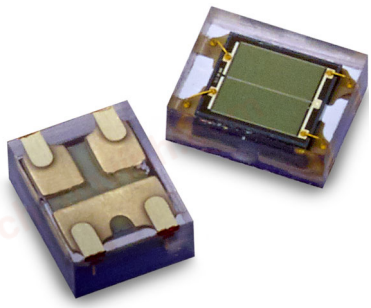
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BROADCOM®

Data Sheet

AFBR-S4P11P012R

NIR Dual-Channel Silicon Photomultiplier



Description

The Broadcom® AFBR-S4P11P012R is a silicon photomultiplier (SiPM) that is optimized for ultra-sensitive detection of light in the near-infrared region of the electromagnetic spectrum. It combines very high photodetection efficiency with a wide dynamic range due to the small cell pitch and the fast recharge time.

The active region is divided in 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-S4P11P012R SiPM best suited for LiDAR and direct time-of-flight (dToF) applications.

This product is lead free and RoHS compliant.

Features

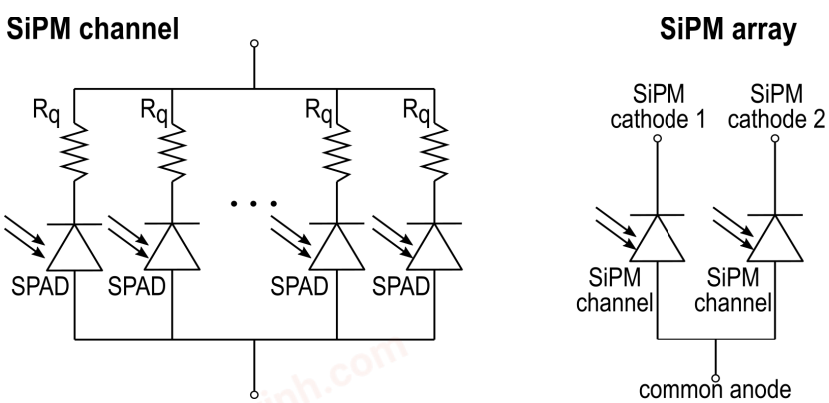
- 28% PDE at λ = 905 nm
- 26% PDE at λ = 650 nm
- Wide dynamic range
- Very fast cell recharge time constant of 15 ns
- Compact molded lead frame package
- Operating temperature range from –40°C to +85°C
- RoHS compliant

Applications

- 3D ranging (LiDAR)
- Direct time of flight (dToF)
- Robotics
- Drones
- Biophotonics

