CENG4480 Homework 1

- **Small-Signal Gain:** For given amp circuits, small changes of input ΔV_{in} will cause output change of ΔV_{out}. Small-signal gain is defined by $\dfrac{\Delta V_{out}}{\Delta V_{in}}$.

Q1 Given a non-inverting amplifier as shown in Fig. 1, calculate the exact finite gain. Assume $A_0 = 1000$, determine the gain difference if the circuit is expected to have an ideal gain of 5 under $A_0 = \infty$.

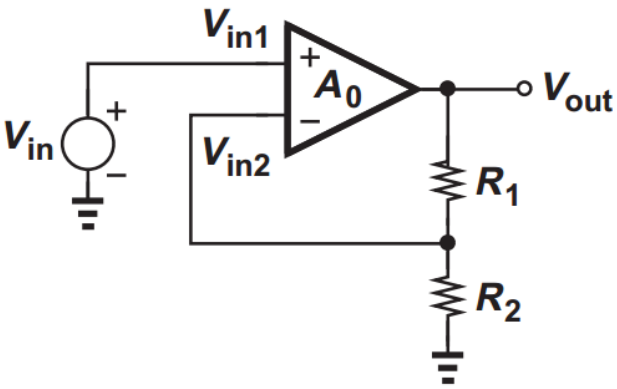

Figure 1: Non-inverting Amplifier

Q2 An op amp exhibits the following nonlinear characteristic:

$$V_{out} = \alpha \tanh[\beta(V_{in1} - V_{in2})]. \tag{1}$$

Determine the small-signal gain of the op amp in the case $V_{in1} \approx V_{in2}$.

Q3 Assuming $A_0 = \infty$, compute the closed-loop gain of the inverting op amp shown in Fig. 2. Verify that the result reduces to ideal version when $R_1 \to 0$.

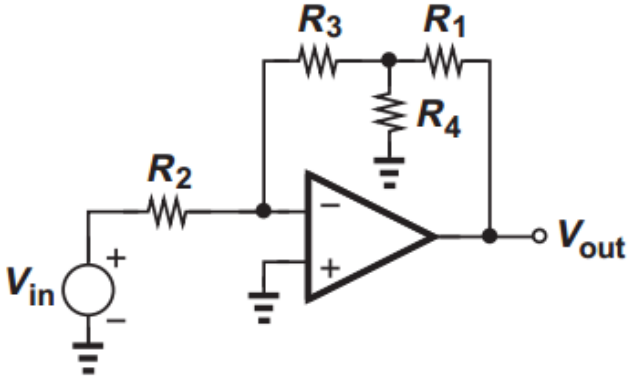

Figure 2: Inverting Op Amp

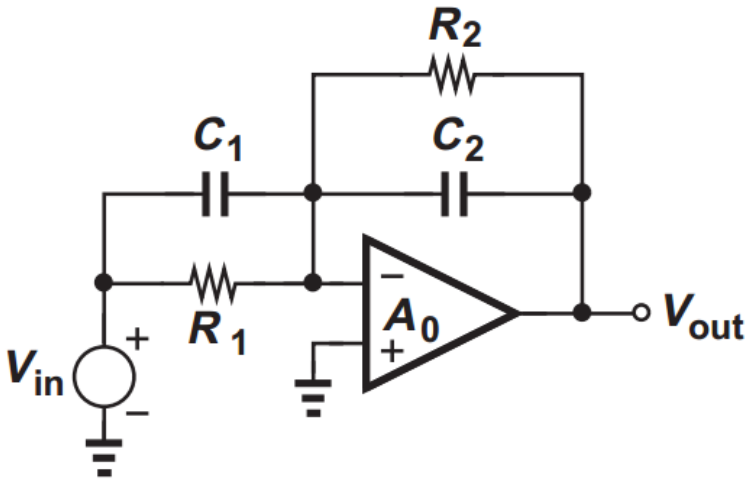

Figure 3: Sample Differentiator

Q4 Calculate the transfer function (in other word, gain) of the circuit shown in Fig. 3 if $A_0 = \infty$. Would it be possible thats $|\frac{V_{out}}{V_{in}}| = 1$ for all frequencies.

