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)

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
- Table with max. frame rates as function of AOI by constant width

Note Different parameters apply for different models.

MARLIN F-033: AOI frame rates

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

$$\text{frame rate} = \frac{1}{30\mu s + 68.5\mu s + (494 - AO\_HEIGHT) \cdot 3.45\mu s + AOI\_HEIGHT \cdot 27.1\mu s}$$

Formula 4: Frame rate calculation MARLIN F-033 as function of AOI height

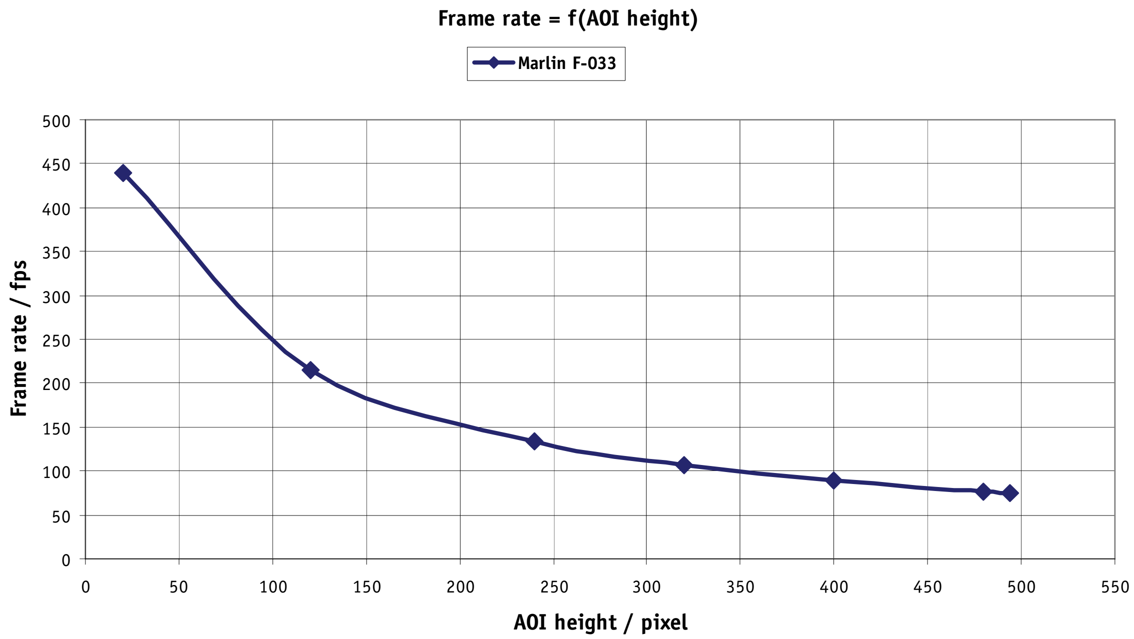


Figure 74: Frame rates MARLIN F-033 as function of AOI height

AOI height / pixel	Frame rate / fps	T_{frame} / ms
494	74.15	13.49
480	76.02	13.15
400	88.79	11.26
320	106.71	9.37
240	133.71	7.48
120	215.48	4.64
20	439.41	2.28

Table 70: Frame rates MARLIN F-033 as function of AOI height

MARLIN F-046: AOI frame rates

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

$$\text{frame rate} = \frac{1}{31\mu s + 88\mu s + (582 - AOI\_HEIGHT) \cdot 4.15\mu s + AOI\_HEIGHT \cdot 32.2\mu s}$$

Formula 5: Frame rate calculation MARLIN F-046 as function of AOI height

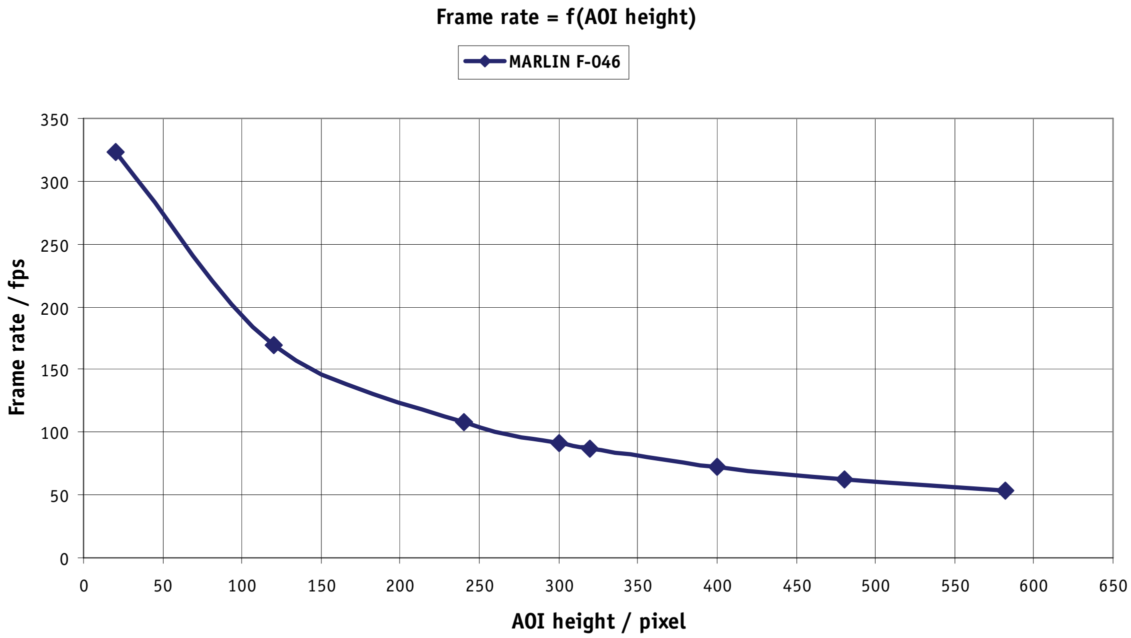


Figure 75: Frame rates MARLIN F-046 as function of AOI height

AOI height / pixel	Frame rate / fps	T_{frame} / ms
582	53.02	18.86
480	62.51	16.00
400	72.70	13.75
320	86.88	11.51
300	91.33	10.95
240	107.92	9.27
120	169.48	5.90
20	323.07	3.10

Table 71: Frame rates MARLIN F-046 as function of AOI height

MARLIN F-080: AOI frame rates

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

$$\text{frame rate} = \frac{1}{71.93\mu s + 129.48\mu s + (779 - AOI\_HEIGHT) \cdot 8.24\mu s + AOI\_HEIGHT \cdot 63.48\mu s}$$

