

**Digital Monochrome (b/w)
Progressive Scan Camera**

 System: **Dual Gigabit Ethernet**
Baumer HXG40 / HXG40-F

Revision 2.0

**Art. No: 11080588 (C-Mount)
11082535 (F-Mount)**

- Dual Gigabit Ethernet progressive scan CMOS camera
- 2048 x 2048 pixel with up to 56 full frames per second
- Burst mode with up to 180 full frames per second using integrated 256 MByte RAM for temporarily image buffering
- GigE Vision™ standard compliant
- Excellent image quality
- Global shutter architecture for minimized motion blur
- Low noise due to correlated double sampling (CDS)
- Binning, subsampling and true partial scan function (ROI) for increased frame rates
- High Dynamic Range (HDR) image acquisition
- External synchronization via industrial compliant process interface (trigger / flash)
- Integrated supplementary function for flexible integration
- Sequence function up to 2³¹-1 frames per sequence
- Jumbo frames supported
- Camera parameter programmable in real-time
- Static Link Aggregation for higher bandwidth and resilience
- Power over Ethernet support
- Compact and lightweight aluminum housing
- Standard RJ45 connector
- Screw-lock type industrial connector
- Baumer-GAPI: Flexible, generic software interface for Windows / Linux


1. Overview

| Model Name | HXG40 / HXG40-F |
|---|---|
| Sensor | 1" progressive scan CMOS |
| Vendor and Model | CMOSIS CMV-4000 (version 3) |
| Shutter / readout mode | global shutter / progressive scan readout |
| Number of pixel | 2048 x 2048 |
| Scan area | 11.26 mm x 11.26 mm |
| Pixel size | 5.5 µm x 5.5 µm |
| Color filter | - |
| Operation modes | |
| Trigger mode | yes, sequential or overlapped operation |
| Free running mode | yes, sequential or overlapped operation |
| Sensor readout channels | 16 / 8 / 4 / 2 channel readout |
| Signal processing | real-time software programmable |
| Pixel clock | 8/10 bit pixel format: 24/40/48 MHz 12 bit pixel format: 20/40 MHz |
| A/D converter | 10 or 12 bit depending on pixel format |
| Internal exposure control (t _{exp}) | total: 20 µsec .. 1 sec step 1 µsec |
| Trigger pulse width exposure control | Yes, via all trigger lines |
| Gain control | 0 .. 12 dB |
| Offset (black level) | 0 .. 255 LSB |
| Image data buffer | max. 60 full resolution images |

Technical specifications subject to change

| Image acquisition | | | | | | | |
|--------------------------------|--|--------------------|--------------|-----------------|----------------------|-----------|-----------------------|
| Camera image format modes | Format (pixel) | GenCam standard | Pixel format | Pixel clock MHz | Frames per sec. (*2) | | t _{treadout} |
| | | | | | Burst mode | Dual GigE | |
| Full frame | 2048 x 2048 | yes | Mono8 (*4) | 48 | 180 | 56 | 5550 μs |
| | | | Mono10 | 48 | 180 | 28 | 5550 μs |
| | | | Mono12 | 40 | 37 | 28 | 26500 μs |
| Binning 2x1 | 1024 x 2048 | yes | Mono8 (*4) | 48 | 180 | 112 | 5550 μs |
| | | | Mono10 | 48 | 180 | 56 | 5550 μs |
| | | | Mono12 | 40 | 37 | 37 | 26500 μs |
| Subsampling 2x2 | 1024 x 1024 | Vendor specific | Mono8 (*4) | 48 | 357 | 223 | 2800 μs |
| | | | Mono10 | 48 | 357 | 112 | 2800 μs |
| | | | Mono12 | 40 | 75 | 75 | 13300 μs |
| Standard features | | | | | | | |
| Image size controls | | | | | | | |
| Binning horizontal | yes, 2 pixel | | | | | | |
| Binning vertical | - | | | | | | |
| Pixel format | Mono8, Mono10, Mono12 (*1) | | | | | | |
| Test image selector | yes, in all modes Off, GreyHorizontalRamp, GreyVerticalRamp | | | | | | |
| Partial scan (ROI) | yes, format freely programmable in all modes, Step size horizontal: 32 pixels Step size vertical: 1 pixel | | | | | | |
| Multi partial scan (Multi ROI) | yes, up to 8 horizontal and vertical regions | | | | | | |
| Analog controls | | | | | | | |
| Gain | - | | | | | | |
| Black Level (Off set) | yes | | | | | | |
| Gamma | yes, via LUT | | | | | | |
| Brightness correction (custom) | yes, in all binning modes | | | | | | |
| Digital controls | | | | | | | |
| Digital gain | yes, factors 1.0 to 4.0 (*5) | | | | | | |
| Acquisition and Trigger | | | | | | | |
| Acquisition mode | Continuous | | | | | | |
| Acquisition frame rate | yes, ON / OFF (only in freerunning mode) 0 .. 21739 Hz, step: 0.01 Hz | | | | | | |
| Trigger source | HardwareTrigger (Line0, Line1, Line2), Software, CommandTrigger (ActionCommand), Off | | | | | | |
| Trigger delay | 0 .. 2 sec, 512 trigger can be tracked, step: 1 μsec | | | | | | |
| Sequencer | Up to 2 ³¹ -1 frames per sequence / one exposure time, one gain value and outputs for each parameter set max. set of sequences: Up to 2 ³¹ -1 frames x 128 parameter sets | | | | | | |
| Digital I/O | | | | | | | |
| Lines | Input: Line0, Line1, Line2 Output: Line3, Line4, Line5 | | | | | | |
| Line source (outputs only) | Line3, Line4, Line5: Off, ExposureActive, ExposureEnlarged, ReadoutActive, FrameActive, TransferActive, TriggerReady, TriggerOverLapped, TriggerSkipped, Timer1Active, Timer2Active, Timer3Active, Line0, Line1, Line2, UserOutput0, UserOutput1, UserOutput2, SequencerOutput0, SequencerOutput1, SequencerOutput2, Counter1Active, Counter2Active | | | | | | |
| Line debouncer | yes, low and high signal separately selectable 0 .. 5 msec step: 1μsec | | | | | | |
| Line inverter | yes, Line0 .. Line5, on or off | | | | | | |
| Event Generation | | | | | | | |
| Events | GigEVisionError, Heartbeattimeout, EventLost, Line[0,1,3]RisingEdge, Line[0,1,3]FallingEdge, Software, Action1, ExposureStart, ExposureEnd, FrameStart, FrameEnd, TriggerReady, TriggerOverlapped, TriggerSkipped | | | | | | |
| Event Notification | yes, ON / OFF | | | | | | |

