University of California, Berkeley
College of Engineering
Dept. of Electrical Engineering and Computer Sciences

EE 105 Midterm II

Spring 2005 Prof. Roger T. Howe April 13, 2005

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Your Name (Last, First)

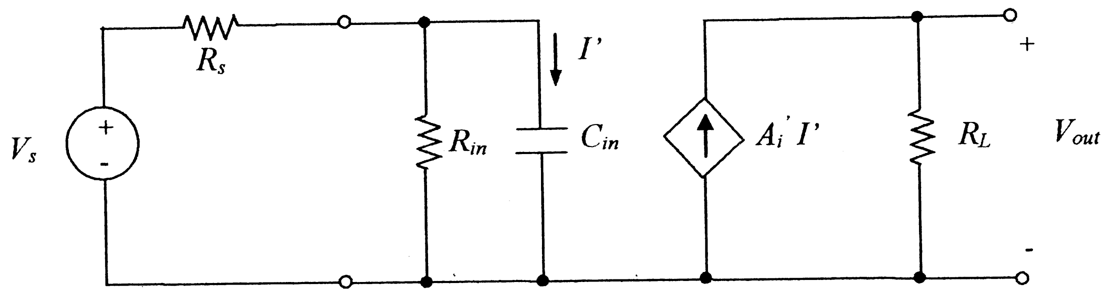
Guidelines

Closed book and notes; one 8.5” x 11” page (both sides) of *your own notes* is allowed.
You may use a calculator.
Do not unstaple the exam.
Show all your work and reasoning on the exam in order to receive full or partial credit.

Score

Problem	Points Possible	Score
1	15	
2	18	
3	17	
Total	50	

1. Phasor Analysis

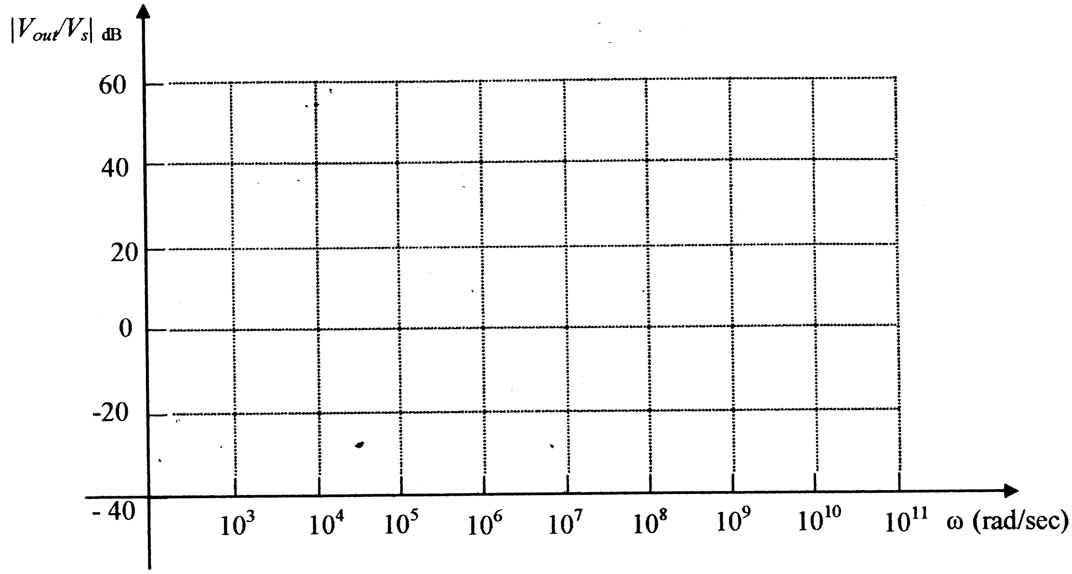


This circuit is a model of a small-signal amplifier. The element values are:

