Single Pixel Test Structures for Characterization and Comparative Analysis of CMOS Image Sensors

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1. ABSTRACT

Single pixel test structures designed to characterize and compare CMOS passive and active pixel sensor parameters are described. The test structures are designed so that they can be rapidly ported from one process to another. They are also designed so that different types of photodetectors can be characterized and compared based on: quantum efficiency, spectral response, sensitivity, input referred read noise, dark current, reduction of quantum efficiency caused by silicide/salicide, digital switching noise sensitivity, dynamic range, and temperature dependency of all measured parameters. Two test chips that include a variety of these structures have been built in two different 0.35μm CMOS processes. The test chips have twenty different types of individual photodetectors including: n+/psub photodiodes, nwell/psub photodiodes, n-type photogates, pnp vertical phototransistors, p+/nwell photodiodes, and p-type photogates.

The circuit of a passive single pixel test structure is shown in Figure 1. It consists of calibration circuits which are not shown and a charge integrating amplifier followed by a voltage amplifier and a unity gain buffer. It also includes noise generating circuits near the photodetectors that are not shown. Offset compensation and correlated double sampling are performed by autozeroing. Figure 2 shows the output voltage from a passive single pixel test structure driven by a 30μm$\times$30μm n+/sub photodiode.

The circuit of an active single pixel test structure is shown in Figure 3. The first amplification stage is identical to an APS pixel where a source follower buffer is used. The second and third amplification stages are identical to those used in the passive pixel test structure. Figure 4 shows the output voltage from an active single pixel circuit driven by a 30μm$\times$30μm n+/sub photodiode.

The single pixel test structures are measured using the optical setup shown in Figure 6. Figure 5 shows the normalized spectral response for an nwell/psub photodiode, an n+/psub photodiode with salicide, and an n–type photogate with silicide. As can be seen from the figure, the nwell/psub photodiode has much higher quantum efficiency than the n+/psub photodiode and the n–type photogate.

