وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا

Ain Shams University – Faculty of Engineering – ECE Dept. – Integrated Circuits Lab.
Dr. Hesham Omran

Analog IC Design
Lab 10
Noise Simulation

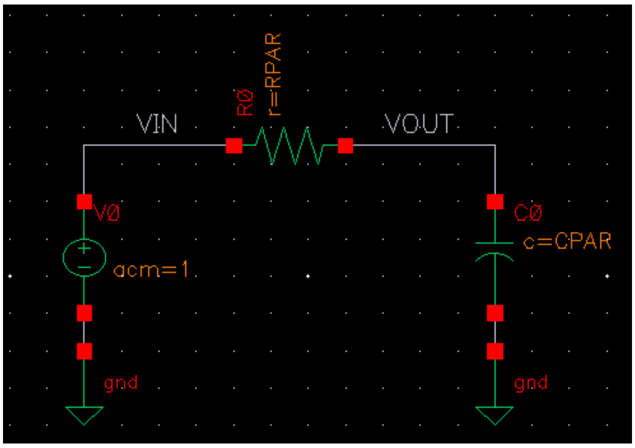
Intended Learning Objectives

In this lab you will:

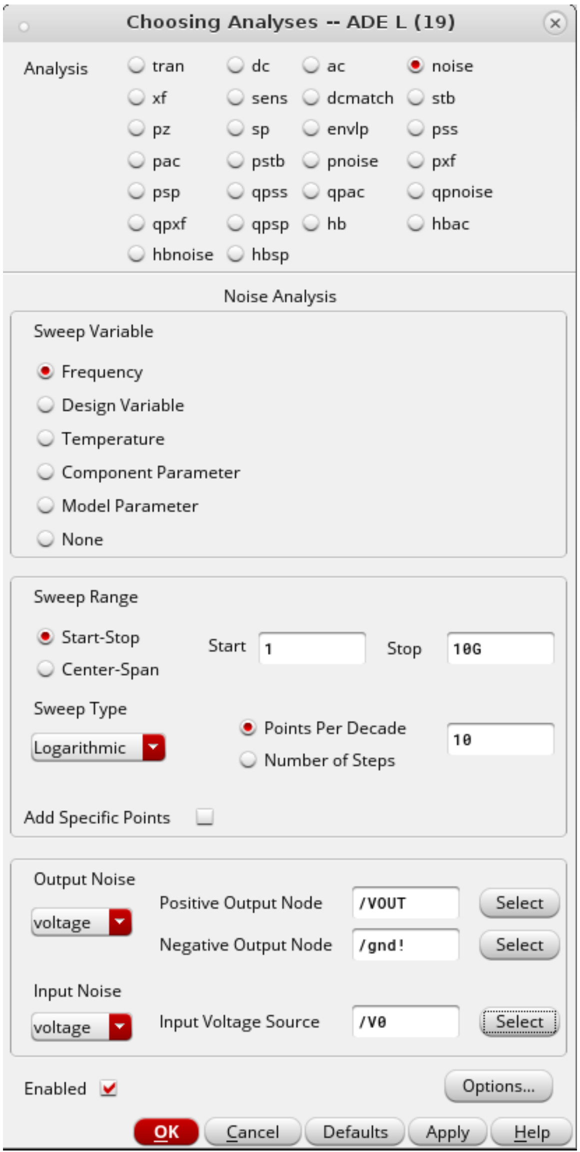
- Learn how to simulate noise in a LPF in both ac and transient simulations.
- Learn how to simulate noise in a 5T OTA in both ac and transient simulations.

PART 1: LPF AC Noise Analysis

1) Create a new cell "lab_09_noise_rc". Create a testbench for a simple 1st order LPF as shown below. Set R and C as parameters.



2) Set up AC analysis (1Hz:10Gz, logarithmic, 10 points/decade).
3) Setup noise analysis as shown below.

