Photron

FASTCAM SA-X2

1-Megapixel CMOS Image Sensor:
1024 x 1024 pixels at 12,500fps
1024 x 1000 pixels at 13,500fps
768 x 768 pixels at 22,500fps
512 x 512 pixels at 45,000fps
512 x 376 pixels at 60,000fps
256 x 280 pixels at 120,000fps

Maximum Frame Rate:
216,000fps (FASTCAM SA-X2 type 200K)
480,000fps (FASTCAM SA-X2 type 480K)
1,080,000fps (FASTCAM SA-X2 type 1080K)

Class Leading Light Sensitivity:
ISO 25,000 monochrome
ISO 10,000 color

Global Electronic Shutter:
1ms to 293ns independent of frame rate
(sub-microsecond shutter available on type
1080K only, subject to export control)

Dynamic Range (ADC):
12-bit monochrome, 36-bit color

Internal Recording Memory:
8GB, 16GB, 32GB, 64GB, or 128GB

Internal Memory Card Drives:
Allowing high-speed download of images to
low cost removable SD memory storage.

Fast Gigabit Ethernet Interface:
Dual Gigabit Ethernet Interface provides
high-speed image download to standard
notebook/PC

Flexible Frame Synchronization:
Frame rate may be synchronized to
external unstable frequencies

Fan Stop Function:
Remotely switch off cooling fans to eliminate
vibration when recording at high magnifications

High performance high-speed camera system

In order to meet the requirements of the most demanding high-speed imaging applications a balance of high frame rate, image resolution, dynamic range and light sensitivity is required. The FASTCAM SA-X2 high-speed camera system has been designed to provide a careful balance of these requirements.

FASTCAM SA-X2 brings together unique CMOS image sensor technologies and digital imaging expertise to provide optimum imaging performance. The system offers recording rates up to 13,500fps at megapixel image resolution with 12-bit dynamic range and high image quality. Frame rates greater than 1 million fps are available at reduced image resolution with shutter speeds as short as 293 nanoseconds (export restrictions may apply).

Light sensitivity is often the most critical performance criteria in high speed imaging. Without high light sensitivity, imaging at high frame rates with short exposure times is not possible. A camera system providing high light sensitivity allows a wide range of objective lenses and lighting techniques to be optimized to visualize complex high-speed phenomena.

The FASTCAM SA-X2 system may be controlled over a high-speed Gigabit Ethernet network or via the optional keypad. Standard operational features of the FASTCAM SA-X2 include a mechanical shutter to allow remote system calibration, dual-channel Gigabit Ethernet Interface for fast image download, and internal memory card drives allowing image download and storage to low cost removable recording media. The system also features memory segmentation to allow recording in one memory partition while at the same time downloading a previous recording, and the ability to remotely switch off cooling fans to eliminate vibration when recording at high magnifications.

The system is supplied with intuitive and feature rich Photron FASTCAM Viewer (PFV) software and Photron Device Control SDK (software development kit) allowing integration with user specific software. Alternatively the camera can be controlled as a device within a MATLAB ® or LabVIEW environment.

Light Sensitivity:

FASTCAM SA-X2	
Monochrome models	ISO 25,000
Color models	ISO 10,000

Monochrome sensors used in the FASTCAM SA-X2 are supplied without an IR absorbing filter, extending the camera's spectral response beyond 900nm. When the sensitivity of the FASTCAM SA-X2 is measured to tungsten light including near IR response an equivalent value of ISO 100,000 is obtained.

Image Sensor:

