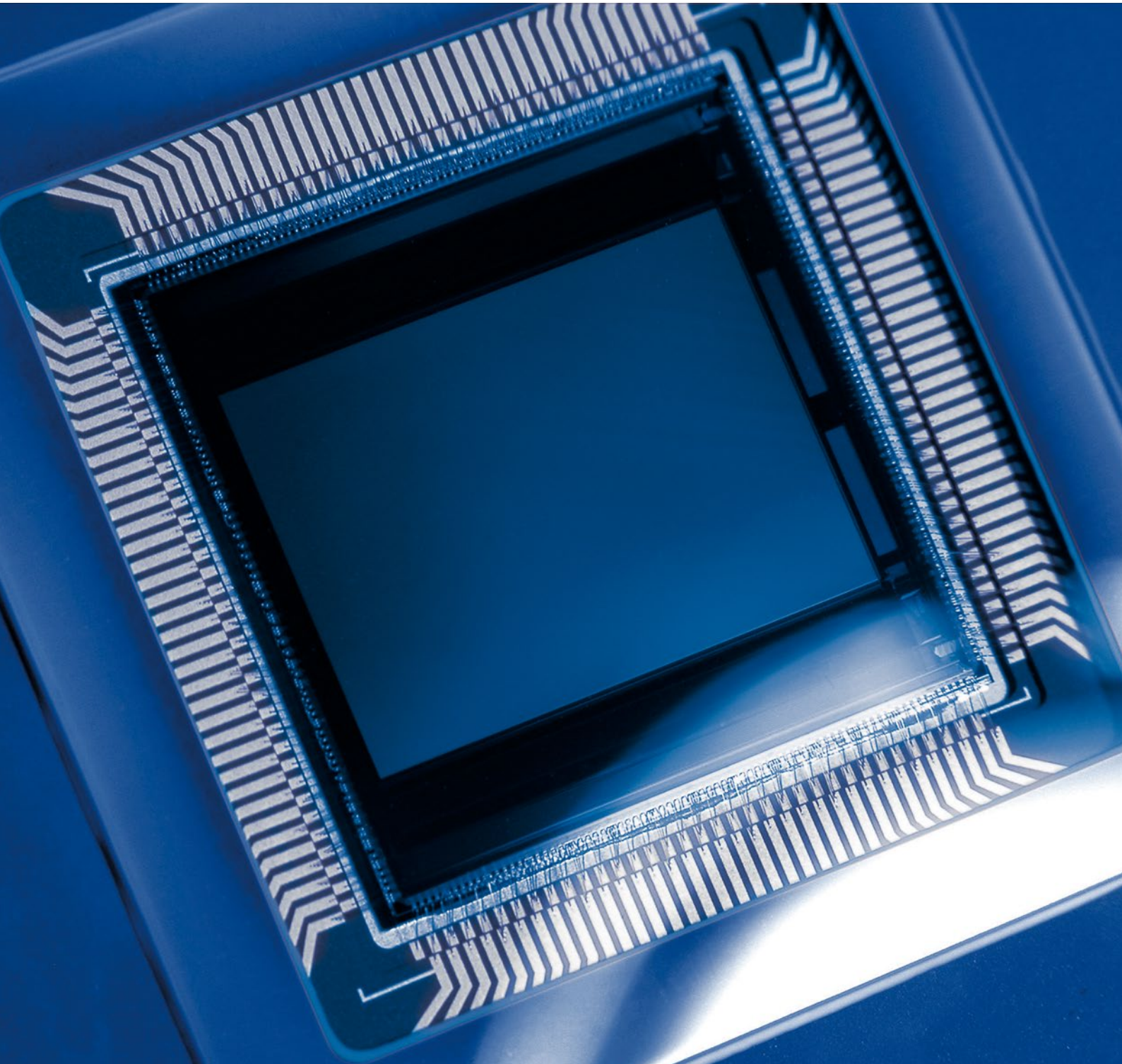


EMVA DATA OVERVIEW

MONOCHROME AREA SCAN CAMERAS



The EMVA 1288 Standard has been developed by the European Machine Vision Association with the goal of standardizing image quality and sensitivity measurements for machine vision cameras and sensors. Based on this standard our cameras are tested and their EMVA data is generated. This document will give you an overview of the EMVA data of our cameras. Detailed measurement reports for each camera model can be downloaded from our website: baslerweb.com/emva-downloads

Functioning of a Sensor

The sensor is the heart of a camera and therefore its most important component. A sensor consists of pixels with photodiodes that convert energy of the incoming photons to an electrical charge which is then converted and processed to generate an image.