Technical specifications subject to change

| | |
|--|--|
| Counters and Timers | |
| Counter | <p>yes, CounterSelector: Counter1, Counter2 CounterEventSource: Off, Input: Line0/Line1/Line2, Software, Action1, ExposureStart, ExposureEnd, FrameStart, FrameEnd, TriggerSkipped CounterResetSource: Off, Input: Line0/Line1/Line2, Software, Action1, ExposureStart, ExposureEnd, FrameStart, FrameEnd, TriggerSkipped</p> |
| Timer | <p>yes, TimerSelector: Timer1, Timer2, Timer3 TimerTriggerSource: Off, Input: Line0/Line1/Line2, Software, Action1, ExposureStart, ExposureEnd, FrameStart, FrameEnd, TriggerSkipped TimerDelay: 0 μsec .. 2 sec, step: 1 μsec TimerDuration: 10 μsec .. 2 sec, step: 1 μsec</p> |
| LUT Controls | |
| LUT selector | 1 LUT: Luminance (12 bit) ON / OFF |
| Image Correction | |
| Defect pixel correction | yes, ON / OFF |
| Defect pixel list | yes, additional pixels can be added during the lifetime of the camera |
| DSNU / PRNU (FPN) correction | yes, ON / OFF, based on offset / factor per column, data set calculated with factory settings during production and stored in camera |
| GigEVisionTransportLayer | |
| PayLoadsize | 576 Byte .. 8.388.880 Byte |
| UserSets | |
| User set selector | Default (factory settings / read only) UserSet1, UserSet2, UserSet3 (read and write) |
| UserSetDefaultSelector | yes, define the start up "UserSet" |
| Advanced features | |
| Image Flip | Horizontal, vertical or both |
| Time stamp function | yes, 64 bit tick = 1 nsec |
| Asynchronous message channel | Yes |
| Concatenation function | Yes |
| User defined identifier | yes, user programmable permanent identifier |
| ActionCommand | yes, ID 0 = Trigger, ID 1 = Timestamp set |
| High Dynamic Range (HDR) | Yes, piecewise linear response, up to 90 dB |
| Data quality | |
| Readout noise | at 20 °C, gain = 1, exposure time = 4 msec, full frame mode $\sigma < 0.3$ LSB (8 bit) typical |
| Dynamic range | typical 60 dB |
| Optical interface | |
| Optical filter | C-Mount on request: F-Mount dust protection on request: super polished, IR cut filter, daylight filter or no filter |
| Process interface functions | |
| Async. Trigger | yes, trigger mode operation, "Off", "software trigger", "hardware trigger", "command trigger" or "all" separately selectable (overtriggered signals and trigger signals during the readout time will be notified in the received image header) |
| Exposure Active (External flash sync) | yes, delay_value ($t_{\text{delay flash}}$) $\leq 4 \mu$ sec, duration_value (t_{duration}): mode = $t_{\text{exp}} + 30 \mu$ sec |
| User Output | yes, ON / OFF, UserOutput0, UserOutput1, UserOutput2 |
| Timer | yes, Timer1 |
| Software reset | Yes |
| Asynchronous reset | - |
| Image info header | yes |
| Temperature measurement | - |

Technical specifications subject to change

| | |
|-------------------------------|--|
| Electrical interface | |
| Data / control | standard dual cable 1000 Base-T, Cat6 recommended / minimum Cat5e option: screw lock type connector |
| Power | Dedicated 3 pin power interface VCC: 20 VDC .. 30 VDC, I: 304 mA .. 397 mA |
| | Power over Ethernet (PoE) Class 0 device (via 1000 Base-T cable) VCC: 48VDC (38 VDC .. 30 VDC) I: 160 mA .. 259 mA, supported by port 1 (at the top) |
| Power consumption | approx. 8,4 Watt (with camera factory settings) |
| Digital input | 1 / 2 / 3: Line 0 / Line 1 / Line 2: trigger signal, opto decoupled $U_{IN(low)} = 0 \dots 4.5 \text{ VDC}$, $U_{IN(high)} = 11 \dots 30 \text{ VDC}$ $I_{IN} = \text{max. } 10 \text{ mA}$ rising edge (invert = false) (*6) min. impulse length (t_{min}): 2 μsec trigger delay out of $t_{readout}$ ($t_{delay \text{ trigger}}$): 4 μsec max. trigger delay during $t_{readout}$ ($t_{delay \text{ trigger}}$): 30 μsec |
| Digital output | 1 / 2 / 3: Line 3 / Line 4 / Line 5: opto decoupled $U_{EXT} = 5 \dots 30 \text{ VDC}$ / 24 VDC typical, $I_{OUT} = \text{max. } 100 \text{ mA}$ high active (invert = false) (***) |
| LED | 1(Camera): green: Power on yellow: Readout active 2 (GigE Port 1): green: Link active green flash: Receiving 3 (GigE Port 1): yellow: Transmitting 4 (GigE Port 2): green: Link active green flash: Receiving 5 (GigE Port 2): yellow: Transmitting |
| Environmental | |
| Storage temperature | -10 °C .. +70 °C |
| Operating temperature | +5 °C .. +50 °C between +15 °C .. +50 °C, note the max. housing and internal temperature |
| Housing operating temperature | max. +50 °C (*7) (measurement point, see item 4) |
| Humidity | 10 % .. 90 % non condensing |
| Conformity | CE, FCC Part 15 class B, RoHS compliant |
| Housing | |
| Aluminum | |
| Dimensions | 52 x 52 x 55 mm ³ (C-Mount) 52 x 52 x 55 mm ³ (F-Mount) |
| Weight | 232 g (C-Mount) 323 g (F-Mount) |
| 1000 Base-T interface | |
| Ports | 2 |
| Ethernet IP configuration | persistent IP / DHCP / LLA |
| Stream channel packet size | 576 Byte (default) .. 65535 Byte jumbo frames supported |
| Interpacketgap | 0 .. 2 ³² -1 ticks |
| Multicast function | yes |
| Resend function | Yes |
| Link aggregation | Yes, according to 802.3ad, static configuration |
| Software | Baumer-GAPI SDK with supported OS socket driver and Baumer filter driver / SDK for Windows XP (32 bit) / Windows Vista (32 bit / 64 bit) / Windows 7 (32 bit / 64 bit) / Linux Kernel 2.6.xx (64 bit / 32 bit) |
| | GigE Vision [®] compatible programs and image processing libraries supported Windows / Linux depending on the actually driver software is used |