The FASTCAM SA-X2 uses an advanced CMOS image sensor optimized for light sensitivity and high image quality that is unique to Photron.
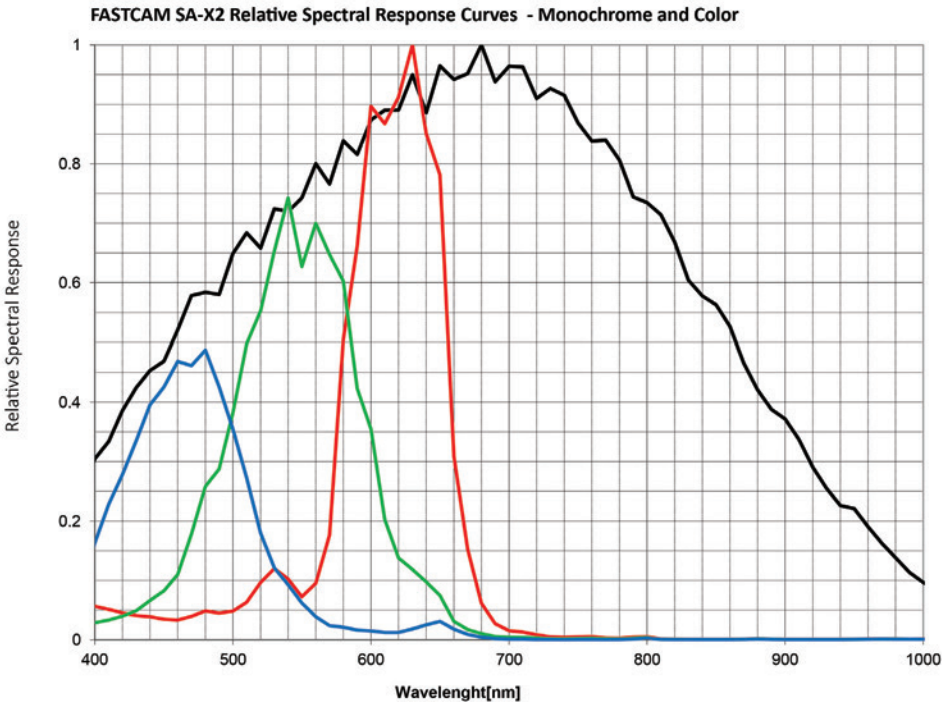
A 20-micron pixel pitch gives a sensor size at full image resolution of 20.48 x 20.48mm (diagonal 28.96mm).

Lenses designed for both FX (35mm full frame) and also DX (APS-C digital SLR) formats are fully compatible with the FASTCAM SA-X2 at full image resolution.

Sensor Type	Proprietary Design Advanced CMOS
Maximum Resolution (pixels)	1024 x 1024 pixels
Sensor Size / Diagonal	20.48 x 20.48mm / 28.96mm
Pixel Size (microns)	20μm x 20μm
Quantum Efficiency	46% at 630nm
Fill Factor	58%
Color Matrix	Bayer CFA (single sensor)
Light Sensitivity	ISO 25,000 monochrome ISO 10,000 color (monochrome sensor equivalent ISO 100,000 including near IR response)
Shutter	Global Electronic Shutter 1ms to 1μs independent of frame rate (1080K only: 293ns shutter available subject to export control)

FASTCAM SA-X2 Relative Spectral Response Curves - Monochrome and Color

Camera Performance Specifications

Model	SA-X2
Full Frame Performance	12,500fps 1024 x 1024 pixels
Maximum Frame Rate	Type 200K: 216,000fps Type 480K: 480,000fps* Type 1080K: 1,080,000fps*
Minimum Exposure	Global electronic shutter to 1μs selectable independent of frame rate (293ns option available with SA-X2 type 1080K only) *
Ruggedized Mechanical Calibration Shutter	Standard Feature
Dynamic Range (ADC)	12-bit monochrome 36-bit color
Memory Capacity Options	8GB: 5,455 frames at full resolution 16GB: 10,916 frames at full resolution 32GB: 21,839 frames at full resolution 64GB: 43,684 frames at full resolution 128GB: TBA - early 2017
Memory Partitions	Up to 128 memory segments
Region of Interest	Selectable in steps of 128 pixels (horizontal) x 8 pixels (vertical)
Trigger Inputs	Selectable +/- TTL 5V and switch closure
Trigger Delay	Programmable on selected input / output triggers: 100ns resolution
Input / Output	Input: Trigger (TTL/Switch), sync, ready, event, IRIG Output: trigger, sync, ready, rec, exposure
Trigger Modes	Start, end, center, manual, random, random reset, random center, random manual, random loop, record on command
Time Code Input	IRIG-B
External Sync	+/- TTL 5Vp-p Variable frequency sync
Camera Control Interface	High-speed Gigabit Ethernet - (Single or Dual connections)
Image Data Display	Frame rate, shutter speed, trigger mode, date/time, status, real time / IRIG time, frame count, resolution
Saved Image Formats	JPEG, AVI, TIFF, BMP, RAW, RAWW, MRAW, PNG, MOV, and FTIF - Images can be saved with or without image data and in 8-bit, 12-bit,16-bit or 36-bit depth of sensor where supported
Supported OS	Microsoft Windows operating system including: 7, 8, 8.1, 10 (32/64-bit)

* Frame rates above 225,000fps and exposure times below 1μs may be subject to export control regulations in some areas

Removable Data Storage Options:

To enable the rapid transfer of camera memory data to high capacity, removable non-volatile storage media the FASTCAM SA-X2 provides two UHS-I (SDR104) compatible SD memory card drives. This allows image data captured to camera memory to be quickly transferred to low cost storage media, allowing a new image sequence to be recorded to camera memory.

