Application Note

AFBR-S4EP001

NIR30 SiPM Evaluation Kit

Overview

This application note introduces the Broadcom® AFBR-S4EP001 evaluation kit, which has been designed to be used as an evaluation platform for the AFBR-S4P11P012R SiPM.

The document describes in detail the boards included in the evaluation kit and the test setup used for the evaluation of the optical and electrical characteristics of this SiPM.

Figure 1 shows the front and back sides of the AFBR-S4EP001 evaluation board.

Features of the Amplifier PCB

- Two 50Ω outputs
- Designed for single-photon and multiple-photon detection, such as scintillator readout
- Operating temperature range from –20°C to +50°C
- RoHS and REACH compliant

Features of the DC Readout PCB

- Over 50Ω load DC
- No amplification stage
- Compatible with Thorlabs SM01 cage frames

Evaluation Kit

The evaluation kit includes the following:

- 1x evaluation board with amplified energy and timing output
- 1x round DC evaluation PCB (unamplified output)
- 1x AFBR-S4P11P012R SiPM (mounted on a test PCB, 1x1 mm^2 active area)

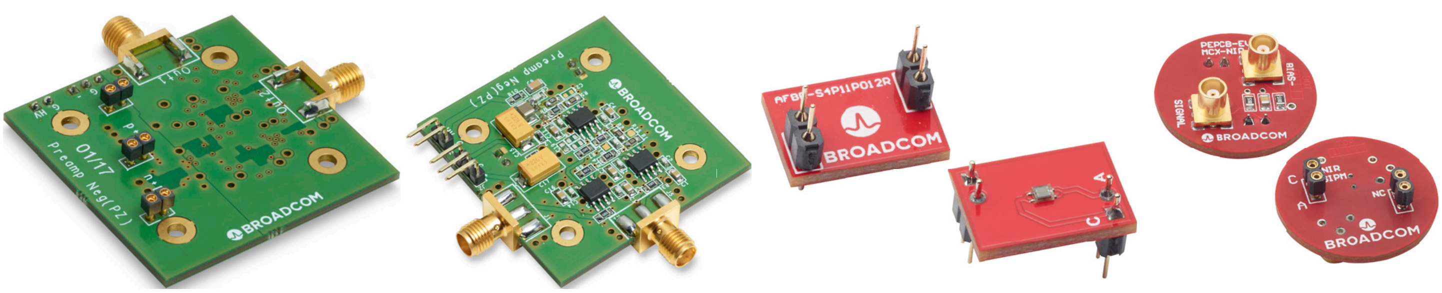
The evaluation kit does *not* include the following:

- SiPM high-voltage source (up to approximately 50V)
- Dual power supply (±2.5V to ±8.5V)
- Cables for readout

Applications

- Prototyping
- Device characterization
- LiDAR
- dTOF
- Fluorescence detection
- Cytometry

Figure 1: Components of the Evaluation Kit Including the Amplifier Board (Left, Center Left), the SiPMs on the PCB (Center Right), and the Round DC Readout PCB (Right)



Amplifier PCB

This section provides details on the amplifier PCB, its connectors, supply voltage requirements, and outputs.

Description

Figure 2 shows the block diagram.