Formula 6: Frame rate calculation MARLIN F-080 as function of AOI height

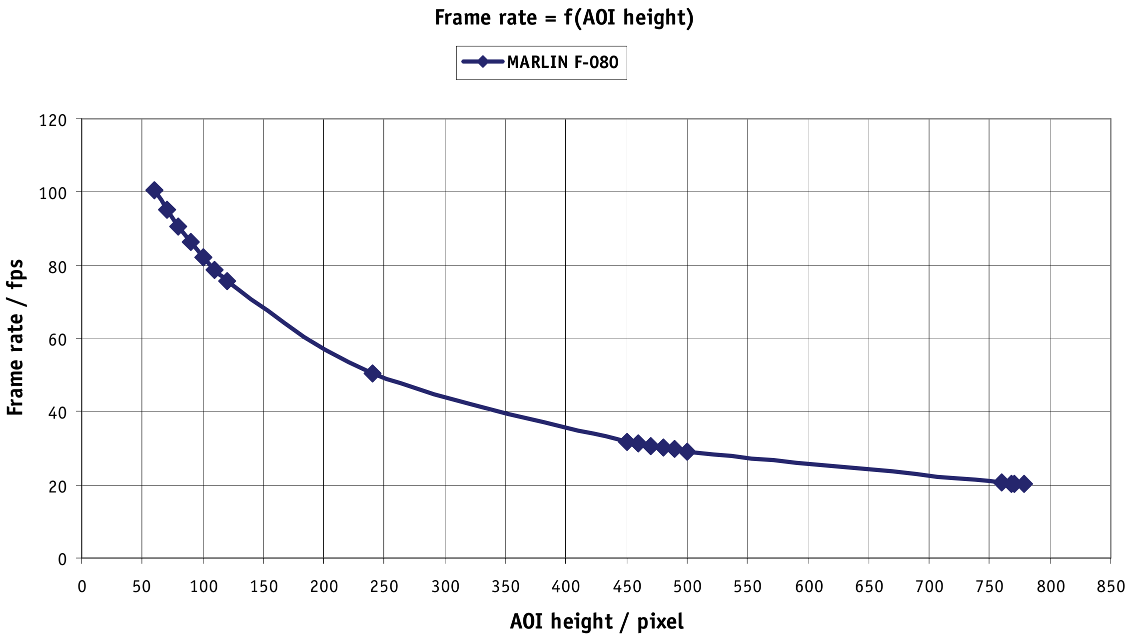


Figure 76: Frame rates MARLIN F-080 as function of AOI height

AOI height	Frame rate / fps	T_{frame} / ms
778	20.16	49.60
770	20.34	49.16
768	**20.39**	49.04
760	20.57	48.60
500	29.21	34.24
490	29.68	33.69
480	**30.18**	33.14

Table 72: Frame rates MARLIN F-080 as function of AOI height

AOI height	Frame rate / fps	T_{frame} / ms
470	30.69	32.58
460	31.22	32.03
450	31.77	31.48
240	**50.31**	19.88
120	75.48	13.25
110	78.76	12.70
100	82.34	12.14
90	86.27	11.59
80	90.58	11.04
70	95.35	10.49
60	100.66	9.93

Table 72: Frame rates MARLIN F-080 as function of AOI height

MARLIN F-080-30 fps: AOI frame rates

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

$$\text{frame rate} = \frac{1}{47.96\mu s + 86.32\mu s + (779 - AOI\_HEIGHT) \cdot 5.5\mu s + AOI\_HEIGHT \cdot 42.32\mu s}$$

Formula 7: Frame rate calculation MARLIN F-080-30 fps as function of AOI height

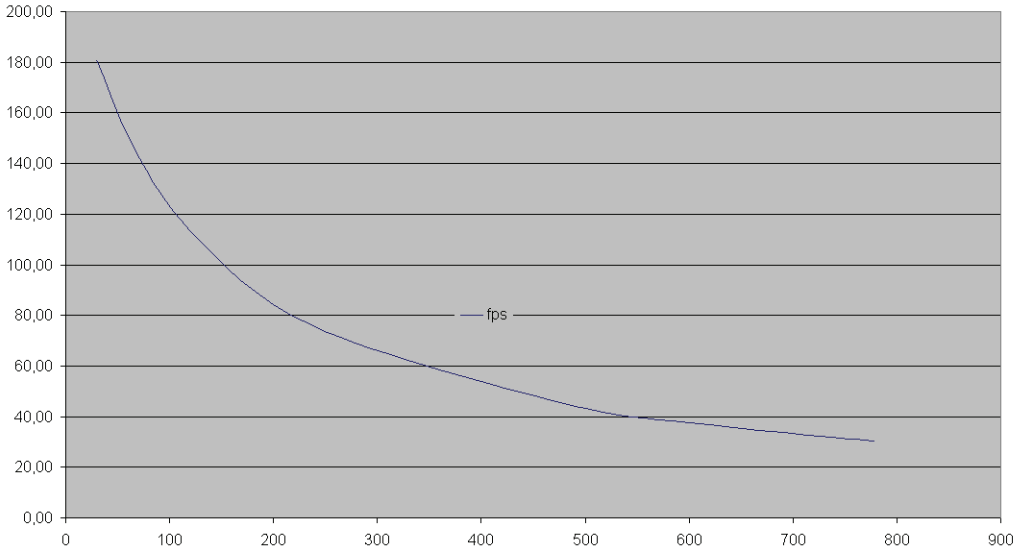


Figure 77: Frame rates of MARLIN F-080-30 fps as function of AOI height

AOI height	Frame rate / fps	T_{frame} / ms
778	30.24	33.06
768	30.58	32.70
600	37.72	26.51
480	45.26	22.09
240	75.44	13.26
120	113.16	8.84
60	150.88	6.63
30	181.05	5.52

Table 73: Frame rates of MARLIN F-080-30 fps as function of AOI height

MARLIN F-145: AOI frame rates

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

$$\text{frame rate} = \frac{1}{105\mu s + 288\mu s + (1040 - AOI\_HEIGHT) \cdot 19.6\mu s + AOI\_HEIGHT \cdot 92.3\mu s}$$

Formula 8: Frame rate calculation MARLIN F-145 as function of AOI height

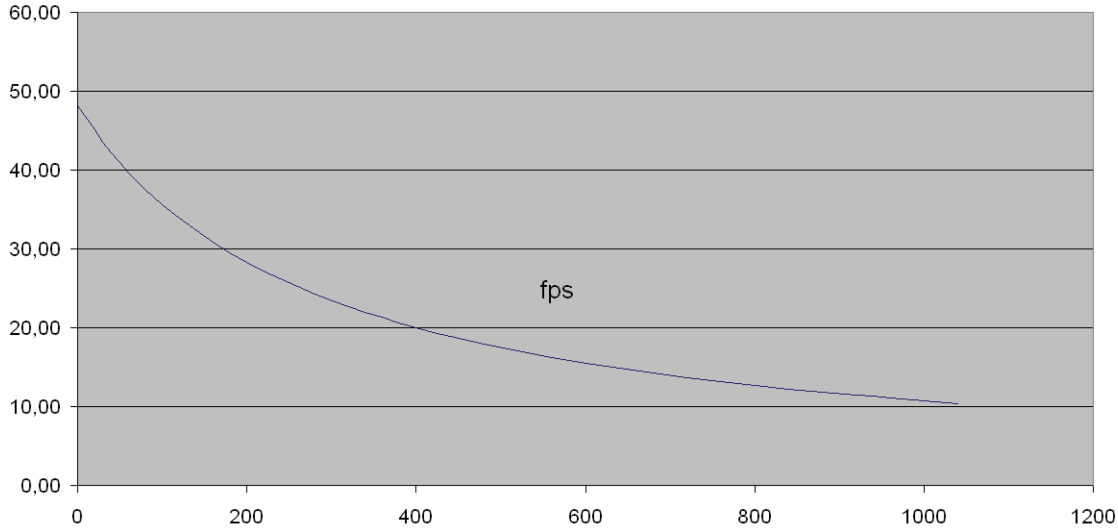


Figure 78: Frame rates MARLIN F-145 as function of AOI height

AOI height	Frame rate / fps	T_{frame} / ms
1040	10.38	96.39
960	11.04	90.57
600	15.53	64.40
480	17.96	55.67
240	26.16	38.23
120	33.90	29.50
60	39.78	25.14