Q5 Repeat Q4 when A_0 is finite.

Q6 Consider the voltage adder shown in Fig. 4, where $V_1 = V_0 \sin\omega t$ and $V_2 = V_0 \sin 3\omega t$. Assume $R_1 = R_2$ and $A_0 = \infty$. Plot V_{out} as a function of time.

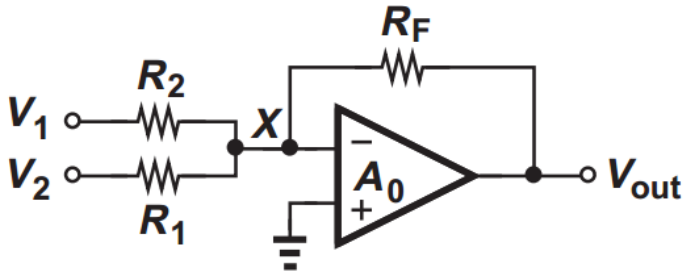

Figure 4: Voltage Adder

Q7 The input/output characteristic of an op amp can be approximated by the piecewise-linear behavior illustrated in Fig. 5, where the gain drops from A_0 to $0.8A_0$ and eventually to zero as $|V_{in1} - V_{in2}|$ increases. Suppose this op amp is used in a non-inverting amplifier (Fig. 1) with an ideal gain of 5. Plot the closed-loop input/output characteristic of the circuit.

Q8 Mental-Oxide-Semiconductor-Field-Effect-Transistor (MOSFET) is the core component of a variety of amplifiers. Fig. 6 shows a common source amplifier circuit with N-type MOS (M1). Typically, when M1 works as amplifier, drain current I_D has the following relationship with bias voltage V_{in}:

$$I_D = k(V_{in} - V_{th})^2, \tag{2}$$

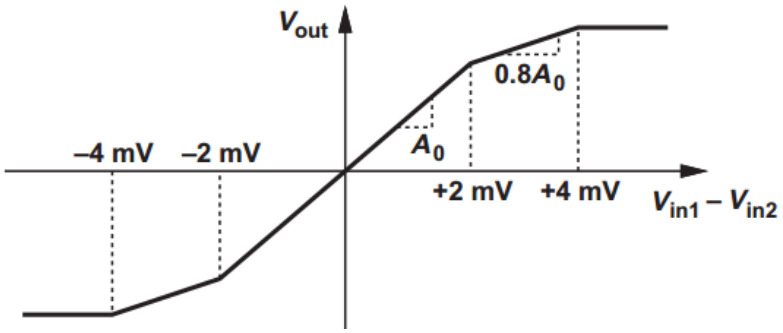

Figure 5: Open-loop Gain Variation

where k is positive and related to material properties of MOSFET and V_{th} is threshold voltage to turn the device on. Calculate small-signal gain of common source amplifier and show that this amplifier is an inverting amplifier.

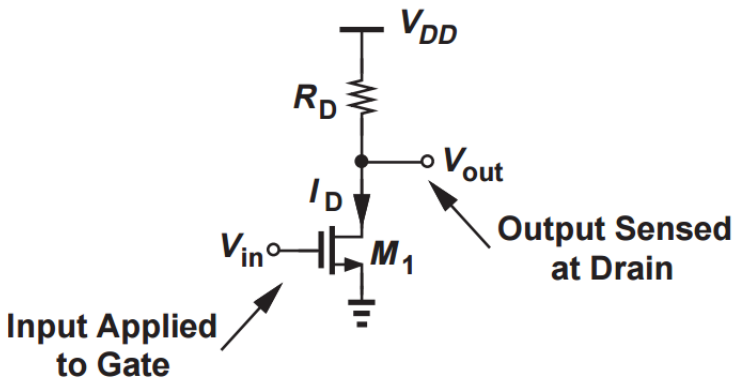

Figure 6: Common Source Amplifier