IX JORNADA DE JÓVENES INVESTIGADORES DEL I3A

Increasing Sensitivity of Optical Receivers using a Divide-and-Conquer Technique

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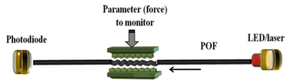
INTRODUCTION

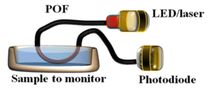
Large-area phototiodes (PD)

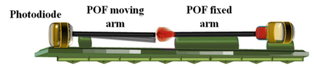
- ❑ Instrumentation
- ❑ Communication



Plastic optical fiber (POF) sensors

- ❑ Oil
- ❑ gas
- ❑ Biotechnoogy
- ❑ Energy



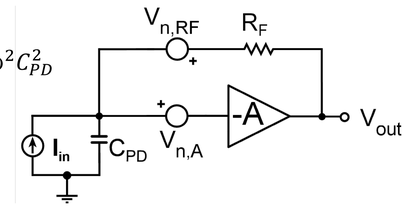


✓ This sensors are inexpensive and cost-effective

Transimpedance amplifier (TIA)

Converts the photogenerated current to a readable voltage

$$i_{n,in}^2 \approx \frac{4K_BT}{R_F} + \frac{v_{n,A}^2}{R_F^2} + v_{n,A}^2\omega^2 C_{PD}^2$$



- K_B is the Boltzmann's constant
- T the temperature
- R_F the feedback resistor of the TIA
- $v_{n,A}^2$ the input voltage noise of the core voltage amplifier
- ω^2 term is proportional to the square of the PD capacitance

very important constrain in large-area PD applications

High intrinsic capacitance large-area photodiodes limit:

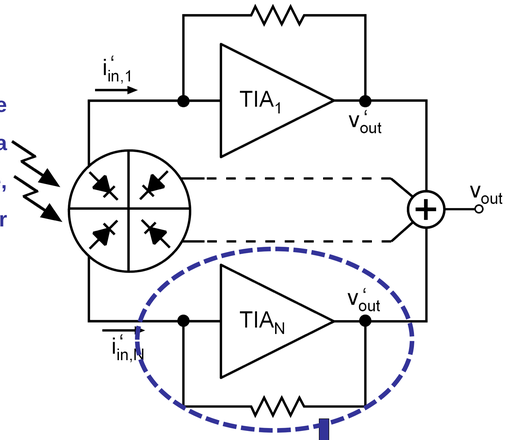
- ❑ achievable bandwidth
- ❑ bumps the equivalent input noise of the circuit

TIA performance is strongly bound to the characteristics of the PD

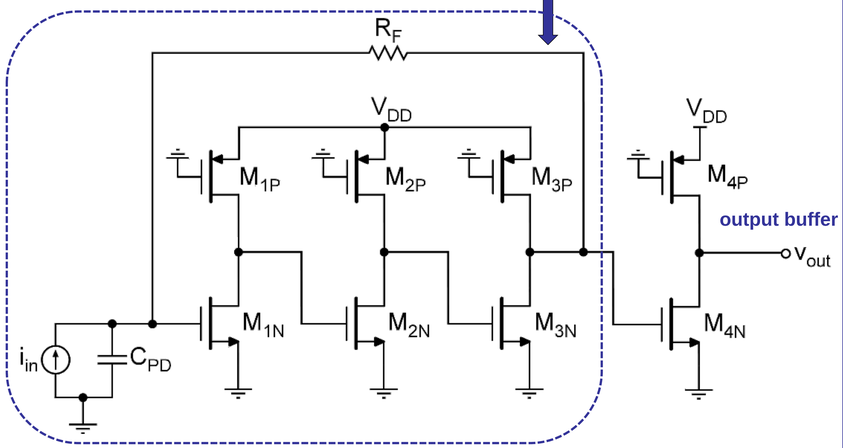
DIVIDE-AND-CONQUER TECHNIQUE

In this work, we propose a technique that consists of **slicing the PD and manufacturing it in N individual pieces,** connecting a dedicated TIA to each of them, while the output signals of the *N* TIAs are linearly added.

Each piece of the original PD presents a parasitic capacitance, C'_{PD}, 1/N times lower than C_{PD}.



The proposed TIA structure

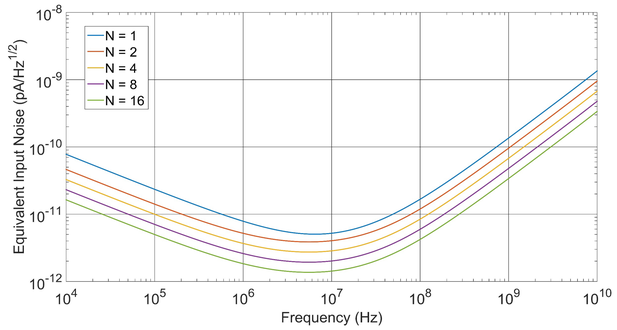


three-cascaded common-source stages with a negative feedback loop

We can achieve a lower input noise and a greater transimpedance

RESULTS

- ❑ The circuit has been implemented in a 65-nm CMOS technology with a single 1.2-V voltage supply
- ❑ The sliced PD technique has been applied dividing the PD in N pieces, choosing powers of 2 for the values of N, up to 16
- ❑ Simulations show that the equivalent input-referred noise clearly decreases at high-frequencies for higher N values



Parameter	N=1	2	4	8	16
R_T (dBΩ)	75.7	75.7	75.8	75.8	75.7
BW (GHz)	1.02	1.20	1.31	1.34	1.35
Input RMS Noise (μA)	4.74	3.89	2.57	1.89	1.58
Sensitivity (dBm)	-11.0	-11.8	-13.7	-15.0	-15.8
Power (mW)	2.9	5.8	11.5	23	46

CONCLUSIONS

A novel optical front-end design technique has been presented in this paper. It consists of slicing the photodiode area and connecting a TIA to each piece, instead of the conventional approach of a single-piece PD. The results show that the sensitivity is improved while maintaining the bandwidth and the achieved transimpedance can be much higher when the technique is applied dividing the PD in a high number of pieces.