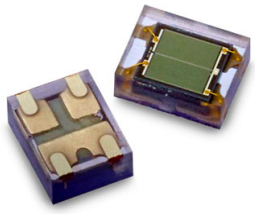
BROADCOM®

Data Sheet

AFBR-S4P0102L3R

NIR Dual-Channel Silicon Photomultiplier



Description

The Broadcom® AFBR-S4P0102L3R is a silicon photomultiplier (SiPM) that is optimized for fast photon counting in the near-infrared region of the electromagnetic spectrum. It combines high photodetection efficiency, low correlated noise, and steep slew rates with a wide dynamic range due to the small cell pitch and the fast recharge time.

The active region is divided into two equal and independent elements, which can be read out independently or connected together to achieve an overall photosensitive area of 1×1 mm^2. This feature enables a higher degree of flexibility for the design of the readout system.

The silicon chip is encapsulated within a robust molded lead frame package through a resin compound that is highly transparent to red and infrared wavelengths, making the AFBR-S4P0102L3R SiPM best suited for LiDAR and direct time-of-flight (dToF) applications.

This product is lead free and RoHS compliant.

Features

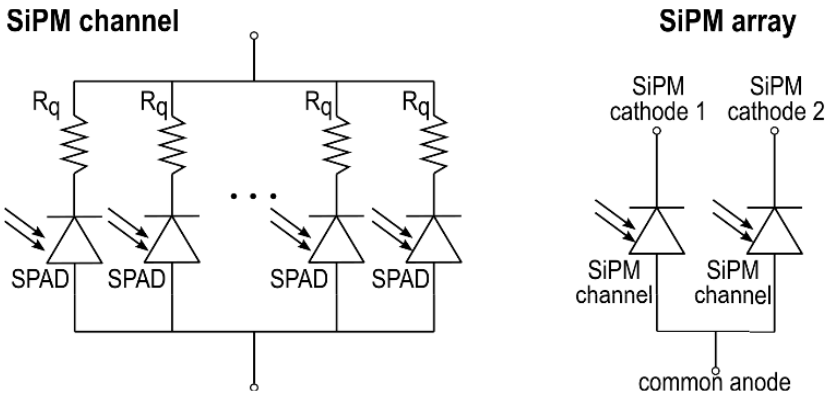
- Fast PDE:
  - 20% at λ = 905 nm (5-ns integration time)
  - 28% at λ = 650 nm (5-ns integration time)
- Low afterpulsing of < 3%
- Wide dynamic range
- Very fast cell recharge time constant of 15 ns
- Compact molded lead frame package
- Operating temperature range: –40°C to +85°C
- RoHS compliant

