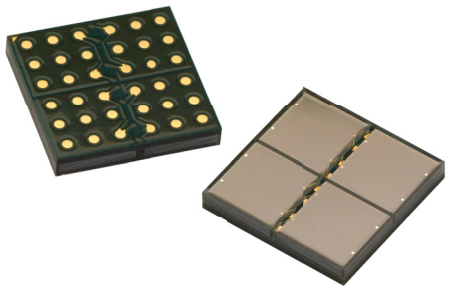
BROADCOM®

Data Sheet

AFBR-S4N44P044M

2 × 2 NUV-MT Silicon Photomultiplier Array



Description

The Broadcom® AFBR-S4N44P044M is a 2 × 2 silicon photomultiplier (SiPM) array that is used for ultra-sensitive precision measurements of single photons. This SiPM is based on the NUV-MT technology, which combines improved photo-detection efficiency (PDE) with decreased dark count rate and reduced crosstalk compared to the NUV-HD technology. The pitch of the SiPMs is 4 mm in both directions. Larger areas can be covered with a pitch of 8.3 mm by tiling multiple AFBR-S4N44P044M arrays almost without any edge losses. The encapsulation for good mechanical stability and robustness is realized by an epoxy clear mold compound, which is highly transparent down to UV wavelengths, resulting in a broad response in the visible light spectrum with high sensitivity toward the blue and near-UV region of the light spectrum. The array is best suited for the detection of low-level pulsed light sources, especially for detection of Cherenkov or scintillation light from the most common organic (plastic) and inorganic scintillator materials (for example, LSO, LYSO, BGO, NaI, CsI, BaF, $LaBr_3$). This product is lead-free and compliant with RoHS.

Features

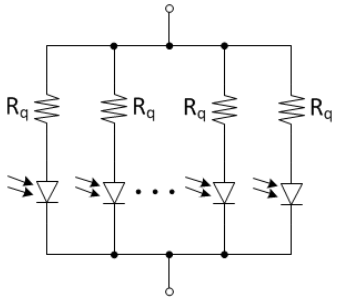
- 2 × 2 SiPM array
- Array size: 8.26 mm × 8.26 mm
- High PDE (63% at 420 nm)
- Excellent SPTR and CRT
- Excellent uniformity of breakdown voltage
- Excellent uniformity of gain
- 4-side tileable, with high fill factors
- Cell pitch: 40 µm
- Highly transparent epoxy protection layer
- Operating temperature range from –20°C to +50°C
- RoHS, CFM, and REACH compliant

Applications

- X-ray and gamma-ray detection
- Nuclear medicine
- Positron emission tomography
- Safety and security
- Physics experiments
- Cherenkov detection

Block Diagram

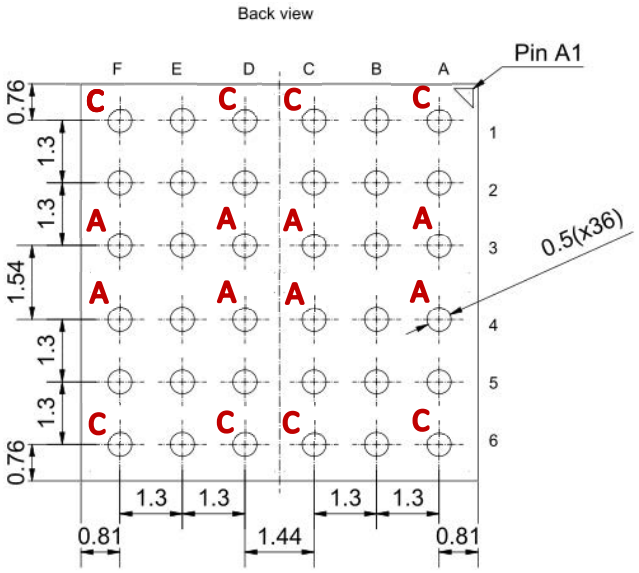
Figure 1: AFBR-S4N44P044M Block Diagram of Single SiPM Element



Pad Layout

The AFBR-S4N44P044M has 16 signal pins. The anode and the cathode of each SiPM chip can be connected separately. The cathodes do not have a common connection on the module. The pad layout is displayed in the following figure.