- (*1) For changing the pixel frequency or the pixel format, the camera has to be stopped.
- (*2) Maximum frame rate in free running mode, effective frame rate depending on camera image format mode settings and set exposure time ($t_{exp} < t_{readout}$). This assumes 16 tap readout at maximum pixel frequency.
- (*3) -
- (*4) Default pixel format
- (*5) Digital gain is applied on the raw data obtained from the sensor. In 10 and 12 bit modes, this is just a bit shift cutting away the MSBs!
- (*6) can be inverted via software
- (*7) housing temperature is limited by CMOS sensor specification
In warm environments take care of adequate dissipation of heat. It is recommended to operate the cameras in mounted condition with a good heat conductor (e.g. aluminum) or with sufficient air flow.

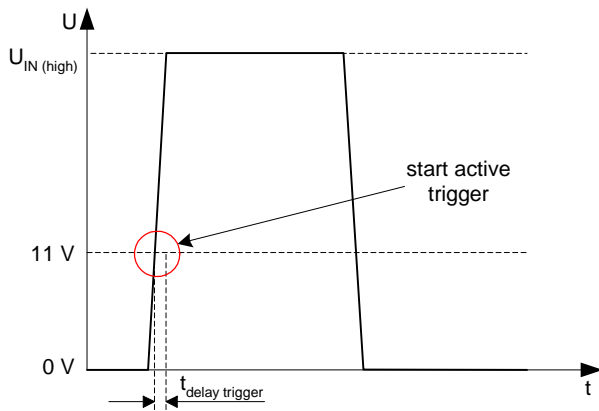
Technical specifications subject to change

2. Camera Factory Settings after Camera Start-up

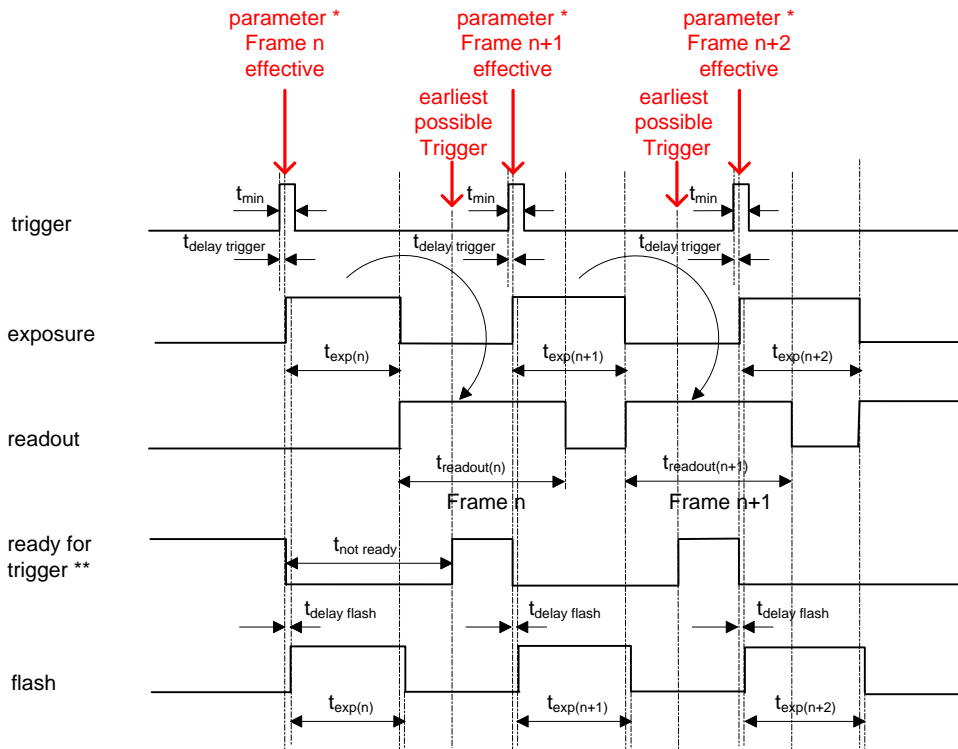
| Camera factory settings after camera start-up or reboot | |
|---|--|
| Operation modes | free running mode, overlapped readout |
| Signal processing | |
| Exposure control | Internal, 4 msec |
| Gain control | factor 1 = 0 dB |
| Offset (black level) | 0 |
| Image acquisition | |
| Camera image format mode | Full frame Mono8, 16 tap readout |
| Pixel frequency | 48 MHz |
| Partial scan function | not active |
| Acquisition frame rate | Off |
| Timer | Off |
| Transmission delay | 0 ticks |
| Test image selector | Off |
| Defect pixel correction | On |
| FPN correction | Off |
| Electrical interface | |
| Digital input | 1 / 2 / 3: Line 0 / Line 1 / Line 2: invert = false |
| Digital output | 1 / 2 / 3: Line 3 / Line 4 / Line 5: Line source=Off, invert = false, digital output set to low status (high impedance) |

