

INSTRUCTIONS

- Read all of the instructions and all of the questions before beginning the exam.
- There are 3 problems on this midterm exam, totaling 115 points. The tentative credit for each part is given to help you allocate your time accordingly. You have a total of 1 hour and 20 minutes to finish this exam. Be careful not to spend all your time on any one part.
- This is a closed book exam, except you can have one two-sided 8.5"×11" sheet of notes.
- Unless otherwise noted on a particular problem, you must show your work (in the space provided plus the backs of the pages) for all problems to receive full credit; simply providing answers will result in only partial or no credit, even if the answers are correct. (But note that writing down a formula by inspection counts as "showing work".) If you require extra space beyond what is provided, be sure to turn in any material that is required to support your solutions. Note that there are extra pages at the end of this exam. Do not use any attached pages until you have exhausted the pages contained in this exam.
- Turn in the entire exam, including this cover sheet.
- Put your name on every page of this exam, as well as on any additional material that you submit.
- Be sure to provide units where necessary.

Signature: _____

Problem 1: / 25 points

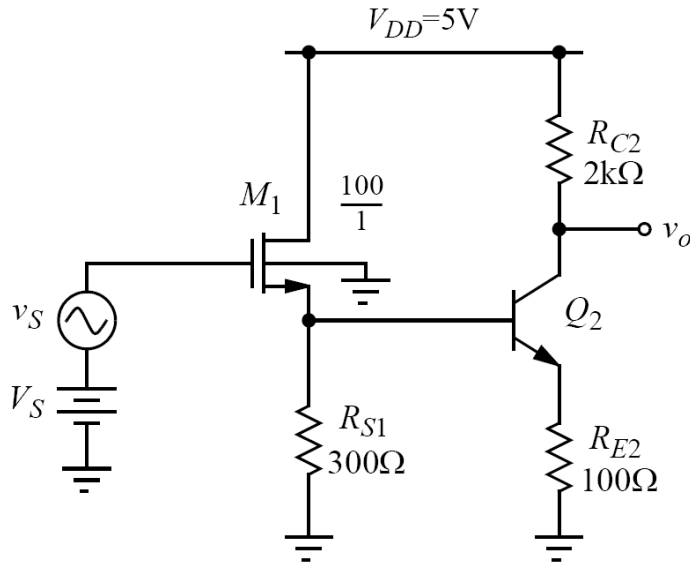
Problem 2: / 45 points

Problem 3: / 45 points

Total: / 115 points

Problem 1. Total 25 points

In the amplifier circuit below, V_S is chosen so that $I_{C2} = 1\text{mA}$ and device parameters (at this bias point) are included to the right, but you actually might not need this information for this problem. The information is given mainly so that you can make educated decisions on what to include and what to neglect when writing out your formulas.



NMOS Data:
 $\mu_n C_{ox} = 60 \mu\text{A}/\text{V}^2$
 $V_{t0} = 0.7\text{V}$
 $\gamma = 0.5\text{V}^{1/2}$
 $C_{gs1} = 150\text{fF}$
 $C_{gd1} = 20\text{fF}$
 $C_{sb1} = 50\text{fF}$
 $C_{db1} = 70\text{fF}$
 $2\phi_f = 0.6\text{V}$

Bipolar Data:
 $\beta_2 = 100$
 $V_{A2} = 200\text{V}$
 $C_{\mu 2} = 50\text{fF}$
 $C_{cs2} = 100\text{fF}$
 $f_{T2} = 10\text{GHz}$

Write expressions for:

- (a) the small signal gain v_o/v_s
- (b) the 3dB cut-off frequency f_H based on open-circuit time constant analysis

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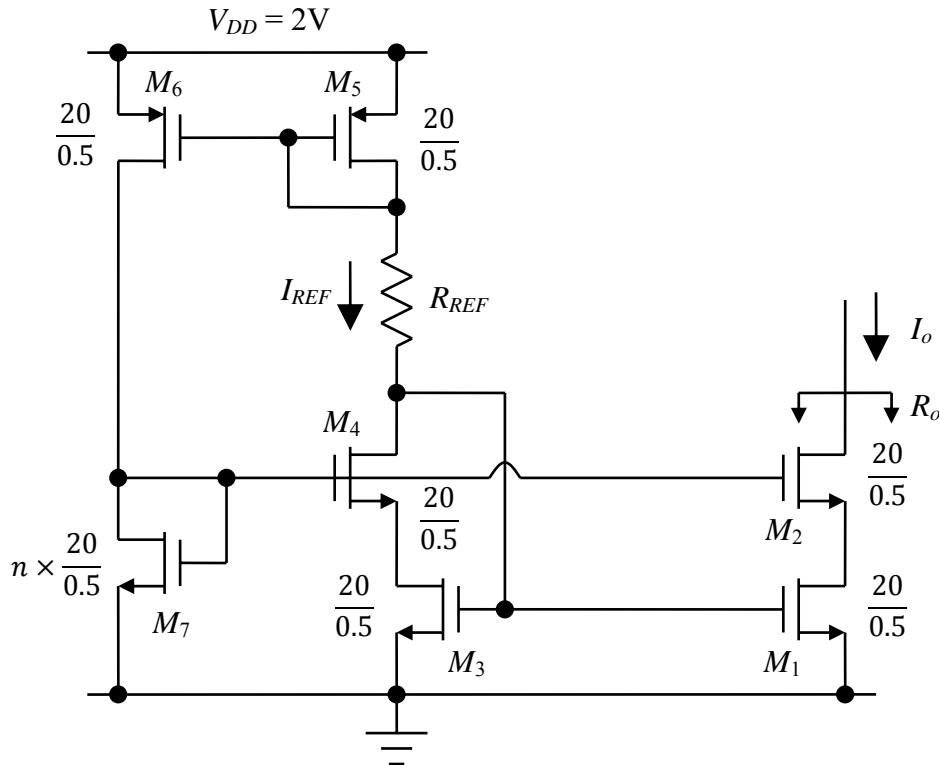
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Problem 1. (continued)

Problem 2. Total 45 points

The circuit below comprises a bias voltage generator (on the left side) for the cascode current source on the right side. The (W/L) ratios given are in microns, and all required device data is provided in the box below. Ignore Body effect in this problem.



Device Parameters:
NMOS: $V_{th0} = 0.7V$, $\mu_n C_{ox} = 200\mu A/V^2$, $\lambda_n = 0.05 V^{-1}$
PMOS: $V_{tp0} = -0.7V$, $\mu_p C_{ox} = 100\mu A/V^2$, $\lambda_p = 0.1 V^{-1}$

- (a) Find the R_{REF} that sets $I_{REF} = 50\mu A$. Give an equation and a numerical value.
- (b) If $I_o = I_{REF} = 50\mu A$, what is the minimum voltage that the drain of M_2 can take while keeping both M_1 and M_2 in saturation.
- (c) Choose n so that the M_1 - M_2 cascode allows the maximum swing for an amplifier using this current source. Give an expression and numerical value for n .
- (d) Assuming $I_{REF} = 50\mu A$, provide an expression and numerical value for the output resistance R_o .
- (e) Suppose $n=1$. What then would be the expression for output resistance R_o ? (No need to calculate it; just give the expression.)

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Problem 2. (continued)

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Problem 2. (continued)

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Problem 3. (continued)

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Problem 3. (continued)

More work space next page.

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Extra Page.