Highly Linear Integrate-and-Fire Modulators with Soft-Reset for Low-Power High-Speed Imagers

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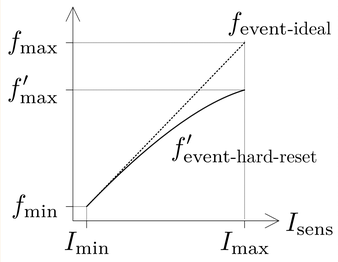
1 Introduction

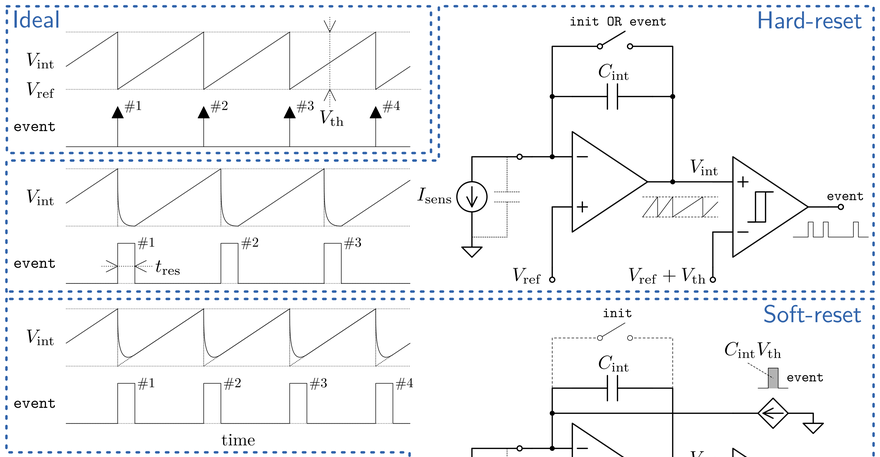
Classic modulators for digital imagers are usually based on integrate-and-fire (IAF) architectures combining a CTIA and a comparator. This classic approach (named here as hard-reset) introduces dead times during the CTIA reset (t_{res}), degrading the current-to-frequency transfer function. Linearity improvements reducing t_{res} demand high-power consumptions.

A complete family of IAF topologies to improve in-pixel signal linearity in digital imagers is presented. Three types of soft-reset (as hard-reset counterpart) schemes are proposed and analyzed for CTIAs, demonstrating linearity improvements of soft-reset schemes and the increase of IAF modulation robustness under low-power circuit operation.

2 Hard vs. Soft-Reset

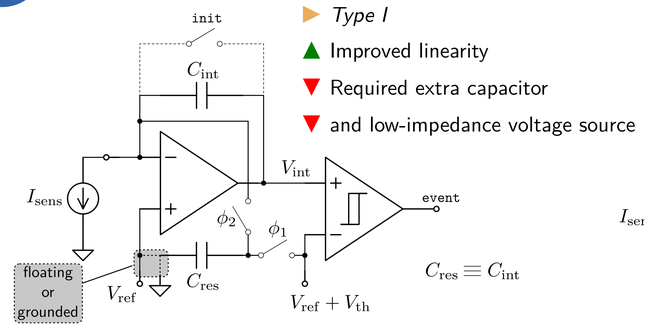
Classic IAF modulators current-to-frequency linearity degradation due to non-null t_{res}.



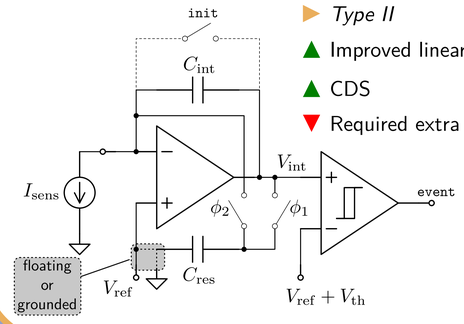


Proposed soft-reset IAF architecture uses a novel scheme to reset the CTIA by injecting a well controlled amount of charge into the input at each event, not blocking the integration of the incoming current signal during the reset time. Thus, the IAF output frequency virtually matches the ideal behavior independently from t_{res}.