Figure 2: Block Diagram

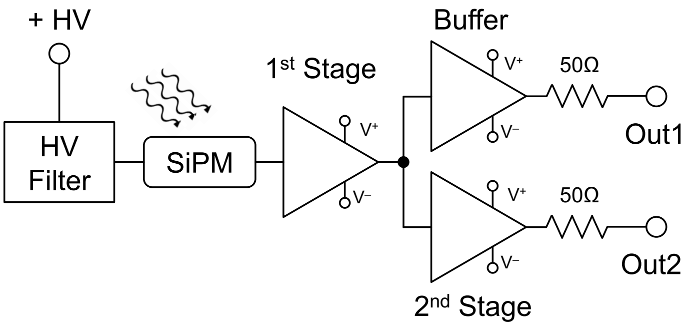


Figure 3: Evaluation Board Front Side

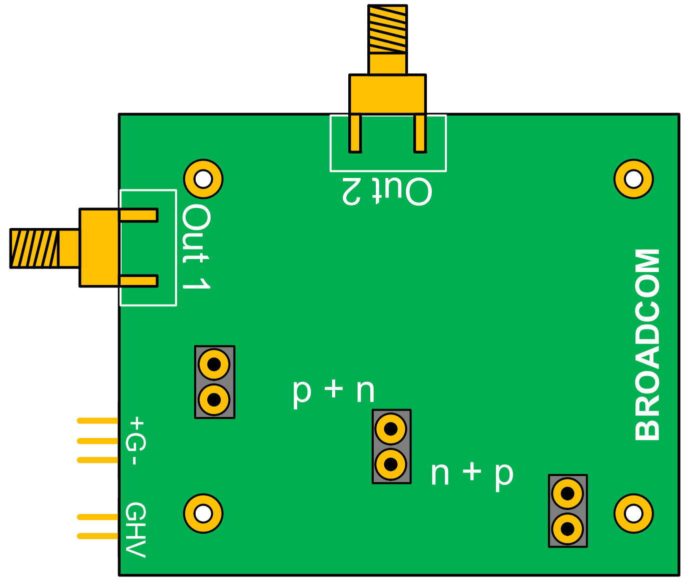
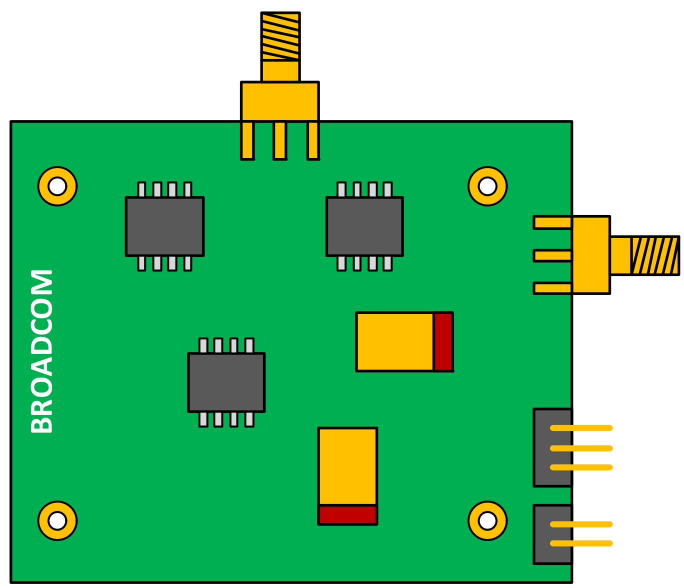


Figure 4: Evaluation Board Back Side



The high voltage is filtered before being applied to the SiPM to minimize the fluctuations in the voltage source. The SiPM output signal goes into a first stage of amplification based on an operational amplifier in a transimpedance configuration. Its output is then split into two lines: the first goes through a buffer with unity gain and is connected to Out1; the second passes through a second stage of amplification including a Pole-Zero (PZ) filtering network and is connected to Out2. Given a flash of light, Out1 is used to estimate the number of detected photons, whereas Out2 gives a precise determination of the timing. Both outputs should be read through a 50Ω termination resistor.

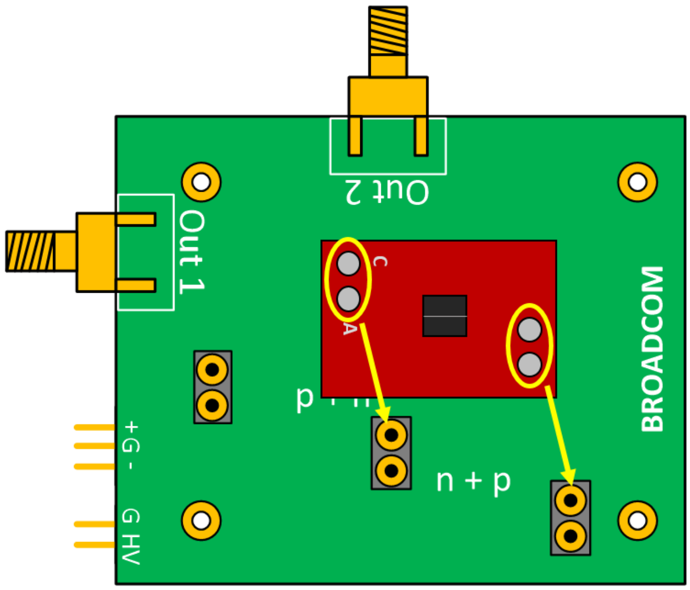
Inputs and Outputs

The board has three inputs (SiPM signal, SiPM high voltage, and power supply) and two outputs (Out1 and Out2). Two additional receptacles are included for mechanical stability only. Figure 3 and Figure 4 show a sketch of the board's front and back view.

SiPM Input

The detector must be connected as shown in Figure 5.

Figure 5: Connection with SiPM PCB



The anode and cathode of the detector are connected to the amplifier's input, whereas the other receptacle has no electrical connection and is used only for mechanical stability.

SiPM High Voltage

SiPM high voltage is provided with the 2-pole connector displayed in Figure 6. The supply voltage must be positive.

Figure 6: SiPM High-Voltage Connector Detail

Board Power Supply

Power for the board is provided by the 3-pole connector displayed in Figure 7.

Figure 7: Board Power-Supply Connector Detail

The following are suggested starting values:

- V^+: +5V
- V^-: –5V

With the suggested values, the absorbed current in each line is approximately 40 mA. The output signals can range from –3.8V to + 3.8V (±1.2V is used by the op-amp and is unavailable). Since Out1 is negative and Out2 is positive, the user might want to shift the output dynamic to avoid saturation in one of the outputs. Typically, it is crucial to avoid saturation on the energy channel rather than on the timing channel. The reason for this is that the timing signal carries the most useful information at the very beginning of its rising edge, where saturation is not an issue.