Sensor or camera properties are measured with different parameters. For the following explanation of the most common parameters we use an example from bottle inspection.

Quantum Efficiency QE [%]

The incident photon to converted electron ratio is called quantum efficiency. The QE depends on the wavelength of the light. The bigger the number of electrons produced by a given number of photons, the higher the QE and the more information is available in an image. A high quantum efficiency is especially important in low light conditions.

Temporal Dark Noise [e-]

Even if no light hits the sensor, some electrons are captured by pixels and create a signal that is called dark noise. Those electrons result from the electronics that surround the sensor. The less dark noise, the clearer the image and the better the signals can be detected.

Saturation Capacity [ke-]

The number of electrons a pixel can hold is limited and given by the saturation capacity. In a saturated pixel no more photons can be converted into electrons and thus image information is lost.

In the example, the fill level of the bottle in fig. 4 is invisible as the saturation capacity of the camera is reached. At a shorter exposure time (fig. 3) the fill level is detectable but at the expense of the barcode visibility.

Dynamic Range [dB]

The ratio between maximum and minimum measurable light intensities is described as dynamic range. A high dynamic range is especially important when there are both, dark and bright details in an image, or when light conditions are changing.

A camera with a higher dynamic range is able to deliver more levels of grey in the images (fig. 2). Details as barcodes, labels or the bottle cap can be inspected more accurately.

Signal to Noise Ratio SNR [dB]

The SNR compares the level of a desired signal to the level of background noise. In the overview on the following pages the best possible SNR is given.

The barcode example shows the image of a camera with high SNR (fig. 2) and one with lower SNR (fig. 3). For a better result, this camera needs a longer exposure time (fig. 4) or a more efficient illumination.



Fig. 1 Test Setup

How Does Basler Measure and Define Image Quality?

Basler is leading the effort to standardize image quality and sensitivity measurement for cameras and sensors. We are giving the EMVA 1288 standard our strongest support because it describes a unified method to measure, compute, and present the specification parameters for cameras and image sensors. Our cameras are characterized and measured in 100 % compliance with the EMVA 1288 standard.



How Does Basler Ensure Superior Quality and Reliable High Performance?

Our approach to quality assurance is rigorous: we continually audit all facets of our business to ensure powerful performance, increase efficiency and reduce costs for our customers. We are compliant with all major quality standards including ISO 9001, CE, RoHS, and more. To ensure consistently high product quality, we employ several quality inspection procedures during manufacturing.

Every Basler camera is subjected to exhaustive optical and mechanical tests before leaving the factory. We have developed a unique combination of optics, hardware, and software tools that can quickly and efficiently calibrate a camera and measure its performance against a set of standard performance criteria. Regardless of what technology or camera model you choose you can be assured of consistent performance.