Figure 2: Pad Layout

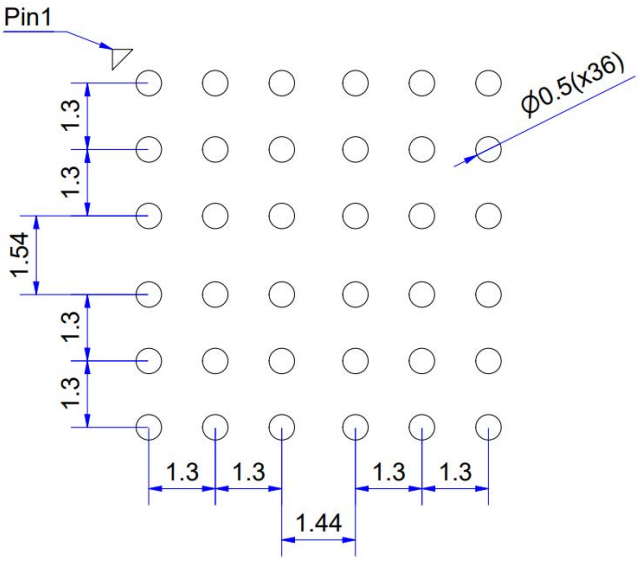


PAD CONNECTION	PAD NO.
Ch. A1 cathode	A1,C1
Ch. A1 anode	A3,C3
Ch. B1 cathode	D1,F1
Ch. B1 anode	D3,F3
Ch. A2 anode	A4,C4
Ch. A2 cathode	A6,C6
Ch. B2 anode	D4,F4
Ch. B2 cathode	D6,F6
Not connected	B1,E1,A2,B2,C2,D2,E2,F2,B3,E3,B4,E4,A5,B5,C5,D5,E5,F5,B6,E6

NOTE:

1. Dimensions are in mm.
2. “A” stands for anode; “C” stands for cathode.

Figure 3: Recommended Landing Pattern



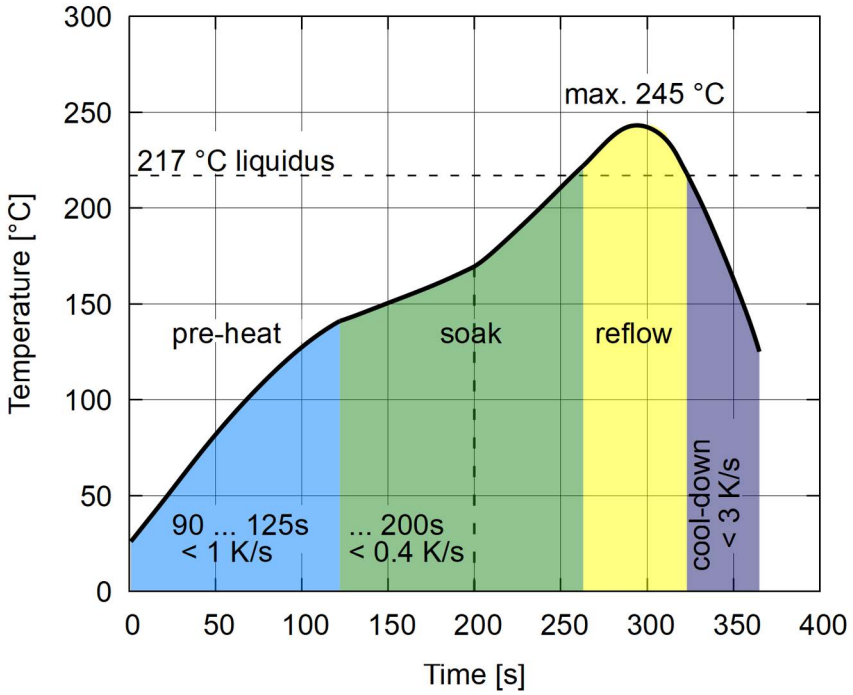
NOTE: Dimensions are in mm.

