

Design of a Pixel Readout Chip for Silicon Drift Detector With Event Driven Readout Method

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Introduction

- The Silicon Drift Detector (SDD) has high energy resolution, high linearity, and low noise, which are optimized for the detection of X-rays in the range of **0.5 keV to 10 keV**.
- A low noise pixel readout chip, fabricated in CMOS 130 nm, designed for SDD used in **X-ray pulsar-based navigation**.
- The core of the IC is a matrix of 40×50 pixels with **80 um × 80 um** pixel size. Each pixel contains a charge sensitive amplifier, a comparator, an edge sense circuit, two data hold circuit, a threshold trimming 3-bit DAC and a digital control circuit.
- The chip uses the **event-driven method** to output the addresses of the pixels being hit and the corresponding energy signal of the incident X-ray photon and outputs the arrival time of the X-ray photon.

Overall architecture

The core of the chip consists of a matrix of 40×50 pixels with a pitch of 80 um. The periphery block of the IC consists of an event-driven readout circuit, Address Coding Unit(ACU), Pulse Processing Unit(PPU), Row and Column Decoding circuit, Output buffer, DACs and Biasing circuit, and readout control circuit(RCU) (see Fig. 1).

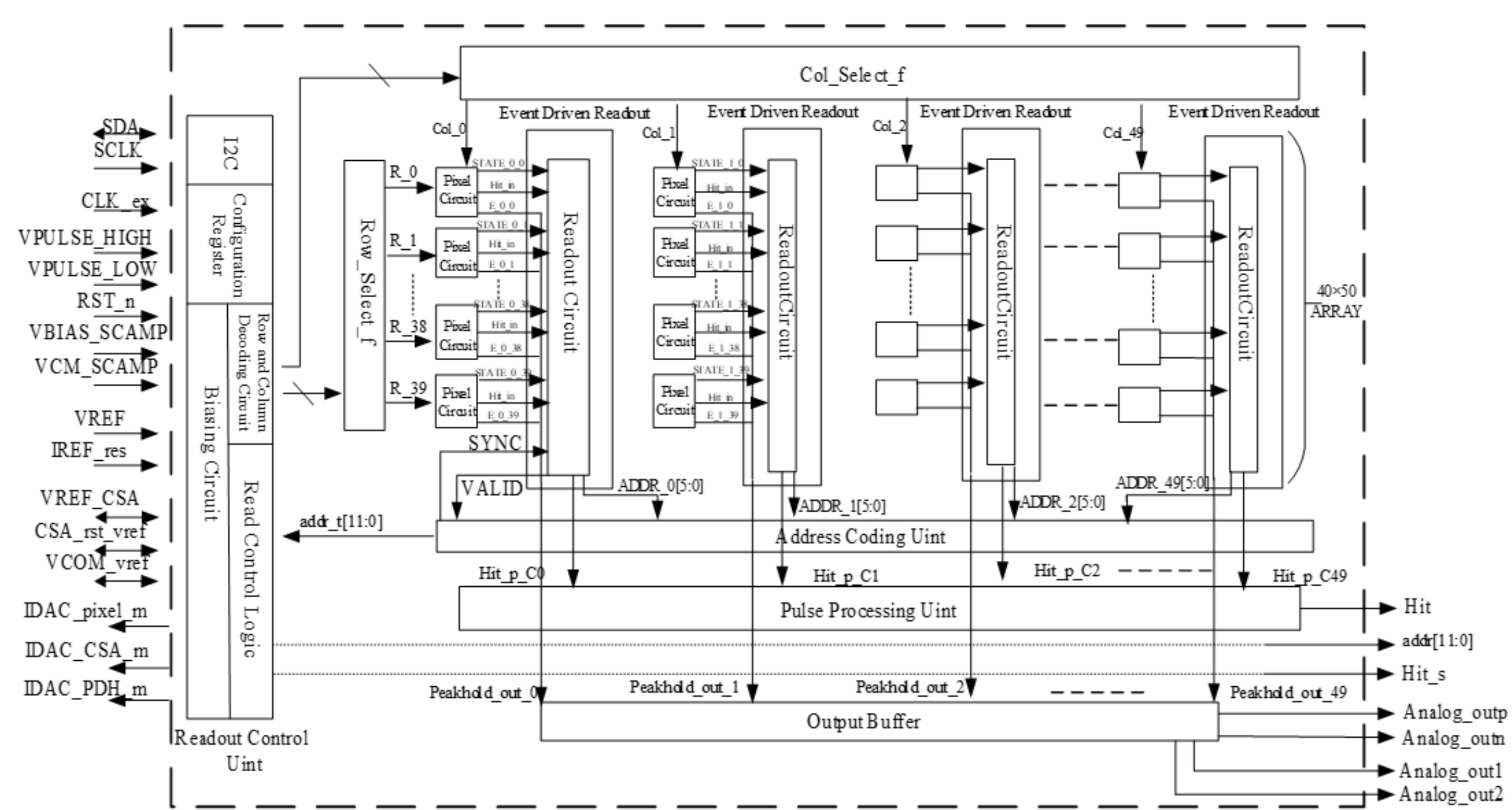


Fig. 1. Structure of the pixel readout chip

Pixel Design

The simplified scheme of a single pixel is shown in Figure 2.

- Each pixel contains a pre-amplifying module, consistency adjustment module, time and address readout module, and energy readout module..
- This front-end electronics allows the processing of sensor signals of **both polarities** (holes or electrons).

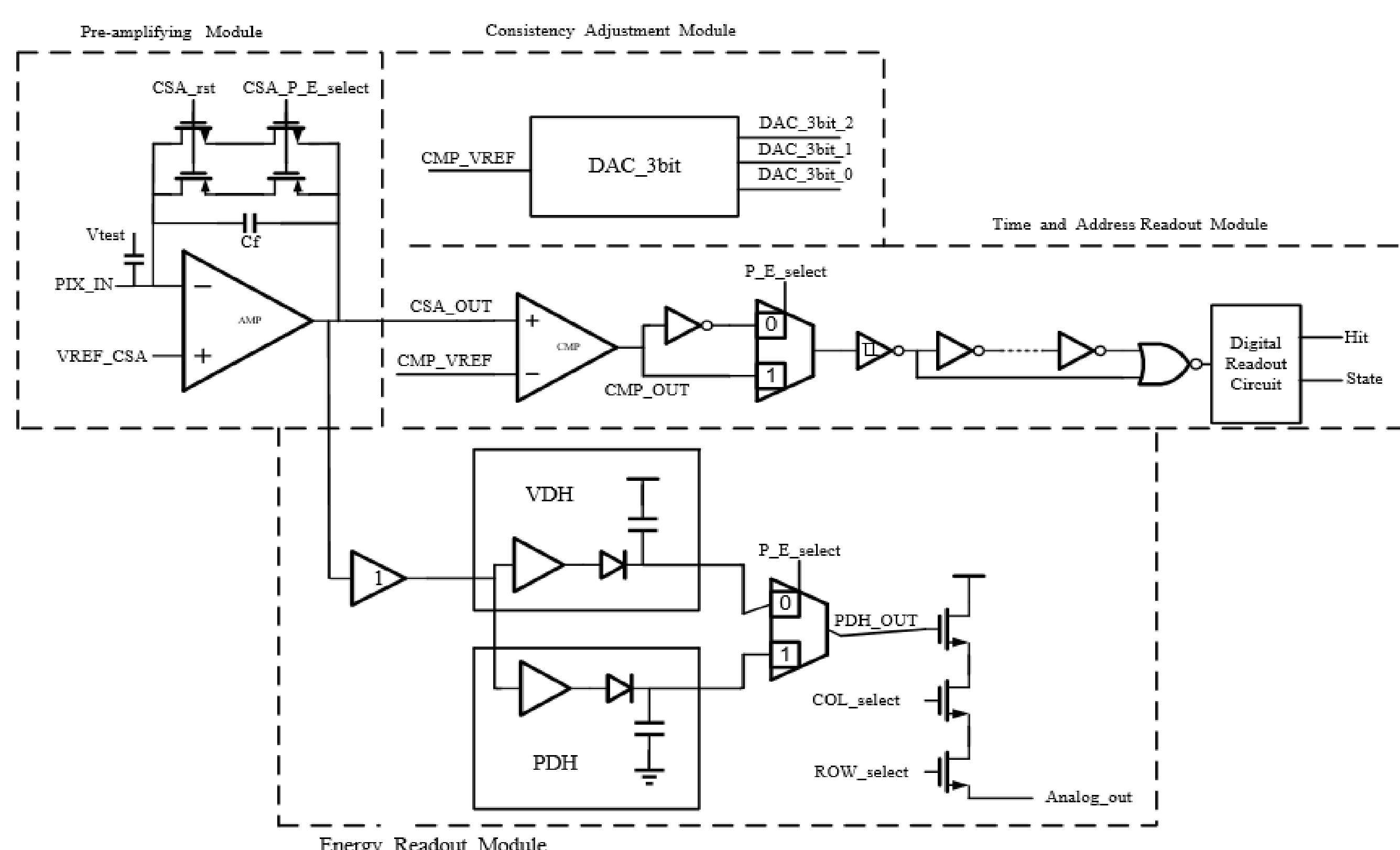


Fig. 2. Simplified scheme of single pixel

Event-driven readout circuit

The event-driven readout circuit is shown in Figure 3.