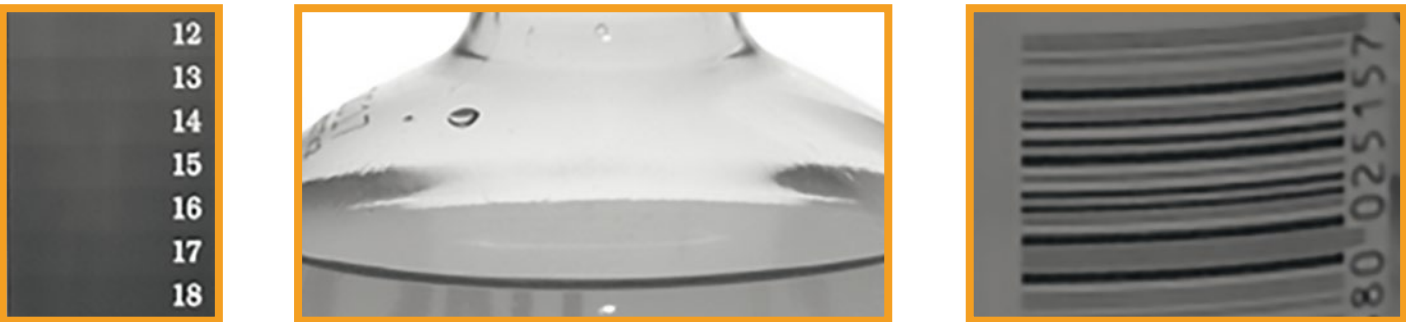


Fig. 2 Camera A with good EMVA properties

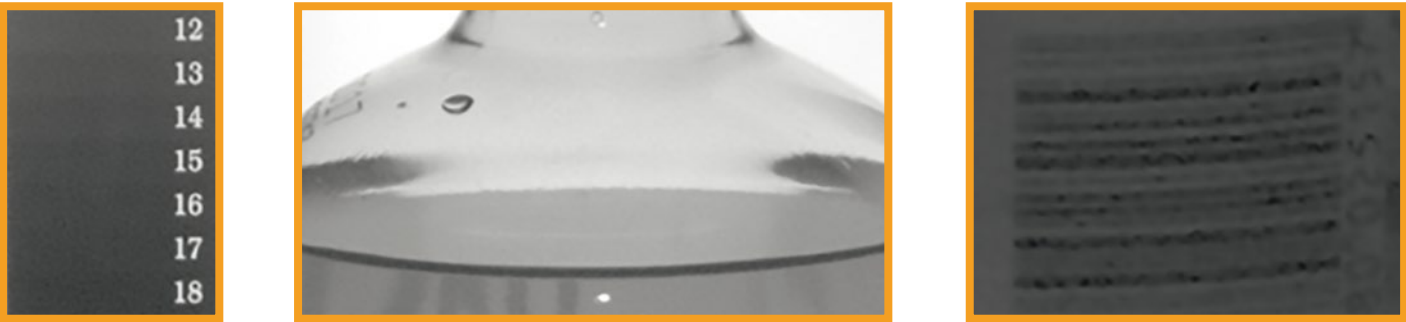


Fig. 3 Camera B with inferior EMVA properties



Fig. 4 Camera B with longer exposure time

Sensor	Type	Shutter	Resolution [MP]	Pixel [H × V]	Pixel Size [μm]	Optical Size ["]	Series	Frame Rate [fps]			QE [%]	Dark Noise [e ⁻]	Sat. Capacity [ke ⁻]	Dynamic Range [dB]	Max. SNR [dB]	
								USB	GIGE	5GIGE						CXP-12
Sony																
ICX618 Replacement	CMOS	global	VGA	659 × 494	5.6	1/4	ace	–	134	–	–	63	5	28.0	75	45
IMX174	CMOS	global	2.3	1920 × 1200	5.86	1/1.2	ace	164	50	–	–	70	7	31.8	74	45
IMX178	CMOS	rolling	6	3088 × 2064	2.4	1/1.8	ace	59	16	–	–	81	3	14.3	73	42
IMX183	CMOS	rolling	20	5472 × 3648	2.4	1	ace	17	5	–	–	75	3	13.8	71	41
IMX226	CMOS	rolling	12	4024 × 3036	1.85	1/1.7	ace	31	8	–	–	83	3	11.0	70	40
IMX249	CMOS	global	2.3	1920 × 1200	5.86	1/1.2	ace	41	42	–	–	70	7	31.9	74	45
IMX250	CMOS	global	5	2448 × 2048	3.45	2/3	ace ace 2	75 –	– –	– 98	–	68	2	10.7	73	40
IMX252	CMOS	global	3	2048 × 1536	3.45	1/1.8	ace	120	–	–	–	69	2	10.5	73	40
IMX253	CMOS	global	12	4096 × 3000	3.45	1.1	ace boost	30 –	– –	– –	– 68	70	2	10.5	73	40
IMX255	CMOS	global	9	4096 × 2160	3.45	1	ace boost	40 –	– –	– –	– 93	70	2	10.5	73	40
IMX264	CMOS	global	5	2448 × 2048	3.45	2/3	ace	35	20	–	–	68	2	10.4	73	40
IMX265	CMOS	global	3	2048 × 1536	3.45	1/1.8	ace	55	35	–	–	68	2	10.5	73	40
IMX267	CMOS	global	9	4096 × 2160	3.45	1	ace	30	12	–	–	69	2	10.2	73	40
IMX273	CMOS	global	1.6	1440 × 1080	3.45	1/2.9	ace	227	73	–	–	63	3	10.5	71	40
IMX287	CMOS	global	VGA	720 × 540	6.9	1/2.9	ace	525	291	–	–	63	7	21.0	74	43