Table 74: Frame rates MARLIN F-145 as function of AOI height

MARLIN F-146: AOI frame rates

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

$$\text{frame rate} = \frac{1}{254\mu s + (1040 - \text{AOI\_HEIGHT}) \cdot 11.80\mu s + \text{AOI\_HEIGHT} \cdot 54.78\mu s}$$

Formula 9: Frame rate calculation MARLIN F-146 as function of AOI height

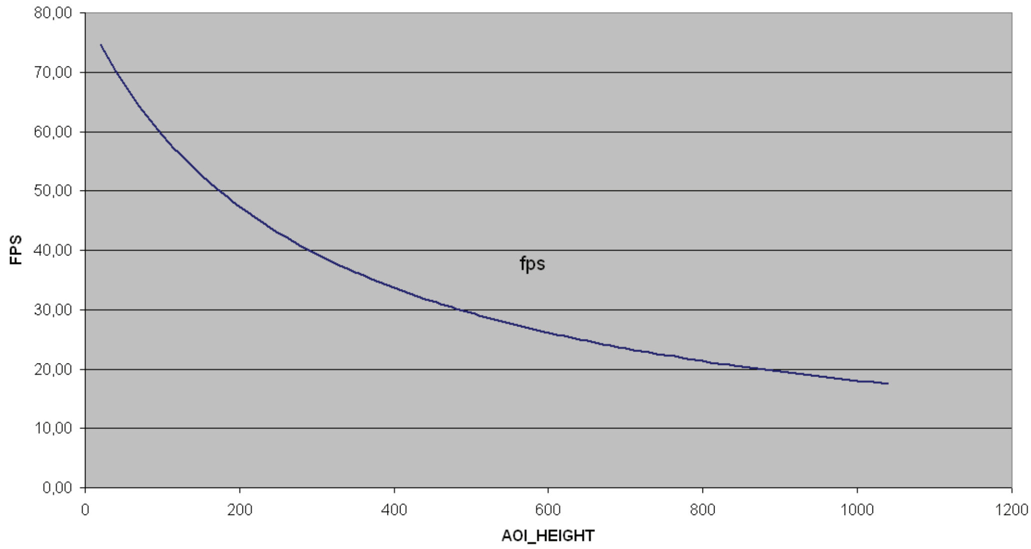


Figure 79: Frame rates MARLIN F-146 as function of AOI height

AOI height	Frame rate / fps	T_{frame} / ms
1040	**17.47**	**57.23**
1024	**17.69**	**56.54**
960	18.59	53.79
768	**21.96**	**45.53**
600	26.10	38.31
480	**30.16**	**33.16**
240	**43.78**	**22.84**
120	56.55	17.68
60	66.20	15.10

Table 75: Frame rates MARLIN F-146 as function of AOI height

MARLIN F-201: AOI frame rates

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

$$\text{frame rate} = \frac{1}{217\mu s + (1236 - AOI\_HEIGHT) \cdot 7.4\mu s + AOI\_HEIGHT \cdot 64.5\mu s}$$

Formula 10: Frame rate calculation MARLIN F-201 as function of AOI height

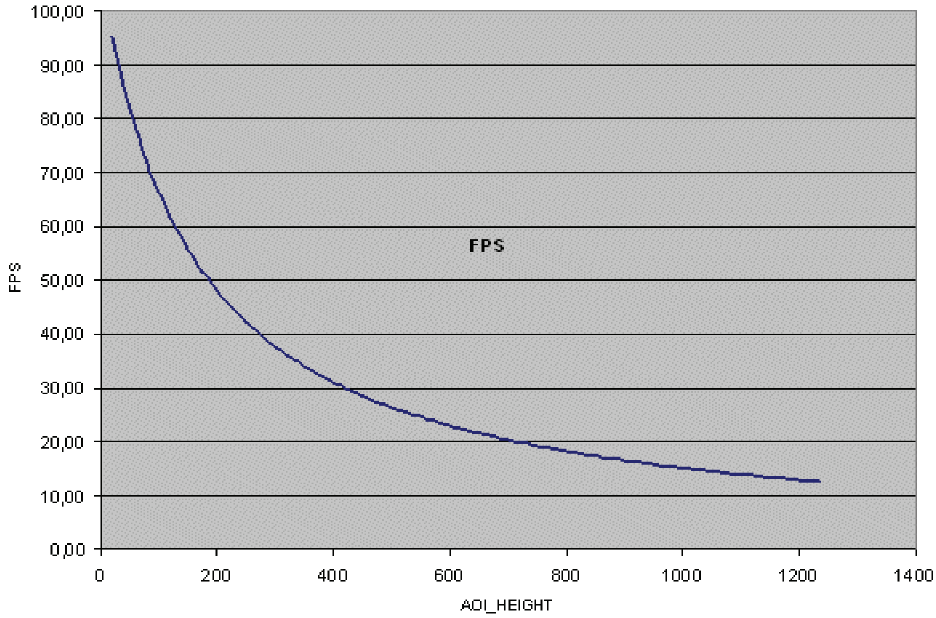


Figure 80: Frame rates MARLIN F-201 as function of AOI height

AOI height	Frame rate / fps	T_{frame} / ms
1236	**12.51**	**79.94**
1200	**12.84**	**77.89**
1100	**13.86**	**72.17**
1040	**14.55**	**68.75**
1024	**14.74**	**67.83**
960	15.58	64.18
768	**18.79**	**53.22**
600	22.92	43.62
480	**27.20**	**36.77**
240	**43.35**	**23.07**
120	61.67	16.22
60	78.19	12.79

Table 76: Frame rates MARLIN F-201 as function of AOI height

MARLIN F-131: AOI frame rates

This model uses a CMOS sensor with global shutter. As mentioned earlier for the non pipelined global shutter, the integration time must be added to the readout time to define the maximum frame rate. The next table gives an example: (it assumes full horizontal width and an integration time of 1 ms).

Read note in Chapter Video formats, modes and bandwidth on page 137.

Limiting the field of view in both vertical as well as horizontal direction gives a proportional increase in speed. This is in contrary to CCD sensors where the horizontal image limit does not increase the frame rate.

AOI height / pixel	Frame rate / fps
1.024	24.42
960	26.01
600	40.97
480	50.69
240	96.46
120	175.84
60	298.78
Format_7, global shutter	
1 ms integration time	

Table 77: Frame rates MARLIN F-131 as function of AOI height (full horizontal width)

In order to calculate the maximum achievable frame rate (with certain exposure time) the following equation can be used:

$$\text{frame rate} = \frac{1}{((200\mu s + \text{Height} \times (\text{Width} \times 25ns) + 4\mu s) + \text{ExpTime})}$$

Formula 11: Frame rate calculation MARLIN F-131 as function of AOI height and width

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.

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

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):

$$\text{framerate} \approx \frac{\text{BYTE\_PER\_PACKET}}{\text{AOI\_WIDTH} \times \text{AOI\_HEIGHT} \times \text{ByteDepth} \times 125\mu s}$$

Formula 13: Maximum frame rate calculation

ByteDepth based on the following values:

Mode	bits/pixel	byte per pixel
Mono8	8	1
Mono16	16	2
YUV422	16	2
YUV411	12	1.5

Table 78: ByteDepth

Example formula for the b/w camera

Mono16, 1392 x 1040, 15 fps desired

$$\text{BYTE\_PER\_PACKET} = 15 \times 1392 \times 1040 \times 2 \times 125\mu s = 5428 > 4096$$

$$\Rightarrow \text{frame rate}_{\text{reachable}} \approx \frac{4096}{1392 \times 1040 \times 2 \times 125\mu s} = 11.32$$

Formula 14: Example max. 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 79: Loading test images in different viewers

Test images b/w cameras

Marlin b/w cameras have two test images that look the same. Both images show a gray bar running diagonally (mirrored at the middle axis).