- In the pixel array of 40 rows and 50 columns, **each column** of pixels is equipped with an event-driven readout circuit..
- Event-driven readout is the process of outputting corresponding information only when a photon hits the pixel and determining the order of pixel readout through priority logic.

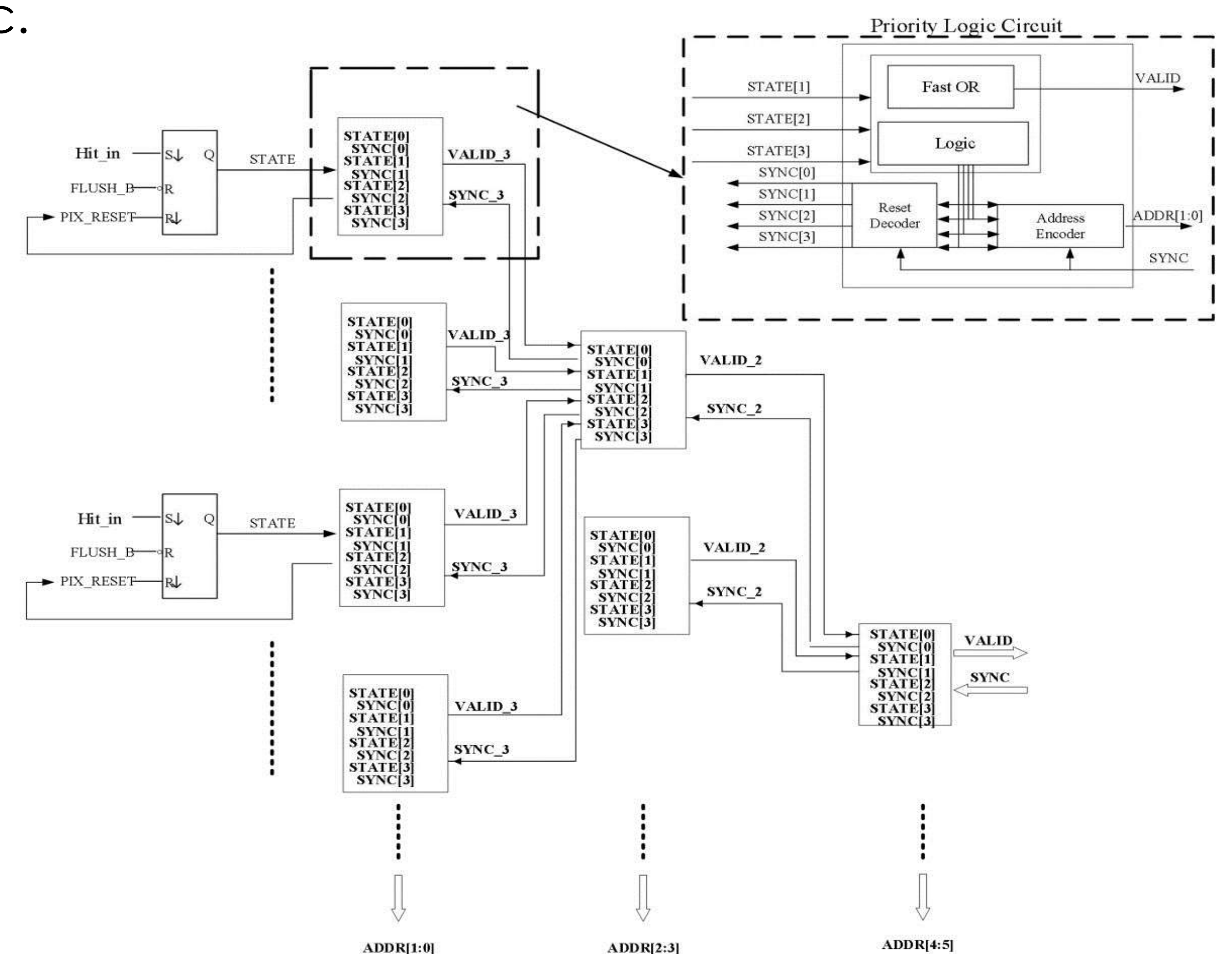


Fig. 3. Structure of the event-driven readout circuit

Results

The Layout of the pixel readout chip is shown in Figure 4.