IMX304	CMOS	global	12	4096 × 3000	3.45	1.1	ace	20	8	–	–	69	2	10.2	73	40
IMX334	CMOS	rolling	5 8.3	2592 × 1944 3840 × 2160	2.0 2.0	1/2.8 1/1.8	ace 2 ace 2	60 45	22 13	–	–	73	2	7.2	69	39
IMX392	CMOS	global	2.3	1920 × 1200	3.45	1/2.3	ace 2	160	51	168	–	62	3	10.5	72	40
IMX421	CMOS	global	3	1936 × 1464	4.5	2/3	boost	–	–	–	400	69	6	24.6	72	44
IMX530	CMOS	global	24.4	5328 × 4608	2.74	1.2	boost	–	–	–	100	66	2	9.6	71	40
IMX531	CMOS	global	20	4504 × 4504	2.74	1.1	boost	–	–	–	100	67	2	9.7	71	40
IMX532	CMOS	global	16.1	5320 × 3032	2.74	1.1	boost	–	–	–	150	65	2	9.6	71	40
IMX535	CMOS	global	12	4096 × 3000	2.74	1/1.1	boost	–	–	–	180	66	3	10	70	40
IMX536	CMOS	global	8	2832 × 2840	2.74	2/3	boost	–	–	–	190	66	3	9.6	70	40
IMX537	CMOS	global	5	2448 × 2048	2.74	1/1.8	ace 2 boost	– –	– –	– –	212 250	66	3	9.8	70	40
IMX540	CMOS	global	24.4	5328 × 4608	2.74	1.2	ace 2	15	4	22	35	66	2	9.7	71	40
IMX541	CMOS	global	20.2	4504 × 4504	2.74	1.1	ace 2	18	5	27	42	66	2	9.7	71	40
IMX542	CMOS	global	16.1	5320 × 3032	2.74	1.1	ace 2	23	7	34	52	66	2	9.7	71	40
IMX545	CMOS	global	12.3	4096 × 3000	2.74	1/1.1	ace 2	30	9	44	67	67	3	9.9	70	40
IMX546	CMOS	global	8	2840 × 2840	2.74	2/3	ace 2	48	14	67	86	66	2	9.8	70	40
IMX547	CMOS	global	5	2448 × 2048	2.74	1/1.8	ace 2	75	23	106	122	66	2	9.9	70	40
IMX676	CMOS	rolling	12.5	3536 × 3536	2	1/1.6	ace 2	31	9	42	–	92	4	11.2	68	40
IMX900	CMOS	global	3.2	2048 × 1536	2.25	1/3.1	ace 2	114	37	114	–	87	5	11.3	65	40

Please note that only monochrome area scan cameras are listed in this overview. Specifications are subject to change without notice.

