The Performance of a CMOS Image Sensor with Two Different Types of Pixel Arrays (3T-APS and PWM Image Sensor) Using 10-bit Single Slope ADC and Edge-Triggered Binary Counter

指導教授：謝志成 組員：林耀斌 陳力豪 宋乃仁 組別：B145

國立清華大學

Abstract

The CMOS image sensors are mainly divided into two types. One of them is the traditional type of Active Pixel Sensor based on voltage domain. The most classic is representative 3T-APS. The other type is called Digital Pixel Sensor based on time domain. The main representative is PWM-DPS. The output of the former pixel is the voltage value, so the exposure intensity can be interpreted only through the conversion of subsequent comparators and other circuits; The pixel output of the latter is a pulse width signal that can represent the intensity of exposure, and then it can be directly converted into digital code through the counter.

Goals

Unlike the traditional sensor designs using the same pixel, we design an image sensor with 3T-APS and PWM pixel arrays on the same chip. Basic objectives are as follows:

- Learn the difference between two pixel arrays and make both of them work well and efficiently.
- After the chip measurement, the photosensitive efficiency and linearity can be compared.

Implementation

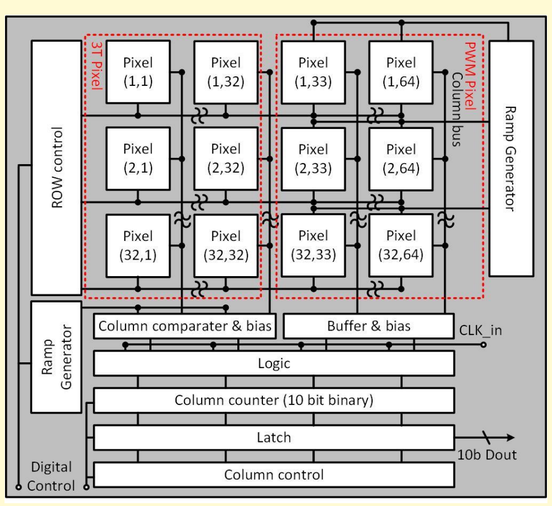

Figure 1. The block diagram

We design a 32x64 pixel array and half of it uses 3T pixels and the other half uses PWM pixels. (Figure 1) After exposure, the row control will select a whole row of pixels and send outputs to the column bus.

The output of 3T pixel is the voltage representing photodiode exposure. Therefore, we compare it with the ramp signal through the comparator on the column to decode the exposure intensity and then convert it into digital code by the counter. (3T: Figure 2)

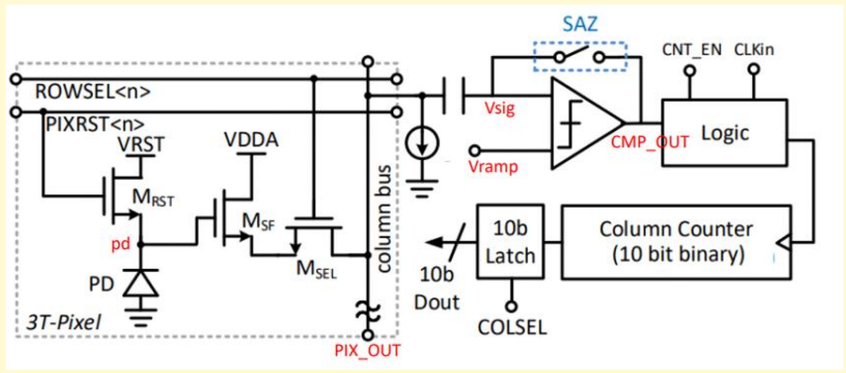

Figure 2. 3T pixel and column circuits

The PWM pixel has the function of comparator in itself, so its output is a pulse width representing the intensity of exposure. Therefore, after the pixel output enters the column, it can directly convert this pulse width into digital code through the counter. (PWM: Figure 3)

