Question 1  What is the major benefit of connecting the counterpart circuits in a differential amplifier as a current mirror rather than as two independent current sources?

Question 2  If Xin is a current and Xout is a voltage in the basic feedback amplifier, which of the 4 types of amplifiers is the \( \beta \) amplifier?

![Amplifier Diagram]

Question 3  We saw that the small signal differential voltage gain for a differential amplifier with a tail current source bias was identical to that with a tail voltage bias. What is the major advantage of the circuit with a tail current bias?

Question 4  What are the two major benefits of the telescopic cascode amplifier over the folded cascode amplifier structure?

Question 5  If a mapping \( A(s)\beta \) is made from the complex plane to the complex plane, what is the image of the imaginary axis under this mapping?
Question 6 If a two-stage amplifier with a gain of 70dB is used in a feedback configuration with a closed-loop gain of 10, and if the high frequency pole of this amplifier is at 10MHz, what is the largest magnitude dominant pole the op amp can have if the phase margin is to be around 70 degrees?

Question 7 If a feedback amplifier has a characteristic polynomial given by \( D_{FB}(s) = s^3 + 2s^2 + as + 60 \) where \( a \) is a variable, what is the minimum value of \( a \) that can be used if the feedback amplifier is to remain stable?

Question 8 How is the standard Miller compensation circuit modified to move the RHP zero back into the LHP?

Question 9 What is the purpose of the CMFB circuit in a fully differential amplifier?

Question 10 When was the OTA originally introduced? (±3 years)
Problem 1 This problem focuses on the design of an operational amplifier.

a) Give the circuit schematic of a two-stage Miller compensated amplifier with differential inputs and a single-ended output. Assume the first stage is to have a cascoded p-channel quarter circuit for the input with tail current bias for the first stage and an n-channel cascoded n-channel tail voltage biased input to the second stage. Number all transistors in your design. If a CMFB circuit is needed in your design, you may simply use a block diagram to represent the CMFB circuit.

b) Give the small signal voltage gain and the GB for your design in terms of the small signal parameters of the devices.
Problem 2  Assume the operational amplifier below is being sold by a competitor and the competitor gives the circuit schematic but refuses to disclose any information about frequency response or anything about device sizes that are on the inside beyond stating that it has an open-loop dc gain of 80dB and that it is fabricated in a 0.5u CMOS process with parameters as described on the top of this exam. Assume you have measured the supply current when biased at a supply voltage of 5V and found it to be 10mA, that the load capacitance is 50pF, and that the output starts to distort when the output voltage exceeds 4.5V.

Determine as many of the following as possible from the information given. If a parameter can not be determined from the information given, state that fact.

a) \( W1/L1 \)

b) \( W3/L3 \)

c) \( GB \)

d) \( SR \)

e) \( V_{OMIN} \)

f) \( W9/L9 \)

g) phase margin of the feedback amplifier if \( \beta = 1 \).
Solution to Problem 2 goes here
Problem 3  The magnitude and phase plot of an operational amplifier are shown.

a) Determine the phase margin if this is used in a feedback amplifier with a feedback factor of $\beta = 0.025$.
b) Is the feedback amplifier stable? Why?
c) What is the maximum value of $\beta$ that can be used if the amplifier is to have a $60^\circ$ phase margin?
d) If $\beta = 0.001$, what is the ideal closed loop gain and what is the percent closed-loop gain error due to the finite dc gain limitations of the op amp?
Solution to problem 3 goes here
Problem 4  A two-stage operational amplifier is shown along with the device sizes in microns. Assume $V_{DD}=5V$ and $V_{XX}=1V$

a) Determine the dc gain of the op amp
b) What is the GB of the op amp if $C_C=4\text{pf}$ and $C_L=1\text{pf}$? Neglect all other capacitances in the amplifier
c) Determine the power dissipation of the amplifier
d) What is the pole $Q$ if used in a noninverting feedback amplifier with $\beta=0.25$?

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