Control of download operation using on-camera user switches or via the optional Remote Control Keypad allows full camera operation and data storage without the requirement for connection to a computer.

Camera Operation Features

Frame Synchronization	Accurate frame synchronization with other cameras and with external and unstable frequencies.
Dual Slope Shutter (Extended Dynamic Range)	Selectable in 20 steps (0 to 95% in 5% increments) to prevent pixel over exposure without post processing.
Memory Partitions	Up to 128 memory segments allow multiple events to be stored in camera memory before downloading, with automatic progression to the next available partition.
Low Light Mode	Operation at minimum frame rate with independent adjustable shutter time to allow easy camera set-up and focus in ambient lighting.
Video Output	Live and playback via dual HD-SDI or RS-170 (NTSC/PAL) (zoom, pan, scroll control via optional LCD keypad).
IRIG Phase Lock	Enables multiple cameras to be synchronized to an IRIG time source.
Internal Delay Generator	Allows programmable delays to be set on input and output triggers, 100ns resolution.
Event Markers	Up to ten user entered event markers to define specific events within the recorded image sequence .
Download While Recording	FASTCAM SA-X2 supports Partition Recording Mode, allowing image data captured in one memory partition to be downloaded while at the same time recording into another partition.
Automatic Download	The system can be set to automatically download image data to the control PC and, when download is complete to re-arm in readiness for the next trigger with automatically incremented file names.
Software Binning	Virtual pixel binning (2x2, 4x4 etc.) allows increased light sensitivity with reduced image resolution without changing camera field of view.
SD Media Storage	Two UHS-I (SDR104) compatible SD memory card drives allow data transfer to low cost and convenient non-volatile removable media.

Software Operation Features

Image Calibration	2D image calibration allows the measurement of distance and angle from the image. A calibration grid overlay can be superimposed on the image.
Image Overlay	A stored reference image may be overlaid on the live image to allow accurate camera positioning to achieve the same view as a previous test.
Import of Multiple Image Sequences	Multiple image sequences can be loaded and simultaneously replayed. Timing of image sequences can be adjusted to create a common time reference. Time based synchronization allows images captured at different frame rates to be synchronized.
High Dynamic Range Mode	Making use of the full sensor dynamic range, HDR mode allows enhanced detail in both light and dark areas of an image to be displayed simultaneously.
Motion Detector	In order to highlight subtle changes in an image, Motion Detector allows a reference image to be subtracted from a recorded sequence. Details including propagation of shock waves and surface changes during impact can be visualized using the feature.
Line Profile	A line profile representing grey levels along a line drawn across any region of the image is displayed. In live mode the Line Profile can be used to ensure optimum image focus is achieved.
Histogram	A histogram displaying grey levels within a user-defined image area is displayed. In live mode the Histogram can be used to ensure that optimum exposure levels are set for the scene being recorded.
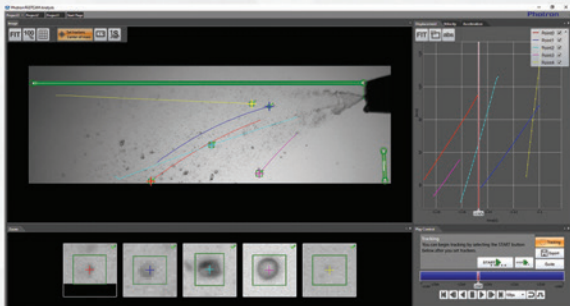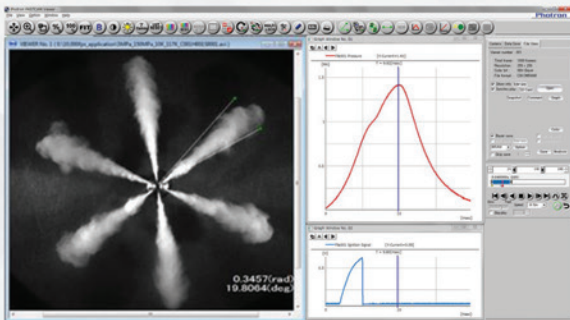
Photron FASTCAM Viewer:
Photron FASTCAM Viewer software (PFV) has been designed to provide an intuitive and feature rich user interface for the control of Photron high-speed cameras, data saving, image replay and simple motion analysis. Advanced operation menus provide access to features for advanced camera operation and image enhancement. Tools are provided to allow image calibration and easy measurement of angles and distances from image data. Also included are a C++ SDK and wrappers for LabView and MATLAB ®.