3. Timing Operation Modes

Trigger Mode: start up time



Trigger Mode: trigger mode 0, overlapped trigger



$$t_{exp} < t_{readout}: t_{earliest\ possible\ trigger\ (n+1)} = t_{readout(n)} - t_{exp(n+1)}$$

$$t_{exp} > t_{readout}: t_{earliest\ possible\ trigger\ (n+1)} = t_{exp(n)}$$

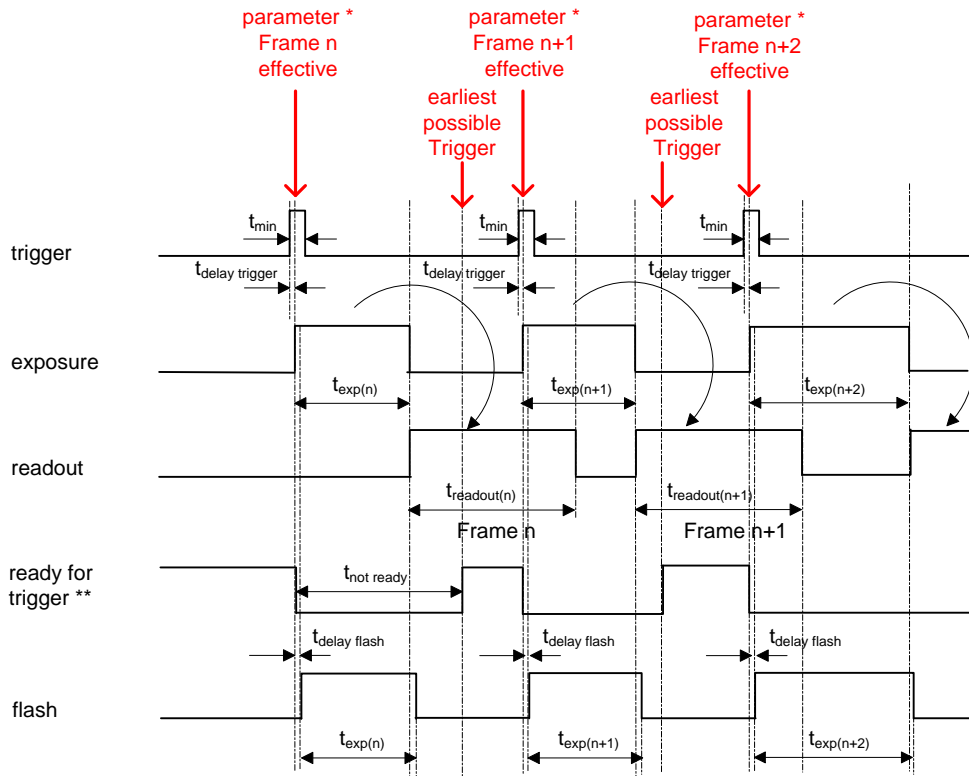
$$t_{exp} < t_{readout}: t_{not\ ready\ (n+1)} = t_{exp(n)} + t_{readout(n)} - t_{exp(n+1)}$$

$$t_{exp} > t_{readout}: t_{not\ ready\ (n+1)} = t_{exp(n)}$$

* image parameter: exposure
offset
gain
readout mode
LUT
flip image

** signal will be notified as event "TriggerReady"

Trigger Mode: trigger mode 0, overlapped trigger , when $t_{exp(n+2)} > t_{exp(n+1)}$



$$t_{exp} < t_{readout}: t_{earliest\ possible\ trigger\ (n+1)} = t_{readout(n)} - t_{exp(n+1)}$$

$$t_{exp} > t_{readout}: t_{earliest\ possible\ trigger\ (n+1)} = t_{exp(n)}$$

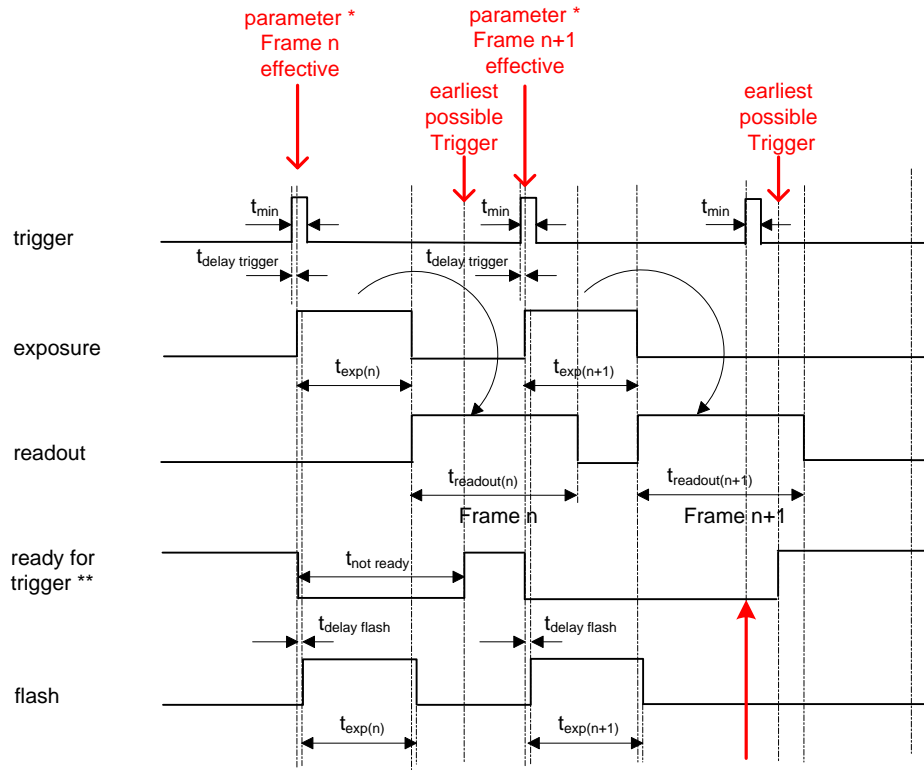
$$t_{exp} < t_{readout}: t_{not\ ready\ (n+1)} = t_{exp(n)} + t_{readout(n)} - t_{exp(n+1)}$$

