CMOS FPA with Multiplexed Pixel level ADC

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Abstract

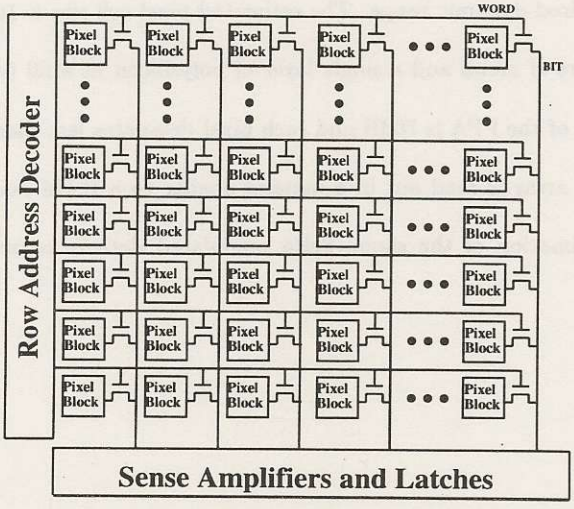
A pixel cell for an FPA with sigma delta modulation based ADC is described. The ADC and sensing devices are shared among four neighboring pixels to reduce transistor count. Each pixel cell consists of a photodiode and four transistors for multiplexing the shared ADC circuits. The ADC consists of a voltage comparator, a one bit DA converter and two access transistors. The total number of shared transistors is 10-15 depending on the desired dynamic range. The estimated pixel cell size is $10\mu m \times 10\mu m$ in $0.5\mu m$ CMOS process with four layers of metal and a single layer of polysilicon at a fill factor of close to 30%. The estimated dynamic range of the FPA is 70dB and each pixel dissipates less than 30nW at $Vcc = 3v$.

The digital data from the array is read out in a manner similar to a RAM using row decoders and simple sense amplifiers. Decimation of the sigma delta modulated data is assumed to be performed externally using FIR filters.

Main Features

- Visible/NIR range sensor
- Uses CMOS technology - low cost and allows integration of digital processing
- Uses pixel level A/D conversion - programmable integration time
- Has automatic gain and level adjustment
- Has programmable data rate
- Is digitally controlled - region of interest windowing
- Achieves ultra low power

Area Image Sensor Block Diagram



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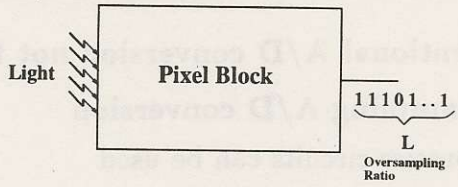
Output of Pixel Block

Uses Oversampled A/D Conversion



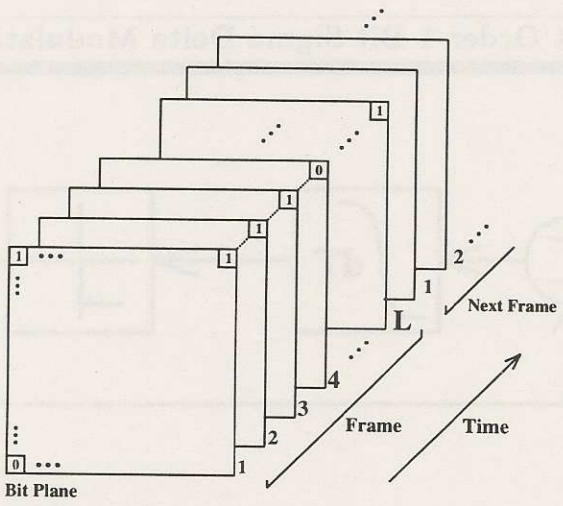
Oversampling ratio L for a desired average SNR

$$\log_2(\mathrm{L}) = \frac{\mathrm{SNR} + 5.2\mathrm{dB}}{9.0}$$

Examples:

- SNR = 48dB (8 bits) $\Rightarrow$ L = 60
- SNR = 20dB (3.3 bits) $\Rightarrow$ L = 7

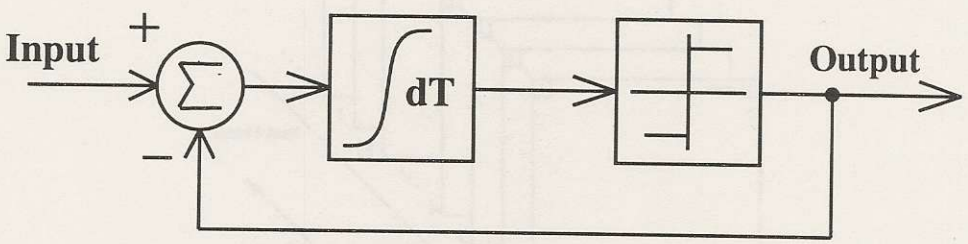
Image Sensor Output per Frame



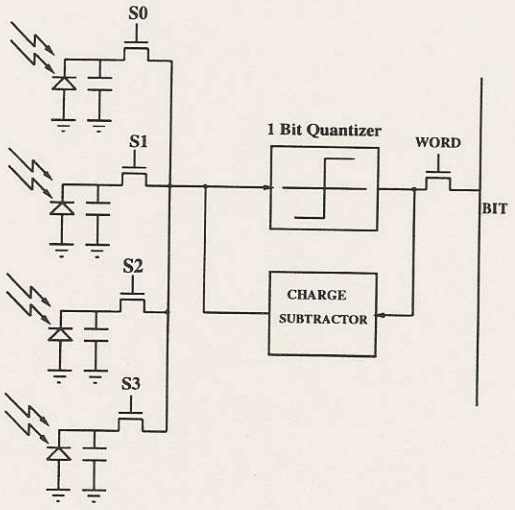
Pixel Level A/D Conversion

- **Conventional A/D conversion not feasible**
- **Oversampling A/D conversion**
  - Imprecise circuits can be used
  - Robust operation
- **Use First Order 1 Bit Sigma Delta Modulation**
  - Requires small silicon area
  - Noise shaping achieves 9dB/octave SNR gain

First Order 1 Bit Sigma Delta Modulation



Muxed 4-Pixel Block



Pixel Block Evolution

	1993	1994	1995
Technology	1.2μm	0.8μm	0.5μm
Trans/Pixel	22	19	4-5
Pixel Size	60μm$\times$60μm	30μm$\times$30μm	10μm$\times$10μm
Fill Factor	3%	14%	$>$ 30%