PRECITEK
LOGOTRON
CH-8135 Langnau a/A
Tel. +41 (0)43 377 60 60
www.precitek-logotron.ch

PerkinElmer™
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IN A NEW LIGHT.

Silicon Avalanche Photodiodes

C30902E, C30902S, C30921E, C30921S

High Speed Solid State Detectors for Fiber Optic and Very Low Light-Level Applications

Description

PerkinElmer Type C30902E avalanche photodiode utilizes a silicon detector chip fabricated with a double-diffused "reach-through" structure. This structure provides high responsivity between 400 and 1000 nm as well as extremely fast rise and fall times at all wavelengths. Because the fall time characteristics have no "tail", the responsivity of the device is independent of modulation frequency up to about 800 MHz. The detector chip is hermetically-sealed behind a flat glass window in a modified TO-18 package. The useful diameter of the photosensitive surface is 0.5 mm.

PerkinElmer Type C30921E utilizes the same silicon detector chip as the C30902E, but in a package containing a lightpipe which allows efficient coupling of light to the detector from either a focussed spot or an optical fiber up to 0.25 mm in diameter. The internal end of the lightpipe is close enough to the detector surface to allow all of the illumination exiting the lightpipe to fall within the active-area of the detector. The hermetically-sealed TO-18 package allows fibers to be epoxied to the end of the lightpipe to minimize signal losses without fear of endangering detector stability.

The C30902E and C309021E are designed for a wide variety of uses including optical communications at data rates to 1 GBit/second, laser range-finding, and any other applications requiring high speed and/or high responsivity.

Features

- High Quantum Efficiency 77% Typical at 830 nm
- C30902S and C30921S in Geiger Mode:
  - Single-Photon Detection Probability to 50%
  - Low Dark-Count Rate at 5% Detection Probability - Typically
  - 15,000/second at +22°C
  - 350/second at -25°C
  - Count Rates to 2×10^6/second
- Hermetically Sealed Package
- Low Noise at Room Temperature
  - C30902E, C30921E - 2.3×10^{-13} A/Hz$^{1/2}$
  - C30902S, C30921S - 1.1×10^{-13} A/Hz$^{1/2}$
- High Responsivity - Internal Avalanche Gains in Excess of 150
- Spectral Response Range - (10% Points) 400 to 1000 nm
- Time Response - Typically 0.5 ns
- Wide Operating Temperature Range - -40°C to +70°C

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The C30902S and C30921S are selected C30902E and C30921E photodiodes having extremely low noise and bulk dark-current. They are intended for ultra-low light level applications (optical power less than 1 pW) and can be used in either their normal linear mode ($V_R < V_{BR}$) at gains up to 250 or greater, or as photon counters in the "Geiger" mode ($V_R > V_{BR}$) where a single photoelectron may trigger an avalanche pulse of about 10^8 carriers. In this mode, no amplifiers are necessary and single-photon detection probabilities of up to approximately 50% are possible.

Photon-counting is also advantageous where gating and coincidence techniques are employed for signal retrieval.

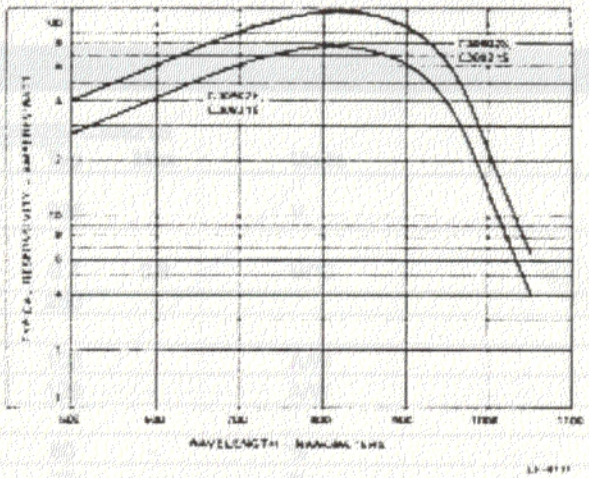

Figure 1. Typical Spectral Responsivity at 22°C

Optical Characteristics

C30902E, C30902S (Figure 13)

Photosensitive Surface:

Shape	Circular
Useful area	0.2 mm^2
Useful diameter	0.5 mm

Field of View:

Approximate full angle for totally illuminated photosensitive surface	100 deg

C30921E, C30921S (Figure 14)

Numerical Aperture of Light Pipe	0.55
Refractive Index (n) of Core	1.61
Lightpipe Core Diameter	0.25 mm

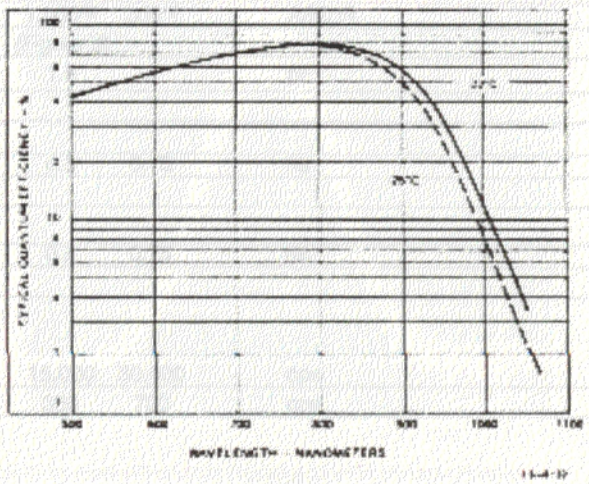

Figure 2. Typical Quantum Efficiency vs. Wavelength

Maximum Ratings, Absolute-Maximum Values (All Types)