An optional software plug-in module provides synchronisation between Photron high- speed cameras and data acquired through National Instruments data acquisition systems. Synchronised data captured by the DAQ system provides waveform information which can be viewed alongside high-speed camera images.

Photron FASTCAM Analysis:
PFV software allows image sequences to be exported directly to optional Photron FASTCAM Analysis (PFA) Motion Analysis software. This entry level Motion Analysis software with an on screen 'step by step guide' function launches automatically from Photron FASTCAM Viewer software, and provides automated tracking of up to 5 points using feature or correlation tracking algorithms for the automated analysis of motion within an image sequence.

Variable Region of Interest:
Region of Interest (ROI) or sub-windowing allows a user-specified portion of the sensor to be defined to capture images. By using a reduced portion of the image area, the frame rate at which images are recorded can be increased. FASTCAM SA-X2 allows the ROI to be set in increments of 128 pixels horizontal and 8 pixels vertical.

Square Image Sensor Format:
Unlike broadcast and media applications where image formats such as 16:9 have now become standard, in scientific and industrial imaging applications an image sensor with a 1:1 image format is generally accepted to be advantageous. To capture the maximum useful image data in applications including microscopy, detonics, combustion imaging and many others, a 1:1 sensor format provides greater flexibility than 'letterbox' image formats. The FASTCAM SA-X2 image sensor allows the user to choose either square or rectangular image formats in order to obtain the maximum subject information.

External Frame Synchronization:
The FASTCAM SA-X2 can be fully synchronized with an external event to allow the timing of when each individual image is captured to be precisely referenced. The camera can be accurately synchronized to unstable frequencies allowing complex events such as combustion in rapidly accelerating or decelerating engines to be recorded and studied.

Record During Download Operation:
FASTCAM SA-X2 recording memory can be divided into multiple active sections. The user can record an on-going event in one memory partition while at the same time downloading a previously recorded image sequence in order to improve workflow and optimize camera operation.

SA-X2 1080K

Resolution	Frame Rate	8GB		16GB		32GB		64GB		128GB	
(h x v pixels)	Max fps	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**
1024 x 1024	12,500	5,455	0.44	10,916	0.87	21,839	1.75	43,684	3.49	87,375	6.99
1024 x 1000	13,500	5,586	0.42	11,178	0.83	22,363	1.66	44,733	3.31	89,472	6.63
1024 x 672	20,000	8,313	0.42	16,635	0.83	33,280	1.66	66,568	3.33	133,144	6.66
896 x 496	30,000	12,874	0.43	25,760	0.86	51,531	1.72	103,074	3.44	206,160	6.87
896 x 368	40,000	17,352	0.44	34,720	0.87	69,456	1.74	138,927	3.47	277,868	6.95
768 x 272	60,000	27,391	0.46	54,805	0.91	109,632	1.83	219,287	3.65	438,597	7.31
640 x 256	72,000	34,924	0.49	69,877	0.97	139,782	1.94	279,592	3.88	559,212	7.77
512 x 512	45,000	21,827	0.49	43,672	0.97	87,363	1.94	174,744	3.88	349,507	7.77
512 x 272	81,000	41,088	0.51	82,209	1.01	164,450	2.03	328,932	4.06	657,897	8.12
384 x 264	100,000	56,445	0.57	112,934	1.13	225,912	2.26	451,868	4.52	903,779	9.04
256 x 152	200,000	147,058	0.74	294,227	1.47	588,564	2.94	1,177,238	5.89	2,354,587	11.77
256 x 80	300,000	279,413	0.94	559,033	1.86	1,118,274	3.73	2,236,755	7.46	4,473,717	14.91
128 x 48	480,000	931,382	1.95	1,863,450	3.88	3,727,585	7.77	7,455,855	15.53	14,912,396	31.07
128 x 40	540,000	1,117,659	2.07	2,236,140	4.14	4,473,103	8.28	8,947,027	16.57	17,894,875	33.14
128 x 8	1,080,000	5,588,307	5.18	11,180,712	10.35	22,365,523	20.71	44,735,144	41.42	89,474,387	82.85