Regulatory Compliance Table

Feature	Test Method	Performance
Electrostatic discharge (ESD) to the electrical pins, human-body model (contact ESD)	JESD22-A114	See Absolute Maximum Ratings.
Electrostatic discharge (ESD) to the electrical pins, charged-device model	JESD22-C101F	See Absolute Maximum Ratings.
Restriction of hazardous substances directive	RoHS Directive 2011/65/EU Annex II	Certified compliant.

Reflow Soldering Diagram

Figure 4: Recommended Reflow Soldering Profile



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 may occur if these limits are exceeded for other than a short period of time.

Parameter	Symbol	Min.	Max.	Unit
Storage Temperature	T_{SG}	–20	+60	°C
Operating Temperature [a]	T_A	–20	+50	°C
Soldering Temperature [b, c]	T_{SOLD}	—	245	°C
Lead Soldering Time [b, c]	t_{SOLD}	—	60	seconds
Electrostatic Discharge Voltage Capability (HBM)	ESD_{HBM}	—	2	kV
Electrostatic Discharge Voltage Capability (CDM)	ESD_{CDM}	—	500	V
Operating Overvoltage	V_{OV}	—	16	V

a. Biased at constant voltage = 12V above breakdown.

b. The tile is reflow solderable according to the solder diagram shown in Figure 4.

c. Baking at 125°C for 16 hours is mandatory prior to soldering. MLD is according to MSL 6 with a floor life of 4 hours at 30°C and 60% relative humidity.

Single Device Specification

Features are measured at 25°C unless otherwise specified.

Geometric Features

Parameter	Symbol	Value	Unit
Single Device Area	DA	3.84 × 3.74	mm^2
Active Area	AA	3.72 × 3.62 × 4	mm^2
Element Active Area	EAA	3.72 × 3.62	mm^2
Micro Cell Pitch	L_{CELL}	40	µm
Number of Micro Cells per Element	N_{CELLS}	8334	—

Optical and Electrical Features

Features are measured at 12V OV and 25°C unless otherwise specified.

Parameter	Symbol	Min.	Typ. [a]	Max.	Unit	Reference Plots
Spectral Range	λ	250	—	900	nm	Figure 5
Peak Sensitivity Wavelength	λ_{PK}	—	420	—	nm	Figure 5
Breakdown Voltage	V_{BD}	32	32.5	33	V	Figure 7
Temperature Coefficient of Breakdown Voltage	$\Delta V_{BD}/\Delta T$	—	30	—	mV/°C	—
Photo-Detection Efficiency [b]	PDE	—	63	—	%	Figure 5, Figure 6
Dark Current per Element	I_D	—	3.3	—	µA	Figure 7
Dark Count Rate per Element [c]	DCR	—	1.7	—	Mcps	Figure 8
Dark Count Rate per Unit Area	DCR_{mm2}	—	125	—	$kcps/mm^2$	—
Gain	G	—	7.3	—	$\times 10^6$	Figure 9
Optical Crosstalk	P_{XTALK}	—	23	—	%	Figure 10
After-Pulsing Probability	P_{AD}	—	< 1	—	%	—
Recharge Time Constant	T_{FALL}	—	55	—	ns	Figure 11
Nominal Terminal Capacitance [d]	C_T	—	580	—	pF	—
Temperature Coefficient of Gain [e]	$\Delta G/\Delta T$	—	1.46	—	$\times 10^4$/°C	—

a. Measured at 12V OV.

b. Measured at peak sensitivity wavelength. The measurement does not include correlated noise, such as after-pulsing or optical crosstalk.

