Overview

The Broadcom AFBR-S4N44P163 4 x 4 element silicon photomultiplier array and Vertilon SIB916 sensor interface board are an ideal combination for use in coincidence detection applications such as positron emission tomography (PET). The compact size and plug-and-play capability make the pair well-suited for use in laboratory experiments that demonstrate near-simultaneous event detection using SiPM devices.

In this application note we describe a simple setup utilizing two Broadcom AFBR-S4N44P163 SiPM arrays in combination with standard, off-the-shelf equipment from Vertilon. The equipment is configured to continuously capture and measure the light from two coincident light sources. Each SiPM array is mounted to a Vertilon SIB916 sensor interface board that is connected using Vertilon interface products, to a Vertilon PhotoniQ IQSP580 charge integrating, 32 channel data acquisition system (DAQ). The setup described is one utilizing a pair of well-controlled synchronized UV laser diode pulsed light sources. Much of this setup is applicable to similar experiments using a sodium 22 source to generate coincident 511 KeV gamma radiation from positron annihilation.

Setup

The Broadcom AFBR-S4N44P163 4 x 4 SiPM arrays are reflow soldered to the SIB916s which are positioned in a light-tight enclosure along with the light sources. The SIB cables from each SIB916 connect to a Vertilon SIB1632 (also in the enclosure) where the 16 outputs from each SiPM array are combined into one SIB cable (SBC090) that connects to a PhotoniQ IQSP580 32 channel data acquisition system. The discriminator output from one SIB916 is fed to the coincidence detector input on the other SIB916 so that a trigger to the PhotoniQ is produced whenever a near-simultaneous radiation event is detected on the SiPM arrays. The energy level threshold for the radiation event is set by the user through the PhotoniQ graphical user interface. Charge signals from the 32 cathodes from the two AFBR-S4N44P163 devices are acquired by the PhotoniQ for each coincidence trigger produced by the SIB916. Digitized output data from the PhotoniQ is sent through a USB 2.0 connection to a PC for display, logging, or real time processing. In the figure above, the PhotoniQ GUI is set to display a dual 4 x 4 image of the energy levels for each event captured.
System Block Diagram

The figure below schematically illustrates all electrical and optical connections in the coincidence detection setup.
**Light-Tight Enclosure**

The exterior and interior views of the light-tight enclosure as well as the connections to other electronic equipment are shown in the photos below. The two SIB916s with their respective SiPM arrays are situated inside of the enclosure. Also within the enclosure is the SIB1632 and associated cabling. The exterior electrical connections are located on the right side of the enclosure and consist of the SIB cable that carries the combined 32 cathode signals from the SiPM arrays, the coincidence output from one of the SIB916s, and the high voltage bias input. Two fiber optic inputs are located on the left side of the enclosure that provide a 405 nm pulsed optical signal to each array.
Coincidence Detection using the Broadcom AFBR-S4N44P163 4 x 4 SiPM Array and the Vertilon SIB916 Sensor Interface Board

Application Note

Light-Tight Enclosure (Interior View)

SiPM Array Fiber Optic Coupling
Operating Conditions

The operating parameters for the SiPM arrays, discriminators, and coincidence detector are set through the PhotoniQ graphical user interface. The SIB916 discriminator parameters are generally determined empirically. For each SIB916, the preamp gain was set to medium, the discriminator was enabled, and the discriminator threshold was set to 15%. Additionally, the coincidence detector on the “A” SIB916 was enabled with an internal feedback connection and a 1 x delta coincidence window. The coincidence detector on the “B” SIB916 was disabled. The function generator was set to produce a 100nsec wide pulse at a repetition rate of 10 KHz on each of its outputs. Both outputs were synchronized to within 1nsec so that every pulse occurrence created a coincidence condition. As a result a 10KHz trigger to the PhotoniQ was generated. The figures below illustrate the software configuration.

Software Configuration

SIB916 (A) Display

SIB916 (B) Display

SIB916 (A) Connected

SIB916 (B) Connected

SIB916 (A) Configuration

Coincidence Detector Enabled

Trigger Rate Equals 10 KHz

External Trigger Derived from SIB916 (A)
Coincidence Timing Signals

The oscilloscope pictures below show the outputs from the function generator and the resulting coincidence trigger signal (purple trace) from the SIB916. Although it is quite difficult to observe in the pictures, the LED source B input (blue trace) is progressively delayed by about 0.5 nsec relative to the LED source A input (yellow trace). The total delay between the A and B inputs therefore ranges from about 0 nsec in the top picture to 1.5 nsec in the bottom picture. It is important to note that the excessive delay shown in these pictures between the occurrence of the coincidence condition and the rising edge of the trigger signal is due to the long delay of the LED drive circuits. Under normal operating conditions this delay will typically be about 10 nsec.