SA-X2 480K

Resolution	Frame Rate	8GB		16GB		32GB		64GB		128GB	
(h x v pixels)	Max fps	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**
1024 x 1024	12,500	5,455	0.44	10,916	0.87	21,839	1.75	43,684	3.49	87,375	6.99
1024 x 1000	13,500	5,586	0.42	11,178	0.83	22,363	1.66	44,733	3.31	89,472	6.63
1024 x 672	20,000	8,313	0.42	16,635	0.83	33,280	1.66	66,568	3.33	133,144	6.66
896 x 496	30,000	12,874	0.43	25,760	0.86	51,531	1.72	103,074	3.44	206,160	6.87
896 x 368	40,000	17,352	0.44	34,720	0.87	69,456	1.74	138,927	3.47	277,868	6.95
768 x 272	60,000	27,391	0.46	54,805	0.91	109,632	1.83	219,287	3.65	438,597	7.31
640 x 256	72,000	34,924	0.49	69,877	0.97	139,782	1.94	279,592	3.88	559,212	7.77
512 x 512	45,000	21,827	0.49	43,672	0.97	87,363	1.94	174,744	3.88	349,507	7.77
512 x 272	81,000	41,088	0.51	82,209	1.01	164,450	2.03	328,932	4.06	657,897	8.12
384 x 264	100,000	56,445	0.57	112,934	1.13	225,912	2.26	451,868	4.52	903,779	9.04
256 x 152	200,000	147,058	0.74	294,227	1.47	588,564	2.94	1,177,238	5.89	2,354,587	11.77
256 x 80	300,000	279,413	0.94	559,033	1.86	1,118,274	3.73	2,236,755	7.46	4,473,717	14.91
128 x 48	480,000	931,382	1.95	1,863,450	3.88	3,727,585	7.77	7,455,855	15.53	14,912,396	31.07
128 x 40	480,000	1,117,659	2.33	2,236,140	4.66	4,473,103	9.32	8,947,027	18.64	17,894,875	37.28
128 x 8	480,000	5,588,307	11.65	11,180,712	23.29	22,365,523	46.59	44,735,144	93.20	89,474,387	186.40

SA-X2 200K

Resolution	Frame Rate	8GB		16GB		32GB		64GB		128GB	
(h x v pixels)	Max fps	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**	Frames	Time (sec)**
1024 x 1024	12,500	5,455	0.44	10,916	0.87	21,839	1.75	43,684	3.49	87,375	6.99
1024 x 1000	13,500	5,586	0.42	11,178	0.83	22,363	1.66	44,733	3.31	89,472	6.63
1024 x 672	20,000	8,313	0.42	16,635	0.83	33,280	1.66	66,568	3.33	133,144	6.66
896 x 496	30,000	12,874	0.43	25,760	0.86	51,531	1.72	103,074	3.44	206,160	6.87
896 x 368	40,000	17,352	0.44	34,720	0.87	69,456	1.74	138,927	3.47	277,868	6.95
768 x 272	60,000	27,391	0.46	54,805	0.91	109,632	1.83	219,287	3.65	438,597	7.31
640 x 256	72,000	34,924	0.49	69,877	0.97	139,782	1.94	279,592	3.88	559,212	7.77
512 x 512	45,000	21,827	0.49	43,672	0.97	87,363	1.94	174,744	3.88	349,507	7.77
512 x 272	81,000	41,088	0.51	82,209	1.01	164,450	2.03	328,932	4.06	657,897	8.12
384 x 264	100,000	56,445	0.57	112,934	1.13	225,912	2.26	451,868	4.52	903,779	9.04
256 x 152	200,000	147,058	0.74	294,227	1.47	588,564	2.94	1,177,238	5.89	2,354,587	11.77
256 x 80	216,000	279,413	1.30	559,033	2.59	1,118,274	5.18	2,236,755	10.36	4,473,717	20.71
128 x 48	216,000	931,382	4.32	1,863,450	8.63	3,727,585	17.26	7,455,855	34.52	14,912,396	69.04
128 x 40	216,000	1,117,659	5.18	2,236,140	10.35	4,473,103	20.71	8,947,027	41.42	17,894,875	82.85
128 x 8	216,000	5,588,307	25.88	11,180,712	51.76	22,365,523	103.54	44,735,144	207.11	89,474,387	414.23

* Approximate recordable image count with 8-bit recording mode can be calculated by multiplying the figures above by 1.5

** Recording time is an estimate and may be different depending on recording conditions and settings. *Specifications subject to change without notice.*

Photo:
Marine Fuel Injection at 7,500fps

Remote Control LCD Keypad:
An optional hand-held remote control keypad is available to enhance field operation. The keypad provides the operator with local control of all primary camera functions to simplify camera set-up and allow operation without PC connection.