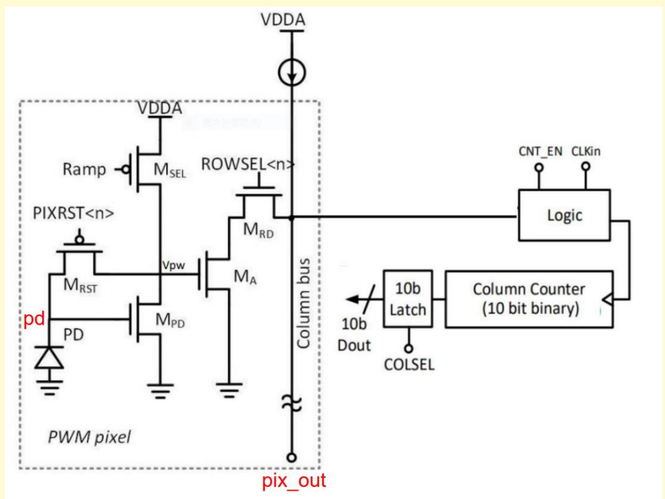

Figure 3. PWM pixel and column circuits

Finally, the solved 10-bit binary code will be send out by selecting different columns in sequence through column control at the next row time.

Results

Simulation results in the 3×6 pixel arrays

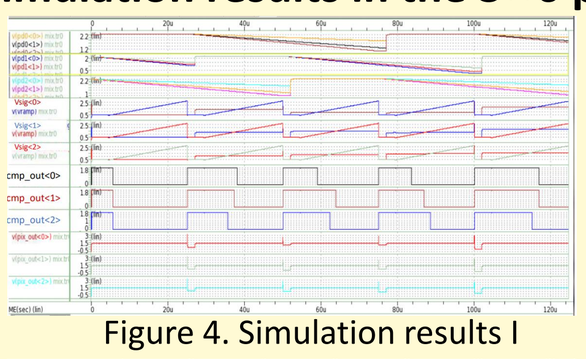

Figure 4. Simulation results I

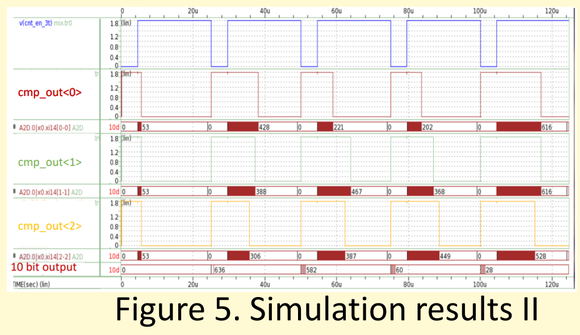

Figure 5. Simulation results II

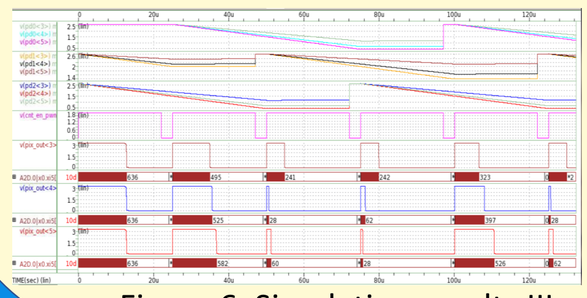

Figure 6. Simulation results III

For the 3T-APS simulation results (Figure 4 & 5):

- Correct waveform
- Transform voltage to digital code successfully
- The digital output is positively correlated with the simulated illumination intensity

For the PWM-DPS simulation results (Figure 6):

- Correct waveform
- The digital output is negatively correlated with the simulated illumination intensity

Conclusion

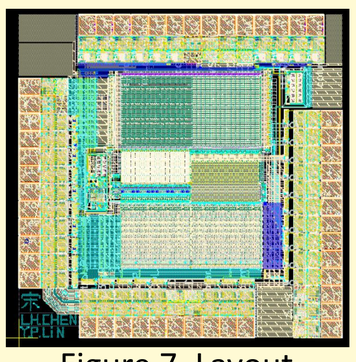

Figure 7. Layout

We learned the differences between the two pixel sensors in circuit designs and simulations. We also learned the differences between the two circuits in implementations and applications after layout(Figure 7). Now we have completed the design and fabrication of PCB(Figure 8). Next, we will complete the measurement of chip parameters to compare the differences in practical circuit characteristics.

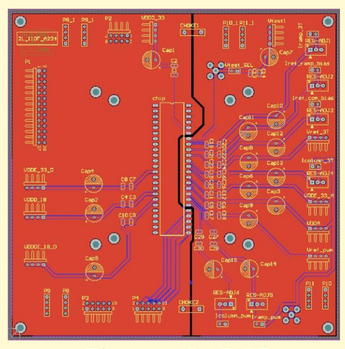

Figure 8. PCB