Problem 1  Identify one operational amplifier that has been published in one of the following in the past 5 years:
IEEE Journal of Solid State Circuits
IEEE Trans. On Circuits and Systems (Part 1 or Part 2)
IEEE International Symposium on Circuits and Systems

Give the circuit schematic, citation information, and briefly summarize the useful properties that the author claims for this circuit.

Problem 2  Identify one operational amplifier that has been patented in the past 5 years. Give the circuit schematic, patent number, and briefly summarize the useful properties that the author claims for this circuit.

Problem 3  Consider the following operational amplifier. The goal is to obtain an expression for the small-signal output voltage in terms of the input variables \( V_{IN+} \) and \( V_{IN-} \).

\[ \text{a)} \quad \text{Write a complete set of small-signal equations that can be solved to obtain } V_{OUT}. \text{ Assume the small-signal parameter } g_o \text{ is present in all MOS devices.} \]

\[ \text{b)} \quad \text{Solve these equations by hand for } V_{OUT} \text{ but, if you do not have a solution at the end of } \frac{1}{2} \text{ hour, stop, and comment on your progress and the amount of effort that you believe would be required to finish the solution.} \]

\[ \text{c)} \quad \text{Obtain a parametric (symbolic) solution for the transfer function } V_{OUT}/V_{IN} \text{ from this set of equations with MATLAB. This solution will be the ratio of two polynomials in } s. \text{ Each coefficient will be comprised of the sum of a number of product terms. How many total product terms appear in this solution? In this part, } V_{in}=V_{in+}-V_{in-}. \]

\[ \text{d)} \quad \text{Simplify the solution obtained with MATLAB under the assumption that all } g_m \text{ terms are small compared to } g_o \text{ terms} \]
Problem 4  Assume the amplifier can be modeled by an input-output relationship

\[ V_{\text{OUT}} = (-A)(V_{\text{IN}} - V_{XQ}) + V_{YQ} \]

a) Derive an expression that shows how the closed-loop output relates to the closed-loop input in the feedback amplifier shown below. Assume the input \( V_{\text{IN}} \) is comprised of a quiescent component \( (V_{\text{inQ}}) \) and a small signal component \( (V_{\text{inss}}) \) and is given by the expression \( V_{\text{IN}} = V_{\text{inQ}} + V_{\text{inss}} \)

b) Show that if \( A \) is large, this expression reduces to

\[ V_{\text{OUT}} = \frac{-R_2}{R_1} V_{\text{inss}} + V_{XQ} + \frac{R_2}{R_1} (V_{XQ} - V_{\text{inQ}}) \]
Problem 5  Assume the amplifier shown below is designed in a 0.5µ CMOS process and that $V_{DD}=5V$, $V_{SS}=-1.5V$, and $I_{DQ}=4mA$.

a)  Analytically determine the $W$ and $L$ needed to establish a quiescent output voltage of 1V.

b)  Verify the transfer characteristics by Spice simulation.

c)  Analytically determine the dc voltage gain at the Q-point established in a)

d)  Using SPICE, obtain a plot of the small signal voltage gain versus the quiescent output voltage.

Problem 6  Assume the amplifier in Problem 5 is used as a single-input, single-output operational amplifier. With this op amp, analytically determine the small signal voltage gain and the quiescent output voltage for the circuit shown below if $R_2=20M$ and $R_1=5M$. Assume that the dc offset of $V_{IN}$ is 1V. Verify the gain of this amplifier with SPICE simulation.
Problem 7  A transresistance amplifier with a gain $R_T$ is shown. Derive an expression for the voltage gain of the amplifier as a function of the transresistance gain $R_T$ and determine what that reduces to if $R_T$ is very large.

![Diagram of a transresistance amplifier with components labeled $V_{IN}$, $V_{OUT}$, $R_1$, $R_2$, and $R_T$.]