EE3235 Analog Integrated Circuit Analysis and Design I

Homework 4
Ideal OP circuit

Due date: 2023.11.29 (Wed.) 13:20 (upload to eeclass system)

Suppose V_{DD}=1.8V, temperature=25°C, TT corner in this homework.

Please note that:

1. **No delay allowed**.
2. Please hand in your report using eeclass system.
3. Please generate your report with **pdf** format, name your report as HWX_studentID_name.pdf.
4. Please hand in the spice code file (.sp) for each work. Do not include output file.
5. Please print waveform with white background, and make sure the X, and Y labels are clear.
6. Please do not zip your report.

In this homework, you have to build an ideal op model(with finite gain=60dB) by SPICE and use this model to construct the following four circuits, including: **Unity-Gain Amplifier, Noninverting Amplifier, Inverting Amplifier, Voltage Adder and Integrator**

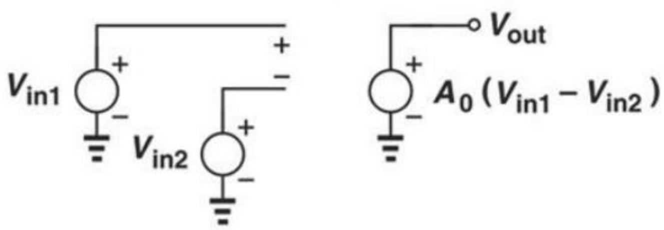

Fig. 1. Ideal op model

You have to build an ideal op model as show in Fig. 1. and **let A_0 = 60dB** (Hint：use E element to build an ideal model). **In the question below, all parts that need to be calculated must consider op as finite gain, otherwise no points will be given.**

Please submit a sp file for each part, a total of 4 sp files, named as: UGA.sp, NIA.sp, IA.sp, and VAI.sp. If you don't submit the assignments in accordance with the above regulations, no points will be given.

1. Unity-gain Amplifier

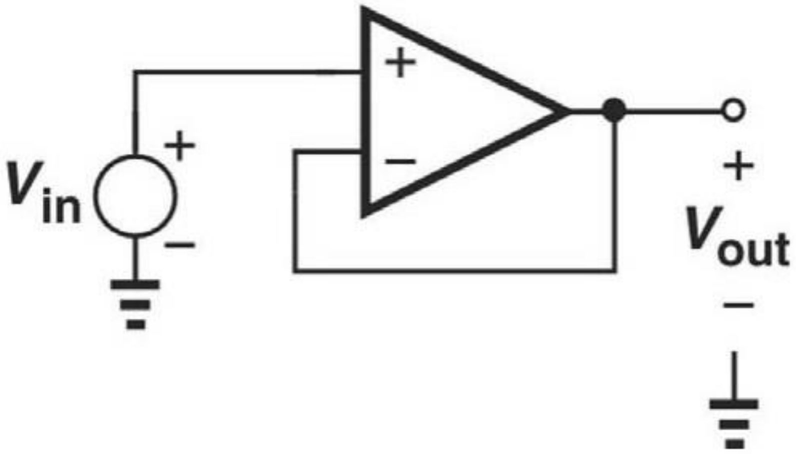

Fig. 2. Unity-gain amplifier

Use your ideal op model to construct an unity gain amplifier as shown in Fig. 2.

(a) DC Sweep

Please probe V_{out} v.s. V_{in} (sweep V_{in} from 0V~5V) and measure the derivative of V_{out} when V_{in} is 2.5V.

(b) TF Analysis

Please run the .TF command in HSPICE to measure the I/O impedance and DC gain A_v. Calculate the **DC gain** and compare it to the simulation result.