Block Diagram

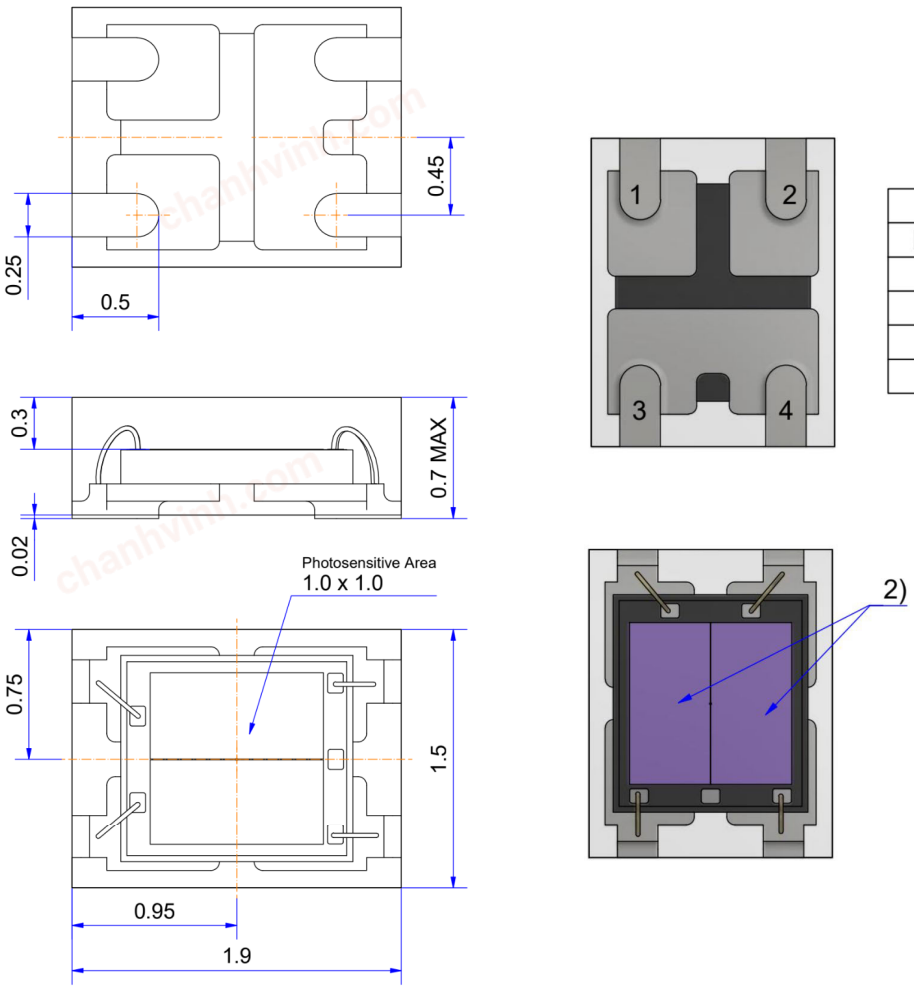
Figure 1: Block Diagram of the AFBR-S4P11P012R for One of the Two SiPM Channels (Left) and the Whole Chip (Right)



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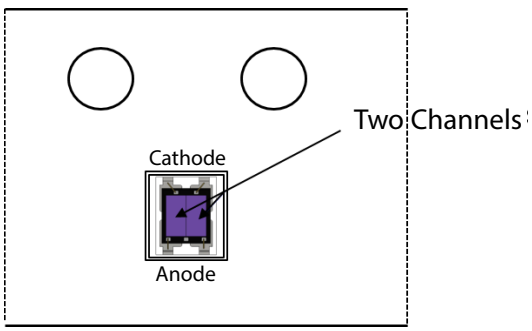
Mechanical Drawing and Pin Layout

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

Figure 3: Device Orientation in Reel



NOTE:

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

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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.

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	s
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	—

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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	
Resin Refractive Index	η	—	1.57	—	—	
Peak Sensitivity Wavelength	λ_{PK}	—	750	—	nm	
Photo Detection Efficiency	PDE at λ_{PK}	—	37	—	%	Figure 4, Figure 5
	PDE at 650 nm	—	26	—	%	
	PDE at 905 nm	—	28	—	%	
Dark Current	I_D	—	61	—	nA	Figure 6
Dark Count Rate[b]	DCR	—	1.17	—	Mcps	Figure 7
Gain	G	—	340	—	$\times 10^3$	Figure 8
Optical Crosstalk Probability	P_{Xcorr}	—	< 2	—	%	Figure 8
Afterpulsing Probability	AP	—	22.6	—	%	Figure 9
Recharge Time Constant	τ_{fall}	—	15	—	ns	
Breakdown Voltage[c]	V_{BD}	35.5	36.5	37.5	V	
Nominal Terminal Capacitance[d]	C_T	—	38	—	pF	
Temperature Coefficient of Breakdown Voltage	$\Delta V_{BR}/\Delta T$	—	70	—	mV/°C	
Temperature Coefficient of Gain[e]	$\Delta G/\Delta T$	—	2.6	—	$\times 10^3$/°C	

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

b. Measured at 0.5 p.e. amplitude. The measurement does not include delayed correlated events.

c. Broadcom will ensure a V_{BD} range of ≤ 800 mV per reel by binning.
Bin A = 35.5V to 36.3V, Bin B = 36.1V to 36.9V, and Bin C = 36.7V to 37.5V.

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

e. Calculated from the gain dependence on V and the breakdown voltage temperature coefficient: $dG/dT = dG/dV \times dV_{BR}/dT$.

