PRODUCT SUMMARY

32 x 32 Geiger-mode Avalanche Photodiode (GmAPD) Camera

The Princeton Lightwave 32 x 32 Geiger-mode avalanche photodiode (GmAPD) camera is a turn-key system containing a single-photon imaging sensor designed for three-dimensional laser radar imaging with time-of-flight information captured at every pixel in the array. GmAPD pixels provide true single photon sensitivity, with cameras available in two wavelength ranges. The 1.06 µm camera is sensitive in the wavelength range from 920 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 920 nm to 1620 nm, covering eye-safe illumination beyond 1400 nm.

The sensor engine of the camera is a 100 µm pixel pitch focal plane array (FPA) consisting of an InP/InGaAsP GmAPD detector array flip-chip bonded to a custom CMOS readout integrated circuit (ROIC). Every pixel contains an independent counter to provide per-pixel timestamps specifying photon detection events with time bin resolution as short as 250 ps. A GaP microlens array is attached to the GmAPD array to provide high fill factor, and the hermetically sealed FPA housing has an integrated two-stage thermoelectric cooler to maintain appropriate operating temperatures. The GmAPD camera is supplied as a fully integrated system with a high-performance personal computer supporting a CameraLink or other industry-standard data interface, RAID 0 storage, and comprehensive GUI-driven control software.

Features

- **Simple camera operation requiring only low-voltage power supply**
- **32 x 32 imaging sensor with Geiger-mode APD pixels**
- **High-efficiency single-photon sensitivity at every pixel**
- **Pixel-level circuitry performs rapid active quenching to minimize crosstalk**
- **Integrated microlens array for high fill factor**
- **Very high frame rates up to 186 kHz with 2 µs range gates**
- **CameraLink interface with base, medium, or full configuration**
- **User-selectable range gate from 4 ns to 10 µs**
- **Independent time-of-flight measurement at every pixel with high resolution 250 ps time bins**
- **Master or slave operation supported for system-level synchronization**
- **External trigger input and laser trigger output**
- **Integrated thermoelectric cooler for sensor temperature control**
- **Robust hermetic sensor packaging**
- **Chassis C-mount for lens attachment**
- **Two camera versions for 1.06 µm and 1.55 µm source lasers**

10 cm x 10 cm x 8 cm

Applications

- **3-D LADAR imaging with single-photon return pulses**
- **Photon counting LIDAR**
- **Passive imaging in photon-starved environments**
- **Single photon detection and timing for quantum optics**
- **Optical tomography**

Specifications subject to change without notice

2555 US Route 130 S.
Cranbury, NJ 08540
Tel: 609-495-2600
http://www.princetonlightwave.com

Rev. 2.0.1

PRODUCT SUMMARY

Princeton Lightwave

Part No.: CAM32X32A-GMA-0

Specifications: 1.06 µm FPA (0.92 – 1.14 µm spectral response)

Operating Conditions: 25°C operating temperature

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Camera Configuration and Operating Conditions							
Array Format					32x32		
Pixel Pitch					100		µm
Wavelength Range	λ			920		1140	nm
Time Bin Duration	T_{bin}	user-defined		0.25		1.25	ns
Gate Duration	T_{gate}	user-defined in 4 ns increments		4		$T_{bin} \cdot 2^{13}$	ns
Readout Time	T_{RO}	Three CameraLink configurations	Full		3.85		µs
			Medium		7.05		
			Base		13.45		
Maximum Frame Rate	FR_{max}	for 2 µs range gates (260 kHz possible in "full" configuration with 0.4 µs gate)	Full	0.01		186	kHz
			Medium	0.01		142	
			Base	0.01		74	
Power Consumption	P_C	at maximum frame rate			12		W
Input Voltage	V_{in}			12		36	V
Input Current	I_{in}				1	1.5	A
Operating Temperature	T_{op}	case temperature		5		30	ºC
Relative Humidity	RH	non-condensing		10		95	%
Electro-optic Performance Summary							
Breakdown Voltage	V_b	at 100 µA dark current for full array		65	80	95	V
Operable pixels	N_{op}	DCR and PDE within 4σ of average values		92	98		%
Average Photon Detection Efficiency	PDE	V_{ex} ~ 3.5 V; λ = 1064 nm; includes microlens array		30	35		%
PDE standard deviation	σ_{PDE}	V_{ex} ~ 3.5 V; λ = 1064 nm; includes microlens array			3	6	%
Pixel fill factor	FF	including microlens array			75		%
Average Dark Count	DCR	at minimum PDE (V_{ex} ~ 3.5 V)			8	20	kHz
DCR standard deviation	σ_{DCR}	at minimum PDE (V_{ex} ~ 3.5 V)			3	5	kHz
Timing Jitter	TJ	standard deviation of jitter PDF			350	500	ps
Total Cumulative Crosstalk Probability	P_{xt}(tot)	probability of 1 or more crosstalk events per primary avalanche; PDE = 30%			15		%
Crosstalk Probability for >1 Event	P_{xt}(n>1)	prob. of > 1 crosstalk event per primary avalanche; PDE = 30%			2		%

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Princeton Lightwave

Part No.: CAM32X32B-GMA-0

Specifications: 1.55 µm FPA (0.92 – 1.62 µm spectral response)