Reverse Current at 22°C:	
Average value, continuous operation	200 μA
Peak value (for 1 second duration, non-repetitive)	1 mA
Forward Current, I_F at 22°C:	
Average value, continuous operation	5 mA
Peak value (for 1 second duration, non-repetitive)	50 mA
Maximum Total Power Dissipation at 22°C	60 mW
Ambient Temperature:	
Storage, T_{stg}	-60 to +100°C
Operating, T_A	-40 to +70°C
Soldering (for 5 seconds)	200°C

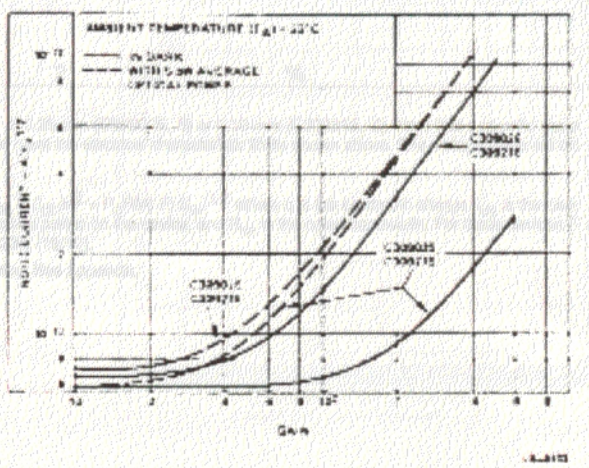

Figure 3. Typical Noise Current vs. Gain

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Electrical Characteristics[1] at T_A = 22°C

	C30902E, C309021E			C30902S, C30921S			
	Min	Typ	Max	Min	Typ	Max	Units
Breakdown voltage, V_{BR}	-	225	-	-	225	-	V
Temperature Coefficient of V_R for Constant Gain	0.5	0.7	0.8	0.5	0.7	0.8	V/°C
Gain	-	150	-	-	250	-	
Responsivity:							
At 900 nm	55	65	-	92	108	-	A/W
At 830 nm	70	77	-	117	128	-	A/W
Quantum Efficiency:							
At 900 nm	-	60	-	-	60	-	%
At 830 nm	-	77	-	-	77	-	%
Dark Current, I_d	-	1.5×10^{-8}	3×10^{-8}	-	1×10^{-8}	3×10^{-8}	A
		(Figure 6)			*(Figure 6)*		
Noise Current, i_n: [2]							
f = 10 kHz, Δf = 1.0 Hz	-	2.3×10^{-13}	5×10^{-13}	-	1.1×10^{-13}	2×10^{-13}	$A/Hz^{1/2}$
		(Figure 3)			*(Figure 3)*		
Capacitance, C_d	-	1.6	2	-	1.6	2	pF
Rise Time, t_r:							
R_L = 50Ω, λ = 830 nm,							
10% to 90% points	-	0.5	0.75	-	0.5	0.75	ns
Fall Time:							
R_L = 50Ω, λ = 830 nm,							
90% to 10% points	-	0.5	0.75	-	0.5	0.75	ns
Geiger Mode *(See Appendix)*							
Dark Count Rate at 5% Photon Detection Probability [3] (830 nm):							
22°C	-	-	-	-	15,000	30,000	cps
-25°C	-	-	-	-	350	700	cps
Voltage Above V_{BR} for 5% Photon Detection Probability [3] (830 nm) *(See Figure 8)*	-	-	-	-	2	-	V
Dead-Time Per Event *(See Appendix)*	-	-	-	-	300	-	ns
After-Pulse Ratio at 5% Photon Detection Probability (830 nm) 22°C [4]	-	-	-	-	2	15	%

Note 1. At the DC reverse operating voltage V_R supplied with the device and a light spot diameter of 0.25 mm (C30902E, S) or 0.10 mm (C30921E, S). Note that a specific value of V_R is supplied with each device. When the photodiode is operated at this voltage, the device will meet the electrical characteristic limits shown above. The voltage value will be within the range of 180 to 250 volts.

Note 2. The theoretical expression for shot noise current in an avalanche photodiode is $i_n = (2q\,(I_{ds} + (I_{db}M^2 + P_oRM)\,F)\,B_w)^{1/2}$ where q is the electronic charge, I_{ds} is the dark surface current, I_{db} is the dark bulk current, F is the excess noise factor, M is the gain, P_o is the optical power on the device, and B_w is the noise bandwidth. For these devices F = 0.98 (2-1/M) + 0.02 M. (Reference: PP Webb, RJ McIntyre, JJ Conradi, "RCA Review", Vol. 35 p. 234, (1974)).

Note 3. The C30902S and C30921S can be operated at a substantially higher Detection Probabilities. See Appendix.

Note 4. After-Pulse occurring 1 microsecond to 60 seconds after main pulse.