Photron
Technical Datasheet

FASTCAM SA-Z

The Photron FASTCAM SA-Z offers scientists, researchers and engineers the ability to capture high resolution digital images at ultra-high speeds to see and understand previously invisible processes and events. Using Photron's proprietary CMOS image sensor technology, FASTCAM SA-Z combines high recording rates with outstanding light sensitivity and excellent image quality to provide the most versatile ultra-high speed digital camera available today.

The ultra-high speed FASTCAM SA-Z provides megapixel image resolution at frame rates up to 21,000 frames per second (fps) from its highly light sensitive image sensor (monochrome ISO 50,000) with 12-bit dynamic range delivering the ultimate imaging performance. The FASTCAM SA-Z provides frame rates greater than 2 million frames per second at reduced image resolution and shutter speeds as short as 159 nanoseconds (export restrictions may apply).

An innovative camera body design exploiting heat-pipe technology provides a thermally stable and reliable high-speed imaging system suitable for use in the most challenging environments. Available in 12-bit monochrome or 36-bit color versions with recording memory options from 8GB to 128GB, the FASTCAM SA-Z offers versatility of use in a wide range of scientific and industrial applications.

Standard operational features of the FASTCAM SA-Z 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.

FASTCAM SA-Z is optionally available with the FASTDrive removable SSD drive permitting high-speed transfer of image data from camera recording memory to removable mass storage media enabling repeated recordings to be made in quick succession without the delays associated with download of data to a PC.

1-Megapixel CMOS Image Sensor:
1024 x 1024 pixels at 20,000fps
896 x 896 pixels at 25,000fps
768 x 512 pixels at 50,400fps
512 x 384 pixels at 87,500fps
512 x 256 pixels at 120,000fps

Maximum Frame Rate:
224,000fps (FASTCAM SA-Z type 200K)
480,000fps (FASTCAM SA-Z type 480K)
2,100,000fps (FASTCAM SA-Z type 2100K)

Class Leading Light Sensitivity:
ISO 12232 Ssat
• ISO 50,000 monochrome
• ISO 20,000 color

Global Electronic Shutter:
1ms to 159ns independent of frame rate
(sub-microsecond shutter available on type 2100K only, subject to export control)

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

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

Optional FASTDrive High Capacity Non-Volatile Data Storage:
1TB or 2TB high-speed solid state drive

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

** Available early 2017

Light Sensitivity:

Expressions of light sensitivity in high-speed cameras can be confusing as a variety of differing measurement techniques are used. Photron publishes light sensitivity figures for its products using the ISO 12232 Ssat Standard.

FASTCAM SA-Z	ISO 12232 Ssat
Monochrome models	ISO 50,000
Color models	ISO 20,000

ISO 12232 Ssat values published by Photron for both monochrome and color cameras are measured excluding infrared sensitivity as defined by the ISO standard measurement procedure ISO 14524.

Monochrome sensors used in the FASTCAM SA-Z are supplied without an IR absorbing filter, extending the camera spectral response beyond 900nm. When the sensitivity of the FASTCAM SA-Z is measured to tungsten light including near IR response an equivalent value of ISO 125,000 is obtained.

Image Sensor:

