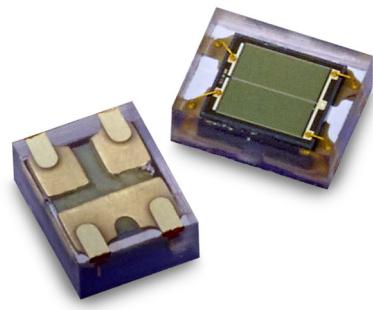


AFBR-S4P11P012R

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.

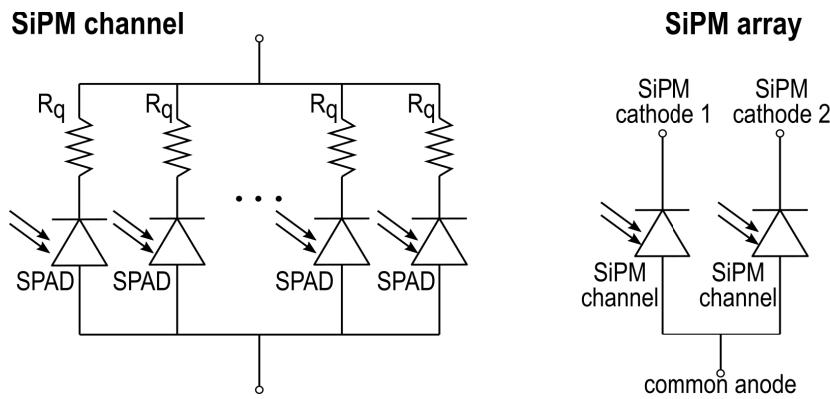
The active region is divided in two equal and independent elements, which can be read out independently or connected together to achieve an overall photosensitive area of $1 \times 1 \text{ mm}^2$. This feature enables a higher degree of flexibility for the design of the readout system.

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.

Block Diagram

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



Features

- 28% PDE at $\lambda = 905 \text{ nm}$
- 26% PDE at $\lambda = 650 \text{ nm}$
- Wide dynamic range
- Very fast cell recharge time constant of 15 ns
- Compact molded lead frame package
- Operating temperature range from -40°C to $+85^\circ\text{C}$
- RoHS compliant

Applications

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

Mechanical Drawing and Pin Layout

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

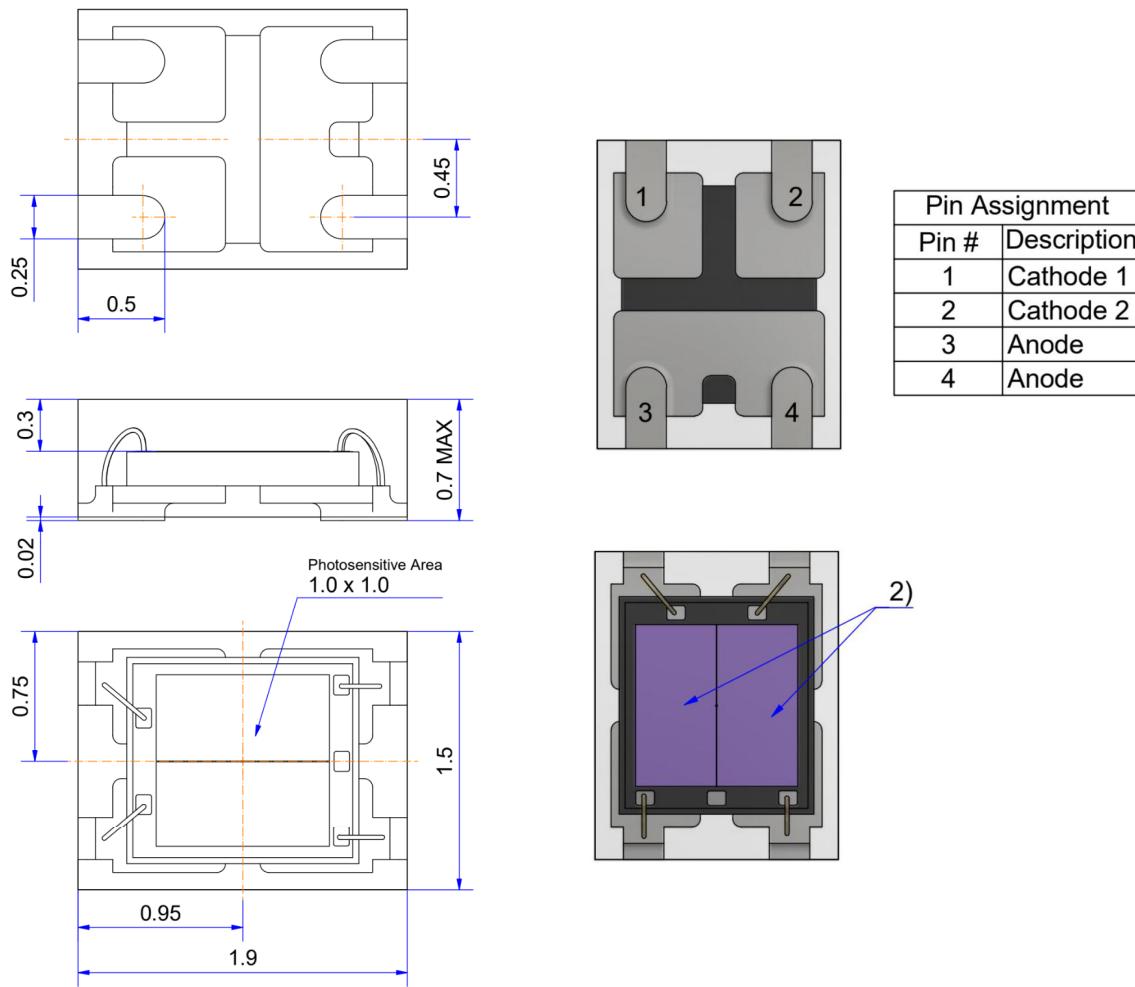
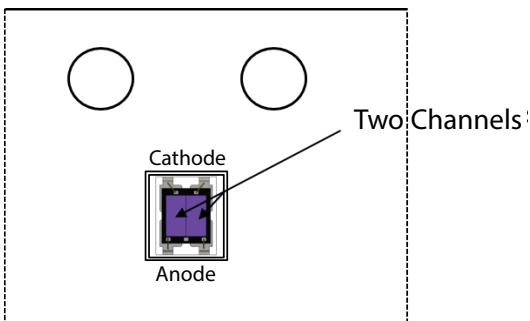