To shift the output range, adjust the bias voltages and keep the overall difference within 11V max. (10V is suggested for safety). Additionally, each voltage cannot be lower than ±2.5V or higher than ±8.5V.

In summary:

- $+2.5V \leq V^+ \leq +8.5V$
- $-2.5V \geq V^- \geq -8.5V$
- $V^+ - V^- \leq 11V$

Out1: Energy

Out1 is the output of the first stage of amplification and provides a DC output signal that is matched to 50 ohm.

The polarity is negative. The gain of the amplification stage (also accounting for termination) is G = 182 V/A. An offset of a few tens of millivolts with respect to ground is common and is due to the operational amplifier chip. The exact value changes from sample to sample and can be positive or negative.

Out2: Timing

Out2 is the output of the second stage of amplification. The polarity is positive. The gain of the amplification stage is not defined because of the presence of the PZ network.

The PZ filter is designed to change the signal shape. Specifically, it suppresses the recovery tail of the SiPM signal, thus reducing the baseline fluctuations due to dark counts. Consequently, the extraction of the timing information (when using a simple leading edge discriminator [LED], as an example) is more accurate and allows for improved timing resolution performance. Hence, Out2 is referred to as the timing signal.

Absolute Maximum Ratings

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

Table 1: Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit
Storage Temperature	T_{STG}	–20	+60	°C
Operating Temperature	T_A	–20	+50	°C
Op-amp Dual Voltage	V±	±2.5	±8.5	V
Op-amp Total Voltage Difference	$V^+ - V^-$	—	11	V
Supply Current	I±	—	100	mA

Round DC Readout PCB

This section provides an overview on the DC readout PCB of the AFBR-S4EP001.

Description

The circular DC SiPM readout PCB is designed for maximum dynamic range readouts, allowing access to the SiPM signal without the potential restrictions of an amplifier circuit (for example, signal amplitude or bandwidth).

The DC PCB is equipped with a low-pass filter on the bias supply line to reduce voltage ripples from the voltage source and with a load resistor (50Ω) in the signal line. This 50Ω load causes an effective load of 25Ω when the signal is read using a 50Ω input impedance on an oscilloscope or data acquisition system (DAQ).

The mechanical dimensions of the circular DC readout PCB are designed to be compatible with Thorlabs SM01 cage mount systems. The circular form factor allows the PCB to be inserted in the Thorlabs cage frames or lens tubes such that the SiPM is aligned with additional optics used in customer setups.

Inputs and Outputs

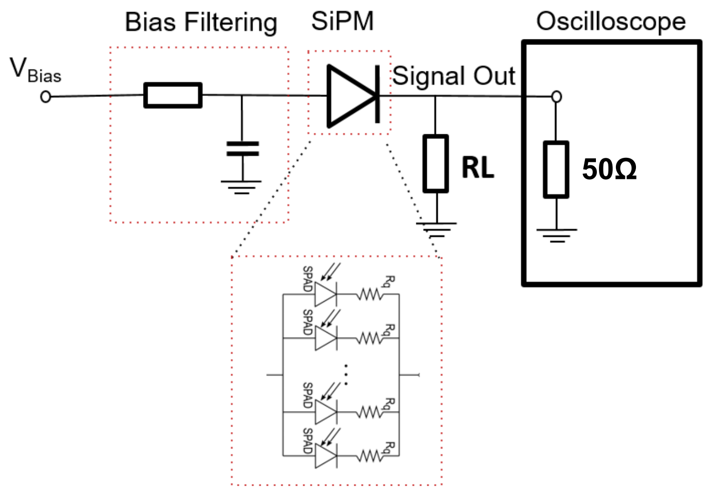
The DC PCB uses MCX connectors (jack, 50Ω) for signal and bias connections.

The negative bias voltage is supplied via the BIAS- input. The SiPM breakdown voltage is between 35.5V and 36.3V (at 25°C), and the maximum allowed overvoltage is 12V. The maximum absolute voltage is 50V.

The SiPM signal is retrieved via the SIGNAL connector and can be directly connected to an oscilloscope.

Figure 8 shows a block diagram when connecting an SiPM to an oscilloscope using the circular DC readout PCB.

Figure 8: Block Diagram of SiPM Readout Using the Circular DC Readout PCB and an Oscilloscope



Connecting the SiPM

The SiPM (on the interposer PCB) is connected to the pin headers on the top side. The pin headers for the SiPM anode and cathode are labeled with “A” and “C” on the circular PCB and the SiPM interposer PCB. The second pair of pins (header) is not connected. These two pins increase mechanical stability and ensure alignment of the SiPM front side with the optics.