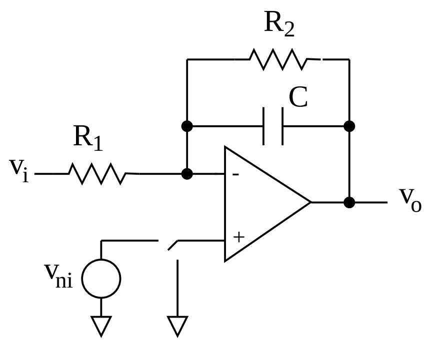
97.477 Lab / PA 6 Noise March 22, 2000, Due in class March 29.

For the following filter, with similar component values to the one designed in the lab:



$C = 1000$ pF

$R_2 = 159$ kΩ

$R_1 = 15.9$ kΩ

$kT = 4.15 \times 10^{-21}$

joules at room temp.

1) Find the output noise due to the thermal noise of the two resistors shown.

2) Using the CMOS opamp designed at the beginning of the term, find the input referred thermal noise due to the opamp itself. This can be estimated by:

$$\overline{v_{ni}}^2 = \frac{16}{3}\frac{kT}{g_{m1}}\left(1 + \frac{g_{m4}}{g_{m1}} + \frac{g_{m10}}{g_{m1}}\right) \qquad \frac{V^2}{Hz}$$

Noise in SPICE can be calculated as part of an AC analysis by adding an analysis line as follows:

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.NOISE V(9) Vi 10
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Where, V(9) is the output noise summing node, Vi is the input source, which must be set as AC. The number 10, results in a summary printout for every 10th point. Change these numbers as appropriate.

A corresponding print line can be used as follows:

```
.PRINT NOISE ONOISE INOISE
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ONOISE and INOISE are output referred noise and input referred noise, both in volts per sqrt(Hz) $V/\sqrt{(Hz)}$. Inside of probe, this will result in outputs labelled v(onoise) and v(inoise). The probe output simply labelled onoise is output noise power.

3) Find the signal to noise ratio assuming the output signal can swing to within 1/2 V of the power supplies, *i.e.*, from 0.5 V to 2.5 V for 0 V and 3 V supply rails. Assume that the output noise is due to the combined thermal noise of the resistors and the opamp as found in 1) and 2) above.

Table of Noise Calculations. Done by ______________________ Number _________

Part 1	R_1	R_2
$4kTR$		
$H(\omega)$		
Ouput Noise Density		
O/P Integrated Noise		
Part 2	Theory $g_m = \sqrt{2k_p \frac{W}{L} I_{DS}}$	g_m from simulation
g_{m1}		
g_{m4}		
g_{m10}		
	Theory	Simulation
Opamp Noise Density ($\overline{v_{ni}}^2$)		
O/P Integrated Noise (Due to opamp, C/L)		N/A
Part 3	Theory	N/A
Signal Size		–
Total O/P $\int$ Noise		–
Dynamic Range		–