

# Kestrel 32 x 32 Geiger-Mode Flash 3-D LiDAR Camera



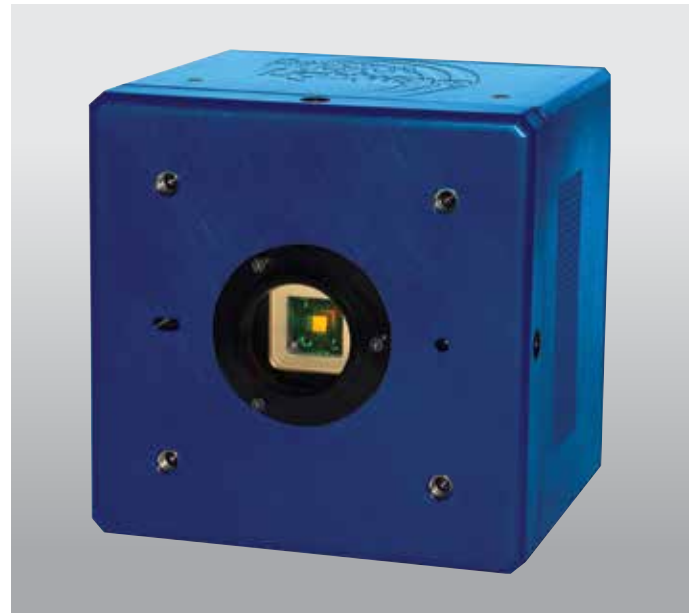
The Kestrel is the most temporally precise near infrared camera for photon starved environments. Based on Princeton Lightwave's expertise in InGaAs Geiger-mode avalanche photodiodes, each of the Kestrel's 32x32 pixels is capable of detecting a single photon to within 250 ps resolution. The Kestrel is typically used for collecting returns from the flash of a 1.0  $\mu\text{m}$  or 1.5  $\mu\text{m}$  laser in range finding applications, providing time-of-flight resolution of 3.75 cm. Its 8,000 period clock provides a range depth of 300 meters, and when the clock is slowed to its maximum period of 1.25 ns, a range depth of 1.5 km. The user can program the triggering of the clock for imaging the particular range depth of interest desired. The Kestrel is capable of collecting 200 million pixel measurement returns per second.

## Applications

- Geiger-mode LiDAR from 1.0  $\mu\text{m}$  to 1.6  $\mu\text{m}$
- Target detection, acquisition, and ranging
- 3-D mapping with 3.75 cm resolution per return
  - Foliage penetration with <12 cm differentiation
  - Coverage of >1,000  $\text{km}^2/\text{hr}$ . at 2 points/ $\text{m}^2$
  - >10 points/ $\text{m}^2$  at  $2^{12}$  relative intensity
- Autonomous navigation
- Passive imaging in photon-starved environments

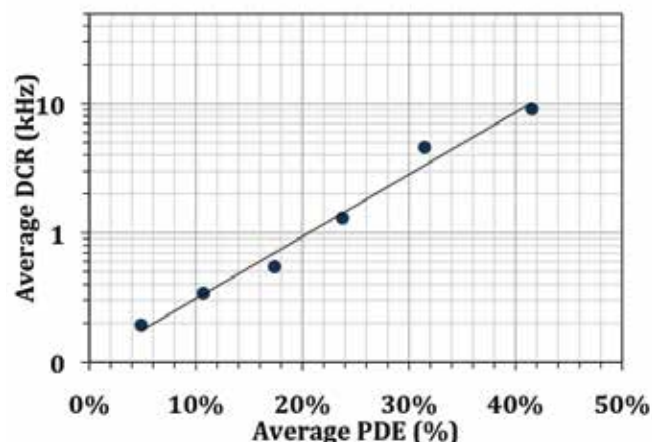
## Key Features and Benefits

- 250 ps, 3.75 cm time-of-flight resolution per return
- 32x32 focal plane array for 3-D point cloud imaging
- Maximum range depth to 1,500 meters per flash
- Triggerable to 186,000 times per second
- Measures up to 200 million returns per second
- Low SWaP: 900  $\text{cm}^3$ ; 1.3 kg; 16 W consumption



Chassis C-mount for lens attachment

## Kestrel - 1064 nm Typical Dark Count Rate vs. Photon Detection Efficiency



## Specifications for 1.064 $\mu\text{m}$ PART NO.: CAM-G1024-S10-00

Operating Conditions: 25°C ambient temperature, PDE tested under collimated input conditions

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
<b>Camera Configuration and Operating Conditions</b>						
Array Format			32 x 32			
Array Dimensions			3.2 x 3.2			mm
Wavelength Range	$\lambda$		1020		1140	nm
Time Bin Duration	$T_{\text{bin}}$	user-defined	0.25		1.25	ns
Gate Duration	$T_{\text{gate}}$	user-defined in 4 ns increments	4		$T_{\text{bin}} \cdot 8000$	ns
Maximum Frame Rate	$FR_{\text{max}}$	For 2 $\mu\text{s}$ range gates	Full		186	kHz
			Medium		142	
			Base		74	
Power Consumption	$P_c$	at maximum frame rate			18	W
Input Voltage	$V_{\text{in}}$		12		36	V
Input Current	$I_{\text{in}}$				1.5	A
Operating Temperature	$T_{\text{op}}$	case temperature	5		30	°C
Relative Humidity	RH	non-condensing	10		95	%
Weight	Wt	no lens		1.3		kg
<b>Electro-optic Performance Summary</b>						
Operable Pixels	$N_{\text{op}}$	DCR and PDE within $\pm 4\sigma$ of average values	92			%
Mean Photon Detection Efficiency	PDE	$\lambda = 1064 \text{ nm}$	30			%
PDE Standard Deviation	$\sigma_{\text{PDE}}$	$\lambda = 1064 \text{ nm}$			6	%
Mean Dark Count Rate	DCR				20	kHz
DCR Standard Deviation	$\sigma_{\text{DCR}}$				5	kHz
Timing Jitter	TJ	Standard deviation of jitter			500	ps
Total Cumulative Crosstalk Probability	$P_{\text{xt}}(\text{tot})$	Probability of 1 or more crosstalk events per primary avalanche in a 9 x 9 subarray; PDE = 30%		15		%
Crosstalk Probability for >1 Event	$P_{\text{xt}}(n>1)$	Prob. of > 1 crosstalk event per primary avalanche in a 9 x 9 subarray; PDE = 30%		2		%

