Time constant measurement for onsemi c-series 30035 SiPMs

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SPAD

- **S**ingle **P**hoton **A**valanche **D**iode
- absorbed photon creates an electron-hole pair in material (silicone)
- reverse bias is used
- if the external electric field is high enough, the charge carrier created in the depletion region will gain enough kinetic energy to create more electron-hole pairs through impact ionization
- Geiger mode
  - electron-hole pairs are being created by impact ionization
  - the ionization cascade is self-perpetuating
    - quenching resistor needed to disrupt it
  - the newly created charge carriers provide a measurable current
  - amplitude of final signal is independent of the number of initial photons

SIPM

- **S**ilicon **P**hoto**m**ultiplier
- microcell
  - basic building block of the SiPM
  - consists of a SPAD and its quenching resistor
  - microcell density is usually in the range of 100 to 1000 microcells per mm^2
- the magnitude of initial photon current is proportional to the ammount of fired microcells

Standard and Fast output

- Standard output
  - readout of signal from cathode (negative polarity) or anode (positive polarity)
  - signal is based on the photocurrent created during Geiger mode
- Fast output
  - positive polarity for P-on-N sensors (blue light sensitive) and negative polarity for N-on-P sensors (red light sensitive)
  - derived from the fast switching pulse in the microcell
  - amplitude is proportional to the ammount of fired microcells
  - no net charge transfer through fast output
  - lower capacitance than standard output

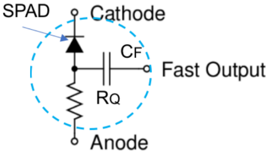


Figure: Internal structure of a microcell.

Application of SiPMs at EIC

- SiPM is a promising candidate for a readout device in electromagnetic calorimetry
  - resistant to magnetic field
  - doesn't take up much longitudinal space
- disadvantages of SiPMs
  - susceptible to neutron radiation damage
  - small dynamic range

onsemi C-series 30035

- output voltage as a function of time from both standard and fast output of six different specimen of the same model was measured
- tested SiPMs
  - onsemi C-series 300035 SiPM on a evaluation board
    - active zone area - 3 $\times$ 3 mm
    - microcell size - 35 μm
    - P on N diodes
    - sensitive to shorter wavelengths
- applied voltage 26.8 V
  - breakdown voltage 24.2 V

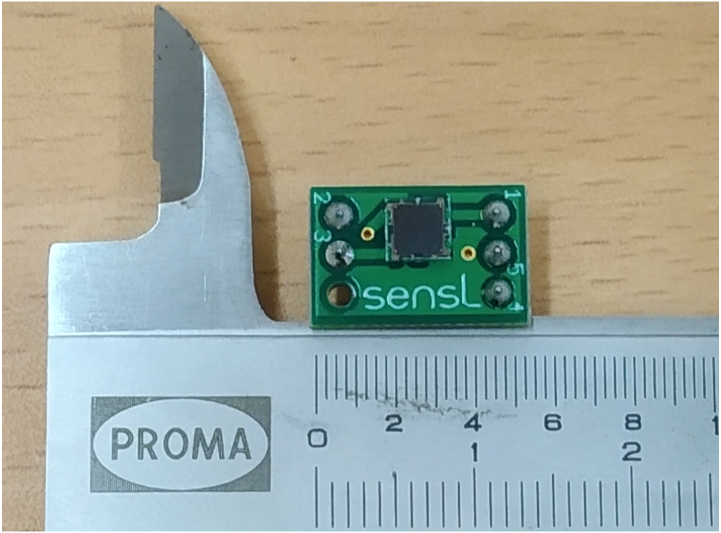
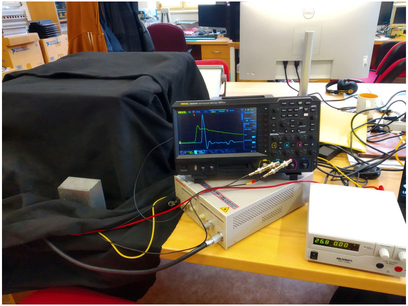


Figure: One of the tested onsemi C-series 30035 SiPMs.