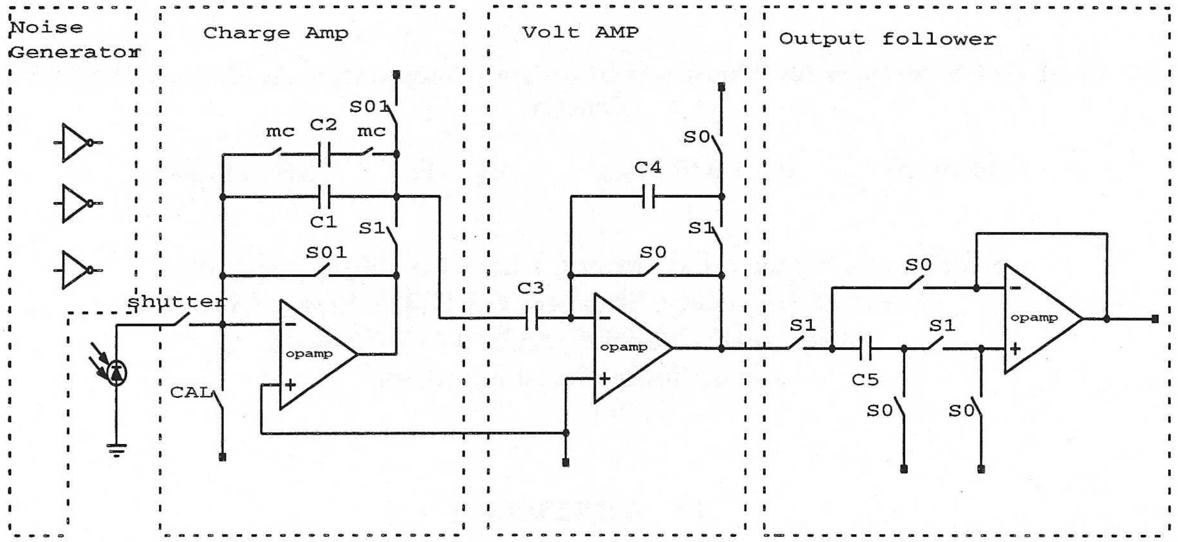

Figure 1: Passive Single Pixel Test Structure Circuit

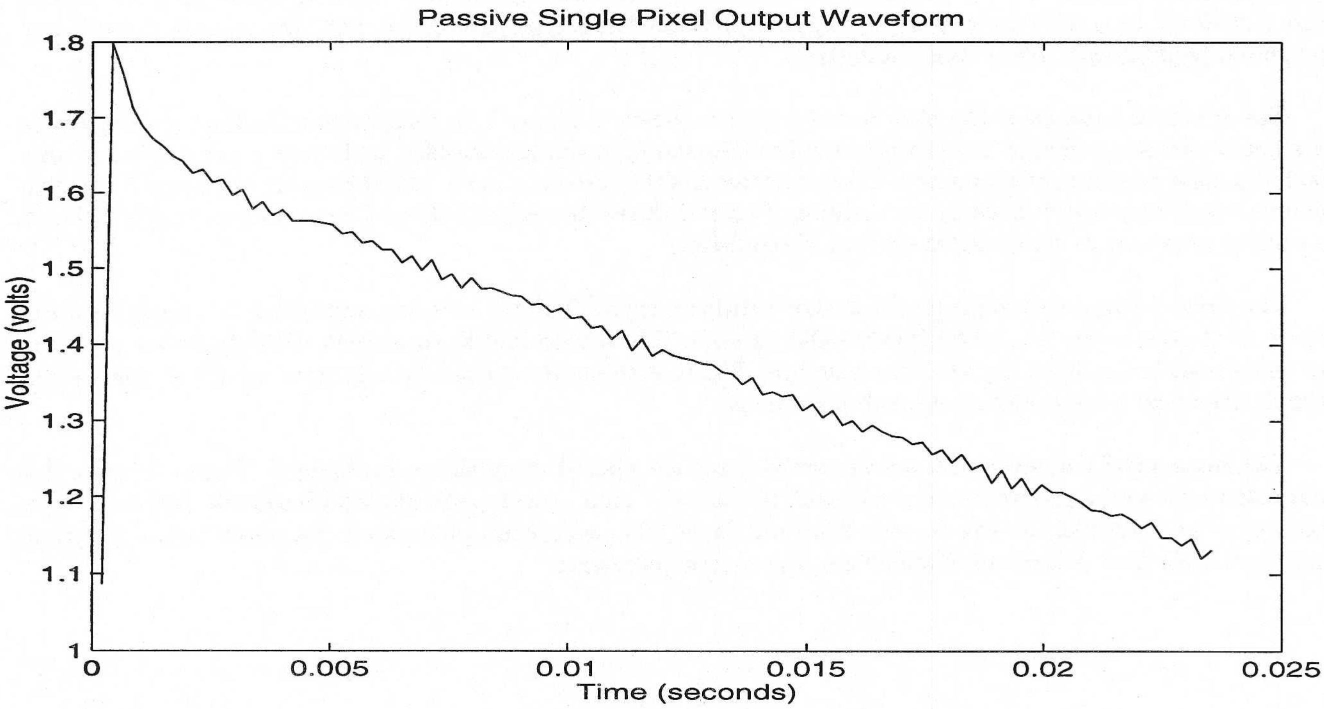

Figure 2: Passive single pixel circuit driven by a 30μm×30μm n+/psub photodiode.