- **Image 1** is static.
- **Image 2** moves upwards by 1 pixel/frame.

Figure 81: Gray bar test image

$$\text{Gray value} = (x + y)\text{MOD256} \qquad \text{(8-bit mode)}$$

Formula 15: Calculating the gray value

Test images for color cameras

The color cameras have the following test images:

YUV422 mode

Figure 82: Color test image

Mono8 (raw data)

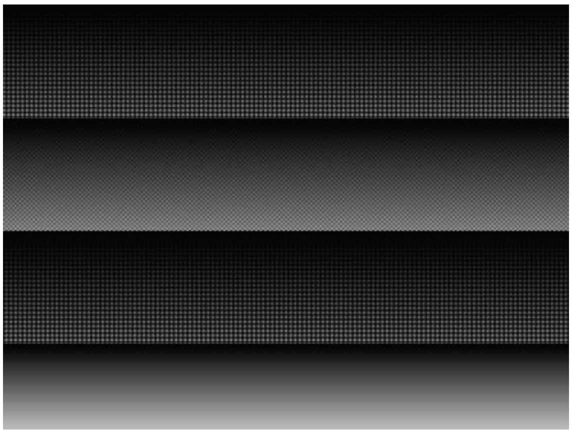


Figure 83: Bayer-coded test image

The color camera outputs Bayer-coded raw data in Mono8 instead of (as described in IIDC V1.3) a real Y signal.

Note

The first pixel of the image is always the red pixel from the sensor. (Mirror must be switched off.)

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 bits long.

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

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

If 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 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 80: 32-bit register

Example

This requires, for example, that to enable **ISO_Enabled mode** (see Chapter ISO_Enable / Free-Run on page 125), (bit 0 in register 614h), the value 80000000 h must be written in the corresponding register.

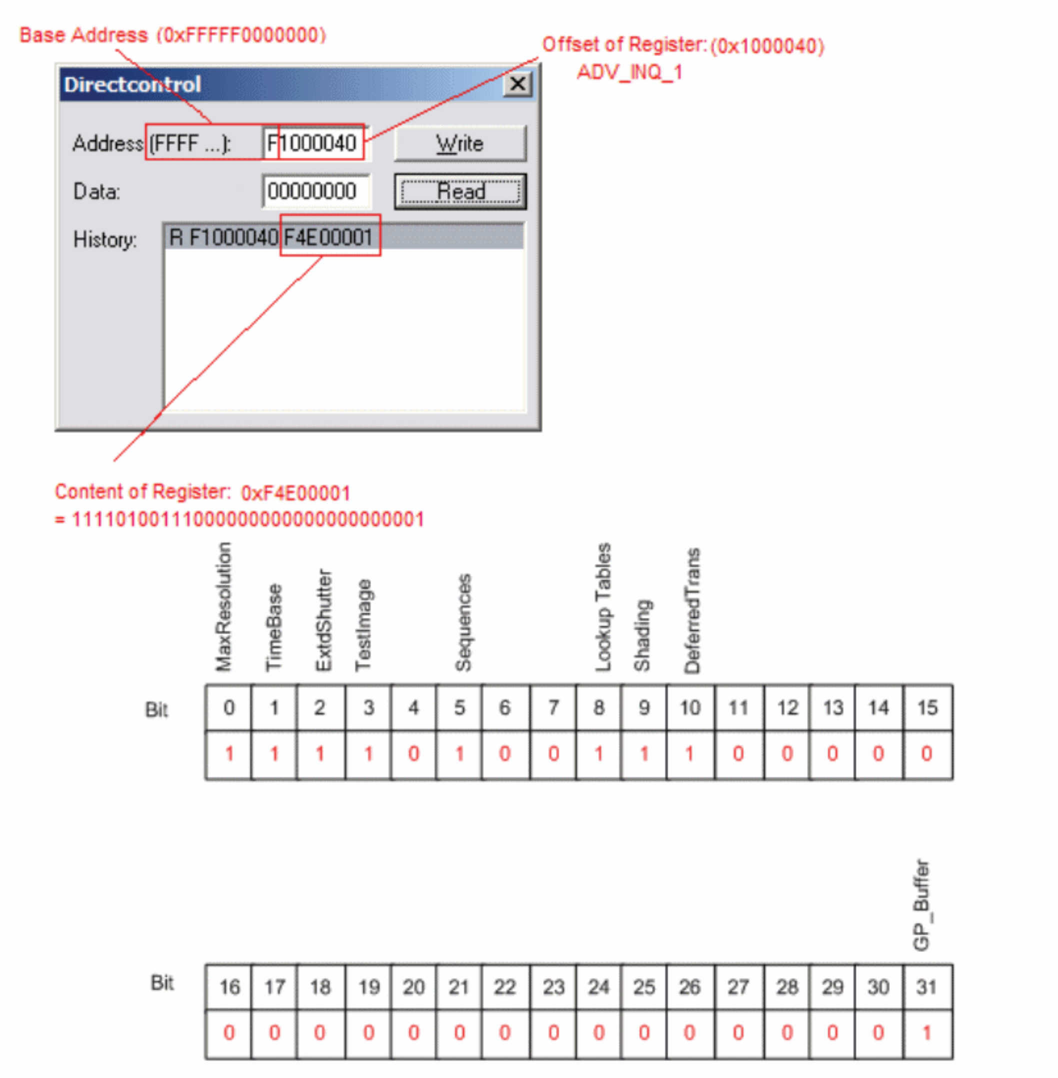


Figure 84: Configuration of the camera

Sample program

The following sample code in C shows how the register is set for frame rate, video mode/format and trigger mode using the **FireCtrl DLL** from the **FirePackage API**. Also shown is how the camera is switched into ISO_Enabled mode:

```
…
WriteQuad(m_cmdRegBase + CCR_FRAME-RATE, Frame-Rate << 29);
WriteQuad(m_cmdRegBase + CCR_VMODE, mode << 29);
WriteQuad(m_cmdRegBase + CCR_VFORMAT, format << 29);
WriteQuad(m_cmdRegBase + CCR_TRGMODE, extTrigger ? 0x82000000 : 0);
Sleep(100);
WriteQuad(m_cmdRegBase + CCR_ISOENABLE, 0x80000000);
…
```

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 ConfigRom is divided into

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

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

	Offset	0-7	8-15	16-23	24-31	
Bus info block	400h	04	24	45	EE	
	404h	31	33	39	34	.... ASCII for 1394
	408h	20	00	A0	00	.... Bus capabilities
	40Ch	00	0A	47	01	.... Node_Vendor_Id, Chip_id_hi
	410h	00	00	Serial number		.... Chip_id_lo
Root directory	414h	00	04	B7	85	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 81: 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 82: Computing effective start address

420h + 000002 x 4 = 428h

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

Table 83: Config ROM

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

424h + 000004 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 84: Config ROM

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

440h + 000001 * 4 = 444h

	Offset	0-7	8-15	16-23	24-31
→	444h	00	03	7F	89
Unit dependent info	448h	40	3C	00	00
	44Ch	81	00	00	02
	450h	82	00	00	06

Table 85: Config 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.

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

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	Description
000h	INITIALIZE	Assert MSB = 1 for Init.