Sensor	Type	Shutter	Resolution [MP]	Pixel [H × V]	Pixel Size [μm]	Optical Size ["]	Series	Frame Rate [fps]					QE [%]	Dark Noise [e ⁻]	Sat. Capacity [ke ⁻]	Dynamic Range [dB]	Max. SNR [dB]
								USB	GIGE	5GIGE	CXP-12	CL					
ams																	
CMV2000	CMOS	global	2	2048 × 1088	5.50	2/3	ace	165	50	–	340	–	63	14	9.3	57	40
CMV4000	CMOS	global	4	2048 × 2048	5.50	1	ace	90	25	–	180	–	62	14	11.9	59	41
CMV4000 NIR-enhanced	CMOS	global	4	2048 × 2048	5.50	1	ace	90	25	–	180	–	62	14	12.4	59	41
CMV12000	CMOS	global	12	4096 × 3072	5.50	1.75	beat	–	–	–	–	62	45	14	11.6	59	41
e2V																	
EV76C560	CMOS	rolling switchable	1.3	1282 × 1026	5.30	1/1.8	ace	–	60	–	–	–	55	10	9.5	60	40
			1.3	1282 × 1026	5.30	1/1.8	ace	–	60	–	–	–	54	25	9.5	52	40
EV76C570	CMOS	switchable	2	1602 × 1202	4.50	1/1.8	ace	–	60	–	–	–	47	22	6.8	50	38
EV76C661 NIR-enhanced	CMOS	switchable	1.3	1280 × 1024	5.30	1/1.8	ace	–	60	–	–	–	59	23	7.4	50	39
onsemi																	
MT9J003	CMOS	rolling	10	3840 × 2748	1.67	1/2.3	ace	14	10	–	–	–	46	6	2.8	54	34
MT9P031	CMOS	rolling	2	1920 × 1080	2.20	1/3.7	ace	25	25	–	–	–	57	6	6.7	60	38
			5	2592 × 1944	2.20	1/2.5	ace	14	14	–	–	–					
PYTHON 300	CMOS	global	VGA	640 × 480	4.80	1/4	ace	751	376	–	–	–	52	11	7.1	57	39
PYTHON 500	CMOS	global	CCIR	800 × 600	4.80	1/3.6	ace	511	240	–	–	–	54	11	7.8	57	39
PYTHON 1300	CMOS	global	1.3	1280 × 1024	4.80	1/2	ace	203	88	–	–	–	53	11	6.9	56	38
PYTHON 2000	CMOS	global	2.3	1920 × 1200	4.80	2/3	ace	150	50	–	–	–	54	11	7.8	57	39
PYTHON 5000	CMOS	global	5	2590 × 2048	4.80	1	ace	60	21	–	–	–	55	12	8.2	57	39
XGS 20000	CMOS	global	20	4500 × 4500	3.2	1.3	boost	–	–	–	45	–	55	4	9.2	66	40
XGS 32000	CMOS	global	32.4	6580 × 4935	3.2	APS-C	boost	–	–	–	35	–	57	4	9.3	66	40
XGS 45000	CMOS	global	44.7	8192 × 5460	3.2	35 mm	boost	–	–		15	–	55	5	9.0	65	40
Gpixel																	
GMAX0505	CMOS	global	25	5120 × 5120	2.5	1.1	boost	–	–	–	150	–	51	4	4.3	60	36
GMAX2505	CMOS	global	5.6	2600 × 2160	2.5	1/2	ace 2	64	20	–	–	–	53	1	4.8	70	37
GMAX2509	CMOS	global	9.1	4200 × 2160	2.5	2/3	ace 2	12	40	–	–	–	53	1	4.6	69	37
GMAX2518	CMOS	global	18	4508 × 4096	2.5	1	ace 2	20	6	–	–	–	56	3	6.7	66	38
GMAX3265	CMOS	global	65	9344 × 7000	3.2	2.3	boost	–	–	–	30 or 70	–	52	8	10.4	61	40
GSPRINT4521	CMOS	global	21	5120 × 4096	4.5	APS-C	boost	–	–	–	230	–	53	33	31.6	59	45
OmniVision																	
OG05C	CMOS	global	5	2448 × 2048	3.45	2/3	ace 2	77	23	115	–	–	85	13	33.8	68	45
Basler specific																	
E2525A	CMOS	global	25	5060 × 5060	2.5	1.1	ace 2	15	4	21	35	–	66	3	8.1	68	39

Please note that only monochrome area scan cameras are listed in this overview. Specifications are subject to change without notice.