Operating Conditions: 25°C operating temperature

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Camera Configuration and Operating Conditions							
Array Format					32x32		
Pixel Pitch					100		µm
Wavelength Range	λ			920		1620	nm
Time Bin Duration	T_{bin}	user-defined		0.25		1.25	ns
Gate Duration	T_{gate}	user-defined in 4 ns increments		4		$T_{bin} \cdot 2^{13}$	ns
Readout Time	T_{RO}	Three CameraLink configurations	Full		3.85		µs
			Medium		7.05		
			Base		13.45		
Maximum Frame Rate	FR_{max}	for 2 µs range gates (260 kHz possible in "full" configuration with 0.4 µs gate)	Full	0.01		186	kHz
			Medium	0.01		142	
			Base	0.01		74	
Power Consumption	P_C	at maximum frame rate			12		W
Input Voltage	V_{in}			12		36	V
Input Current	I_{in}				1	1.5	A
Operating Temperature	T_{op}	case temperature		5		30	ºC
Relative Humidity	RH	non-condensing		10		95	%
Electro-optic Performance Summary							
Breakdown Voltage	V_b	at 100 µA dark current for full array		65	80	95	V
Operable pixels	N_{op}	DCR and PDE within 4σ of average values		92	98		%
Average Photon Detection Efficiency	PDE	V_{ex} ~ 3.5 V; λ = 1550 nm; includes microlens array		18	22		%
PDE standard deviation	σ_{PDE}	V_{ex} ~ 3.5 V; λ = 1550 nm; includes microlens array			3	6	%
Pixel fill factor	FF	including microlens array			75		%
Average Dark Count	DCR	at minimum PDE (V_{ex} ~ 3.5 V)			20	50	kHz
DCR standard deviation	σ_{DCR}	at minimum PDE (V_{ex} ~ 3.5 V)			5	15	kHz
Timing Jitter	TJ	standard deviation of jitter PDF			350	500	ps
Total Cumulative Crosstalk Probability	P_{xt}(tot)	probability of 1 or more crosstalk events per primary avalanche; PDE = 18%			35		%
Crosstalk Probability for >1 Event	P_{xt}(n>1)	prob. of > 1 crosstalk event per primary avalanche; PDE = 18%			15		%

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PRODUCT SUMMARY

Camera System Components

- Windows XP Professional Operating System with 3.3 GHz Quad Core Intel I5 Processor
- 4 GB System RAM and 500 GB System Hard Drive
- Two 240 GB Solid State Drives in RAID0 configuration (480 GB total) for data storage at full frame rate
- 1000 GB Hard Drive for data archiving
- National Instruments PCIe-1430 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 Cable, Two 3-meter CameraLink Cables, and Trigger/External Clock Cable

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.

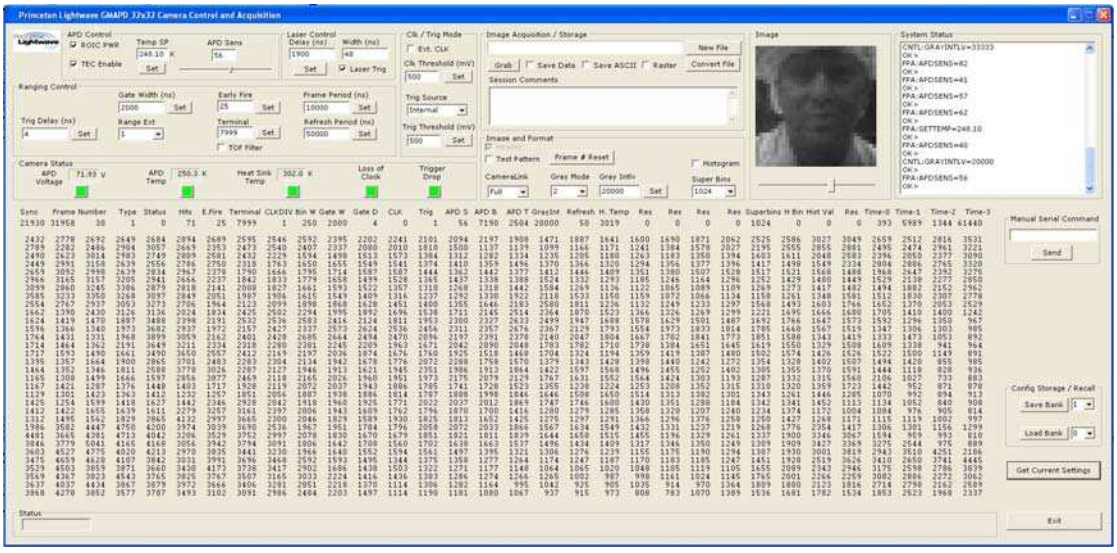
Temperature and Bias Control. The APD array temperature is managed by an internal temperature control module with programmable set-point and temperature monitoring functions. Sensor temperature and APD bias are handled automatically. Ambient and FPA-level temperatures are monitored in real time, and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

Frame-level Header Row. If enabled, a header row is included with every data frame to provide operational status information and real-time diagnostics and signal processing such as real-time per-frame range histogram information.

Real-time Range Histograms. The camera can generate range histograms for every frame using a user-specified number of superbins. Position and count value for the histogram mode are returned in each frame’s header row.

Real-time Grayscale Imaging. The camera can provide frame-averaged grayscale contrast images for a user-specified number of frames up to 32,768. After averaging the specified number of frames, each grayscale image frame is read out in place of a raw data frame accompanied by an appropriate flag in the header row.

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



GUI-driven software provides intuitive camera control and data acquisition

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