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

d. Measured using the input sine wave with f = 200 kHz and Vin = 500 mV.

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

Reference Plots

Features are measured at 25°C unless otherwise specified. The plotted data represents typical values per single element.

Figure 5: PDE vs. Wavelength

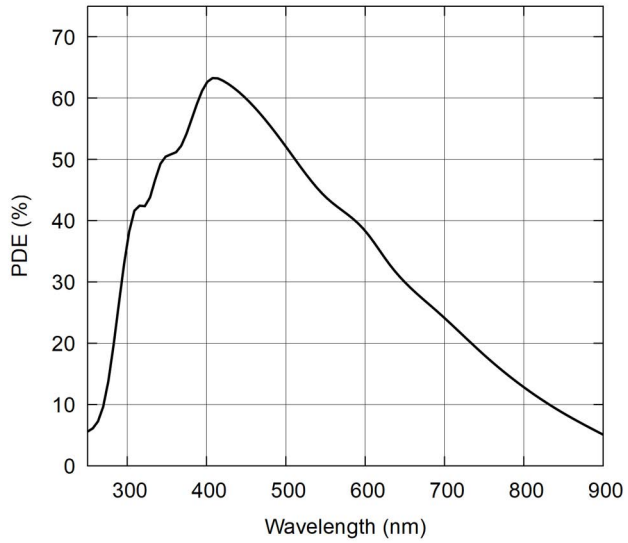


Figure 6: PDE at Peak λ vs. OV (Overmolded Package)