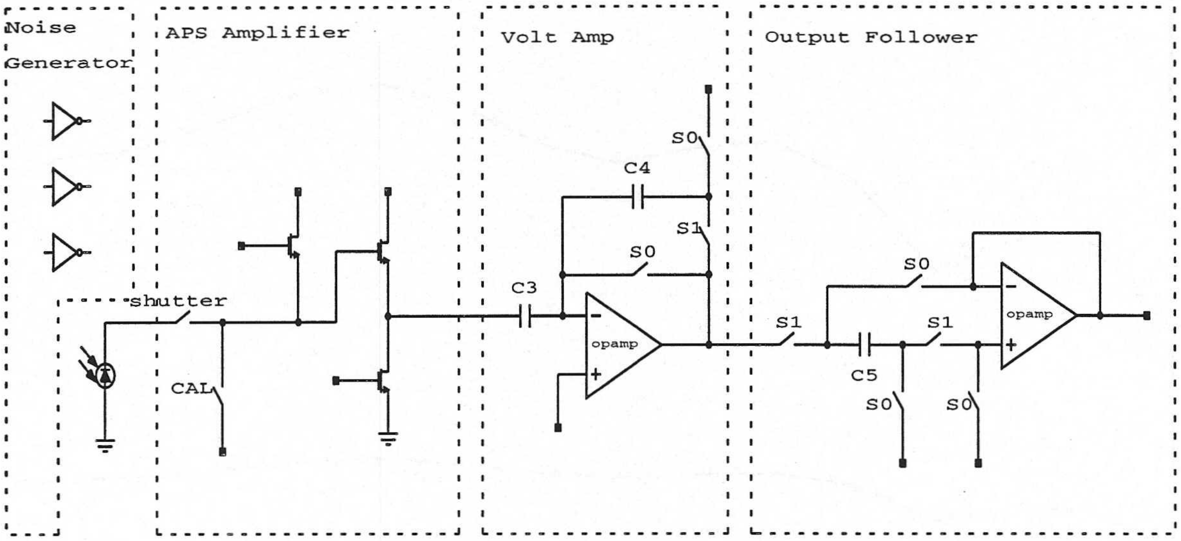

Figure 3: Active Single Pixel Test Structure Circuit

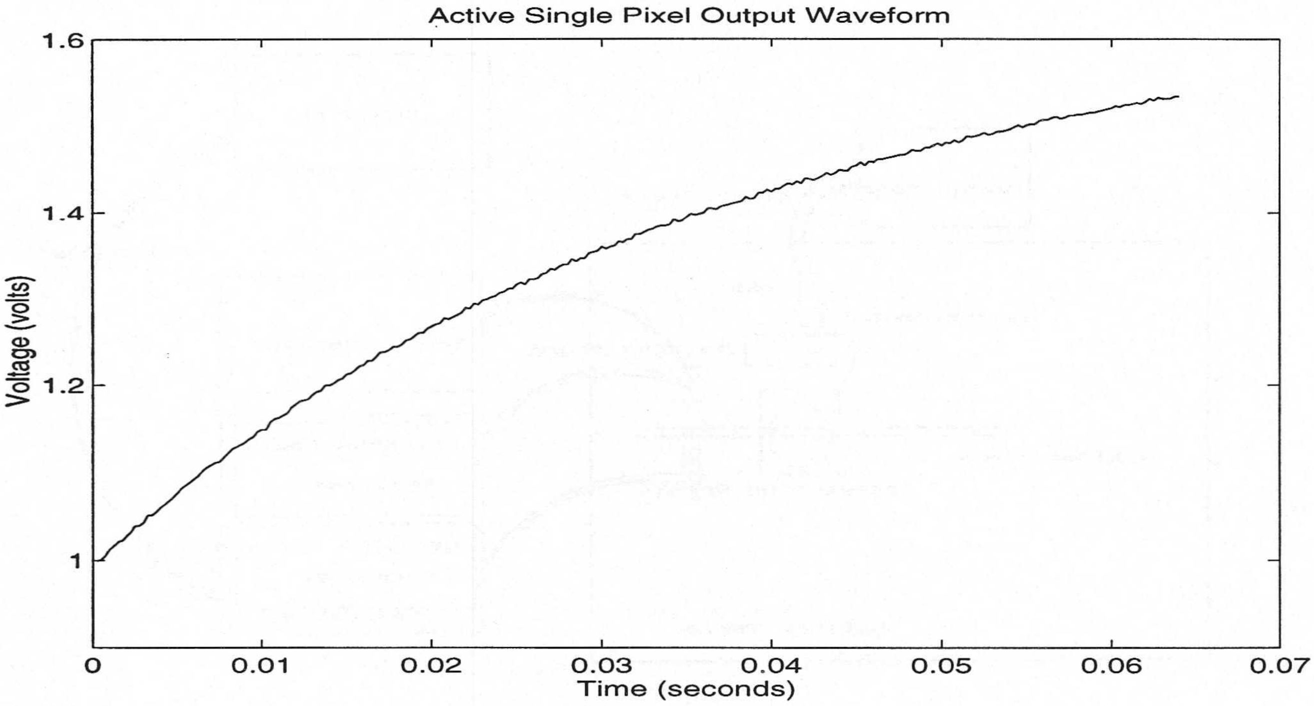

Figure 4: Active single pixel circuit driven by a 30μm×30μm n+/psub photodiode.