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Reference Plots

Features are measured at 25°C unless otherwise specified.

Figure 4: PDE vs. Overvoltage at 905 nm

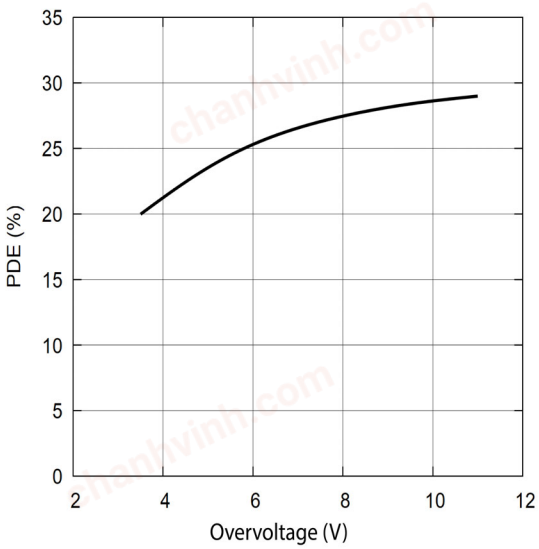


Figure 5: PDE Spectrum at 10V Overvoltage

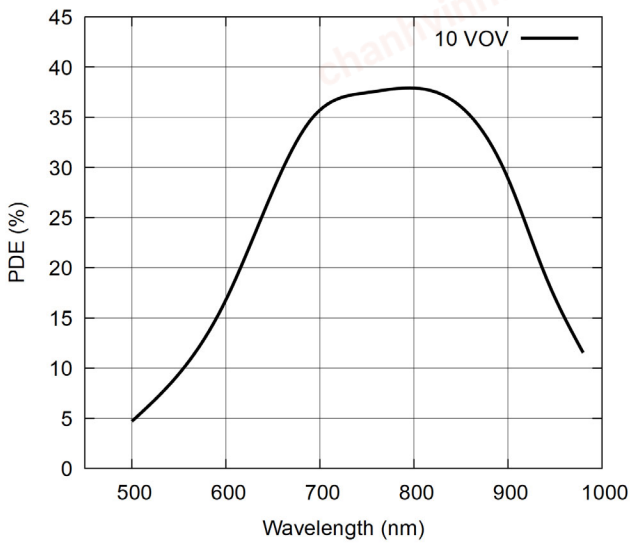


Figure 6: Typical I-V Curve

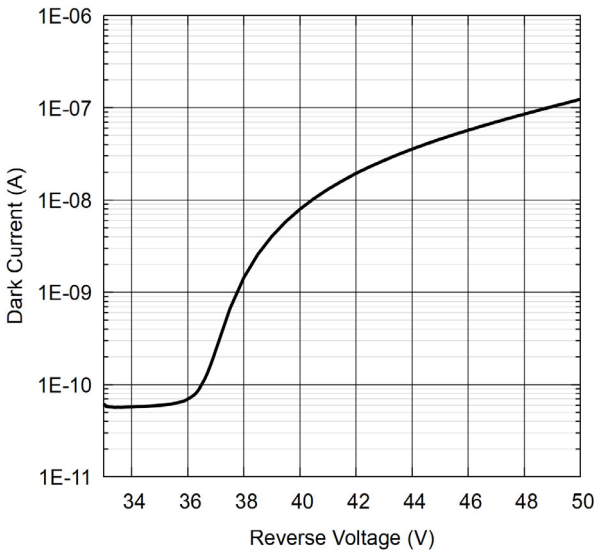
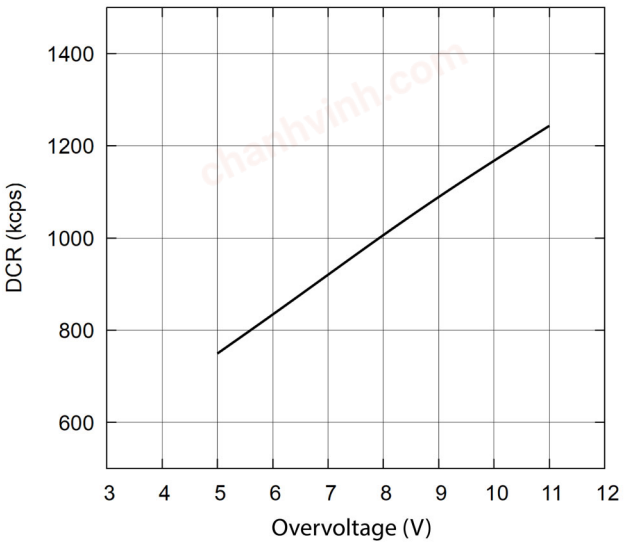