2. Noninverting Amplifier

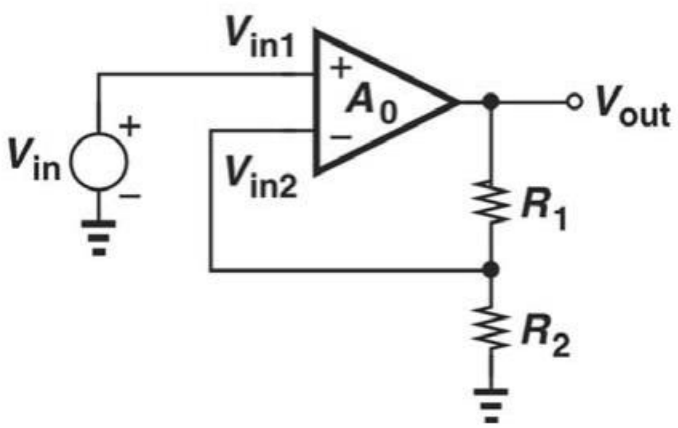

Fig. 3. Noninverting Amplifier

Use your ideal op model to design an Noninverting Amplifier as shown in Fig. 3.
With closed-loop gain = 30 (error < 1%).

(a) DC Sweep

Please probe V_{out} v.s. V_{in} (sweep V_{in} from 0V~5V) and measure the derivative of V_{out} when V_{in} is 2.5V.

(b) TF Analysis

Please run the .TF command in HSPICE to measure the I/O impedance and DC gain A_v. Calculate the **DC gain** and compare it to the simulation result.

(c) How do you design your circuit to meet the SPEC? Describe your design considerations.

3. Inverting Amplifier

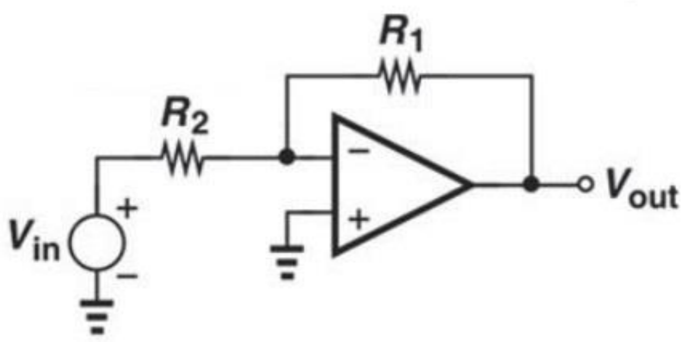

Fig. 4. inverting Amplifier

Use your ideal op model to design an inverting Amplifier as shown in Fig. 4. **With closed-loop gain = 30 (error < 1%).**

(a) DC Sweep

Please probe V_{out} v.s. V_{in} (sweep V_{in} from 0V~5V) and measure the derivative of V_{out} when V_{in} is 2.5V.

(b) TF Analysis

Please run the .TF command in HSPICE to measure the I/O impedance and DC gain A_v. Calculate the **DC gain** and compare it to the simulation result.

(c) How do you design your circuit to meet the SPEC? Describe your design considerations.