Table 86: **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 87: **Format** inquiry register

Inquiry register for video mode

Offset	Name	Field	Bit	Description
180h	V_MODE_INQ (Format_0)	Mode_0	[0]	160 x 120 YUV444
		Mode _1	[1]	320 x 240 YUV422
		Mode _2	[2]	640 x 480 YUV411
		Mode _3	[3]	640 x 480 YUV422
		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 YUV422
		Mode _1	[1]	800 x 600 RGB
		Mode _2	[2]	800 x 600 Mono8
		Mode _3	[3]	1024 x 768 YUV422
		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 YUV422
		Mode _1	[1]	1280 x 960 RGB
		Mode _2	[2]	1280 x 960 Mono8
		Mode _3	[3]	1600 x 1200 YUV422
		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 88: **Video mode** inquiry register

Offset	Name	Field	Bit	Description
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 88: **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 89: **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 89: **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 89: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
224h	V_RATE_INQ	FrameRate_0	[0]	Reserved
	(Format_1, Mode_1)	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	FrameRate_0	[0]	Reserved
	(Format_1, Mode_2)	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 89: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
230h	V_RATE_INQ	FrameRate_0	[0]	1.875 fps
	(Format_1, Mode_4)	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	FrameRate_0	[0]	1.875 fps
	(Format_1, Mode_5)	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	FrameRate_0	[0]	1.875 fps
	(Format_1, Mode_6)	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 89: **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 89: **Frame rate** inquiry register

Offset	Name	Field	Bit	Description
248h	V_RATE_INQ	FrameRate_0	[0]	1.875 fps
	(Format_2, Mode_2)	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	FrameRate_0	[0]	1.875 fps
	(Format_2, Mode_3)	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	FrameRate_0	[0]	1.875 fps
	(Format_2, Mode_4)	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 89: **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, Mode0)			Always 0
2C4h .. 2DFh	Reserved V_REV_INQ_6_x (for other Mode_x of Format_6)			Always 0

Table 89: **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 89: **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 90: **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 91: **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 CSR's from the base address of initial register space (Vendor unique) This register is the offset for the Access_Control_Register and thus the base address for Advanced Features. Access_Control_Register does not prevent access to advanced features. In some programs it should still always be activated first. **Advanced Feature Set Unique Value** is 7ACh and **CompanyID** is A47h.
484h	PIO_Control_CSR_Inq	PIO_Control_Quadlet_Offset	[0..31]	Quadlet offset of the PIO_Control CSR's from the base address of initial register space (Vendor unique)
488h	SIO_Control_CSR_Inq	SIO_Control_Quadlet_Offset	[0..31]	Quadlet offset of the SIO_Control CSR's from the base address of initial register space (Vendor unique)
48Ch	Strobe_Output_CSR_Inq	Strobe_Output_Quadlet_Offset	[0..31]	Quadlet offset of the Strobe_Output signal CSR's from the base address of initial register space (Vendor unique)

Table 91: **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]	Min. value for this feature
		Max_Value	[20..31]	Max. value for this feature
504h	AUTO_EXPOSURE_INQ	Same definition as Brightness_inq.		
508h	SHARPNESS_INQ	Same definition as Brightness_inq.		
50Ch	WHITE_BAL_INQ	Same definition as Brightness_inq.		
510h	HUE_INQ	Same definition as Brightness_inq.		
514h	SATURATION_INQ	Same definition as Brightness_inq.		
518h	GAMMA_INQ	Same definition as Brightness_inq.		
51Ch	SHUTTER_INQ	Same definition as Brightness_inq.		
520h	GAIN_INQ	Same definition as Brightness_inq.		
524h	IRIS_INQ	always 0		
528h	FOCUS_INQ	always 0		
52Ch	TEMPERATURE_INQ	Same definition as Brightness_inq.		

Table 92: **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 rigger input
		---	[7..15]	Reserved
		Trigger_Mode0_Inq	[16]	Presence of Trigger_Mode 0
		Trigger_Mode1_Inq	[17]	Presence of Trigger_Mode 1
		Trigger_Mode2_Inq	[18]	Presence of Trigger_Mode 2
		Trigger_Mode3_Inq	[19]	Presence of Trigger_Mode 3
		---	[20..31	Reserved
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 92: **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	Bits [0..2] for the frame rate		
604h	CUR-V-MODE	Bits [0..2] for the current video mode		
608h	CUR-V-FORMAT	Bits [0..2] for the current video format		
60Ch	ISO-Channel	Bits [0..3] for channel, [6..7] for ISO-speed		
610h	Camera_Power	Always 0		
614h	ISO_EN/Continuous_Shot	Bit 0: 1 for continuous shot; 0 for stop		
618h	Memory_Save	Always 0		
61Ch	One_Shot, Multi_Shot, Count Number	See Chapter One-shot on page 123 See Chapter Multi-Shot on page 125		
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 92: **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 93: **Absolute value** inquiry register

Status and control register for feature

The **OnePush** feature, WHITE_BALANCE, is currently implemented. If this flag is set, the feature becomes immediately active, even if no images are being input (see Chapter One-push automatic white balance on page 72).

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 94: **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 94: **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 94: **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 Timebase
820h	GAIN			See above
824h	IRIS			Always 0
828h	FOCUS			Always 0
82Ch	TEMPERATURE			Always 0
830h	TRIGGER-MODE			Can be effected via Advanced Feature IO_INP_CTRLx.
834h .. 87C	Reserved for other FEATURE_HI			Always 0
880h	Zoom			Always 0
884h	PAN			Always 0
888h	TILT			Always 0
88Ch	OPTICAL_FILTER			Always 0
890 .. 8BCh	Reserved for other FEATURE_LO			Always 0
8C0h	CAPTURE-SIZE			Always 0
8C4h	CAPTURE-QUALITY			Always 0
8C8h .. 8FCh	Reserved for other FEATURE_LO			Always 0

Table 94: **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 95: Feature control error register

Video mode control and status registers for Format_7

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 89: Frame rate inquiry register on page 179) gives 003C2000h.

4 x 3C2000h = F08000h so that the base address for the latter (Table 96: Format_7 control and status register on page 199) 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 89: Frame rate inquiry register on page 179) gives 003C2400h.

4 x 003C2400h = F09000h so that the base address for the latter (Table 96: Format_7 control and status register on page 199) 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
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

Table 96: Format_7 control and status register

Offset	Name	Notes
040h	PACKET_PARA_INQ	See note
044h	BYTE_PER_PACKET	According to IIDC V1.3

Table 96: 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 65
- 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	Table 98: Advanced register: Version information on page 204
0XF1000040	ADV_INQ_1	See Table 100: Advanced register: Advanced feature inquiry on page 206
0XF1000044	ADV_INQ_2	
0XF1000200	MAX_RESOLUTION	See Table 101: Advanced register: Maximum resolution inquiry on page 207
0XF1000208	TIMEBASE	See Table 102: Advanced register: Time base on page 208
0XF100020C	EXTD_SHUTTER	See Table 104: Advanced register: Extended shutter on page 210
0XF1000210	TEST_IMAGE	See Table 105: Advanced register: Test image on page 211
0XF1000220	SEQUENCE_CTRL	except MARLIN F-131x
0XF1000224	SEQUENCE_PARAM	See Table 51: Advanced register: Sequence mode on page 131
0XF1000240	LUT_CTRL	See Table 107: Advanced register: LUT on page 213
0XF1000244	LUT_MEM_CTRL	
0XF1000248	LUT_INFO	
0XF1000250	SHDG_CTRL	See Table 108: Advanced register: Shading on page 214
0XF1000254	SHDG_MEM_CTRL	
0XF1000258	SHDG_INFO	