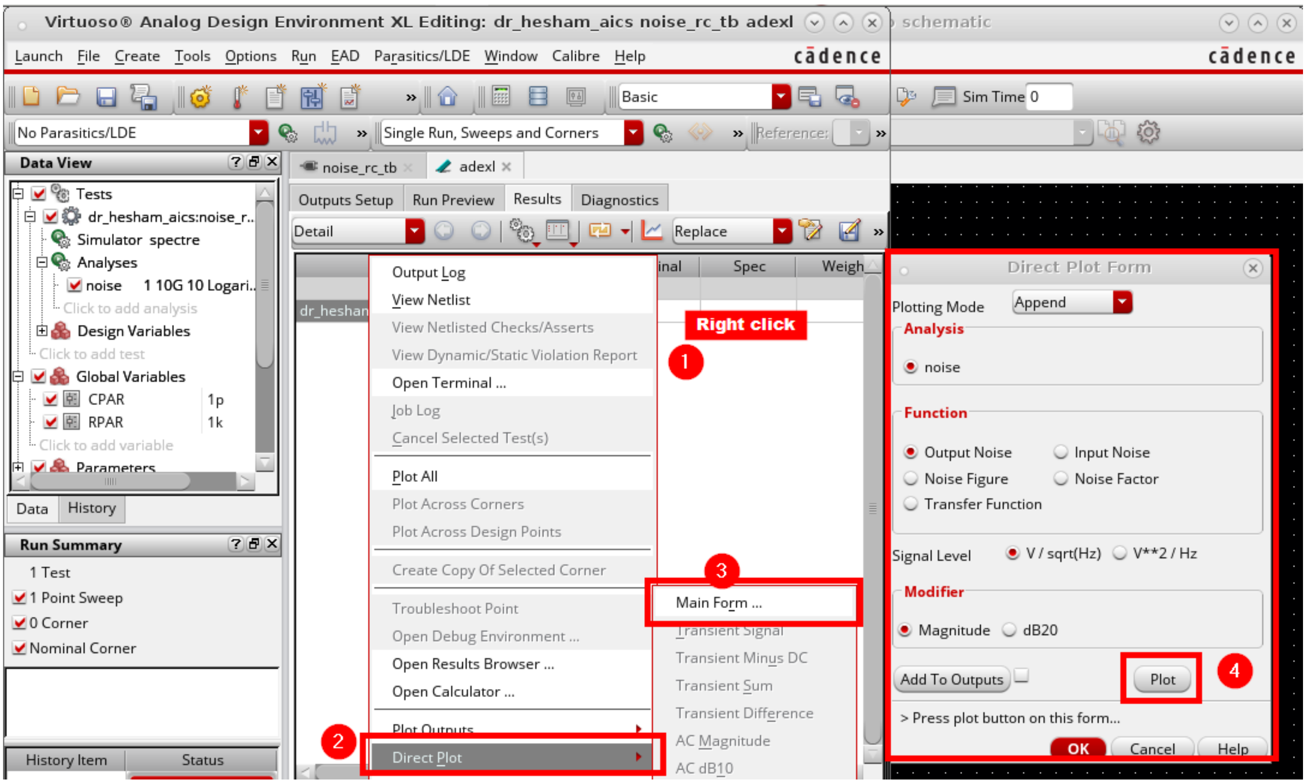


4) Set RPAR = 1k and CPAR = 1p.

5) Run noise analysis.

6) Report output noise vs frequency. Annotate voltage noise density and bandwidth in the plot.

➔ Cadence Hint: From adexl Results tab, right click and choose “Direct Plot” -> “Main Form” as shown below.



7) Calculate rms output noise using rms noise function in the calculator.

➔ Cadence Hint: In the calculator use rmsNoise(1 10G).

➔ Cadence Hint: Another very powerful tool for noise simulation is Noise Summary: From adexl Results tab, right click and choose “Print” -> “Noise Summary”.

8) Compare the simulation results (noise density, bandwidth, and rms) with hand analysis.

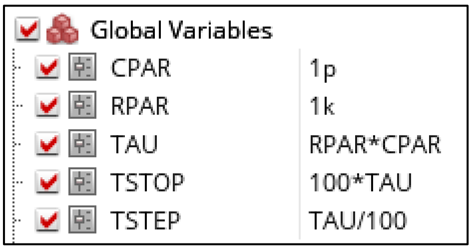
9) Run parametric sweep for RPAR = 1k, 10k, 100k, 1000k.

10) Plot output noise overlaid on the same plot. Using log-scale for y-axis. Comment on the results.

