Exam is open-book, open-notes. Clearly mark results with box around. No credit for ambiguous solutions. Show derivations. Return this cover page. Good luck!

UID #:____________________________

Name:____________________________

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1. [50] An active source follower circuit is shown below. Note that M1 is a PMOS whereas M2 is an NMOS. $V_{BIAS}$ is a DC biasing voltage source. You may assume that the small-signal parameters of the four transistors are known, i.e., $g_m$’s and $r_o$’s of M1 – M4 are all known. Ignore body effect in your derivations.

1) Derive a closed-form expression for the small-signal output resistance $R_o$ of the source follower looking into node $V_o$. Ignore $R_{SS}$ in this derivation. [20]

2) Re-derive $R_o$ of 1) including $R_{SS}$. Does it make a difference with or without $R_{SS}$? [10]

3) If there is a supply variation of $\Delta$ (i.e., $V_{DD} \rightarrow V_{DD} + \Delta$) as shown in the diagram, how much of this variation will show up on the output node $V_o$? Again, derive a closed-form expression for this. You can ignore $R_{SS}$ in this derivation. [20]
2. [50] In the pseudo-differential amplifier shown below, we are trying to perform a single-ended to differential conversion by employing a feedback amplifier to stabilize the common-mode voltage at the output. You may assume that A1 is fixed, A2 is very large (i.e., $A_2 \gg 1$), and $R_3 << R_4$. The input resistances of the three op-amps are all infinite.

1) With $V_x$ connected to ground, derive the output differential voltage ($V_{od} = V_{op} - V_{on}$) as a function of the single-ended input $V_i$. Determine the differential gain $A_{dm}$. You need to derive a close-form expression. [10]

2) Also derive an expression for the output common-mode ($V_{ocm} = 0.5*(V_{op} + V_{on})$) as a function of $V_i$. Determine the common-mode gain $A_{cm}$. What is your CMRR = $|A_{dm}/A_{cm}|$? [10]

3) With $V_x$ connected to $V_y$, derive the output differential voltage again as a function of the single-ended input $V_i$. Determine the differential gain $A_{dm}$. [20]

4) Again derive an expression for the output common-mode. Determine the common-mode gain $A_{cm}$. What is your revised CMRR = $|A_{dm}/A_{cm}|$? Does the feedback seem to stabilize the output common mode? [10]