Table 97: **Advanced registers** summary

Register	Register name	Description
0XF1000260	DEFERRED_TRANS	See Table 109: Advanced register: Deferred image transport on page 215
0XF1000270	FRAMEINFO	See Table 110: Frame information register on page 216
0XF1000274	FRAMECOUNTER	See FRMCNT_STAMP
0XF1000280	HDR_CONTROL	MARLIN F-131x only See Table 111: High dynamic range configuration register on page 217
0XF1000284	KNEEPOINT_1	
0XF1000288	KNEEPOINT_2	
0XF100028C	KNEEPOINT_3	
0XF1000290	DSNU_CONTROL	MARLIN F-131B only; Firmware 2.02 See Table 112: Advanced register: DSNU on page 218
0XF1000294	BLEMISH_CONTROL	MARLIN F-131x only; Firmware 2.02 See Table 113: Advanced register: Blemish on page 219
0XF1000300	IO_INP_CTRL1	See Table 18: Advanced register: Input control on page 53
0XF1000304	IO_INP_CTRL2	
0XF1000308	IO_INP_CTRL3	Dolphin series only
0XF1000320	IO_OUTP_CTRL1	See Table 24: Advanced register: Output control on page 58
0XF1000324	IO_OUTP_CTRL2	
0XF1000328	IO_OUTP_CTRL3	Dolphin series only
0XF1000340	IO_INTENA_DELAY	See Table 114: Advanced register: Delayed Integration Enable (IntEna) on page 220
0XF1000360	AUTOSHUTTER_CTRL	MARLIN/OSCAR series only See Table 115: Advanced register: Auto shutter control on page 221
0XF1000364	AUTOSHUTTER_LO	
0XF1000368	AUTOSHUTTER_HI	
0XF1000370	AUTOGAIN_CTRL	MARLIN/OSCAR series only See Table 116: Advanced register: Auto gain control on page 221
0XF1000390	AUTOFNC_AOI	MARLIN/OSCAR series only See Table 117: Advanced register: Autofunction AOI on page 222
0XF10003A0	COLOR_CORR	MARLIN/OSCAR CCD type color cameras only See Table 119: Advanced register: Color correction on page 223

Table 97: **Advanced registers** summary

Register	Register name	Description
0XF1000400	TRIGGER_DELAY	See Table 120: Advanced register: Trigger Delay on page 223
0XF1000410	MIRROR_IMAGE	MARLIN/OSCAR series only See Table 121: Advanced register: Mirror on page 224
0XF1000510	SOFT_RESET	See Table 122: Advanced register: Soft reset on page 224
0XF1000550	USER_PROFILE	See Table 128: Advanced register: User profiles on page 231
0XF1000600	TIMESTAMP	aka secure image signature (SIS) See Table 123: Advanced register: Time stamp on page 226
0XF1000610	FRMCNT_STAMP	See Table 126: Advanced register: Frame counter on page 228
0XF1000620	TRGCNT_STAMP	See Table 127: Advanced register: Trigger counter on page 229
0XF1000FFC	GPDATA_INFO	See Table 131: Advanced register: GPData buffer on page 235
0XF1001000	GPDATA_BUFFER	

Table 97: **Advanced registers** summary

Note

Advanced features should always be activated 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 inquiry

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

Register	Name	Field	Bit	Description
F1000010	VERSION_INFO1	µC type ID	[0..15]	Reserved
		µC version	[16..31]	Bcd-coded vers.#
F1000014			[0..31]	Reserved
F1000018	VERSION_INFO3	Camera type ID	[0..15]	See Table 99: Camera type ID list on page 204
		FPGA version	[16..31]	Bcd-coded vers.#
F100001C			[0..31]	Reserved

Table 98: 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	Camera type
1	F145b
2	F145c
3	F201b
4	F201c
5	F145b-1
6	F145c-1
7	F201b-1
8	F201c-1
9	MF033B
10	MF033C
11	MF046B
12	MF046C
13	MF080B
14	MF080C
15	MF145B2

Table 99: Camera type ID list

ID	Camera type
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
47	M2F201B
48	M2F201C
49	M2F146B
50	M2F146C

Table 99: Camera type ID list

Note

- MARLINs with serial numbers beginning with 6xx identify itself as M2F…

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]	
		FrmCntStamp	[23]	
		TrgCntStamp	[24]	
		---	[25..30]	Reserved
		GP_Buffer	[31]	

Table 100: 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 100: Advanced register: **Advanced feature** inquiry

Maximum resolution

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

This register normally outputs the MAX_IMAGE_SIZE_INQ Format_7 Mode_0 value.

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 38.

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

Table 101: 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 a value in the range of 1 to 4095 can be entered.

Marlin 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 103: Timebase ID on page 209

Table 102: Advanced register: **Time base**

The time base IDs 0-9 are in bits 28 to 31. See Table 103: Timebase ID on page 209. Refer to the following table for code.

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.

The **ExpOffset** field specifies the camera specific exposure time offset in microseconds (µs). This time (which should be equivalent to Table 43: Camera-specific minimum exposure time on page 121) has to be added to the exposure time (set by any shutter register) to compute the real exposure time.

The **ExpOffset** field might be zero for some cameras: this has to be assumed as an unknown exposure time offset (according to former software versions).

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

Table 103: Timebase 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 sec. can be entered with µs-precision via the EXTENDED_SHUTTER register.

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

Table 104: 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.
- Changes in this register have immediate effect, even when camera is transmitting.
- Extended shutter becomes inactive after writing to a format/mode/framerate register.
- Extended shutter setting will thus be overwritten by the normal timebase/shutter setting after Stop/Start of FireView or FireDemo.

Test images

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

- auto gain
- auto shutter
- auto white balance

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 105: Advanced register: **Test image**

Sequence control

It is possible to make certain settings for a sequence of images beforehand by using this register.

Register	Name	Field	Bit	Description
0xF1000220	SEQUENCE_CTRL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	Reserved
		AutoRewind	[5]	
		ON_OFF	[6]	Enable/Disable this feature
		---	[7..15]	Reserved
		MaxLength	[16..23]	Maximum possible length of a sequence (read only)
		SeqLength	[24..31]	Length of the sequence
0xF1000224	SEQUENCE_PARAM	---	[0..4]	Reserved
		ApplyParameters	[5]	Apply settings to selected image of sequence; auto-reset
		IncImageNo	[6]	Increment ImageNo after ApplyParameters has finished
		---	[7..23]	Reserved
		ImageNo	[24..31]	Number of image within a sequence

Table 106: Sequence control register

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 shows 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 107: 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 editing. 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 108: 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 108: Advanced register: **Shading**

Deferred image transport

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

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

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

Register	Name	Field	Bit	Description
0xF1000260	DEFERRED_TRANS	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..4]	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]	Write: Number of images to send Read: Number of images in buffer

Table 109: Advanced register: **Deferred image transport**

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 110: Frame information register

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.

High dynamic range mode (MARLIN F-131B/C only)

The CMOS sensor of the MARLIN F-131 offers a special mode by which various nonlinearity points, the so-called knee points, can be freely adjusted. This enables the high dynamic range of the sensor to be compressed into 8 bit, preserving interesting details of the image. This mode is also known as multiple slope (dual slope).

