INF 5460 Electrical noise -- Estimates and countermeasures.

Mandatory task number 2.

Deadline for delivery: March 19 at 8:15.
Evaluation: Approved / not approved.
The tasks are delivered on an individual basis. The reports shall consist of the schematics that have been used, simulation results and text that explain what has been done as well as an analysis of the results. The report is delivered electronically as an email attachment.

1. Ideal amplifier.

We will first look at an ideal amplifier in an ideal differential amplifier set up. You may base the simulations on the amplifier cell entitled "opamp" in the "Educational" cell library. Make sure to include the "include" statement. Draw a resistor network as specified in Figure 3-4 "Differential amplifier using one op amp" p56 in Motchenbacher. Let all the time R3=R1 and R2 = R4 = 10 * R1 = 10 * R3.

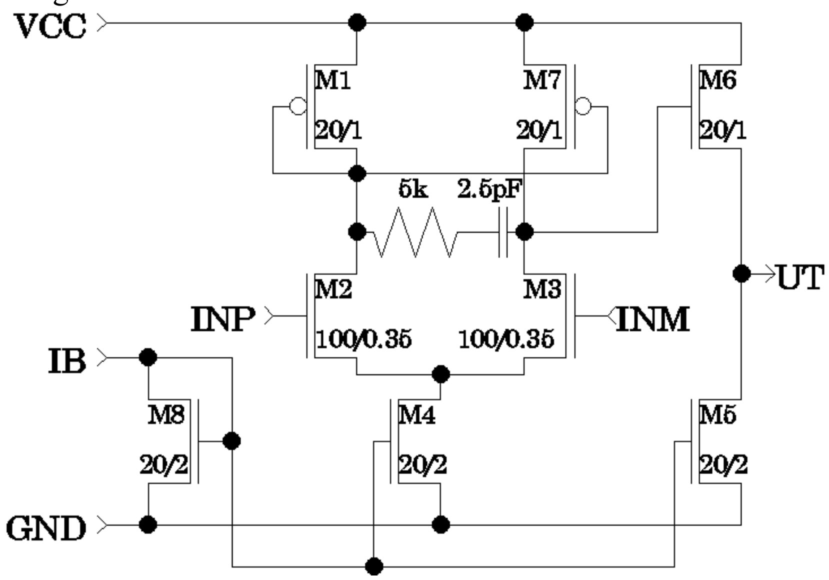
a) Let R1 be 1kΩ, 10kΩ and 100kΩ. (Change R2, R3 and R4 so that the ratio between the resistors are kept as specified in the previous paragraph). Does the gain change in these three cases? Find the output noise and equivalent input noise for the three cases for frequencies below the corner point. Find the equivalent input noise at both the positive and the negative input. What types of noise are represented? Estimate the noise from each of the resistors by calculation.

2. Simple CMOS amplifier.

The ideal amplifier provides incorrect behaviour at higher frequencies. We shall now replace the amplifier with a simple 8 CMOS transistor amplifier.

Before we can draw the amplifier, we must retrieve the model files and symbols. Download standard.mos and replace the original model file that is located in /lib/cmp/ with this. Download symbols for pmos and nmos (pmos4.asy and nmos4.asy) and put these symbols in the folde where you keep your schematics. (Links are also on the lecture schedule.).

Redraw the following schematic:



Change the model designations, respectively to MODP and MODN. Let the bias reference current IB be 50µA.

Then, create a symbol with the exact same name as the schematic. (When the simulator finds a symbol it looks for a schematic with the exact same name as the symbol.)

a) Set up the same simulation as in task 1 with the new real amplifier. Let R1 = 1kΩ.
b) We want to read the noise level at some frequencies and the integrated noise over some frequency regions. (As the lower frequency we use the estimated lifetime of the universe, 13billion year that corresponds to a frequency of about 1aHz ≈ 0.001fHz). Read the equivalent input noise (*inoise*) at 1aHz, 1pHz, 1µHz, 1Hz, 1kHz and 1MHz.
c) Find the total integrated noise at the input and output for the entire area 1aHz-1GHz. We divide the area into several sub areas and find the noise level within each of these: 1aHz-1Hz, 1Hz-1kHz, 1kHz-1MHz and 1MHz-1GHz. How do we add these?
d) Finally, divide the last area into three areas 1MHz-10MHz, 10MHz-100MHz and 100MHz-1GHz and find the noise within each of these areas by simulation. If we try to reduce noise by reducing the bandwidth: Should we do it in the upper or lower part of the frequency spectrum or is it equally important at both ends?

(Voluntary task:
e) We see that the noise is dominated by flicker noise at low frequencies. How is this type of noise changing with frequency? Show in the simulation that this is correct by multiplying with the inverse expression for the frequency dependency.)

f) Perform the same simulation as in task 1 with R1 = 1kΩ, R1 = 10kΩ and R1 = 100kΩ. Simulate with a load of 0.001fF and 50pF. Comment on the result.

3. Open loop and two closed loops.

Find noise at 1MHz, and integrated from 1Hz til1GHz on input and output. Find it for the open loop, for a 10x (with the network over) as well as for a follower.