

Merlin 32 x 32 Geiger-mode Free-Running Flash 3-D LiDAR Camera



The Princeton Lightwave asynchronous 32 x 32 Geiger-mode avalanche photodiode (GmAPD) camera is a turn-key system containing a single-photon imaging sensor in which every pixel provides time-of-flight information with free-running operation and fully asynchronous timestamp readout. The camera can collect sub-nanosecond resolution timestamps for arbitrarily long periods of time as well as emulate gated (framed) operation, and the sensor can generate timestamps at rates of nearly 1 Gsamples/second. The sensor engine of the camera is a focal plane array (FPA) with hexagonal geometry pixels on a 65.8 μm pixel pitch formatted in a rectangular imaging area of 2.1 mm x 1.8 mm. The FPA is assembled by flip-chip bonding an InP/InGaAsP GmAPD detector array to a custom CMOS readout integrated circuit (ROIC) and then attaching a GaP microlens array to the GmAPD array to provide a high optical fill factor. The hermetically sealed FPA housing has an integrated two-stage thermoelectric cooler to maintain appropriate operating temperature with closed-loop feedback adjustment. The GmAPD camera is supplied as a fully integrated system controlled by a high-performance personal computer with on-board SSD storage and GUI-driven control software.

GmAPD pixels provide true single-photon sensitivity, with asynchronous cameras available in two wavelength ranges. The 1.06 μm camera is sensitive in the wavelength range from 1020 nm to 1140 nm, including common pulsed laser wavelengths at 1064 nm and 1030 nm. The 1.55 μm camera is sensitive in the wavelength range from 1400 nm to 1620 nm, covering eye-safe illumination beyond 1400 nm.

Key Features and Benefits

- 32 x 32 imaging sensor with Geiger-mode APD pixels
- Free-running pixels with fully asynchronous (non-framed) timestamp readout
- Arbitrarily long continuous photon timing collection
- High-efficiency single-photon sensitivity at every pixel
- Pixel-level circuitry performs rapid quenching to minimize crosstalk
- Integrated microlens array for high fill factor
- Photon arrival timestamp generation up to 0.7 Gsamples/second
- Independent time-of-flight measurement at every pixel with sub-nanosecond timing resolution
- Dual external timing reference signals
- Integrated thermoelectric cooler for FPA temperature control
- Fluid cooling for stable temperature control
- Robust hermetic sensor packaging
- Chassis C-mount for lens attachment
- Simple low-voltage power supply
- Two camera versions for 1.06 μm and 1.55 μm source lasers

Applications

- Coherent detection 3-D LiDAR
- Direct detection 3-D LiDAR (multiple counts per frame)
- Free-space optical communications
- Acquisition, tracking, and pointing
- Passive imaging in photon-starved environments
- Single-photon detection and timing for quantum optics
- Optical tomography



5.0 in x 5.0 in x 4.5 in

Part No: CAM-G1024-F15-00

Specifications: 1.55 μm Camera (1.40 – 1.62 μm spectral response)

Operating conditions: 25°C operating temperature, 20°C fluid coolant temperature

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Camera Configuration and Operating Conditions						
Array Format			32 x 32			
Photosensitive Area	μ		2.1 x 1.8			mm ²
Wavelength Range	λ		1440		1620	nm
Time Bin Resolution	T_{bin}		0.31			ns
Pixel Reset Time	T_{reset}		0.5		5	μs
Pixel Counting Rate	R_{pixel}				$1 / T_{\text{reset}}$	
Array Sampling Rate	R_{array}	Saturated output			0.7	GS/s
Power Consumption	P_{C}	At saturated output rate		40		W
Input Voltage	V_{in}			28		V
Input Current	I_{in}			1.5		A
Operating Temperature	T_{op}	Case temperature	0		40	°C
Relative Humidity	RH	Non-condensing	10		95	%
Electro-Optic Performance Summary						
Operable Pixels	N_{op}	DCR and PDE within $\pm 4\sigma$ of average values	95	98		%
Mean Photon Detection Efficiency	PDE	$\lambda = 1550 \text{ nm}$	13	15		%
PDE Standard Deviation	σ_{PDE}	$\lambda = 1550 \text{ nm}$			3	%
Mean Dark Count Rate	DCR	At minimum PDE		30	50	kHz
DCR Standard Deviation	σ_{DCR}	At minimum PDE		10	20	kHz
Timing Jitter	TJ	Standard deviation of jitter PDF		200	350	ps
Total Cumulative Crosstalk Probability	P_{xt}	Cumulative for entire array; at minimum PDE		15		%
Total Cumulative Afterpulse Probability	P_{ap}	With 1.0 μs pixel reset time; at minimum PDE		15		%

Part No: CAM-G1024-F10-00

Specifications: 1.06 μm Camera (1.02 – 1.14 μm spectral response)

Operating conditions: 25°C operating temperature, 20°C fluid coolant temperature

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Camera Configuration and Operating Conditions						
Array Format			32 x 32			
Photosensitive Area	μ		2.1 x 1.8			mm ²
Wavelength Range	λ		1020		1140	nm
Time Bin Resolution	T_{bin}		0.31			ns
Pixel Reset Time	T_{reset}		0.5		5	μs
Pixel Counting Rate	R_{pixel}				$1 / T_{\text{reset}}$	
Array Sampling Rate	R_{array}	Saturated output			0.7	GS/s
Power Consumption	P_{C}	At saturated output rate		40		W
Input Voltage	V_{in}			28		V
Input Current	I_{in}			1.5		A
Operating Temperature	T_{op}	Case temperature	0		40	°C
Relative Humidity	RH	Non-condensing	10		95	%
Electro-Optic Performance Summary						
Operable Pixels	N_{op}	DCR and PDE within $\pm 4\sigma$ of average values	95	98		%
Mean Photon Detection Efficiency	PDE	$\lambda = 1064 \text{ nm}$		30		%
PDE Standard Deviation	σ_{PDE}	$\lambda = 1064 \text{ nm}$		3		%
Mean Dark Count Rate	DCR	At minimum PDE		10		kHz
DCR Standard Deviation	σ_{DCR}	At minimum PDE		3		kHz
Timing Jitter	TJ	Standard deviation of jitter PDF		200	350	ps
Total Cumulative Crosstalk Probability	P_{xt}	Cumulative for entire array; at minimum PDE		15		%
Total Cumulative Afterpulse Probability	P_{ap}	With 1.0 μs pixel reset time; at minimum PDE		15		%

Specification for Merlin 1064/1550 Camera System Components

- Windows 7 64-bit Professional Operating System with 3.2 GHz Quad Core Intel i7 Processor
- 16 GB System RAM
- 512 GB Solid State Drive for operating system and data storage at full frame rate
- 2 TB Hard Drive for data archiving
- Stratix V Altera Dev Board with QFSP Connector
- 24" LCD Monitor, Wireless Keyboard, and Mouse
- Comprehensive GUI Camera Software enabling execution of all camera functions and visual display
- Power Cable

Ordering Information

CAM-G1024-F15-00

Merlin 32x32 Geiger-mode Flash 3-D LiDAR Camera for 1400 to 1620 nm use

CAM-G1024-F10-00

Merlin 32x32 Geiger-mode Flash 3-D LiDAR Camera for 1020 to 1140 nm use

Camera System Features

Control Interface Control of camera functions is supported 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 an external clock input to operate the camera in the user's system clock domain.

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.

Integrated Metadata Output data streams include metadata indicating operational status information and real-time diagnostics.

Test Pattern The camera provides test pattern generation for operational verification of the data acquisition system.

Specifications subject to change without notice

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