

Exercise: Noise

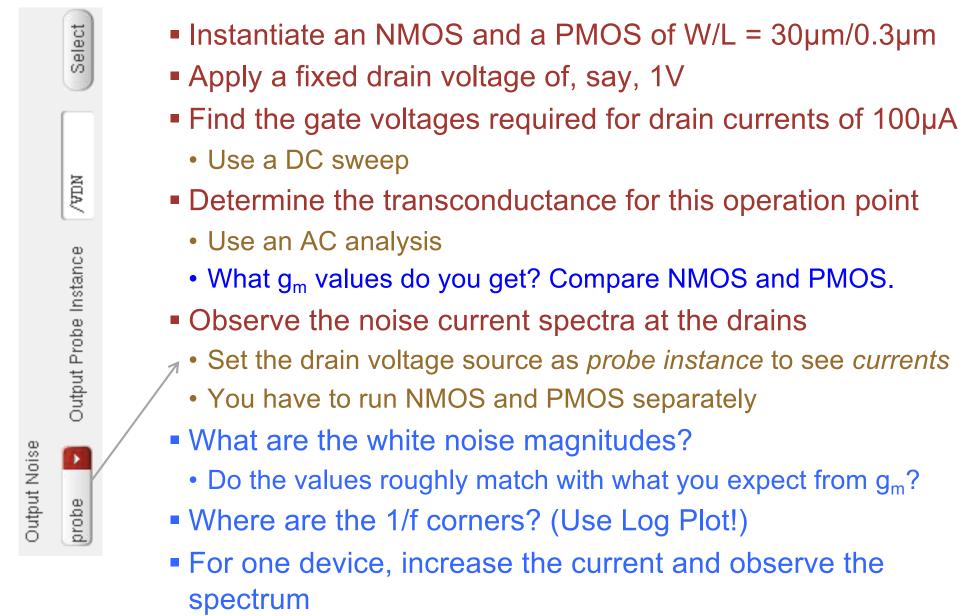
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Exercise 1: Noise in Resistors

- Connect a $1k\Omega$ resistor (from AnalogLib) on one side to gnd!
- Simulate the voltage noise spectrum on the other side
 - Is it flat?
 - Is the absolute value what you expect? Note how the prefixes (e.g. 'a' for Atto) are used...
- Add an ideal low pass filter with corner frequency 10 MHz
 - Use a simple RC and set the 'Generate Noise?' flag of R to 'No'
 - Choose R much larger than $1k\Omega$ to not 'load' the 'source'
 - How does the spectrum look like?
 - How much has noise decreased at the corner?
 - Integrate over a large frequency range to get the rms noise
 - Is it what you expect?
- Determine the overall RMS noise (totalNoise("noise" nil nil))
 - Is it what you calculate?

Exercise 2: Noise in MOS Transistors



Exercise 3: Noise in Current Mirror

- Make an 1:1 PMOS current mirror, using the same PMOS as in the previous exercise.
 - (PMOS is better for lower 1/f noise here)
- Load the output with 1V. Inject a current at the input and verify that you get the current at the output
- Plot the noise at the output.
- Now add a decoupling capacitor (to gnd!) to the bias node.
- Plot the noise spectrum for $C_{dec} = 1/10/100/...$ fF
 - Observe how larger decoupling cuts down the noise at lower frequencies
 - Why is there no added noise at very high frequency ?
 - Check that the 'corner' frequencies for various caps are where you expect them !

Exercise 4: Charge Amplifier

- Design a charge amplifier followed by a (passive) CR-RC filter with corner frequency τ ~ 1µs with input cap of 1 pF.
 - For the amplifier, use a simple NMOS (W/L~10µ/0.3µ) gain stage with a PMOS current mirror load (30µ/0.3µ). Decouple the bias node.
 - Bias at ~100µA.
 - Use a feedback capacitor of 100 fF. Put a $100M\Omega$ resistor in parallel to set the dc operation point.
 - Implement the filter as passive RCs, with parameterized τ. Use vcvs buffering between the stages. You may want to switch off noise in the resistors...
- In a transient simulation, inject a 1fC charge (1V step across a 1fF injection capacitor)
 - Observe the output of preamp / shaper, and the preamp input
 - Is the virtual ground at the input 'ok'?
 - Is the shaper signal as expected (amplitude, peaking)? Vary τ !

Hint for Exercise 4: Nice Filter

- To make the schematic more tidy, you may make a symbol + schematic of a CR-RC filter with a parameter (peaking time, or corner frequency).
- Turn off the noise of the resistors in the filter, so that we can concentrate on the other stuff.

Exercise 5: Noise in Charge Amplifier

- Perform a noise simulation for τ = 0.5 µs and 5 µs
- For *τ* = 1 μs:
 - Determine the total noise at the shaper output by integration
 - Take the square root to get the RMS (voltage) noise
 - Divide by the signal for one electron to get the ENC
 - What do you get ?
- Double C_{in} to 2 pF
 - What is the ENC now?
- Find out which noise type / contribution dominates your circuit by using Noise Analysis