A.1.2 SG6012 Dependence of the SiPM Properties on the Bias Voltage

Related Experiment
A.1.1
C.2.1
D.1

Ordering Options

Equipment	
Code	**Description**
WK5600XEAAAA	SP5600E - Educational Photon Kit
or the all inclusive Premium Version	
WK5600XANAAA	SP5600AN - Educational Kit - Premium Version

Purpose of the experiment

Study the dependence of the main SiPM figures of merit on the bias voltage. Measurement of the breakdown voltage and identification of the optimal working point. The experiment requires the use of the LED source included in the kit.

Fundamentals

The main features of the SiPM are expected to depend on the bias voltage or, more specifically, on the overvoltage, the voltage in excess of the breakdown value:

- The gain is expected to depend linearly on the overvoltage
- The triggering efficiency, i.e. the probability for a charge carrier to generate an avalanche by impact ionization, increases with the overvoltage till a saturation value is achieved. As a consequence, the Photon Detection Efficiency (PDE) increases together with the stochastic events (Dark Count Rate, Cross Talk and After Pulses) affecting the sensor response.

Actually, spurious events are expected to grow super-linearly and the determination of the optimal working point requires the definition of a proper figure of merit. Referring to the photon number resolving capability of the SiPM, the bias can be set to optimize the resolution power, i.e. the maximum number of resolved photons.

The Photomultipliers Tubes are a commercial product since 1934, at RCA; during the golden age of the discovery of the quantum world (Photoelectric effect, Einstein, 1905). Since then, the PMT continuously evolved, serving the industrial and scientific community with a wealth of different design & specification. In 1947, the transistor birth fixed the start of a new detectors generation that has brought to the Silicon Photomultipliers (SiPM) development. The SIPM are very appealing for different reason:

- high detection efficiency (single photo-electron discrimination)
- compactness and robustness
- low operating voltage and power consumption
- low cost
- withstanding to magnetic field

These features make this technology in fashionable in different application fields i.e. medical applications, homeland security, spectrometry, high energy physics …

Equipment

SP5600E - Educational Photon Kit

Model	SP5600	DT5720A	SP5601	SP5650C
Description	Power Supply and Amplification Unit 	Desktop Digitizer 250 MS/s 	LED Driver 	Sensor Holder for SP5600 with SiPM 
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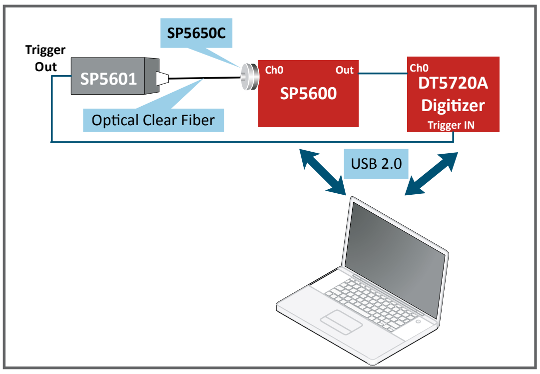
Requirements

No other tools or instruments are needed.



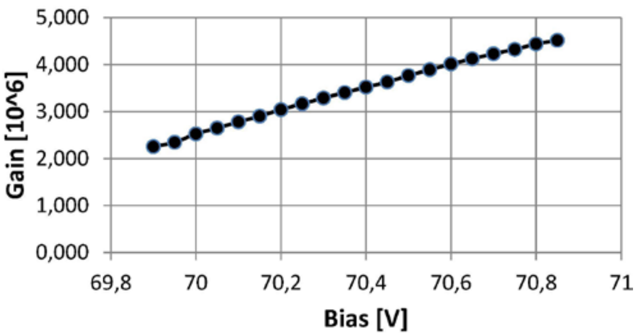
Experimental setup block diagram.

Carrying out the experiment

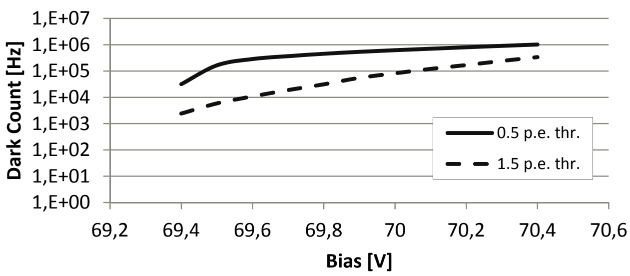
Mount one of the sensors (SP5650C) on the SP5600 and connect the analog output to the input of the DT5720A digitizer. Optically couple the LED and the sensor via the optical fiber, after having used the index matching grease on the tips. Set the internal trigger mode on the SP5601 and connect its trigger output on the DT5720A trigger IN. Connect via USB the modules to the PC and power ON the devices. Through the LabView graphical user interface (GUI), properly synchronize the signal integration and, for every voltage value, record the photon spectrum and measure directly the Dark Count and the Optical Cross talk. The measurement of the After Pulse is also possible but it requires most advanced analysis techniques.

Results

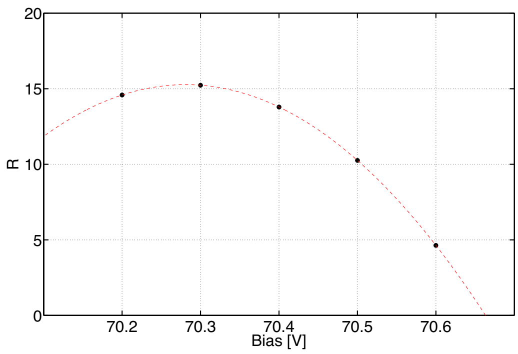
As exemplary illustration, the trend of the gain vs. the bias voltage is shown, allowing as well the measurement of the breakdown voltage corresponding to the value at zero gain. The optimal working point by a measurement of the resolution power on the multi-photon peak spectrum is also shown.



SiPM gain versus bias voltage.



Dark count versus bias voltage.



Scan of the resolution power R as
a function of the bias voltage.