## Specifications for 1.55 $\mu\text{m}$ PART NO.: CAM-G1024-S15-00

Operating Conditions: 25°C ambient temperature, PDE tested under collimated input conditions

Parameter	Symbol	Conditions	Min	Typ.	Max	Units	
<b>Camera Configuration and Operating Conditions</b>							
Array Format			32 x 32				
Array Dimensions			3.2 x 3.2			mm	
Wavelength Range	$\lambda$		1400		1620	nm	
Time Bin Duration	$T_{\text{bin}}$	user-defined	0.25		1.25	ns	
Gate Duration	$T_{\text{gate}}$	user-defined in 4 ns increments	4		$T_{\text{bin}} \cdot 8000$	ns	
Maximum Frame Rate	$FR_{\text{max}}$	For 2 $\mu\text{s}$ range gates	Full			186	kHz
			Medium			142	
			Base			74	
Power Consumption	$P_c$	at maximum frame rate			18	W	
Input Voltage	$V_{\text{in}}$		12		36	V	
Input Current	$I_{\text{in}}$				1.5	A	
Operating Temperature	$T_{\text{op}}$	case temperature	5		30	°C	
Relative Humidity	RH	non-condensing	10		95	%	
Weight	Wt	no lens		1.3		kg	
<b>Electro-optic Performance Summary</b>							
Operable Pixels	$N_{\text{op}}$	DCR and PDE within $\pm 4\sigma$ of average values	92			%	
Mean Photon Detection Efficiency	PDE	$\lambda = 1550 \text{ nm}$	18			%	
PDE Standard Deviation	$\sigma_{\text{PDE}}$	$\lambda = 1550 \text{ nm}$			6	%	
Mean Dark Count Rate	DCR				50	kHz	
DCR Standard Deviation	$\sigma_{\text{DCR}}$				15	kHz	
Timing Jitter	TJ	Standard deviation of jitter			500	ps	
Total Cumulative Crosstalk Probability	$P_{\text{xt}}(\text{tot})$	Probability of 1 or more crosstalk events per primary avalanche in a 9 x 9 subarray; PDE = 18%		35		%	
Crosstalk Probability for >1 Event	$P_{\text{xt}}(n>1)$	Prob. of > 1 crosstalk event per primary avalanche in a 9 x 9 subarray; PDE = 18%		15		%	

## Specification for Kestrel 1064/1550 Camera System Components

- Windows 7 64-bit Professional Operating System with 3.2 GHz Quad Core Intel I7 Processor
- 4 GB System RAM
- 512 GB solid state drive for operating system and for data storage at full frame rate
- 2 TB Hard Drive for data archiving
- National Instruments PCIe-1433 CameraLink Frame Grabber Interface
- 24" LCD Monitor, Wireless Keyboard, and Mouse
- Comprehensive GUI Camera Software enabling execution of all camera functions and visual display
- Power Cables, Two 3-meter CameraLink Cables, and Trigger/External Clock Cables

### Ordering Information

#### **CAM-G1024-S10-00**

Kestrel 32 x 32 Geiger-mode Flash 3-D LiDAR Camera for 1020 to 1140 nm use (previously known as the CAM32X32A-GMA-0 synchronous camera)

#### **CAM-G1024-S15-00**

Kestrel 32 x 32 Geiger-mode Flash 3-D LiDAR Camera for 1400 to 1620 nm use (previously known as the CAM32X32B-GMA-0 synchronous camera)

## Camera System Features

**Control Interface** Control of camera functions is supported by the CameraLink control channel using a comprehensive serial command set. The PC graphical user interface (GUI) allows for simple camera configuration and control, and custom software can be developed by the user utilizing the serial command set. The camera supports both internal and external master clocks, as well as internal and external triggering for image acquisition.

**Sensitivity Settings** The photon detection efficiency (PDE) is determined by a user-specified “sensitivity” setting from 1 to 100. A factory calibration of sensitivity versus average PDE is provided with each camera.

**Temperature and Bias Control** The APD array temperature is managed by an internal temperature control module with programmable set-point and temperature monitoring functions. Sensor temperature and APD bias are handled automatically. Ambient and FPA-level temperatures are monitored in real time, and if ambient temperature conditions change, the camera automatically adjusts temperature set-points and FPA bias levels to maintain a fixed sensitivity.

These and additional features are fully detailed in the Interface Control Document, available under NDA. To request, please email [sales@princetonlightwave.com](mailto:sales@princetonlightwave.com)

#### ***Specifications subject to change without notice***

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