

Design and Simulation of a Dual Readout Analog Front-End for Silicon Photomultiplier Sensors

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Abstract

Silicon Photomultipliers (SiPMs) are widely used in applications such as medical imaging, high-energy physics experiments, radiation detection, and LiDAR systems due to their high sensitivity, fast response, and ability to detect low levels of light. To accurately process the electrical signals generated by SiPM sensors, an efficient Analog Front-End (AFE) circuit is essential. Conventional readout circuits often optimize either signal amplitude or timing performance, limiting their suitability for applications requiring both high energy resolution and precise timing information.

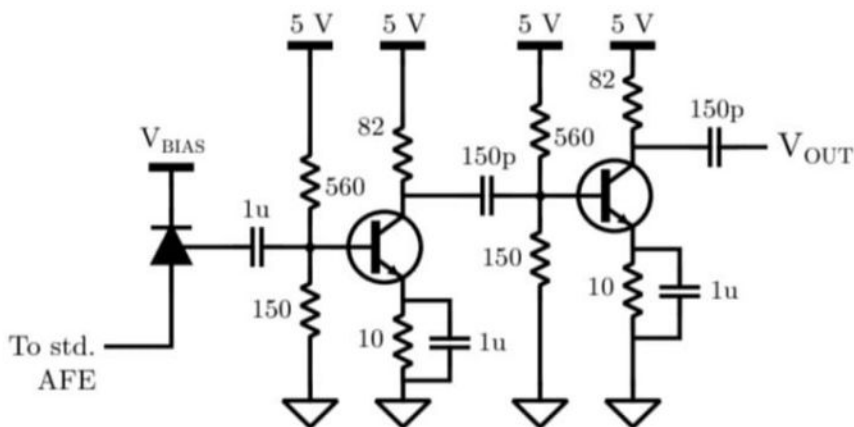
Introduction

Silicon Photomultipliers (SiPMs) are highly sensitive photodetectors used in applications such as medical imaging, radiation detection, and LiDAR systems. To accurately process the weak current signals generated by SiPMs, a high-performance Analog Front-End (AFE) circuit is required. This project focuses on the design and simulation of a dual-readout AFE using eSim, featuring separate signal paths for precise amplitude measurement and fast timing analysis. The proposed design is validated through SPICE simulations to evaluate its performance using an open-source EDA platform.

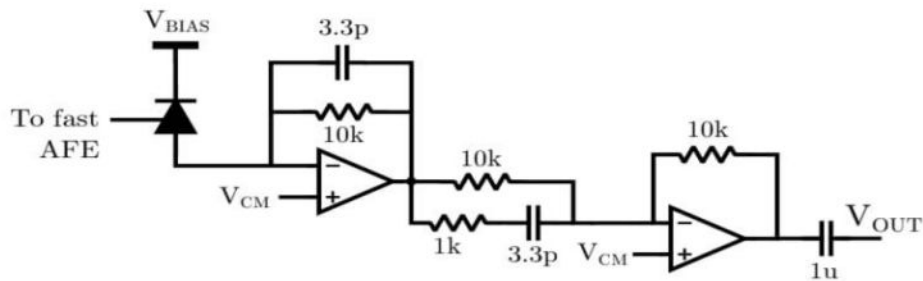
Architecture Overview

The proposed architecture consists of a dual-readout Analog Front-End (AFE) that processes the output current from a Silicon Photomultiplier (SiPM) through two parallel signal paths. The Standard Output Path employs a Transimpedance Amplifier (TIA) followed by a voltage amplifier for accurate signal amplitude measurement, while the Fast Output Path uses a high-speed transistor amplifier to preserve fast pulse characteristics for precise timing analysis. The complete architecture is designed and validated in eSim using SPICE simulations to evaluate gain, transient response, and overall circuit performance.

STANDARD OUTPUT:



FASTEST OUTPUT:



Working Principle

The SiPM generates a current pulse when it detects incident light, and this signal is simultaneously processed through two parallel Analog Front-End paths. The **Standard Output Path** measures the signal amplitude using a Transimpedance Amplifier (TIA), while the **Fast Output Path** preserves the pulse timing using a high-speed amplifier for accurate timing analysis.

Advantages

- Simultaneous Signal Processing
- High Performance
- High-Speed Response

Conclusion

The proposed Dual Readout Analog Front-End successfully processes SiPM signals through separate amplitude and timing paths, improving overall signal analysis. The complete architecture can be designed and validated using eSim, demonstrating the effectiveness of open-source tools for advanced analog front-end circuit development.

Reference

1. Lucas Finazzi et al., **Front End Amplifiers for Simultaneous Dual Readout of SiPM Sensors**, 2026.
[arXiv Paper](#)