CMOS Successive Approximation ADC Used In Active Pixel Sensor On-Chip

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Abstract - Recent advancements in CMOS image sensor technology are reviewed, including both passive pixel sensors and active pixel sensors. CMOS active pixel sensor (APS) with on chip column-parallel successive-approximation analog-to-digital converter (ADC).Active pixel sensor consists of a pixel that converts the incoming light in to a charge. A CMOS imaging sensor uses active pixel sensor (APS) technology where charge to voltage conversion is carried out on the pixel itself .In this active pixel sensor technology the voltage generated by each pixel is in line by line fashion ,Initially the first row and first column is activated and we can read the data and so on . The system integration is very similar to the integrated circuit we can integrate the peripheral components on to a single chip using ADC, requires single power supply typically 3.3v to 5v and consumes less power. This method can also used to increase high speed, low noise and low sensitivity as the amplifiers used are not identical.

I. INTRODUCTION

Driven by the demands of multimedia application, image sensors have become a major category of high volume semiconductor production. An active pixel sensor (APS) is an image sensor where each picture element/pixel has photo detector and an active amplifier. CMOS active pixel sensor is most commonly used in cell phone cameras and web cameras.

Active pixels typically have a full factor of only 50-70% which reduces the photon generation signal however reduces the capacitance in each pixel leads to lower read noise for the array which increases both dynamic range and signal to noise ratio. Active pixel electronic image sensor are based on analog pixel where data conversion is done at broad level.

Camera on chip technology will enhance, or enable, many applications including robotic and machine vision, guidance and navigation automotive applications and consumer electronics. Future applications will also include scientific sensors such as those suitable for highly integrated imaging system. [3]

II. ADVANTAGES OF CMOS APS OVER CCD

Before the CMOS Active pixel converters the CCD that is Charge-coupled device where used for pixel conversion. Since CCD cannot be easily integrated with CMOS circuits due to additional fabrication complexity. CCD'S needs many different voltage levels to ensure high charge transfer efficiency to maintain signal fidelity .CCD'S need to achieve nearly perfect charge transfer efficiency[4].CCD uses shift charge techniques[3].Advantage of CMOS imagers is that analog signal processing can be integrated on to the same substrate.

III. HISTORICAL BACKGROUND

The term active pixel sensor was coined in 1985 by Tsutomu Nakamura and more broadly defined by Eric Fossum in 1993. In 1968 Nobel created sensory arrays with active MOS readout amplifiers per pixel. The first CCD was invented in 1969 at bell labs.Charge-Coupled devices (CCD) were most widely used technology for implementing area image sensors in 1990's [1]. To implement a camera on a-chip with a full digital interface requires an on-chip analog to digital converter (ADC). There are many considerations for on-chip ADC [5]. CCD's are higher capacitance devices resulting in drive electronics that dissipate large power levels for large area arrays. In addition, CCD's require many different voltage levels to ensure high charge transfer efficiency. These limitations can be overcome by the APS [3]. A low resolution N-channel MOSFET imager with intra pixel amplification was demonstrated in 1981. Active pixel sensors were in wide spread use by the mid-1980s.Fossum invented image sensor that used intra pixel charge transfer along with an in-pixel amplifier and low temporal noise operation and published first article predicting the emergence of Active Pixel Sensor imagers as the successors of CCDs.

IV. BLOCK DIAGRAM

The image from the real world is captured with help of lens in the form of light. The light is applied through the filter so that only red, green or blue light passes through the photo diode. The photodiode changes the light intensity to charge the charge is converted to voltage and is passed to the column line. The brighter the light bigger voltage change will get on the column line.