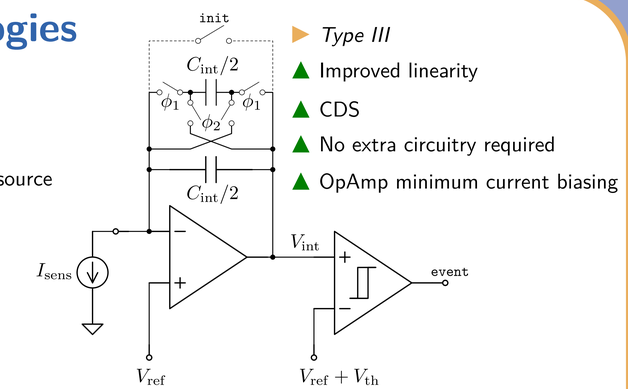
3 Proposed Soft-Reset Topologies



- *Type I*
- ▲ Improved linearity
- ▼ Required extra capacitor
- ▼ and low-impedance voltage source

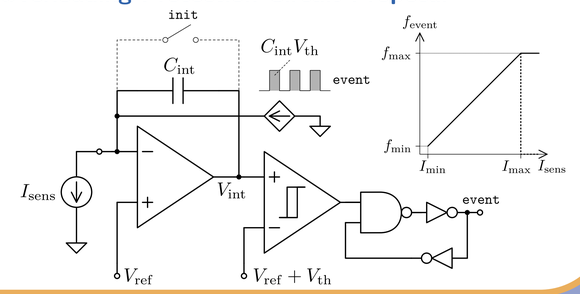


- *Type II*
- ▲ Improved linearity
- ▲ CDS
- ▼ Required extra capacitor

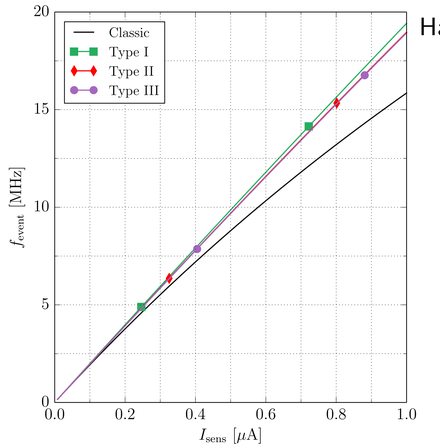


- *Type III*
- ▲ Improved linearity
- ▲ CDS
- ▲ No extra circuitry required
- ▲ OpAmp minimum current biasing

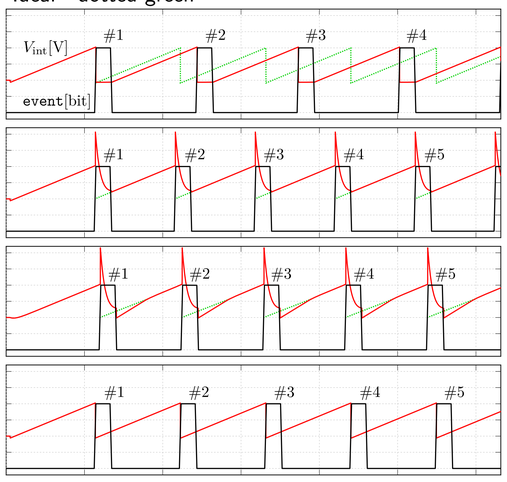
Overloading Protection Circuit Proposal



4 Simulation Results

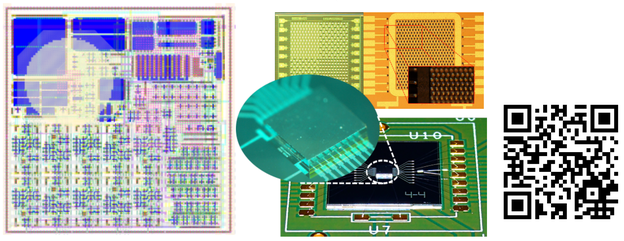


Ideal - dotted green

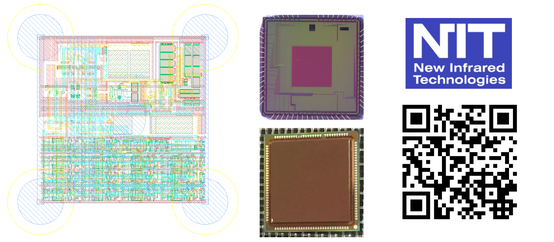


5 Applications

Proposed circuits have been succesfully exploited in low-power and compact CMOS IR (Type II floating and overloading protection) and X-Ray (Type II grounded) imagers.



- ▶ Hybrid direct X-Ray imager. 55um-pitch pixel. UMC-180nm.



- ▶ Uncooled MWIR imagers. 50um-pitch pixel. XFAB-180nm.

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