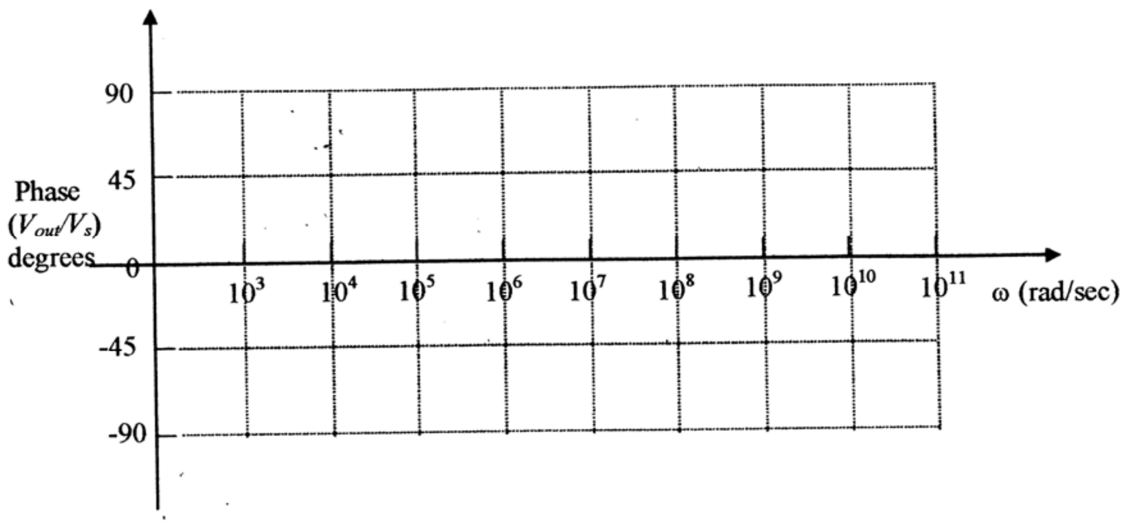
Source resistance $R_s = 20$ kΩ
Input resistance $R_{in} = 5$ kΩ
Input capacitance $C_{in} = 25$ pF
Current gain $A'_i = 100$
Load resistance $R_L = 25$ kΩ

(a) [4 pts.] Find the phasor current I' in terms of the phasor source voltage V_s and R_s, R_{in}, and C_{in}. There is no need to substitute numerical values for the elements.

(b) [4 pts.] Sketch the magnitude of V_{out}/V_s using straight-line approximations.

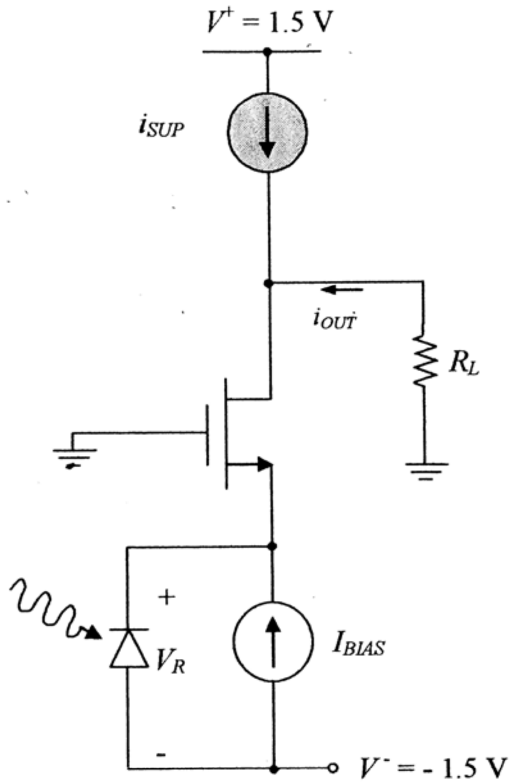


(c) [4 pts.] Sketch the phase of V_{out}/V_s using straight-line approximations.



(d) [3 pts.] If the phasor source voltage $V_s = (2.5mV)e^{j0°}$ at a frequency of 10^4 rad/sec, what is $v_{out}(t)$ based on the information in your Bode plots?

2. MOSFET single stage amplifier [18 pts.]



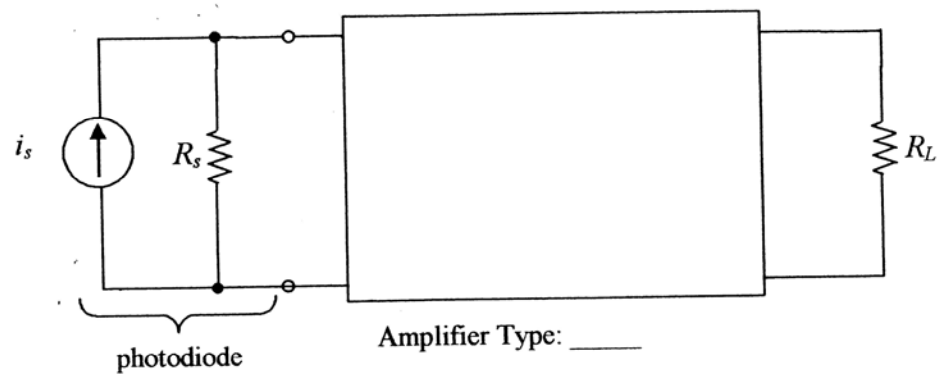
Given:
$W = 50\ \mu m$, $L = 0.5\ \mu m$
$\mu_n C_{ox} = 50\ \mu A/V^2$
$V_{Tn} = 0.5$ V
$\lambda_n = 0.025\ V^{-1}$
neglect g_{mb}

$R_L = 20\ k\Omega$
$I_{SUP} = 200\ \mu A$
$r_{oc} = 80\ k\Omega$

(a) [2 pts.] Find the numerical value of the bias current I_{BIAS} such that the DC output current $I_{OUT} = 0$ A. The effect of channel-length modulation can be neglected for this part.