Nikon G-Type Compatible Lens Fitting:
The FASTCAM SA-X2 camera is equipped with an objective lens mount compatible with readily available Nikon G-type lenses. Controls provided within the lens mount allow the control of lens aperture on lenses without external iris control.

Canon EF Lens Mount Option:
An optional lens mount supporting Canon EF lenses is available for the FASTCAM SA-X2 providing remote control of lens aperture and iris hrough Photron PFV software.

Rugged Design:
The FASTCAM SA-X2 has been designed for operation in harsh environments. Usage of the system in high shock conditions has been confirmed by testing the system at 25G,11ms, 6-axes during operation.

Operation Environments:
An optional 'sealed case' version of the FASTCAM SA-X2 camera is available, designed specifically for use in high temperature conditions and locations where high levels of dust or particle contaminants may be present.

The FASTCAM SA-X2 RV camera utilizes thermal management structures within the camera body to ensure that during operation heat can be dissipated via a high performance heat sink on the top of the camera body. An externally mounted fan ensures optimum air flow and prevents dust and corrosive particles from being ingested within the camera body.

Specifications subject to change without notice.

All measurements are in millimeters (mm)
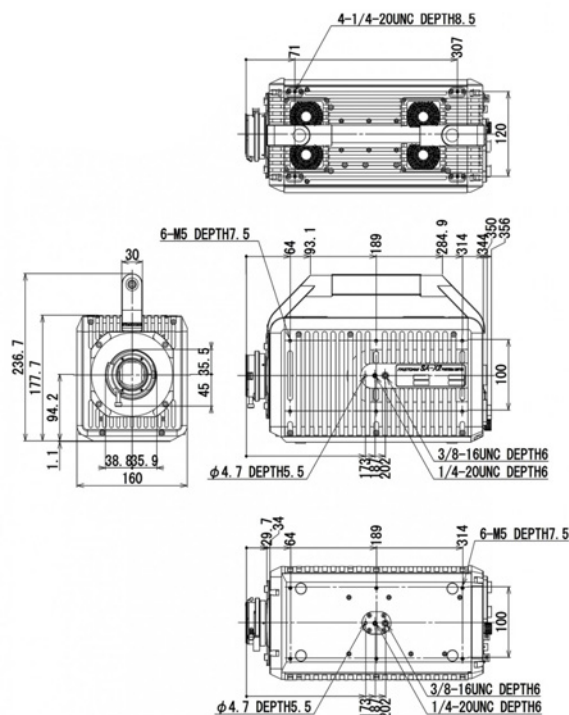
Mechanical and Environmental Specifications

Mechanical	
Lens Mount	F-mount (G-type lens compatible) and C-mount provided - Optional lens mounts available include Canon EF remote control mount
Camera Mountings	7 x 1/4 - 20 UNC (base, top and sides), 3 x 3/8 - 16 UNC (base and sides)
External Dimensions	
Camera Body (excluding protrusions)	177.7mm (H) x 160mm (W) x 350mm (D) 7.0" (H) x 6.3" (W) x 13.7" (D)
Camera Body *RV Model* (excluding protrusions)	230.3mm (H) x 160mm (W) x 350mm (D) 9.0" (H) x 6.3" (W) x 13.7" (D)
Weight	
Camera Body	9.9kg (21.82lbs)
Camera Body *RV Model*	13.7kg (30.3 lbs)
Environmental	
Operating Temperature	0 to 40C, 32˚ to 104˚F
Operating Temperature *RV Model*	0 to 45C, 32˚ to 113˚F
Storage Temperature	-20 to 60C, -4˚ to 140˚F
Humidity	80% or less (non-condensing)
Operational Shock	Tested to 25G, 11ms, 6-axes, 10 times/axis
Cooling	Internal fan cooling (fan-off mode supported)
Cooling *RV Model*	External fan / sealed housing (fan-off mode supported)
Power	
AC Power (with supplied adapter)	100 to 240V, 50 to 60Hz
DC Power	20 to 36V, 210VA