$$t_{exp} > t_{readout}: t_{not\ ready\ (n+1)} = t_{exp(n)}$$

- * image parameter:
- exposure
 - offset
 - gain
 - readout mode
 - LUT
 - flip image

** signal will be notified as event "TriggerReady"

Trigger Mode: trigger mode 0, overlapped trigger , when $t_{exp(n+2)} < t_{exp(n+1)}$



Frame n+2
not started / overtriggered

$$t_{exp} < t_{readout}: t_{earliest\ possible\ trigger\ (n+1)} = t_{readout(n)} - t_{exp(n+1)}$$

$$t_{exp} > t_{readout}: t_{earliest\ possible\ trigger\ (n+1)} = t_{exp(n)}$$

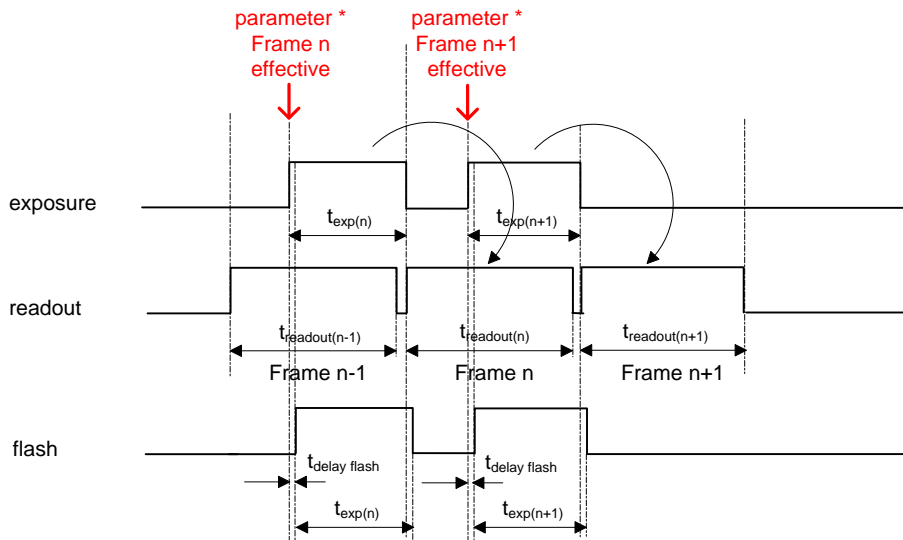
$$t_{exp} < t_{readout}: t_{not\ ready\ (n+1)} = t_{exp(n)} + t_{readout(n)} - t_{exp(n+1)}$$

$$t_{exp} > t_{readout}: t_{not\ ready\ (n+1)} = t_{exp(n)}$$

- * image parameter:
- exposure
 - offset
 - gain
 - readout mode
 - LUT
 - flip image

** signal will be notified as event "TriggerReady"

Free Running Mode: overlapped operation



- * image parameter:
- exposure
 - offset
 - gain
 - readout mode
 - LUT
 - flip image