Applications

- 3D ranging (LiDAR)
- Robotics
- Drones

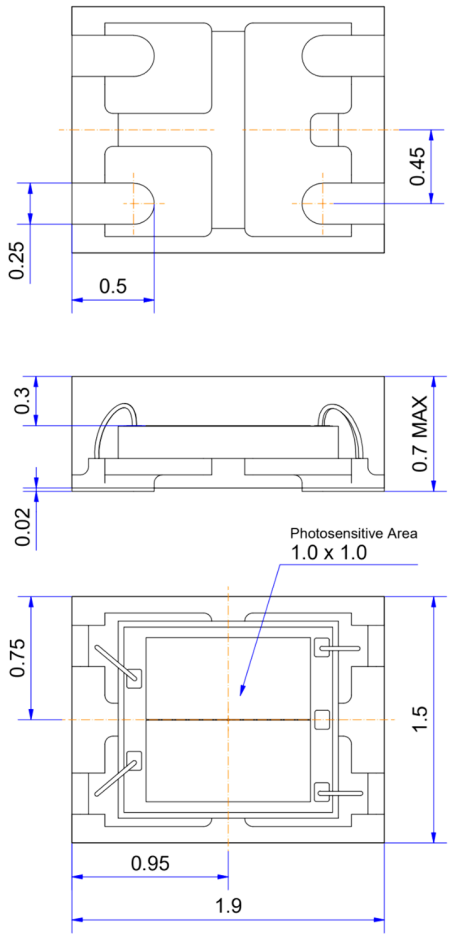
Block Diagram

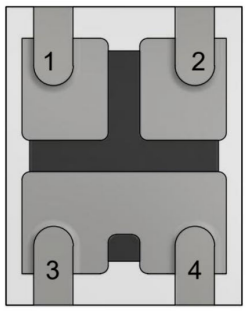
Figure 1: Block Diagram of the AFBR-S4P0102L3R for One of the Two SiPM Channels (Left) and the Whole Chip (Right)



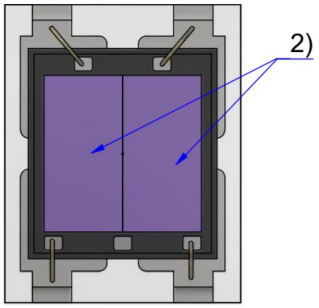
Mechanical Drawing and Pin Layout

Figure 2: Package Drawing with Dimensions (Left); Bottom and Top Views with Pin Assignment Scheme (Right)





Pin Assignment	
Pin #	Description
1	Cathode 1
2	Cathode 2
3	Anode
4	Anode



NOTE:

- Dimensions are in millimeters.
- The active area is divided in two equal independent sections, which can be read out separately or connected together.

Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause damage to the devices. Limits apply to each parameter in isolation. Absolute maximum ratings are those values beyond which damage to the device might occur if these limits are exceeded for other than a short period of time.

Parameter	Symbol	Min.	Max.	Unit
Storage Temperature	T_{STG}	–40	+85	°C
Operating Temperature	T_A	–40	+85	°C
Soldering Temperature[a]	T_{SOLD}	—	260	°C
Lead Soldering Time[a]	t_{SOLD}	—	10	seconds
Electrostatic Discharge Voltage Capability HBM	ESD_{HBM}	—	500	V
Operating Overvoltage	V_{OV}	—	12	V
DC Operating Current[b]	I_{MAX}	—	10	mA

a. According to JEDEC J-STD-020D, the moisture sensitivity classification is MSL3.

b. With thermal resistance junction to solder point of 40° K/W.

Device Specification

Features are measured at 25°C unless otherwise specified.

Geometric Features

Parameter	Symbol	Value	Unit
Device Area	DA	1.9 × 1.5	mm²
Total Active Area	AA	1.0 × 1.0	mm²
Element Active Area	EAA	0.5 × 1.0	mm²
Micro Cell Pitch	L_{cell}	12.5	µm
Number of Micro Cells	N_{cells}	6216	—

Optical and Electrical Features

Parameters in the following table are measured in the 1×1 mm^2 configuration, that is two cathodes connected together and at 10V overvoltage.

Parameter	Symbol	Min.	Typical[a]	Max.	Unit	Reference Plots
Spectral Range	λ	500	—	980	nm	Figure 4
Resin Refractive Index	η	—	1.57	—	—	
Peak Sensitivity Wavelength	λ_{PK}	—	710	—	nm	Figure 4
Photon Detection Efficiency at 650 nm	PDE_5ns	—	28	—	%	Figure 4
	PDE_tot	—	29	—	%	
Photon Detection Efficiency at 905 nm	PDE_5ns	—	20	—	%	Figure 3, Figure 4
	PDE_tot	—	21	—	%	
Dark Current per mm^2	I_D	—	35	—	nA	Figure 5
Dark Count Rate	DCR	—	800	—	kcps	Figure 6
Gain	G	—	340	—	$\times 10^3$	Figure 7
Optical Crosstalk Probability	P_{Xcorr}	—	< 2	—	%	Figure 8
Afterpulsing Probability	AP	—	< 3	—	%	Figure 8
Recharge Time Constant	τ_{fall}	—	15	—	ns	Figure 9
Breakdown Voltage[b]	V_{BD}	33.2	34.8	36.4	V	Figure 5
Nominal Terminal Capacitance[c]	C_T	—	40	—	pF	
Temperature Coefficient of Breakdown Voltage	$\Delta V_{BR}/\Delta T$	—	60	—	mV/°C	

a. Typical values are measured at 10V above breakdown and 25°C ambient temperature.