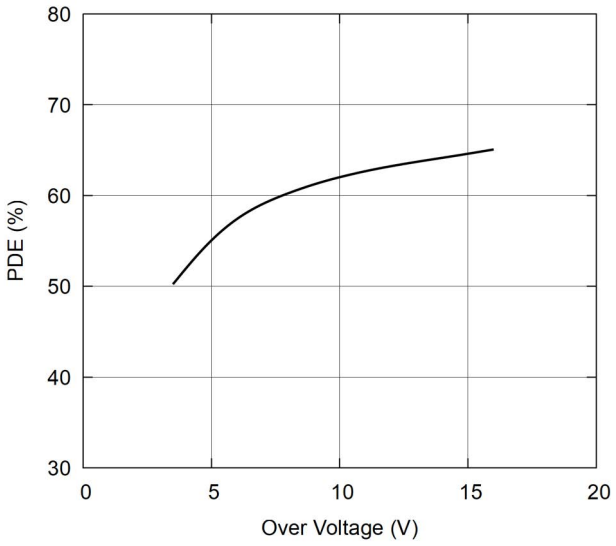


Figure 7: Reverse I-V Curve

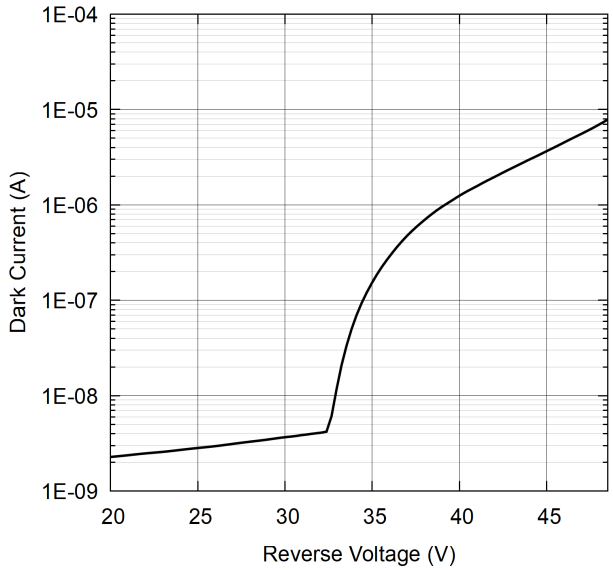


Figure 8: Dark Count Rate vs. OV

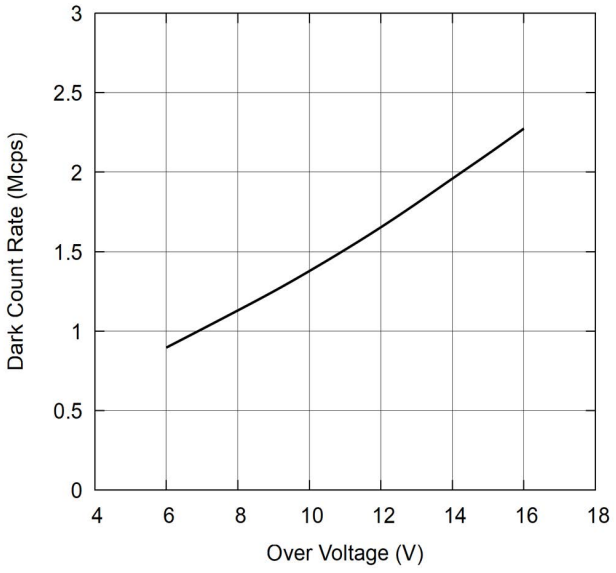


Figure 9: Gain vs. OV

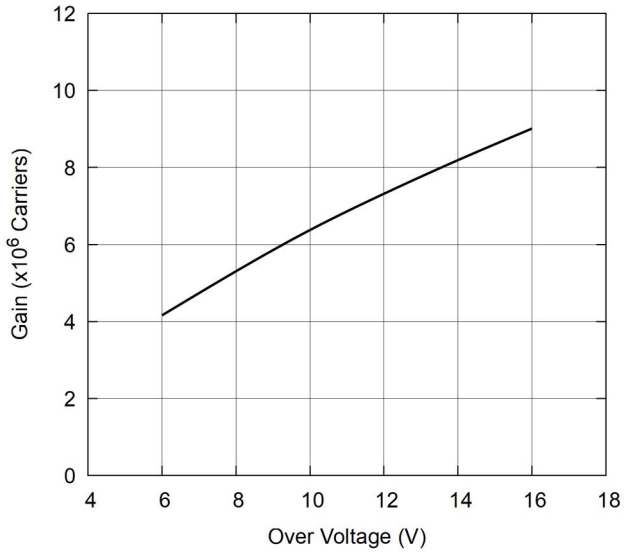


Figure 10: Correlated Noise vs. OV

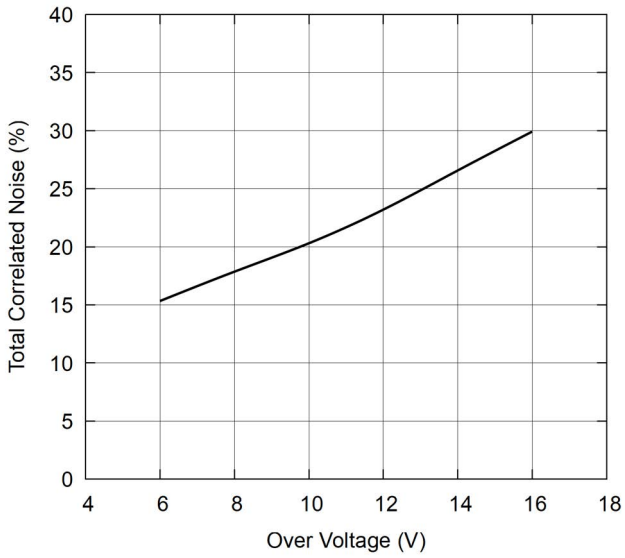
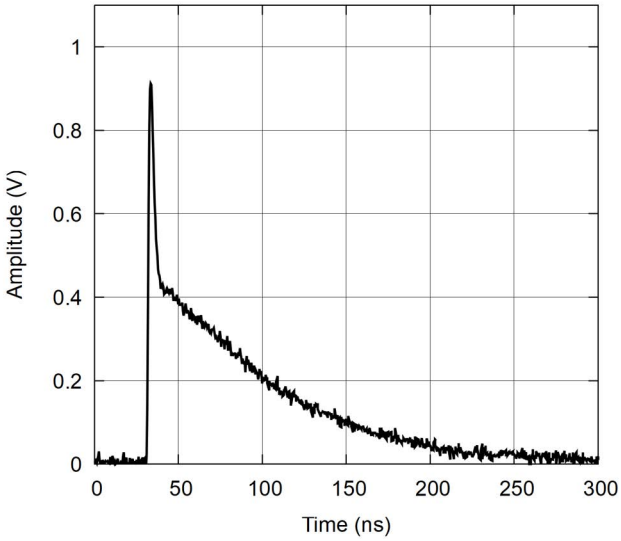