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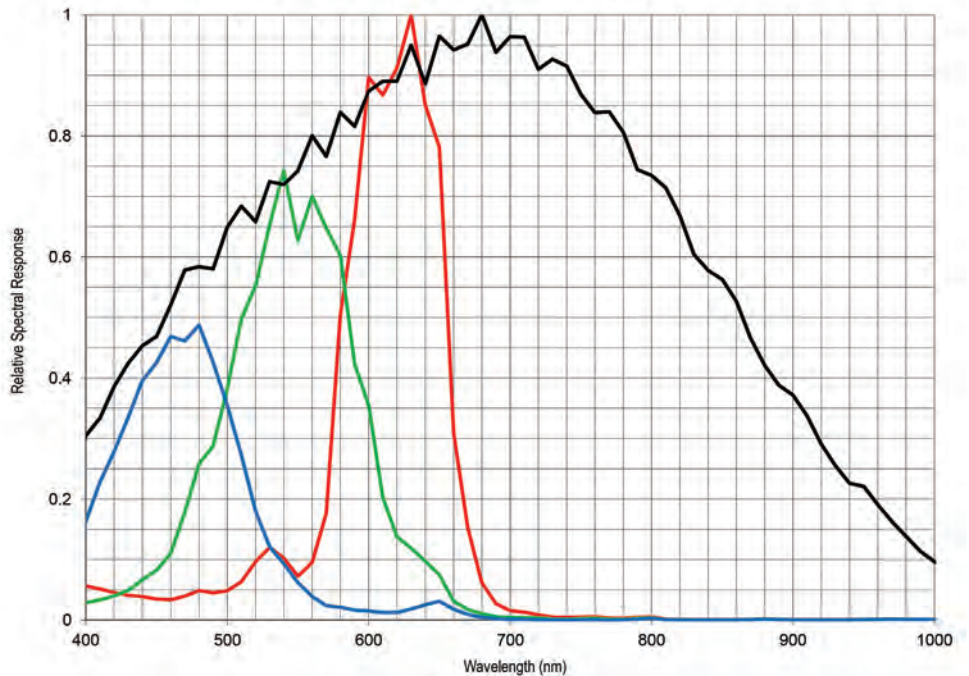
A 20-micron pixel pitch gives a sensor size at full image resolution of 20.48 x 20.48mm (diagonal 28.96mm).

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

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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)
ISO 12232 Ssat sensitivity	ISO 50,000 monochrome ISO 20,000 color (monochrome sensor equivalent ISO 125,000 including near IR response)
Shutter	Global Electronic Shutter 1ms to 1µs independent of frame rate (2100K only: 159ns shutter available subject to export control)

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

# Camera Performance Specifications

Camera Performance Specifications

Model	SA-Z
Full Frame Performance	20,000 fps 1024 x 1024 pixels
Maximum Frame Rate	Type 200K: 224,000fps Type 480K: 480,000fps* Type 2100K: 2,100,000fps*
Minimum Exposure	Global electronic shutter to 1µs selectable independent of frame rate (159ns option available with SA-Z type 2100K 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,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-Z offers two options:

Supplied as standard with the system are two UHS-I (SDR104) compatible SD memory card drives. Readily available high capacity SD cards compatible with these drives offer a low cost and convenient non-volatile removable storage option.

Optionally, the FASTCAM SA-Z can be supplied with the Photron FASTDrive high capacity removable SSD media system in place of SD card drives. The ultra-high data rate FASTDrive system allows a 64GB camera memory recording to be transferred to a removable SSD media drive in approximately 1 minute. Recorded data can then be directly accessed while coupled to the camera or the drive may be removed and inserted into the portable FASTDock station connected to any Windows PC.
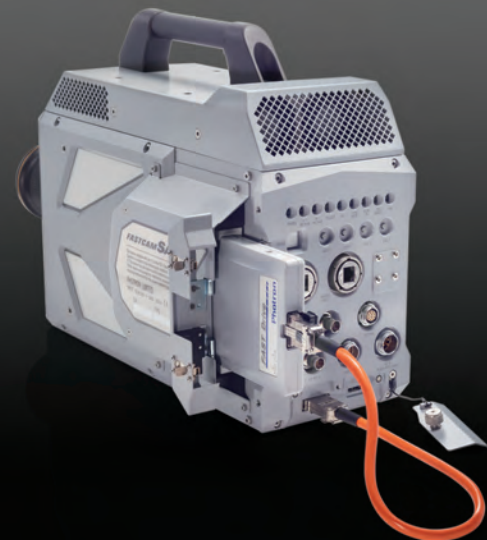
Camera Operation Features