The **SWIR sensors** listed below use InGaAs technology and should not be directly compared to CMOS sensors.
If you have any questions, please contact our sales team: baslerweb.com/sales.

SENSOR	TYPE	SHUTTER	RESOLUTION [MP]	PIXEL [H × V]	PIXEL SIZE [μm]	OPTICAL SIZE ["]	SERIES	FRAME RATE [fps]					QE [%]	DARK NOISE [e ⁻]	SAT. CAPACITY [ke ⁻]	DYNAMIC RANGE [dB]	MAX. SNR [dB]
								USB	GIGE	5GIGE	CXP-12	CL					
SWIR																	
IMX990	InGaAs	global	1.3	1280 × 1024	5	1/2	ace 2	125	80	–	–	–	62	232	13.8	55	51
IMX991	InGaAs	global	VGA	640 × 512	5	1/4	ace 2	240	240	–	–	–	62	232	13.8	55	51
IMX992	InGaAs	global	5.2	2560 × 2048	3.45	1/1.4	ace 2	70	20	–	131	–	88	201	67.3	51	48
IMX993	InGaAs	global	3.1	2048 × 1536	3.45	1/1.8	ace 2	110	35	–	173	–	88	201	67.3	51	48

Contrary to the requirements of the EMVA1288 standard, the wavelength of 541 nm may not meet the sensitivity maximum for sensors that are also sensitive outside the visible spectral range.

The **UV sensor** listed below should not be directly compared to other CMOS sensors since it is sensitive in another spectral range.
If you have any questions, please contact our sales team: baslerweb.com/sales.

SENSOR	TYPE	SHUTTER	RESOLUTION [MP]	PIXEL [H × V]	PIXEL SIZE [μm]	OPTICAL SIZE ["]	SERIES	FRAME RATE [fps]			QE [%]	DARK NOISE [e ⁻]	SAT. CAPACITY [ke ⁻]	DYNAMIC RANGE [dB]	MAX. SNR [dB]	
								USB	GIGE	5GIGE						CXP-12
Sony																
IMX487	CMOS	global	8.1	2856 × 2848	2.74	2/3	ace 2	48	14	67	–	51	3	9.9	70	40

Contrary to the requirements of the EMVA1288 standard, the wavelength of 541 nm may not meet the sensitivity maximum for sensors that are also sensitive outside the visible spectral range.

SONY
ICX618 Replacement acA640-121gm
IMX174 acA1920-50gm acA1920-155um
IMX178 acA3088-16gm acA3088-57um
IMX183 acA5472-5gm acA5472-17um
IMX226 acA4024-8gm acA4024-29um
IMX249 acA1920-40gm acA1920-40um
IMX250 acA2440-75um a2A2440-98g5mBAS
IMX252 acA2040-120um
IMX253 acA4112-30um boA4112-68cm
IMX255 acA4096-40um boA4096-93cm
IMX264 acA2440-20gm acA2440-35um
IMX265 acA2040-35gm acA2040-55um
IMX267 acA4096-11gm acA4096-30um
IMX273 acA1440-73gm acA1440-220um
IMX287 acA720-290gm acA720-520um

SONY
IMX304 acA4112-8gm acA4112-20um
IMX334 a2A3840-13gmBAS/PRO a2A2590-22gmBAS/PRO a2A3840-45umBAS/PRO a2A2590-60umBAS/PRO
IMX392 a2A1920-51gmBAS/PRO a2A1920-51gmIP67 a2A1920-160umBAS/PRO a2A1920-165g5mBAS a2A1920-168mgm
IMX421 boA1936-400cm
IMX530 boA5328-100cm
IMX531 boA4504-100cm
IMX532 boA5320-150cm
IMX535 boA4096-180cm
IMX536 boA2832-190cm
IMX537 a2A2448-210cm boA2448-250cm
IMX540 a2A5328-4gmBAS/PRO a2A5328-4gmIP67 a2A5328-15umBAS/PRO a2A5328-19mgm a2A5328-22g5mBAS a2A5328-35cm
IMX541 a2A4504-5gmBAS/PRO a2A4504-5gmIP67 a2A4504-18umBAS/PRO a2A4504-27g5mBAS a2A4504-42cm