Figure 7: Dark Count Rate



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Figure 8: Gain vs. Overvoltage

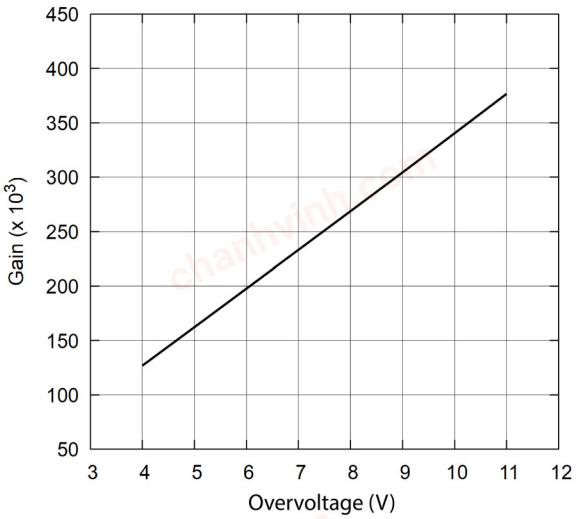


Figure 9: Correlated Noise vs. Overvoltage

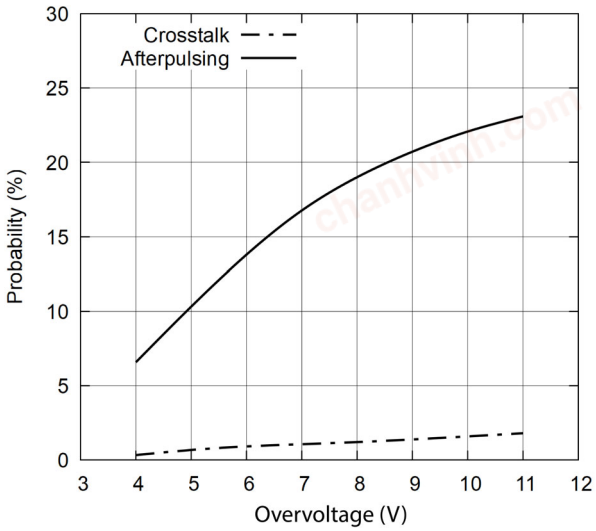
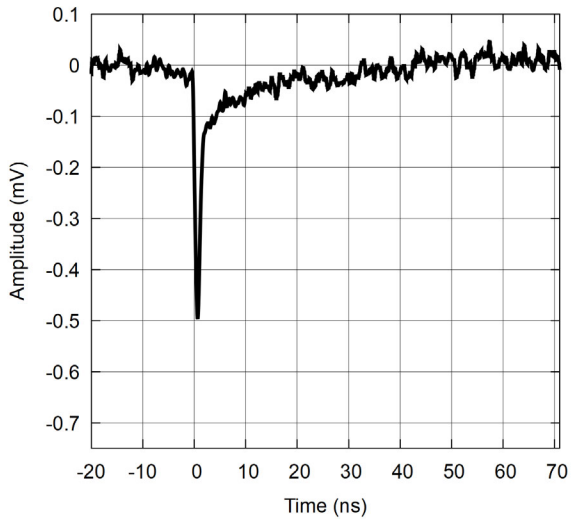


Figure 10: Typical 2 Photoelectron Waveform (10V Overvoltage, 25Ω without Amplifier)



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