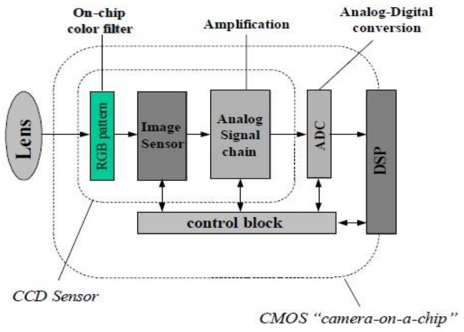

Fig.1: Block diagram of typical digital camera system

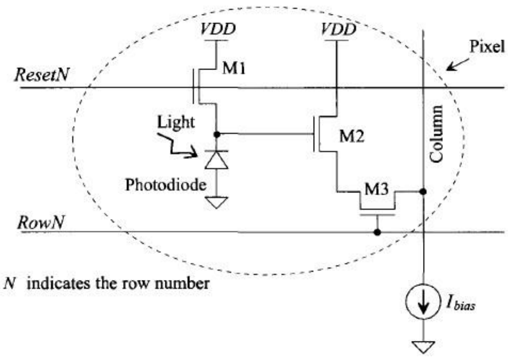

FIG 2: CMOS active pixel sensor

A. *SUCSSESSIVE APPROXIMATION ADC*

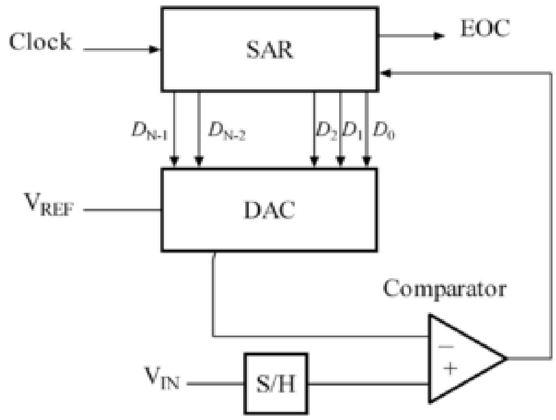

FIG3: Successive Approximation ADC

ADC is a type of analog to digital convertor that converts a continuous waveform into discrete digital representation via a binary search through all possible quantization levels before converging upon a digital output for each conversion.

A successive approximation ADC consists of *sample and hold circuit* to get Vin, voltage *comparator* that compares Vin to output of DAC, a successive approximation register sub circuit designed to supply an approximate digital code of V_{in} to the internal DAC, an internal reference DAC that, for comparison with V_{REF}, supplies the comparator with an analog voltage equal to the digital code output of the SAR in.

V. GENERAL ARCHITECTURE OF APS

As in a traditional rolling-shutter APS, this imager is constructed of a two dimensional pixel array. Each pixel contains an optical sensor to receive light, a reset input and an electrical output representing the illumination received. The outputs of a selected row are read through the column-parallel signal chain, and at certain points in time are also compared with an appropriate threshold in the comparison circuits. If a pixel value exceeds the threshold, a reset is given at that time to that pixel. The binary information concerning the reset is saved in digital storage for the later calculation of the scaling factor. The pixel value can then be determined as a floating-point number, where the exponent comes from the scaling factor for the actual integration time and the mantissa from the regular A/D output. Therefore, the actual pixel value would be

$$\mathbf{Value = Man \cdot (T\ (T\ X\ EXP\ )) = Man \cdot X\ EXP}$$

where *Value* is the actual pixel value, *Man* (mantissa) is the analog or digitized output value that has been read out at the time *T*, *X* is a constant greater than one, and *EXP* is the exponent value describing the scaling factor. This digital value is read out at the upper part of the chip. For each pixel, only the last readouts of a certain number of rows are kept to enable the correct output for the exponent bits.

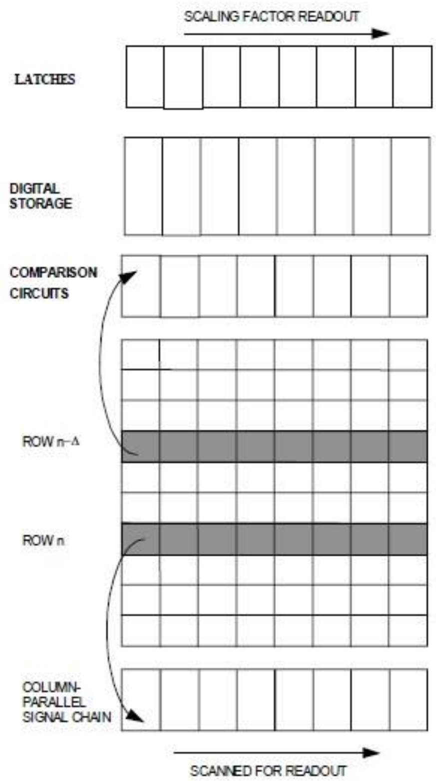

FIG4: General Architecture Of CMOS APS

VI. RESULTS

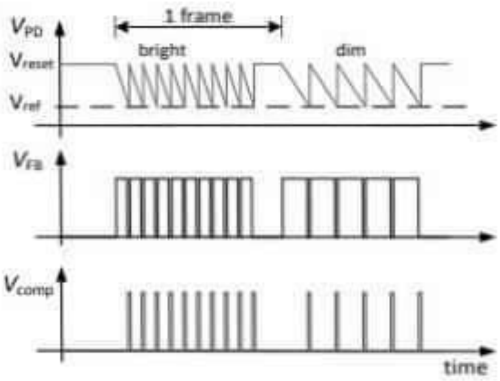

FIG5: simulation for bright light

The simulation output of the CMOS Active Pixel Sensor is as shown in the Fig5.Each bit of light on the pixel is converted to voltage and this voltage on rows and columns of each pixel is then converted to digital binary bit form.

VII. CONCLUSION

By the result and observation we can conclude that the CMOS APS is currently most used pixel sensor imagers in cameras and camcorders. among various pixel designs optimized for limiting crosstalk, integration with micro-lenses, comparatively CMOS APS was observed to be good.

VIII. REFERENCES

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