b. Broadcom will ensure a V_{BD} range of ≤ 800 mV per reel by binning.
Bin A = 33.2V to 34.0V, Bin B = 33.8V to 34.6V, Bin C = 34.4V to 35.2V, Bin D = 35.0V to 35.8V, Bin E = 35.6V to 36.4V.

c. Measured using an input sine wave with f = 200 kHz and V_{in} = 500 mV at 10V overvoltage.

Reference Plots

Features are measured at 25°C unless otherwise specified.

Figure 3: PDE vs. Overvoltage

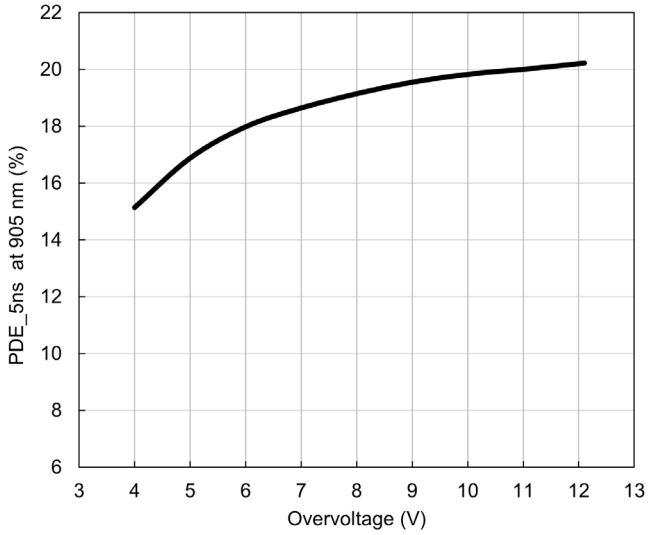