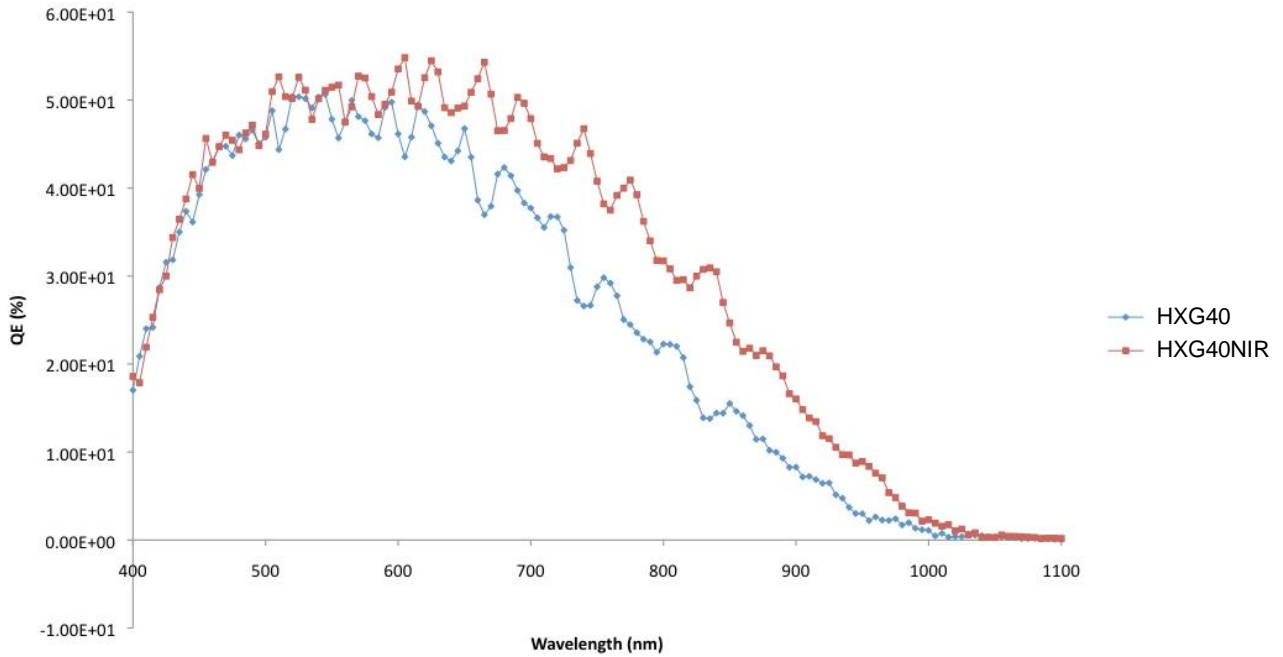
4. Region of Interest (ROI) Examples

The following table lists achievable frame rates in burst mode for a short time using the integrated image buffer of 256 MB and continuously over the Dual GigE interface.

| Format | Resolution | max. fps burst mode (buffered) | max. fps continuously (Single GigE) (*1) | max. fps continuously (Dual GigE) (*1) |
|-----------|-------------|--------------------------------|--|--|
| 2kx2k | 2048 x 2048 | 180 | 28 | 56 |
| | 2048 x 1080 | 338 | 53 | 106 |
| HDTV | 1920 x 1080 | 338 | 56 | 113 |
| | 1280 x 720 | 504 | 127 | 253 |
| XGA | 1024 x 768 | 473 | 149 | 298 |
| DVD | 736 x 576 | 627 | 277 | 536 |
| VGA | 640 x 480 | 748 | 382 | 640 |
| CIF | 352 x 288 | 1.221 | 1044 | 1044 |
| QCIF | 176 x 144 | 2.319 | 1983 | 1983 |
| Line Scan | 2048 x 1024 | 357 | 56 | 112 |
| | 2048 x 512 | 703 | 112 | 223 |
| | 2048 x 256 | 1.363 | 224 | 443 |
| | 2048 x 128 | 2.576 | 447 | 877 |
| | 2048 x 64 | 4.637 | 888 | 1736 |
| | 2048 x 32 | 7.712 | 1753 | 3231 |
| | 2048 x 16 | 11.560 | 3437 | 6021 |
| | 2048 x 8 | 15.407 | 6531 | - |
| | 2048 x 4 | 18.436 | - | - |
| | 2048 x 2 | 20.349 | - | - |
| | 2048 x 1 | 21.653 | - | - |

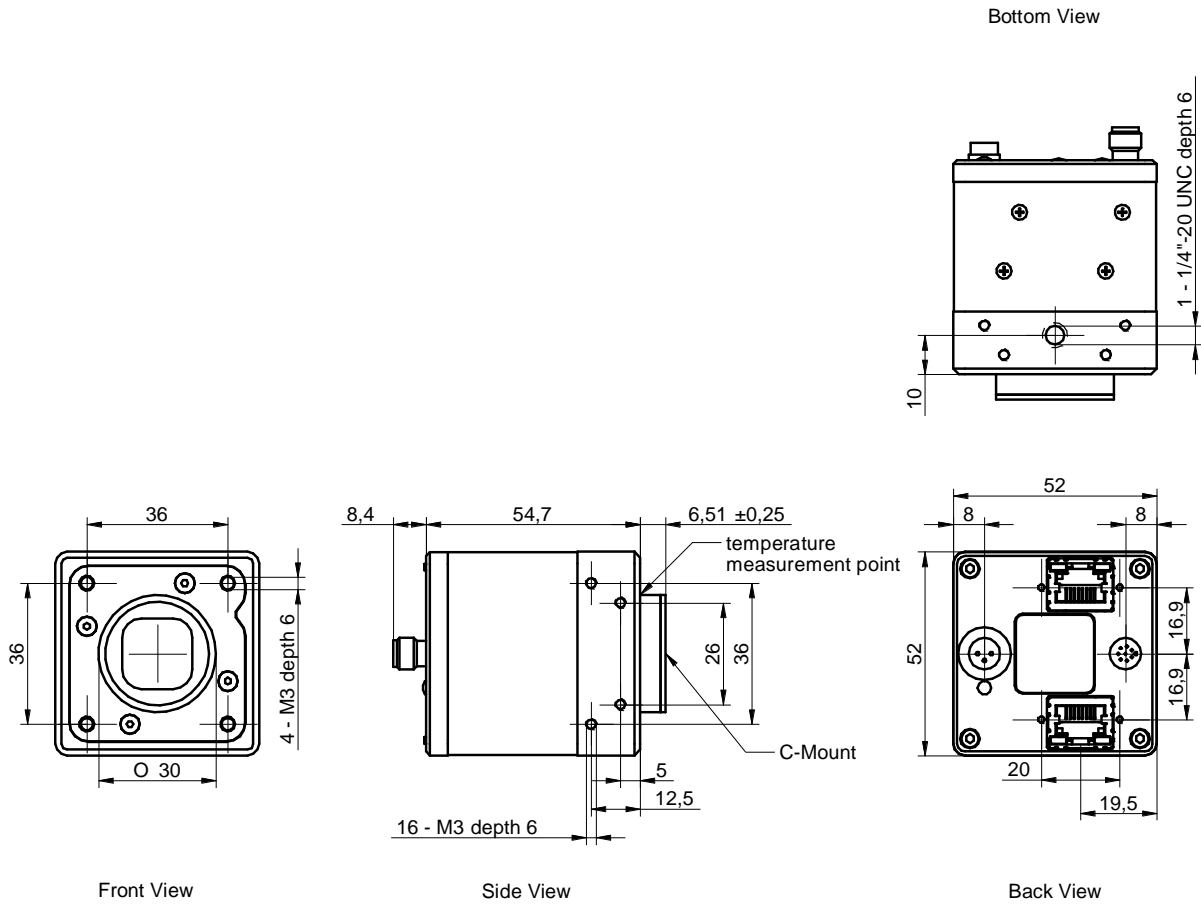
(*1) For small ROI settings many packets are transmitted and have to be processed by the PC. The actual frame rate depends on the PC performance. If the PC is not fast enough to process the incoming packets an overload situation may occur.