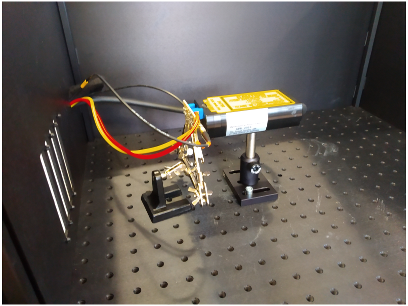
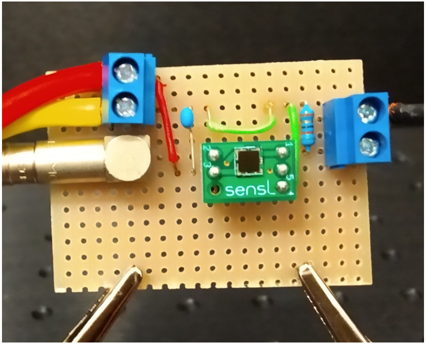


Figure: Experimental setup used for measurements.



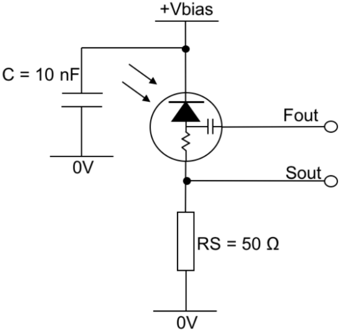


Figure: Readout circuit for the used SIPM
(optimal configuration recommended by producer).

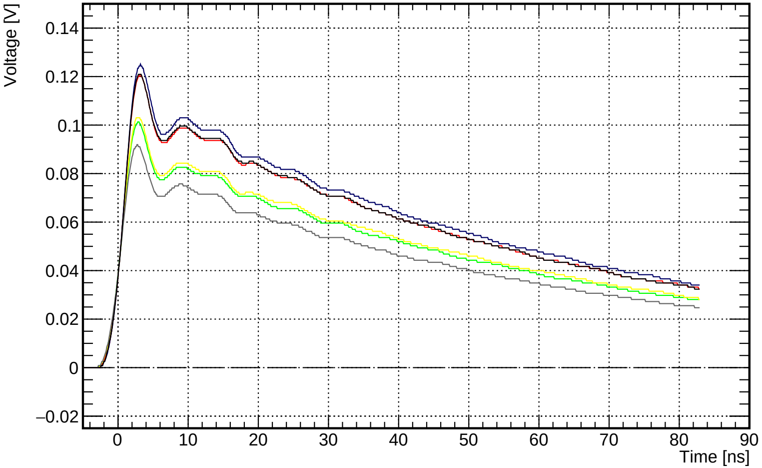


Figure: Output voltage as a function of time at standard output terminal.

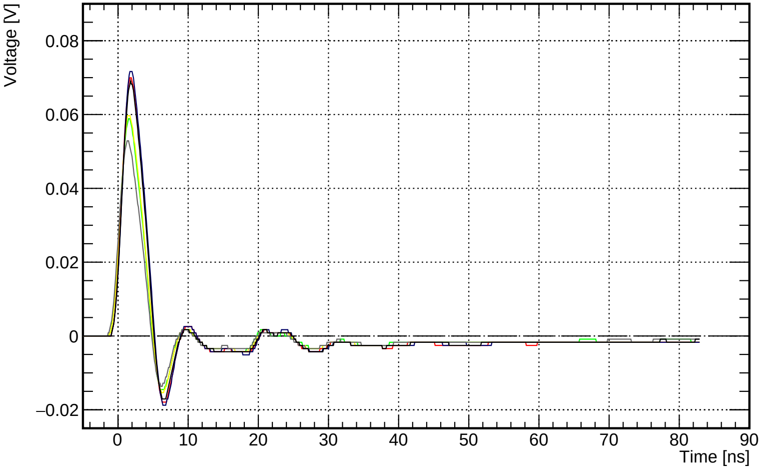


Figure: Output voltage as a function of time at fast output terminal.

Summary

- pulse shapes are compatible for all tested SiPMs
- lengths of pulses are almost identical
- next steps
  - LTspice simulation of circuits modeled after SiPMs

Bibliography

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