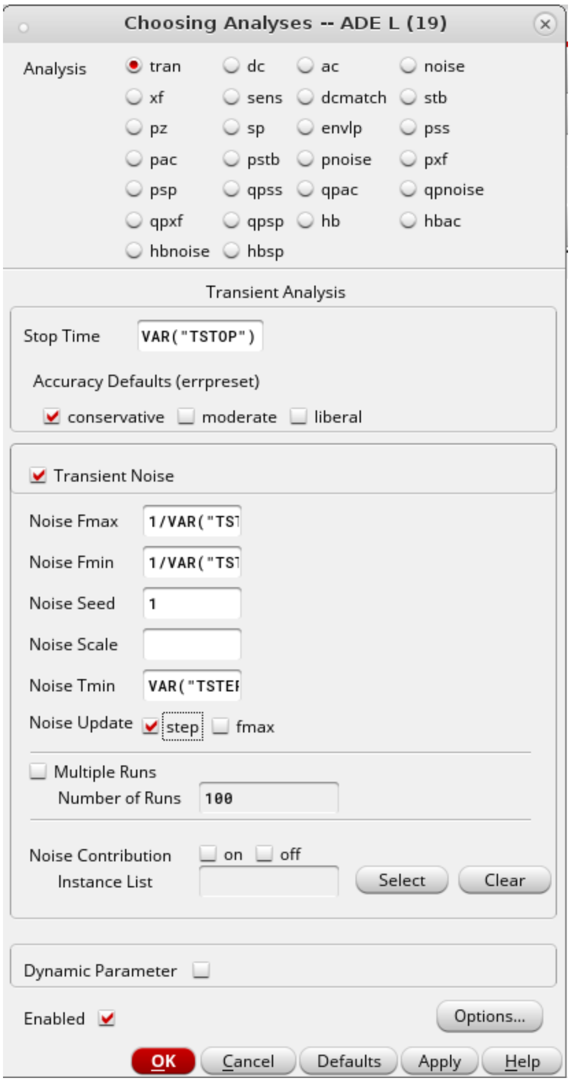
11) Calculate the rms noise using the calculator. Comment on the results.

PART 2: LPF Transient Noise Analysis

1) Create a new simulation configuration for transient noise. Define new parameters TAU, TSTOP, and TSTEP as shown below.



2) Setup transient noise analysis as shown below. Fmax is set to 1/TSTEP and Fmin is set to 1/TSTOP. You can think of these as the start and end frequencies used in generating the noise samples (i.e., equivalent to the start and end frequencies used in integrating the PSD). Only one transient noise simulation run will be performed.



3) Report the noise output waveform. Annotate the min and max values.

4) Use the rms function in the calculator to calculate the rms noise. Compare it to the value calculated in Part 1.

➔ Cadence Hint: rms(VT("/VOUT"))

5) Repeat the simulation with TSTEP = TAU/10. Does the calculated rms noise increase or decrease? Why?

6) Back to TSTEP = TAU/100. Change the transient noise options as shown below. Now it will run 20 runs of transient noise iterations.

7) Report the rms noise vs iteration.

➔ Cadence Hint: rms(VT("/VOUT"))

8) Use the calculator to calculate the average rms noise. Compare the calculated value with the rms noise previously obtained in Part 1 and Part 2.

PART 3: 5T OTA AC Noise Analysis

1) Create a new testbench. Connect the 5T OTA you designed in Lab 07 in unity-gain buffer configuration. Similar to Part 1, run ac noise analysis.
2) Report output thermal noise vs frequency. Annotate noise density and bandwidth in the plot. Compare the simulation results with hand analysis.
3) Report total output noise (thermal + flicker) vs frequency. Estimate the Flicker noise corner.
4) Calculate rms output noise (calculate the rms noise due to thermal noise only using Noise Summary).
5) Compare the simulation results (noise density, bandwidth, and rms) with hand analysis.

PART 4: 5T OTA Transient Noise Analysis

1) Create a new simulation configuration. Keep the 5T OTA connected in unity-gain buffer configuration.
2) Set the input signal as a sin wave with amplitude = 10mV and fin = 10kHz frequency superimposed on a CM level equal to the middle value of the CMIR.
3) Run transient analysis with max time step = 0.02/fin (50 points for cycle) and stop time = 4/fin (simulate 4 cycles).
4) Plot input and output overlaid and make sure they match well (verify that the circuit behaves as a buffer).
5) Now we will run transient noise analysis similar to Part 2. Use a single noise simulation run. Set transient noise upper frequency at 10 times the OTA GBW.
6) Report the "noisy" output waveform (zoom-in to highlight the noise). Notice that output signal and noise are superimposed.
7) Change the transient noise options to run 20 simulation runs. Now Spectre will run 20 runs of transient noise.
8) Report the rms noise vs iteration.
9) Use the calculator to calculate the average rms noise. Compare the calculated value with the rms noise previously obtained in Part 3.

Lab Summary

- In Part 1 you learned:
    - How to do ac noise simulation of a LPF.
    - How the rms noise change with the filter's resistor value.
- In Part 2 you learned:
    - How to do transient noise simulation of a LPF.
    - The need for multiple transient simulation runs for plotting rms noise spectrum.
- In Part 3 you learned:
    - How to do ac noise simulation of a 5T OTA.
- In Part 4 you learned:

- How to do transient noise simulation of a 5T OTA.
- The need for multiple transient simulation runs for plotting rms noise spectrum.

Acknowledgements

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