The charge to voltage gain of CSA is **96.13 μV/e-** and the equivalent noise charge (ENC) is equal to **36 e- rms** (@detector self-capacitance **Cdet=50fF**). The pixel-to-pixel offset spread of the pixel matrix reached $\sigma = 10.6$ mV rms, and it was reduced to $\sigma = 1.51$ mV rms after correction by trim DAC.

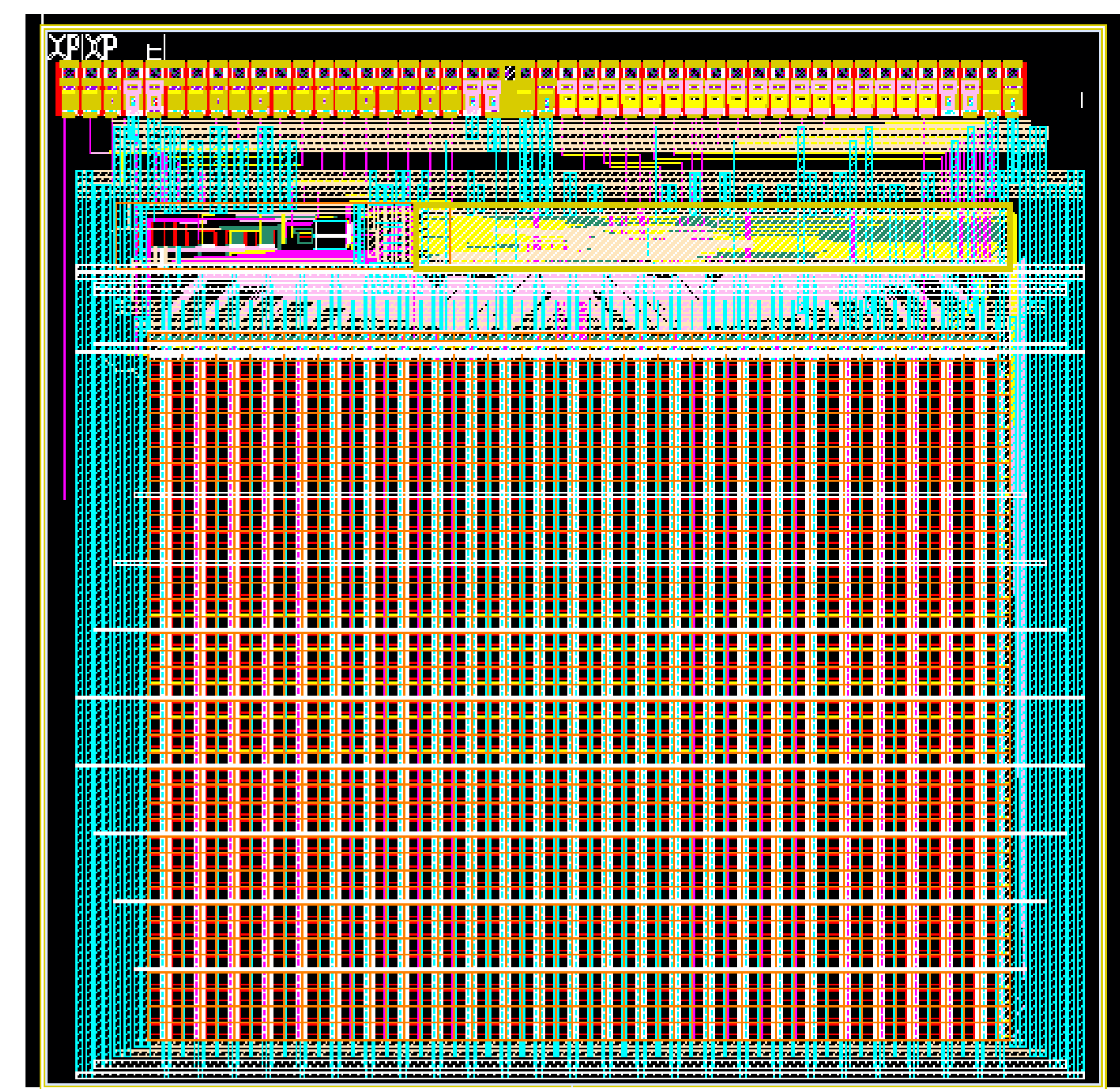


Fig. 4. Layout of the pixel readout chip