SONY
IMX542 a2A5320-7gmBAS/PRO a2A5320-7gmIP67 a2A5320-23umBAS/PRO a2A5320-29mgm a2A5320-34g5mBAS a2A5320-52cm
IMX545 a2A4096-9gmBAS/PRO a2A4096-9mIP67 a2A4096-30umBAS/PRO a2A4096-44g5mBAS a2A4096-67cm
IMX546 a2A2840-14gmBAS/PRO a2A2840-14gmIP67 a2A2840-48umBAS/PRO a2A2840-67g5mBAS a2A2840-86cm
IMX547 a2A2448-23gmBAS/PRO a2A2448-23gmIP67 a2A2448-75umBAS/PRO a2A2448-90mgm a2A2448-105g5mBAS a2A2448-120cm
IMX676 a2A3536-9gmBAS/PRO a2A3536-31umBAS/PRO a2A3536-37mgm a2A3536-42g5mBAS
IMX900 a2A2048-37gmBAS/PRO a2A2048-114umBAS/PRO a2A2048-114g5mBAS

SONY SENSWIR
IMX990 a2A1280-80gmSWIR a2A1280-125umSWIR
IMX991 a2A640-240gmSWIR a2A640-240umSWIR
IMX992 a2A2560-20gmSWIR a2A2560-70umSWIR a2A2560-131cmSWIR
IMX993 a2A2048-35gmSWIR a2A2048-110umSWIR a2A2048-173cmSWIR
SONY UV
IMX487 a2A2840-14gmUV a2A2840-48umUV a2A2840-67g5mUV

BASLER SPECIFIC
E2525A a2A5060-4gmBAS a2A5060-15umBAS a2A5060-21g5mBAS a2A5060-35cm
AMS
CMV2000 acA2000-50gm acA2000-165um acA2000-340km
CMV4000 acA2040-25gm acA2040-90um acA2040-180km
CMV4000 NIR acA2040-25gmNIR acA2040-90umNIR acA2040-180kmNIR
CMV12000 beA4000-62km

GPIXEL
GMAX0505 boA5120-150cm
GMAX2505 a2A2600-20gmBAS/PRO a2A2600-64umBAS/PRO
GMAX2509 a2A4200-12gmBAS/PRO a2A4200-40umBAS/PRO
GMAX2518 a2A4508-6gmBAS/PRO a2A4508-20umBAS/PRO
GMAX3265 boA9344-30cm boA9344-70cm
GSPRINT4521 boA5120-230cm
E2V
EV76C560 acA1280-60gm acA1300-60gm
EV76C570 acA1600-60gm
EV76C661 acA1300-60gmNIR

ONSEMI
MT9J003 acA3800-10gm acA3800-14um
MT9P031 acA2500-14gm acA2500-14um acA1920-25gm acA1920-25um
PYTHON 300 acA640-300gm acA640-750um
PYTHON 500 acA800-200gm acA800-510um
PYTHON 1300 acA1300-75gm acA1300-200um
PYTHON 2000 acA1920-48gm acA1920-150um
PYTHON 5000 acA2500-20gm acA2500-60um
XGS 20000 boA4500-45cm
XGS 32000 boA6500-36cm
XGS 45000 boA8100-16cm

