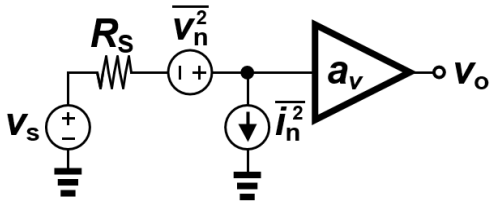
University of California, Berkeley *Spring 2019*
EECS 240B *Prof. A. Niknejad*

Problem Set 2
Due Fri Feb 22, 2019
Submit through bCourses

1. **Electronic Noise.**

   You are given two amplifiers modeled by the circuit below. Both amplifier have the same gain a_v but different input referred noise (Table 1) and are otherwise ideal. The amplifiers are driven by a resistive voltage source R_S.



Noise source	Amplifier A	Amplifier B
$\sqrt{\frac{\overline{v_n^2}}{\Delta f}}$	$1\,\frac{\text{nV}}{\sqrt{\text{Hz}}}$	$10\,\frac{\text{nV}}{\sqrt{\text{Hz}}}$
$\sqrt{\frac{\overline{i_n^2}}{\Delta f}}$	$1\,\frac{\text{pA}}{\sqrt{\text{Hz}}}$	$1\,\frac{\text{fA}}{\sqrt{\text{Hz}}}$

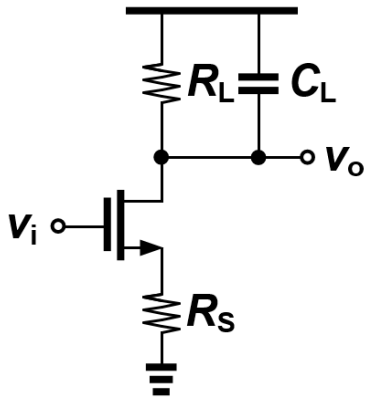
   (a) Calculate the input referred voltage noise in $\text{V}/\sqrt{\text{Hz}}$ achieved with the two amplifiers, respectively. Report your result in Table 2 below. You may assume that the amplifier voltage and current noise sources are uncorrelated (usually not the case).

R_s	Amplifier A	Amplifier B
50 Ω		
5 MΩ		

   (b) Briefly comment on the significance of your result.

2. **Amplifier Noise.**

For the amplifier shown below, derive analytical expressions as a function of g_m, γ, f_T, R_L, R_S, and C_L.



(a) The voltage gain $a_v(s) = v_o/v_i$

(b) The PSD of the noise in $\mathrm{V}/\sqrt{\mathrm{Hz}}$ at node v_o

(c) The total noise integrated over all frequencies at node v_o

(d) The dynamic range of the circuit as a function of the peak-to-peak voltage range $V_{o,pp}$ at node v_o

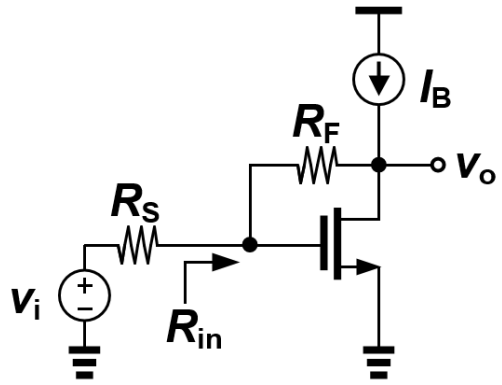
(e) The minimum detectable signal in $\mathrm{nV}/\sqrt{\mathrm{Hz}}$ at low frequency and μV_{rms} based on the total noise at the output of the amplifier.

(f) Comment on the effect of R_s on the dynamic range and minimum detectable signal of the circuit.

(g) Find the component values that meet the following requirements: $a_{vo} = -5$, a 3-dB bandwidth at v_o of 500-MHz, $\gamma = 1$, $V^* = 150\mathrm{mV}$, $f_T = 50\mathrm{GHz}$, 50-dB dynamic range at v_o, $V_{o,pp} = 500\mathrm{mV}$, $R_s = 500$ and minimum power dissipation.

(h) Verify your result from part (g) with SPICE. Model the transistor as an ideal transconductor with input capacitance C_{GS} and a drain current noise source. Model the transistor as an ideal transconductor with gate-to-source capacitance and drain current noise. Assume infinite output resistance.

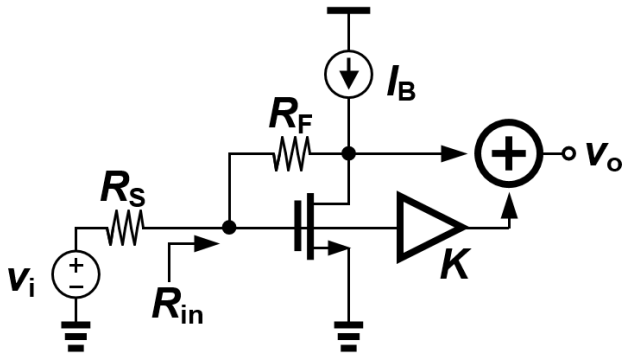
3. **Noise Cancelling Amplifier**



(a) Find the input impedance R_{in}.

(b) What is the output noise under the constraint of impedance matching ($R_{in} = R_S$)? Ignore noise from current source I_B.

(c) What is the output noise with the modified topology below, under a matching condition? How would you pick the value of K? Is K positive or negative?



(d) Replace the functional block above with real circuit, and re-calculate output noise.