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 separately 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 together with other instrumentation equipment to a master external 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-Z 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.
FASTDrive:	Optional 1TB / 2TB solid state drive (SSD) memory pack provides ultra high data rate transfer to 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.
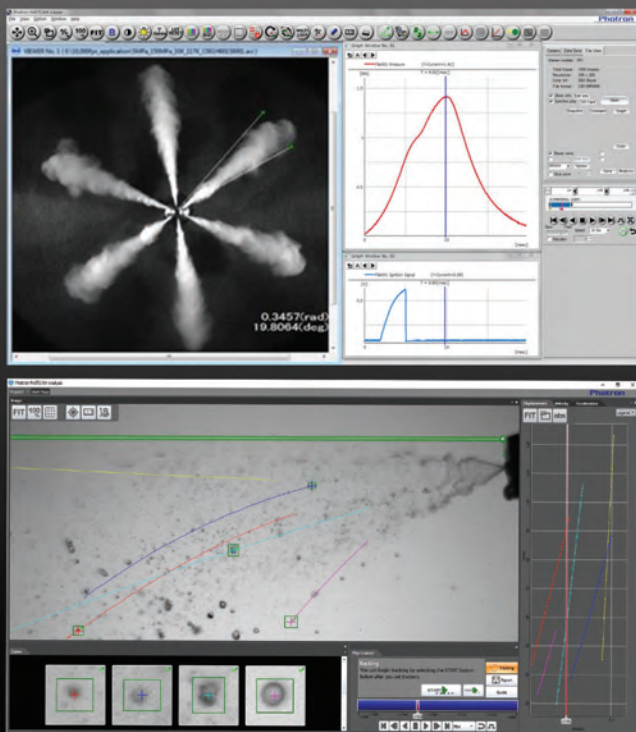
Photron FASTCAM Viewer:
Photron FASTCAM Viewer software (PFV) has been designed to provide an intuitive and feature rich user interface for the control of Photron high-speed cameras, data saving, image replay and simple motion analysis. Advanced operation menus provide access to features for enhanced 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-Z 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-Z 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-Z 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-Z 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.

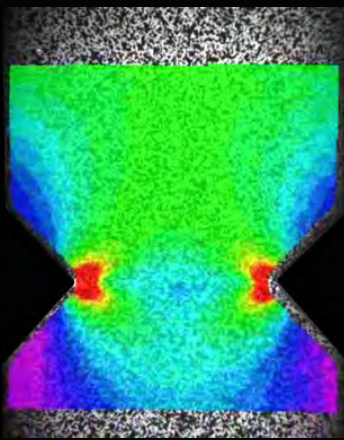**Photo:**
Tensile Test with Digital Image Correlation

Image Resolution	Frame Rate (fps)		
(h x v pixels)	Type 200K	Type 480K	Type 2100K
1024 x 1024	20,000	20,000	20,000
1024 x 1000	21,000	21,000	21,000
1024 x 840	25,000	25,000	25,000
1024 x 512	40,000	40,000	40,000
640 x 488	60,000	60,000	60,000
512 x 456	75,000	75,000	75,000
640 x 280	100,000	100,000	100,000
512 x 256	120,000	120,000	120,000
384 x 176	224,000	200,000	200,000
512 x 56	224,000	480,000	480,000
384 x 64	224,000	480,000	525,000
256 x 56	224,000	480,000	700,000
128 x 56	224,000	480,000	900,000
256 x 24	224,000	480,000	1,008,000
128 x 32	224,000	480,000	1,200,000
128 x 8	224,000	480,000	2,100,000

Recordable Duration 12-bit recording mode

Image Resolution	Record Duration (frames)				
(h x v pixels)	8GB Memory	16GB Memory	32GB Memory	64GB Memory	128GB Memory**
1024 x 1024	5,455	10,916	21,839	43,684	TBA
1024 x 1000	5,586	11,178	22,363	44,733	TBA
1024 x 840	6,650	13,308	26,623	53,254	TBA
1024 x 512	10,912	21,835	43,680	87,371	TBA
640 x 488	18,320	36,656	73,327	146,670	TBA
512 x 456	24,508	49,036	98,092	196,204	TBA
640 x 280	31,931	63,887	127,801	255,627	TBA
512 x 256	43,656	87,347	174,728	349,491	TBA
384 x 176	84,669	169,402	338,869	677,803	TBA
512 x 56	199,580	399,309	798,766	1,597,681	TBA
384 x 64	232,844	465,861	931,894	1,863,962	TBA
256 x 56	399,162	798,620	1,597,535	3,195,365	TBA
128 x 56	798,327	1,597,242	3,195,073	6,390,733	TBA
256 x 24	931,382	1,863,450	3,727,585	7,455,855	TBA
128 x 32	1,397,075	2,795,176	5,591,379	11,183,784	TBA
128 x 8	5,588,307	11,180,712	22,365,523	44,735,144	TBA