(b) [3 pts.] Find the DC reverse bias voltage across the photodiode, V_R, in Volts.

(c) [3 pts.] The photodiode's small-signal model is a current source $i_s(t)$ in parallel with a source resistance of R_s = 20 kΩ. (i) label the two-port model as CS, CG, or CD and (ii) fill in the block with the circuit elements for the correct amplifier type (transconductance, current, or voltage). There is no need to evaluate the two-port model parameters for this part.

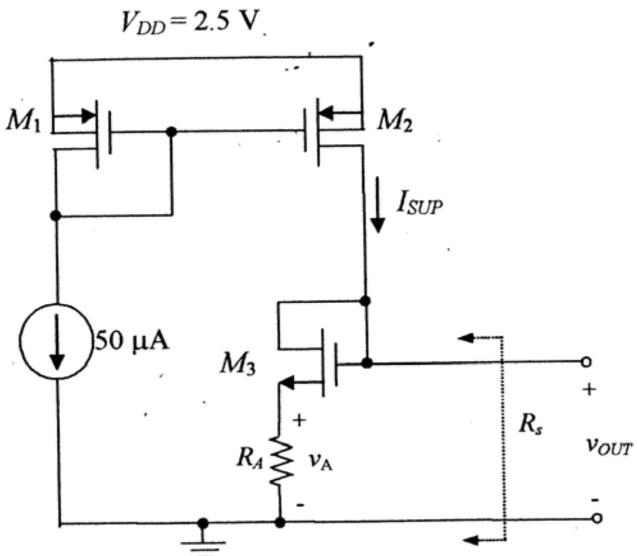


(d) [3 pts.] What is the numerical value of the input resistance R_{in} of this amplifier?

(e) [3 pts.] What is the numerical value of the output resistance R_{out} of this amplifier?

(f) [4 pts.] If the photodiode's source current is $i_s = 15$ μA, find the numerical value of the output current i_{out} in μA.

3. Voltage supply [17 points]



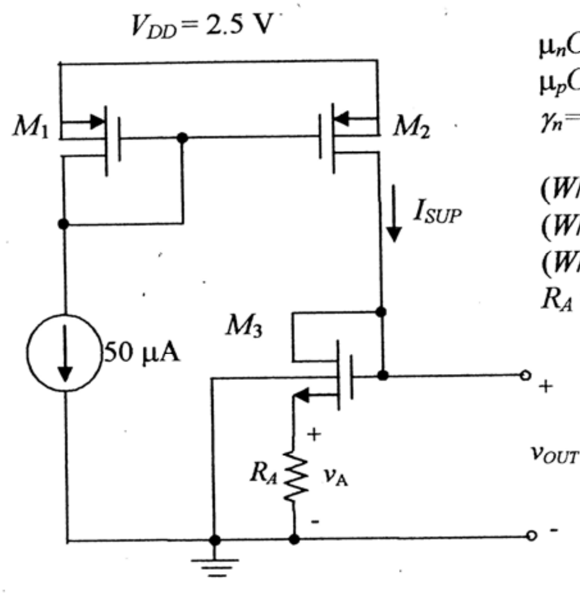
(a) [3 pts.] Find the numerical value of v_A in Volts. Neglect the backgate effect and channel-length modulation.

(b) [4 pts.] Find the width of transistor M_3 (in µm) such that the output voltage v_{OUT} = 1.5 V. You can neglect channel-length modulation and the backgate effect. If you couldn't solve part (a), you can assume that v_A = .75 V for this part.

(c) [4 pts.] Draw the small-signal circuit for finding the Thévenin resistance R_s looking into the output voltage terminals (see schematic on previous page). You can ignore the backgate transconductance for this part. *There is no need to solve for* R_s.

(d) [3 pts.] Find the numerical value of the Thévenin resistance R_s looking into the output voltage terminals. If you couldn't solve part (b), you can assume that the W_3 = 20 μm for this part. You can also ignore the backgate transconductance for this part; you should also make judicious approximations.

(e) [3 pts.] The bulk terminal of M_3 is connected to ground. Using your results from part (b) for the width of M_3, what is the numerical value of the output voltage v_{OUT} in Volts? Ignore channel-length modulation. If you couldn't solve part (b), you can assume that the W_3 = 20 μm for this part.



$\mu_n C_{ox} = 50\ \mu A/V^2$, $V_{TOn} = 0.5$ V, $\lambda_n = 0.1 / L\ V^{-1}$
$\mu_p C_{ox} = 25\ \mu A/V^2$, $V_{TOp} = -0.5$ V, $\lambda_p = 0.1 / L\ V^{-1}$
$\gamma_n = 0.5\ V^{-1/2}$, $-2\phi_p = 0.9$ V

$(W/L)_1 = 4$ μm / 1 μm
$(W/L)_2 = 8$ μm / 1 μm
$(W/L)_3 = ?$ μm / 1 μm
$R_A = 5$ kΩ