Figure 4: PDE Spectrum

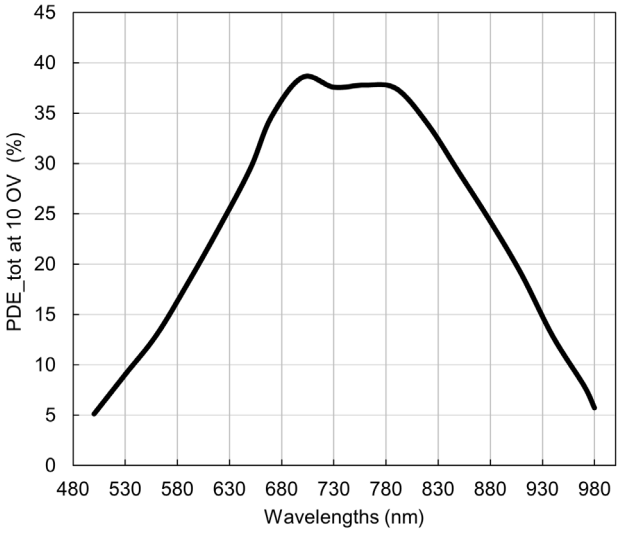


Figure 5: Typical I-V Curve

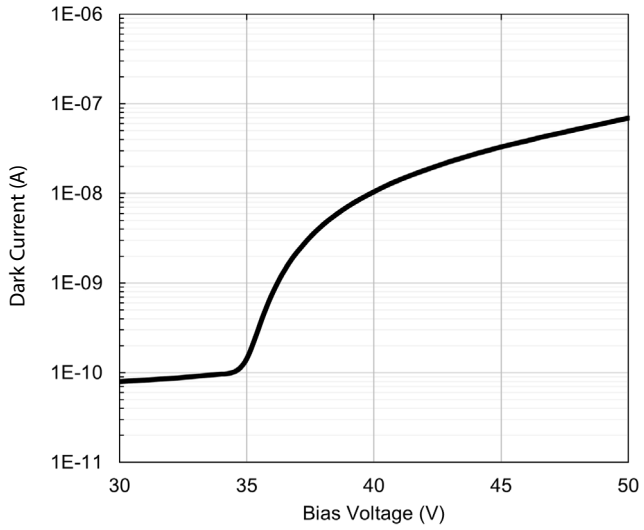


Figure 6: Dark Count Rate

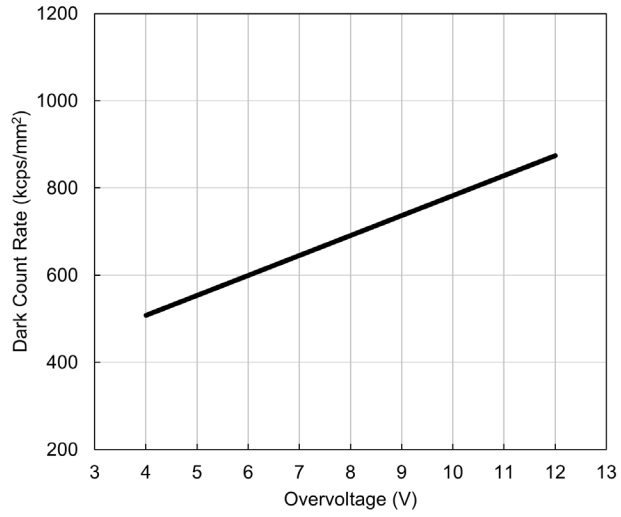


Figure 7: Gain vs. Overvoltage

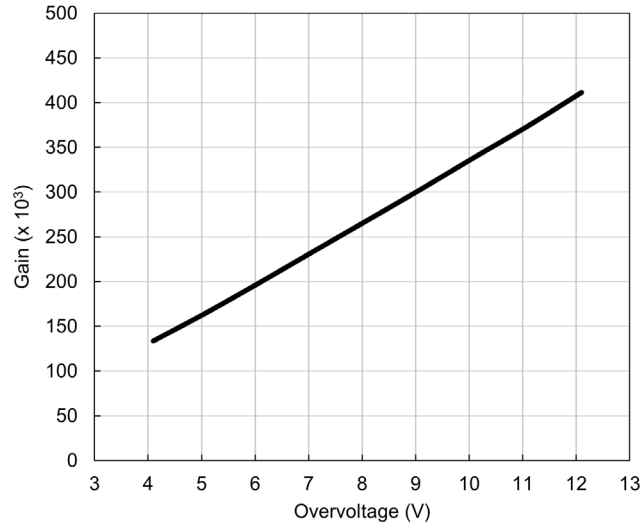


Figure 8: Correlated Noise vs. Overvoltage

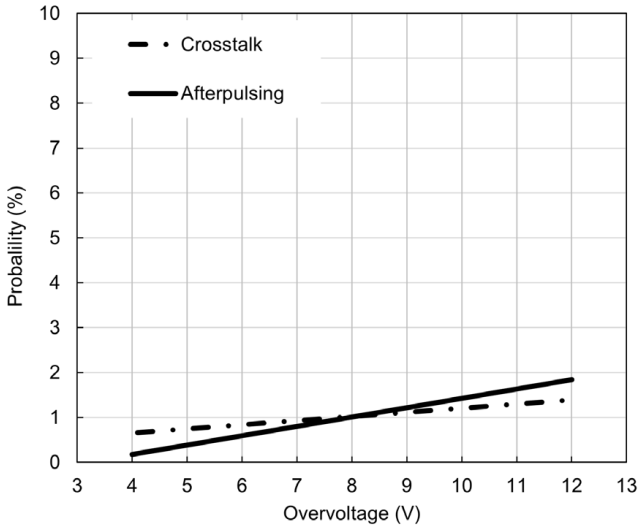


Figure 9: Typical Waveform (Normalized Amplitude)