* Approximate recordable image count with 8-bit recording mode can be calculated by multiplying the figures above by 1.5
**128GB memory available early 2017

Mechanical & Environmental Specifications

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)	261.6 (H) x 150 (W) x 375.4 (D) mm 10.3" (H) x 5.9" (W) x 14.8" (D)
Weight	
Camera Body	10.4 kg / 22.93 lbs.
Environmental	
Operating Temperature	0 to 45C, 32˚ to 113˚F
Storage Temperature	-20 to 60C, -4˚ to 140˚F
Humidity	85% or less (non-condensing)
Operational Shock	Tested to 25G, 11ms, 6 axes, 10 times/axis
Cooling	Internal fan cooling (fan-off mode supported)
Power	
AC Power (with supplied adapter)	100 to 240V, 50 to 60Hz
DC Power	20 to 36V, 230VA
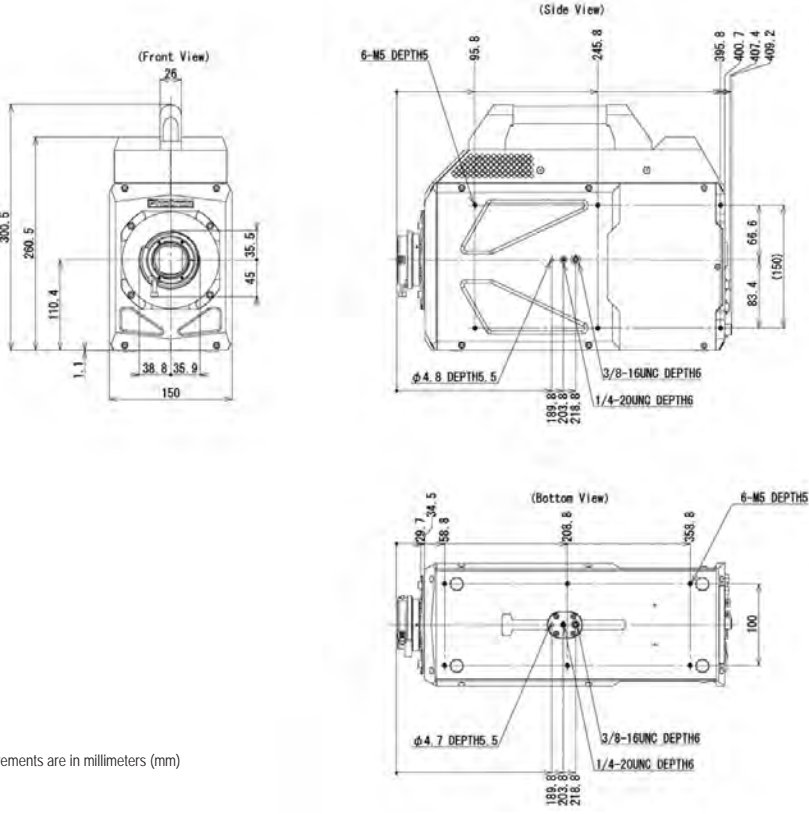
All measurements are in millimeters (mm)

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-Z 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-Z providing remote control of lens aperture and iris through Photron PFV software.

Rugged Design:
The FASTCAM SA-Z 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, 10times/axis during operation.

Operation Environments:
The 'sealed body' design of the FASTCAM SA-Z utilizes heat-pipe technology to ensure that during operation heat can be effectively drawn out from the inside of the system and dissipated via externally mounted fans. This ensures optimum air flow and prevents dust and corrosive particles from being ingested within the camera body where they can damage sensitive electronics. The fans may be disabled during recording for any vibration sensitive measurements.

The FASTCAM SA-Z camera has been extensively tested to ensure operation for extended periods in

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