Register	Name	Field	Bit	Description
0xF1000280	HDR_CONTROL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Enable/disable HDR mode
		---	[7..19]	Reserved
		MaxKneePoints	[20…23]	Number of knee-points possible in this mode
		---	[24..27]	Reserved
		KneePoints	[28..31]	Number of active knee-points
0xF1000284	KNEEPOINT_1	---	[0..15]	Reserved
		Kneepoint1	[16..31]	Time in µs
0xF1000288	KNEEPOINT_2	---	[0..15]	Reserved
		Kneepoint2	[16..31]	Time in µs
0xF100028C	KNEEPOINT_3	---	[0..15]	Reserved
		Kneepoint3	[16..31]	Time in µs

Table 111: High dynamic range configuration register

DSNU control

The table below shows the advanced register map, required to control this functionality.

Register	Name	Field	Bit	Description
0xF1000290	DSNU_CONTROL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		ComputeError	[1]	tbd
		---	[2..3]	Reserved
		ShowImage	[4]	Show correction data as image
		ComputeData	[5]	Compute new DSNU correction data
		ON_OFF	[6]	DSNU correction On/Off OFF: High
		Busy	[7]	Computation in progress
		---	[8]	Reserved
		LoadData	[9]	Load factory DSNU correction data
		ZeroData	[10]	Zero DSNU correction data
		---	[11..23]	Reserved
		GrabCount	[24..31]	Number of images

Table 112: Advanced register: **DSNU**

Having generated the correction data it is possible to separately control the blemish pixel correction with the help of the following register:

Register	Name	Field	Bit	Description
0xF1000294	BLEMISH_CONTROL	Presence_Inq	[0]	Indicates presence of this feature (read only)
		ComputeError	[1]	see DSNU_CONTROL
		---	[2..3]	
		ShowImage	[4]	see DSNU_CONTROL
		ComputeData	[5]	see DSNU_CONTROL
		ON_OFF	[6]	blemish correction On/Off ON: High Default: OFF
		Busy	[7]	see DSNU_CONTROL
		SaveData	[8]	Save blemish correction data to flash
		LoadData	[9]	Load blemish correction data from flash
		ZeroData	[10]	see DSNU_CONTROL
		---	[11..23]	Reserved
		GrabCount	[24..31]	see DSNU_CONTROL

Table 113: Advanced register: **Blemish**

Input/output pin control

Note

- See Chapter Input/output pin control on page 53
- See Chapter IO_INP_CTRL 1-2 on page 53
- See Chapter IO_OUTP_CTRL 1-2 on page 58
- See Chapter Output modes on page 59

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

- Please note that only one edge is delayed.
- If **IntEna_Out** is used to control an exposure, it is possible to have a variation in brightness or to precisely time a flash.

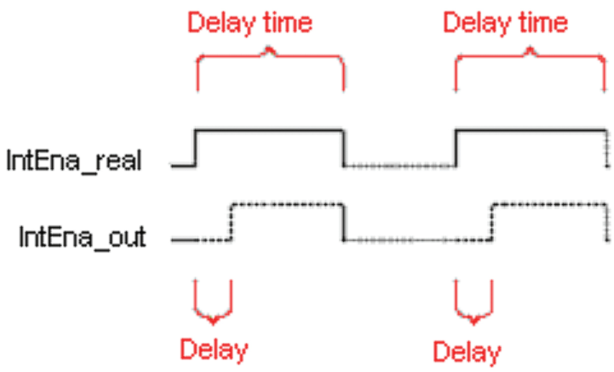


Figure 85: Delayed integration timing

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 114: 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 115: Advanced register: **Auto shutter control**

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
		Max Value	[4..15]	Maximum auto gain value
		---	[16..19]	Reserved
		Min value	[20..31]	Minimum auto gain value

Table 116: 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

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

As a reference it uses a grid of at least 300 samples equally spread over the area of interest or a fraction of it. The position and size of the control area (Auto_Function_AOI) can be set via the following advanced registers.

Register	Name	Field	Bit	Description
0xF1000390	AUTOFNC_AOI	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..3]	Reserved
		ShowWorkArea	[4]	Show work area
		---	[5]	Reserved
		ON_OFF	[6]	Enable/Disable AOI
		---	[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 117: Advanced register: **Autofunction AOI**

The possible increment of the work area position and size is 128 pixel. The camera automatically adjusts your settings to allowed values.

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

Region	Valid Values
Left, Top	0, 128, 256, 384, 512, 768, 1024...
Width, Height	128, 256, 384, 512, 768, 1024...

Table 118: Legal values for AF_AREA_SIZE

Due to the fact that the active image size might not be dividable by 128 without a remainder, the auto function AOI work-area size might be greater.

This allows for the positioning of the work-area to be at the bottom of the active image.

E.g. if the active image size is 640 x 480 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.

Color correction

Register	Name	Field	Bit	Description
0xF10003A0	COLOR_CORR	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	Color correction on/off default: on Write: 02000000h to switch color correction **OFF** Write: 00000000h to switch color correction **ON**
		---	[7..31]	Reserved

Table 119: Advanced register: **Color correction**

For an explanation of the color correction matrix and for further information read Chapter Color interpolation and correction on page 104.

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 120: 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.

Note

Trigger delay works with external trigger modes only.

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 121: Advanced register: **Mirror**

Soft Reset

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

Table 122: 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.

Secure image signature (SIS)

Definition

Secure image signature (SIS) is the synonym for data, which is inserted into an image to improve or check image integrity.

With the new firmware V3.03, all CCD Marlin models can insert

- **Time stamp** (1394 bus cycle time at the beginning of integration)
- **Frame counter** (frames read out of the sensor)
- **Trigger counter** (external trigger seen only)

into a selectable line position within the image. **Time stamp**, **frame counter** and **trigger counter** are available as advanced registers to be read out directly.

Advanced register: time stamp

The **time stamp** feature is controlled by the following advanced feature register:

Register	Name	Field	Bit	Description
0xF1000600	TIMESTAMP	Presence_Inq	[0]	Indicates presence of this feature (read only)
		---	[1..5]	Reserved
		ON_OFF	[6]	SIS (time stamp) on/off
		---	[7]	Reserved
		Format_0_Inq	[8]	Presence of Format_0 0: n/a 1: available
		---	[9]	Reserved
		---	[10]	Reserved
		---	[11]	Reserved
		---	[12]	Reserved
		---	[13..15]	Write as 0. Reserved
		LinePos	[16..31]	Line position of SIS (time stamp)

Table 123: Advanced register: **Time stamp**

Enabling this feature, time stamp data will be inserted into any captured image. The size of the time stamp depends on the selected time stamp format.

The LinePos field indicates at which line the stamp will be inserted.

Enter a

- **positive value** from 0..HeightOfImage to specify a position relative to the top of the image. LinePos=0 specifies the very first image line.
- **negative value** from -1..-HeightOfImage to specify a position relative to the bottom of the image. LinePos=-1 specifies the very last image line.

Note

SIS outside the visible image area:

For certain Format_7 modes the image frame transported may contain padding (filling) data at the end of the transported frame. Setting LinePos=HeightOfImage places the stamp in this padding data area, outside the visible area (invisible SIS).

If the transported image frame does not contain any padding data the camera will not relocate the SIS to the visible area automatically (no SIS).

Take in mind that the accuracy of the time stamp might be affected by asynchronous traffic – mainly if image settings are changed.

Note

The IEEE 1394 **cycle counter** will be inserted into the **very first 4 bytes/pixels of a line**.

