EE539: Analog Integrated Circuit Design; HW4

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$0.18\,\mu$m technology parameters: $V_{Tn} = 0.5\,$V; $V_{Tp} = 0.5\,$V; $K_n = 300\ \mu$A$/V^2$; $K_p = 75\ \mu$A$/V^2$; $A_{VT} = 3.5\,mV\ \mu$m; $A_\beta = 1\%\,\mu$m; $V_{dd} = 1.8\,$V; $L_{min} = 0.18\ \mu$m, $W_{min} = 0.24\ \mu$m; Ignore body effect unless mentioned otherwise.

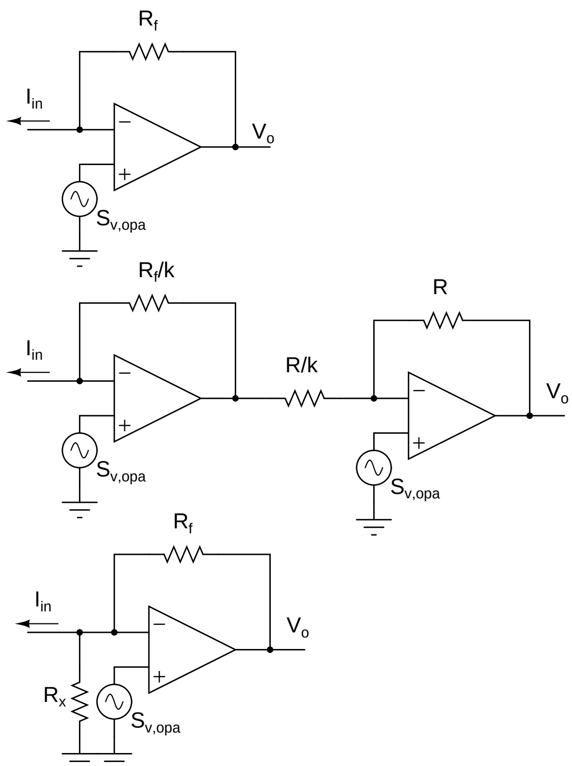

Figure 1:

1. Determine the output noise spectral density and input referred (current) noise spectral density of the transimpedance amplifiers in Fig. 1. The opamp has an input referred voltage noise spectral density of $S_{v,opa}$ V^2/Hz and is otherwise ideal.

2. You are given a photodiode with a capacitance C_d and asked to realize a transimpedance of R_f. There should be no peaking in the frequency response. Express the bandwidths of the amplifiers in Fig. 2(a,b) in terms of R_f, C_d, and the unity gain frequency of the opamp. Explain how you will increase the bandwidth in each case.

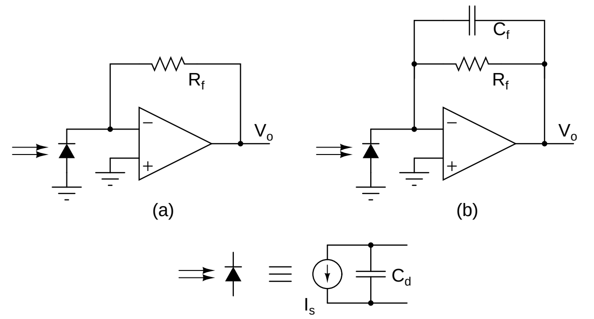

Figure 2:

3. Design a transimpedance amplifier with a gain of $10\,\mathrm{k}\Omega$ and the highest possible bandwidth without peaking using an OPA656 opamp. (The opamp's data sheet and models are on the course webpage.) The photodiode has a 2 pF capacitance. Simulate the frequency response, step response (100 μA step input), and input referred and output noise spectral densities. How does the simulated noise compare to analytical calculations? What fraction of noise is contributed by the R_f? (The relative contribution of different components can be printed out in the simulator)

4. The filter in Fig. 3 is driven by a sinusoid at $\omega = 1/RC$. Calculate the output noise voltage, output signal to noise ratio (ratio of mean squared signal to mean squared noise voltages), and the power dissipated in the circuit. If the impedances of all components are scaled up by a factor α, what happens

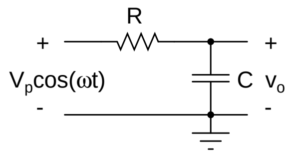

Figure 3:

to the transfer function of the circuit, output noise voltage, output signal to noise ratio, and the power dissipation?

Derive a relationship between the signal to noise ratio, power dissipation, and the bandwidth of the circuit (in Hz). What tradeoffs does this relationship represent?