5. Spectral response (QE)

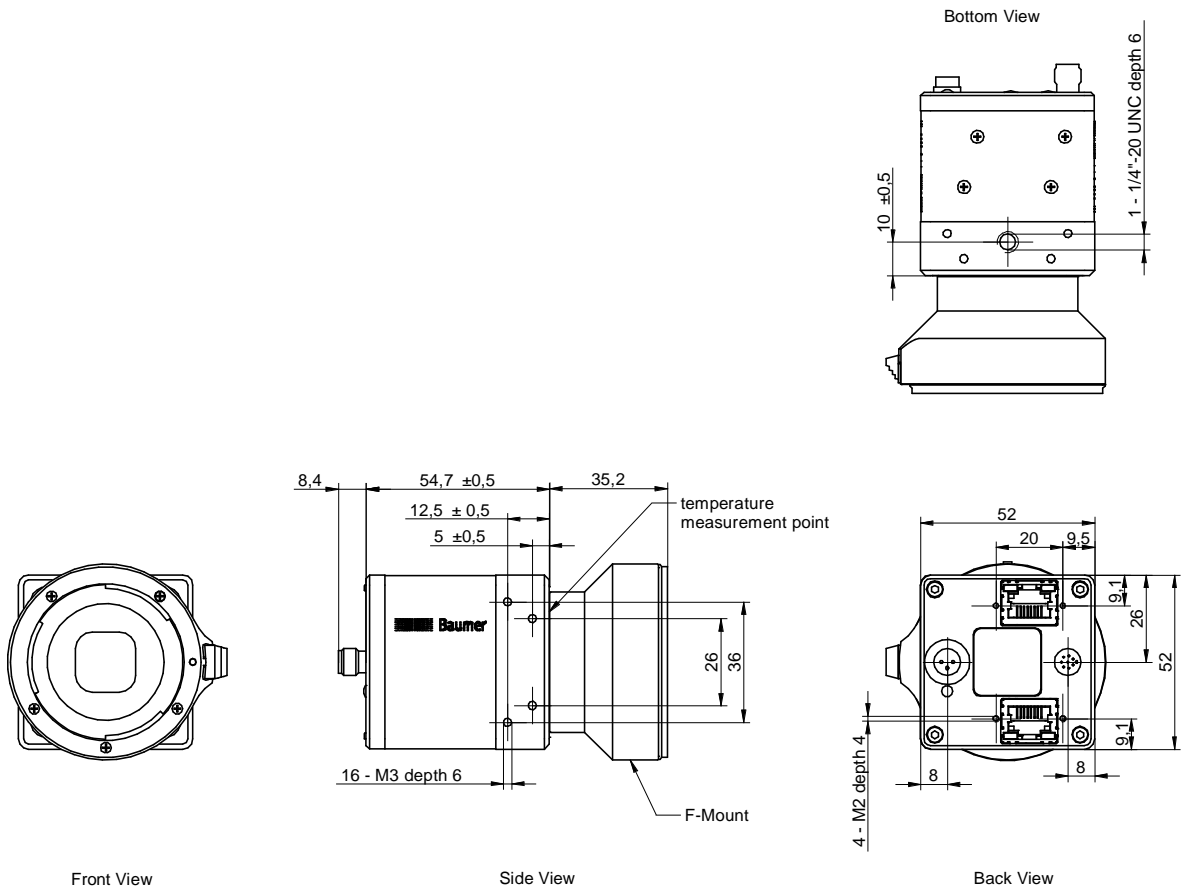


6. Housing

6.1 C-Mount



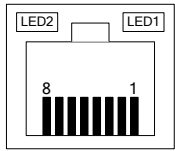
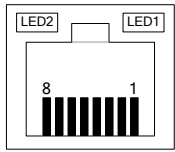
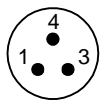
6.2 F-Mount

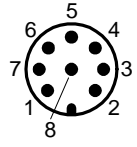
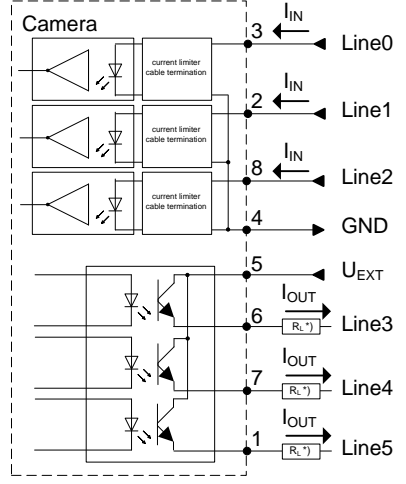