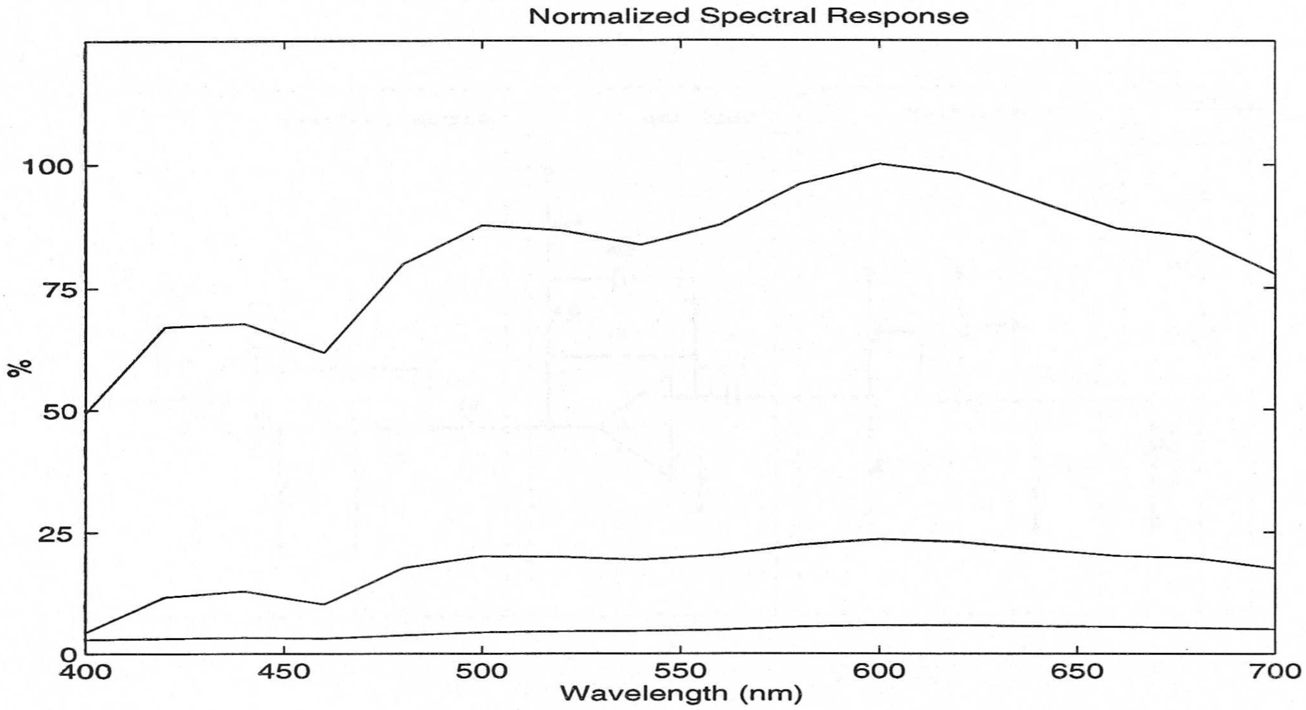

Figure 5: Spectral Response of nwell/psub photodiode, n+/psub photodiode with salicide and n–type photogate with silicide.

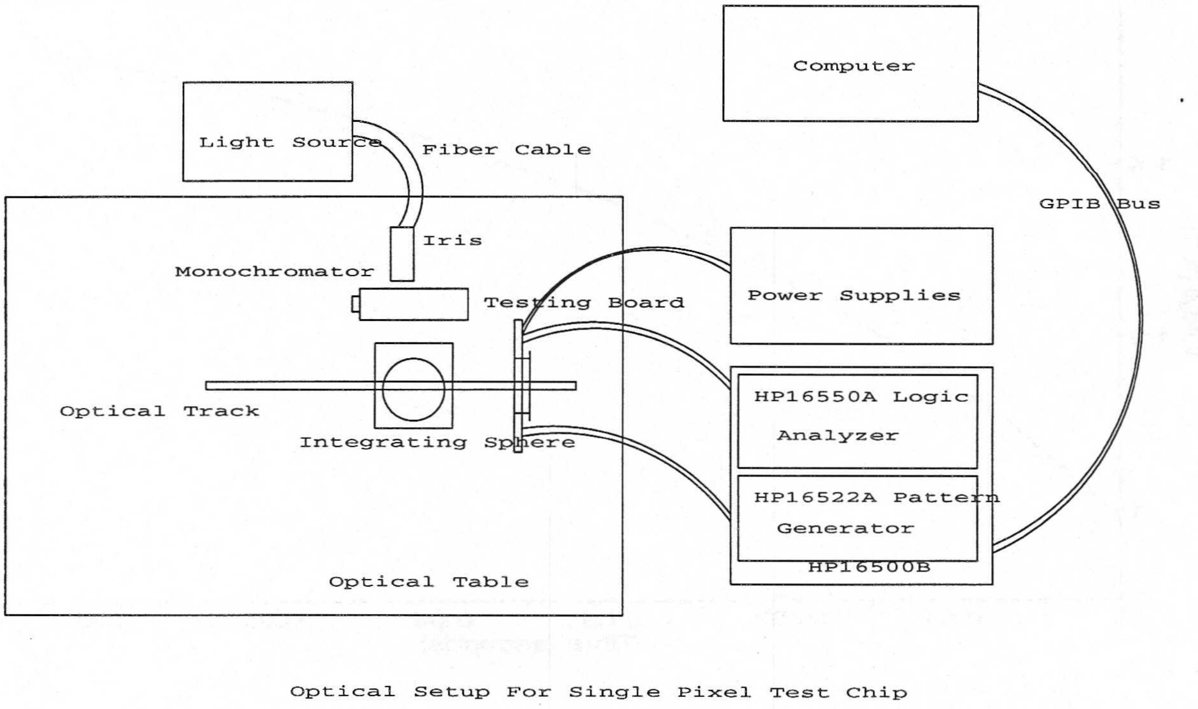

Figure 6: Single Pixel Optical Test Setup