Cycle offset	Cycles	Seconds
Cycle offset 12 bit	Cycle count 13 bit	Second count 7 bit
0 .. 3071 cycle offsets (40.69 ns)	0 .. 7999 cycles	0 .. 127 seconds
24.576 MHz cycle timer counter	8000 Hz cycle timer counter	1 Hz cycle timer counter

Table 124: 32-bit cycle timer layout

Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Cycle offset 12 bit												Cycle count ...			

Bit	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	... Cycle count 13 bit									Second count 7 bit						

Table 125: Cycle timer layout

Advanced register: frame counter

The **frame counter** feature is controlled by the following advanced feature register:

Register	Name	Field	Bit	Description
0xF1000610	FRMCNT_STAMP	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Reset	[1]	Reset frame counter
		---	[2..5]	Reserved
		ON_OFF	[6]	SIS (time stamp) on/off
		---	[7]	Reserved
		---	[8..15]	Reserved
		LinePos	[16..31]	Line position of SIS (time stamp)
0xF1000614	FRMCNT		[0..31]	Frame counter

Table 126: Advanced register: **Frame counter**

Having this feature enabled, the current **frame counter** value (images read out of the sensor, equivalent to # FrameValid) will be inserted as a 32-bit integer value into any captured image.

Setting the **Reset** flag to 1 resets the frame counter to 0 — the **Reset** flag is self-cleared.

The **ON_OFF** and **LinePos** fields are simply mirrors of the time stamp feature. Settings of these fields are applied to all image stamp features.

Note

The 4 bytes of the **frame counter** value will be inserted as the **5th to 8th byte of a line**.

Additionally there is a register for direct read out of the frame counter value.

Advanced register: trigger counter

The **trigger counter** feature is controlled by the following advanced feature register:

Register	Name	Field	Bit	Description
0xF1000620	TRGCNT_STAMP	Presence_Inq	[0]	Indicates presence of this feature (read only)
		Reset	[1]	Reset trigger counter
		---	[2..5]	Reserved
		ON_OFF	[6]	SIS (time stamp) on/off
		---	[7]	Reserved
		---	[8..15]	Reserved
		LinePos	[16..31]	Line position of SIS (time stamp)
0xF1000624	TRGCNT		[0..31]	Trigger counter

Table 127: Advanced register: **Trigger counter**

Having this feature enabled, the current **trigger counter** value (external trigger seen by hardware) will be inserted as a 32-bit integer value into any captured image.

Setting the **Reset** flag to 1 resets the **trigger counter** to 0 – the Reset flag is self-cleared.

The **ON_OFF** and **LinePos** fields are simply mirrors of the time stamp feature. Settings of these fields are applied to all image stamp features.

Note

The 4 bytes of the **trigger counter** value will be inserted as the **9th to 12th byte of a line**.

Additionally there is a register for direct read out of the **trigger counter** value.

Where to find time stamp, frame counter and trigger counter in the image

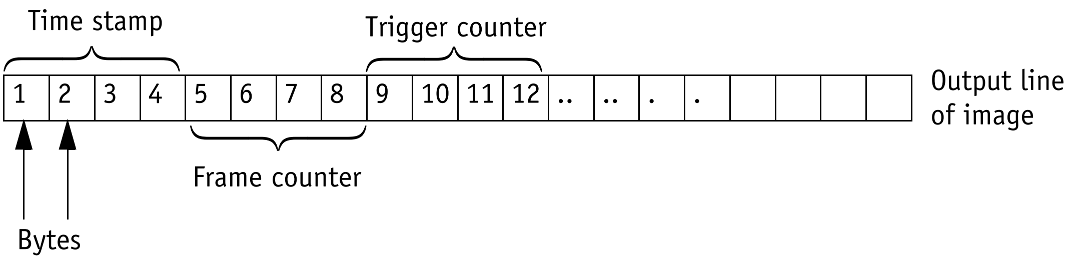


Figure 86: SIS in the image

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.

With firmware 3.03 (MARLIN CCD) and firmware 3.45 (MARLIN CMOS) cameras, can store up to three user profiles (plus the factory default) nonvolatile in the camera.

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 129: User profile: Error codes on page 232.
		---	[24..27]	Reserved
		ProfileID	[28..31]	ProfileID (memory channel)

Table 128: 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 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

ErrorCode #	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 129: User profile: **Error codes**

Reset of error codes

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

You may also reset the **ErrorCode**

- by writing 00000000h to the **USER_PROFILE** register.

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.

Stored settings

The following table shows the settings stored inside a profile:

Standard registers	Standard registers (Format_7)	Advanced registers
Cur_V_Frm_Rate Cur_V_Mode Cur_V_Format ISO_Channel ISO_Speed BRIGHTNESS AUTO_EXPOSURE (Target grey level) SHARPNESS WHITE_BALANCE (+ auto on/off) HUE (+ hue on) SATURATION (+ saturation on) GAMMA (+ gamma on) SHUTTER (+ auto on/off) GAIN TRIGGER_MODE TRIGGER_DELAY ABS_GAIN ABS_TRIGGER_DELAY	IMAGE_POSITION (AOI) IMAGE_SIZE (AOI) COLOR_CODING_ID BYTES_PER_PACKET	TIMEBASE EXTD_SHUTTER IO_INP_CTRL IO_OUTP_CTRL IO_INTENA_DELAY AUTOSHUTTER_CTRL AUTOSHUTTER_LO AUTOSHUTTER_HI AUTOGAIN_CTRL AUTOFNC_AOI (+ on/off) COLOR_CORR (on/off) TRIGGER_DELAY MIRROR_IMAGE HIGH_SNR TIMESTAMP LUT_CTRL (LutNo; ON_OFF is not saved) LUT_DATA

Table 130: User profile: stored settings

The user can specify which user profile 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 into the camera.

GPDATA_BUFFER

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

GPDATA_INFO Buffer size query

GPDATA_BUFFER indicates the actual storage range

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

Table 131: 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 132: 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

Note

Please make sure that the new Marlin firmware matches with the serial numbering. This means Marlins with serial numbers xx/yy-6zzzzzzz need **different** firmware than Marlins with other serial numbers.

Caution

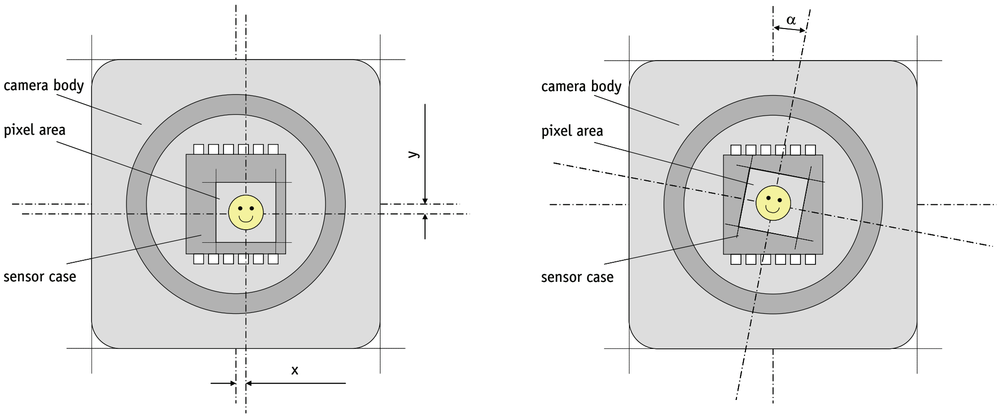
Any mixture may result in a nonfunctional or even damaged camera.

Note

Please contact your local dealer for further information.

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 87: AVT sensor position accuracy

Index

Numbers

A

B

C

D

E

T