Technical specifications subject to change

7. Connectors / Electrical Interfaces

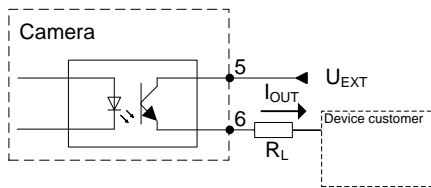
7.1 Pin assignment:

| | |
|---|--|
| Data / Control 1000 Base-T (Port 1) | Type: RJ45 8P8C mod jack |
|  | 1: MX1+ 2: MX1- 3: MX2+ 4: MX3+ 5: MX3- 6: MX2- 7: MX4+ 8: MX4- |
| Data / Control 1000 Base-T (Port 2) | Type: RJ45 8P8C mod jack |
|  | 1: MX1+ 2: MX1- 3: MX2+ 4: MX3+ 5: MX3- 6: MX2- 7: MX4+ 8: MX4- |
| Power | Type: Lumberg RSMESD / 3 pin |
|  | 1: Power VCC+ 3: GND 4: not used |
| | Power cable wires color: 1 = brown 3 = blue 4 = black |

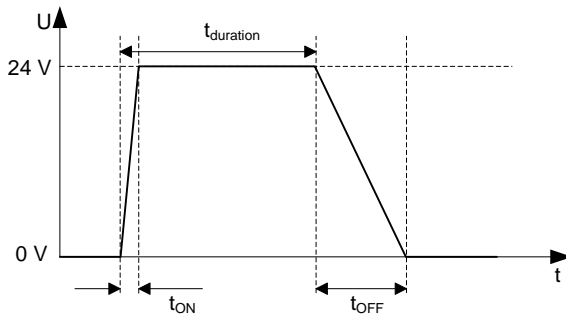
| | |
|--|---|
| Input / Output | Type: Lumberg RSMESD 8pin. |
|  |  |
| | *) resistor must be used, drawing shown above example for using high active signal |
| | I/O cable wires color *): 1 = white 2 = brown 3 = green 4 = yellow 5 = grey 6 = pink 7 = blue 8 = red |

*) shielded trigger / flash cable should be used and ordered separately

7.2 Flash sync sample $U_{EXT} = 24\text{ VDC}$ high active:

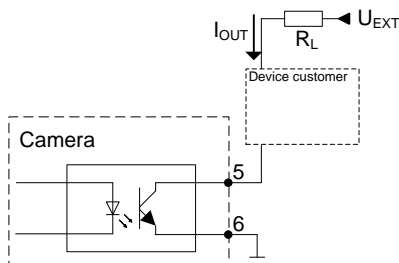


Timing example:
 measurement condition $U_{EXT} = 24\text{ VDC} / I_{OUT} = 16\text{ mA}$
 $R_L = 1.5\text{ kOhm}$

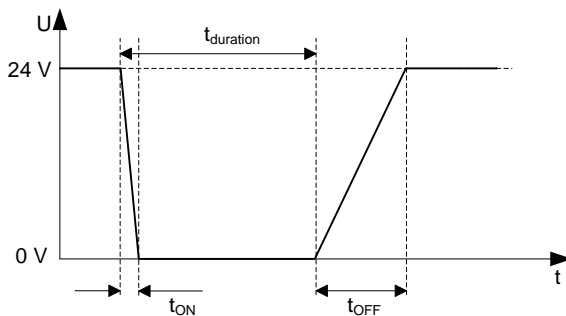


t_{ON} time = typ. $2\text{ }\mu\text{sec}$
 t_{OFF} time = typ. $40\text{ }\mu\text{sec}$

7.3 Flash sync sample $U_{EXT} = 24\text{ VDC}$ low active:



Timing example:
 measurement condition $U_{EXT} = 24\text{ VDC} / I_{OUT} = 16\text{ mA}$
 $R_L = 1.5\text{ kOhm}$



t_{ON} time = typ. $2\text{ }\mu\text{sec}$
 t_{OFF} time = typ. $40\text{ }\mu\text{sec}$

End of Document

History of TDS Baumer HXG40

| Date | Version | Name | Pages/ Chapter | Change |
|------------|---------|------|----------------|--|
| 21.06.2011 | 0.1 | mibe | all | Initial version based on HXC40, SXG80 |
| 05.10.2011 | 0.1 | mibe | 1 | SAP# F-Mount, Image HXG C-Mount, F-Mount tbd., GigE payload |
| 04.11.2011 | 0.2 | mibe | all | Factory settings, F-Mount image from SXG |
| 21.11.2011 | 0.3 | mibe | all | FPN, PoE only on Port 1, Payload Size |
| 06.12.2011 | 0.4 | mibe | all | F-Mount, voltage range, power consumption, operating temperature |
| 13.12.2011 | 0.5 | mibe | 10 | ROI frame rate |
| 09.01.2012 | 0.6 | mibe | 4 | Operating temperature |
| 20.01.2012 | 0.7 | mibe | 13 | New F-Mount drawing without Nikon dust protection |
| 26.01.2012 | 0.8 | mibe | 2,10 | Slightly reduced frame rates |
| 01.02.2012 | 1.0 | mibe | 1 | Removed preliminary note |
| 27.02.2013 | 1.0 | mibe | 1, 3 | Changes for Firmware Revision 2 Support of v3 Sensors (not mentioned) Modified DSNU/PRNU (FPN), added HDR/Multi ROI Removed Temperature measurement |
| 30.5.2013 | 1.0 | mibe | 2 | Burst mode frame rate with 10 bit corrected (=8bit) Added V3 Sensor Notification |
| 23.07.2013 | 1.1 | zira | 1 | according SFNC: Naming changed from <i>User</i> to <i>UserOutput</i> , <i>CounterTriggerSource</i> to <i>CounterEventSource</i> , <i>SoftwareTrigger</i> to <i>Software</i> , <i>ActCmdTrigger</i> to <i>Action1</i> , added <i>CounterActive</i> ReadoutTime unit in μ s |
| 06.8.2013 | 1.1 | mibe | 1 | Minimum exposure = 20 μ s |
| 12.08.2013 | 1.0 | mibe | 1 | Change name <i>_R2_</i> , corrected read out time Footer www.baumeroptronic.com -> www.baumer.com |

Technical specifications subject to change