Figure 3: Device Orientation in Reel



NOTE:

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

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 | mm ² |
| Total Active Area | AA | 1.0×1.0 | mm ² |
| Element Active Area | EAA | 0.5×1.0 | mm ² |
| 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 $1 \times 1 \text{ mm}^2$ 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 | — | $\times 10^3/^\circ\text{C}$ | |

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: $dG/dT = dG/dV \times dV_{BR}/dT$.

Reference Plots

Features are measured at 25°C unless otherwise specified.

Figure 4: PDE vs. Overvoltage at 905 nm

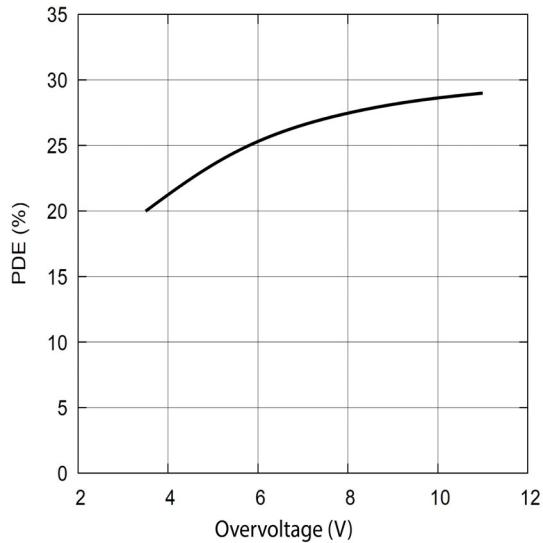


Figure 5: PDE Spectrum at 10V Overvoltage

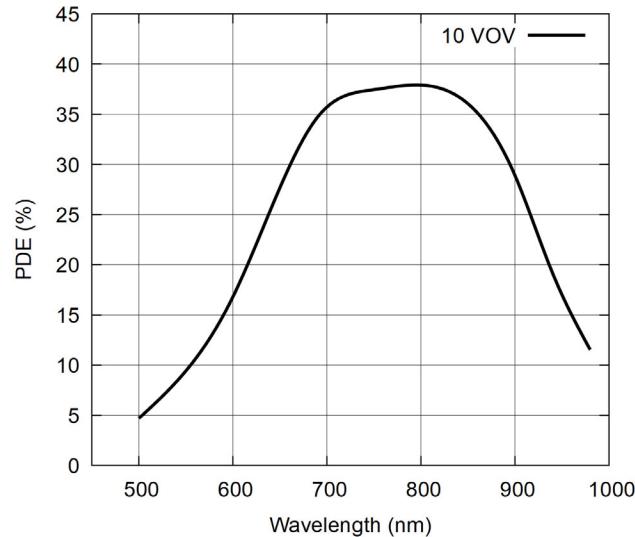


Figure 6: Typical I-V Curve

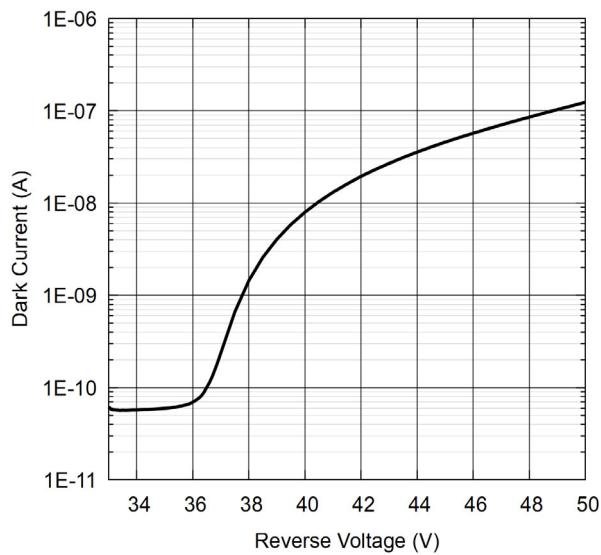


Figure 7: Dark Count Rate

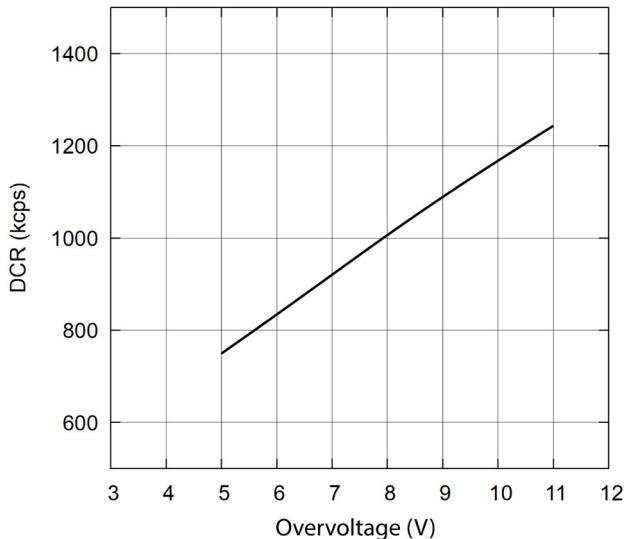
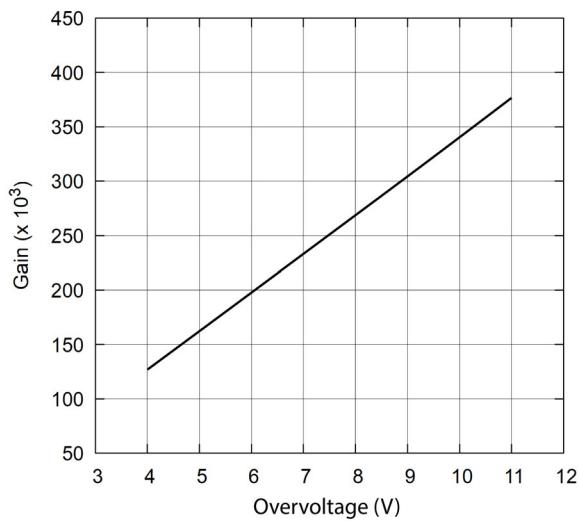
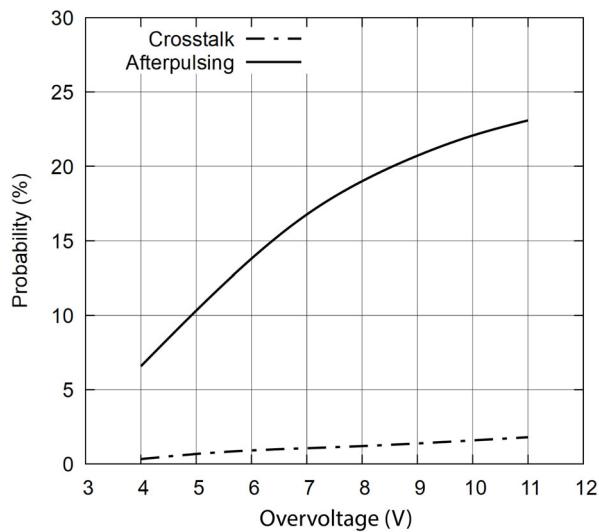
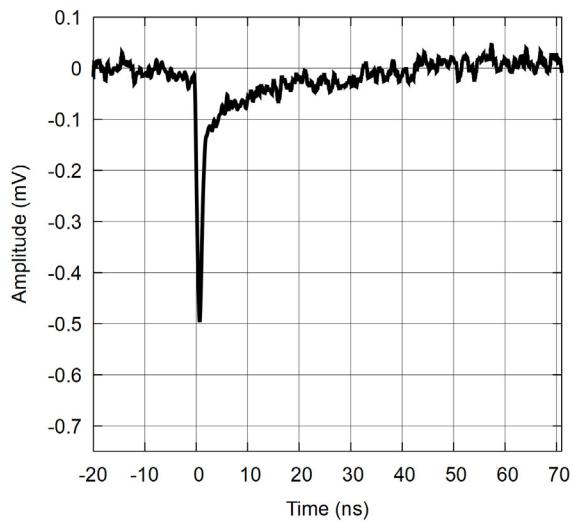


Figure 8: Gain vs. Overvoltage**Figure 9: Correlated Noise vs. Overvoltage****Figure 10: Typical 2 Photoelectron Waveform
(10V Overvoltage, 25Ω without Amplifier)**

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