OMNIVISION
OG05C a2A2464-23gmBAS/PRO a2A2464-77umBAS/PRO a2A2464-115g5mBAS

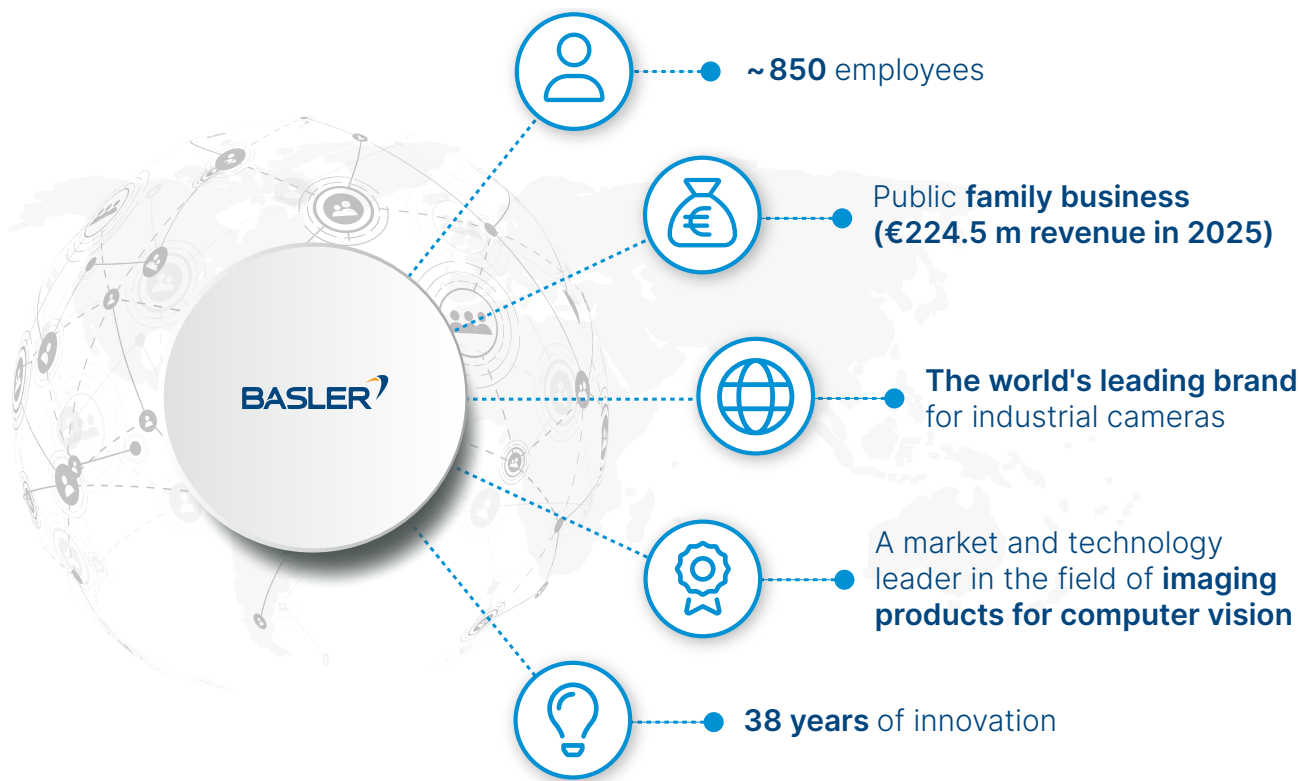
How to Read Our Camera Model Names

ac	A	2040	180	k	m	NIR
Model	Type	Resolution	Frame Rate	Interface	Color	Spectrum
a2 = ace 2 ac = ace bo = boost da = dart dm = dart M pu = pulse ra = racer r2 = racer 2	A = Area scan L = Line scan T = TDI	Horizontal pixels	Number of frames per second (fps) at full AOI	k = CL c = CoaXPress g = GigE g5 = 5GigE u = USB 3.0 mg = GMSL m = BCON for MIPI	m = mono c = color	NIR = Near Infrared SWIR = Short Wavelength Infrared UV = Ultraviolet Product Line BAS = Basic PRO = Pro ISP i = Internal ISP for MIPI cameras IP67 IP67 = Ingress Protection 67

Specifications are subject to change without notice.

About Basler

Basler AG is an international leader and experienced expert in computer vision. The company offers a broad coordinated portfolio of vision hardware and software. In addition, it enables customers to solve their vision application issues by developing customer-specific products or solutions. Founded in 1988, the Basler Group employs around 850 people at its headquarters in Ahrensburg, Germany, as well as other sales and development locations throughout Europe, Asia, and North America.





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