Figure 11: Example Signal Measured at 12V OV



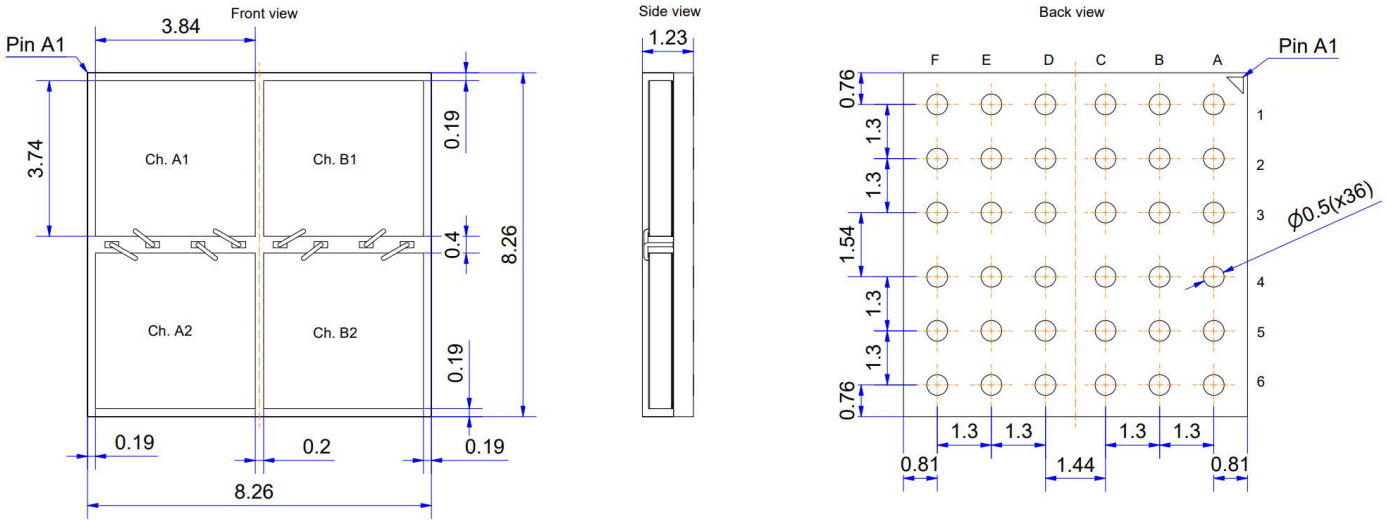
Array Specification

The array consists of four wire-bonded SiPM dies arranged in a 2×2 matrix with a package fill factor of 79% (active area versus total package area).

Parameter	Symbol	12V OV			Unit
		Min.	Typ.	Max.	
Dark Current Sum at 12V OV	ΣI_D	—	14	—	µA

Mechanical Data – Package Outline

Figure 12: Package Outline Drawing



NOTE:

1. Dimensions are in mm.
2. Numbers are rounded to two decimal places.