4. Voltage Adder + Integrator

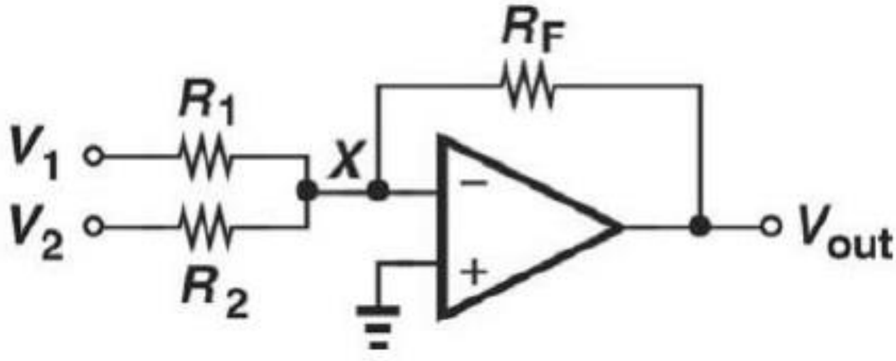

Fig. 5. Voltage Adder Circuit

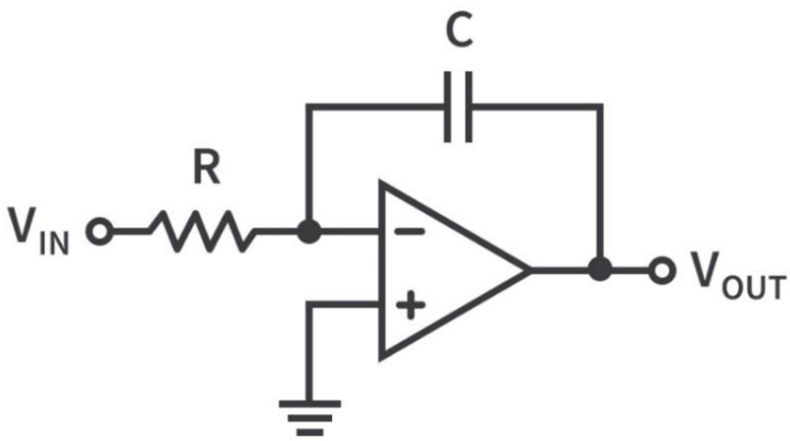

Fig. 6. Integrator

The voltage adder is shown in Fig. 5 and the integrator is shown in Fig.6. Use only your ideal op model, 2 integrators, and 1 voltage adder to design a circuit satisfied the following equation.

$$V_y(t) = \int \left(\int -600\mathrm{V_x}(t) - 1200V_y(t)dt \right) dt$$

(a) Describe your design consideration and show the schemetic.

(b) Suppose all initial conditions are 0 and $V_x(t)$ is an unit step input. Please do hand calculation to find the transient response of $V_y(t)$ and the period of the waveform at $V_y(t)$.

(c) Let $V_x(t)$ be an unit step input. Plot the transient response of $V_y(t)$ and measure the period of $V_y(t)$. The output waveform should looks like Fig. 7.

The unit step input **has to** be generated using the following instruction and the transient response time **has to** be larger than 6(s).

Vin Vx GND PULSE 0 1 5 1n 1n 10

(d) What is the error between calculated waveform period and the simulation waveform period?

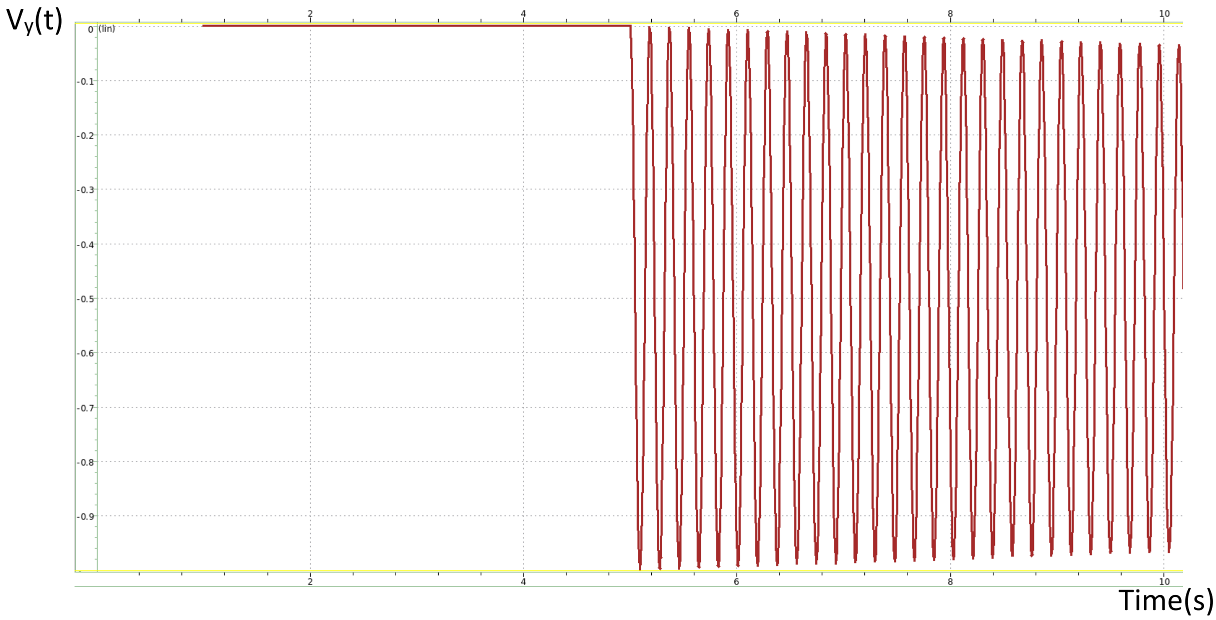

Fig. 7. $V_y(t)$ waveform in 4.(b)