Mid-Term Exam, ECE-137B
Wednesday, May 6, 2009

Closed-Book Exam

There are 2 problems on this exam , and you have 50 minutes.
1) show all work. Full credit will not be given for correct answers if supporting work is not shown.
2) please write answers in provided blanks
3) Don't Panic !
4) 137a, 137b crib sheets, and 2 pages personal sheets permitted.

Do not turn over the cover page until requested to do so.

Name:

____

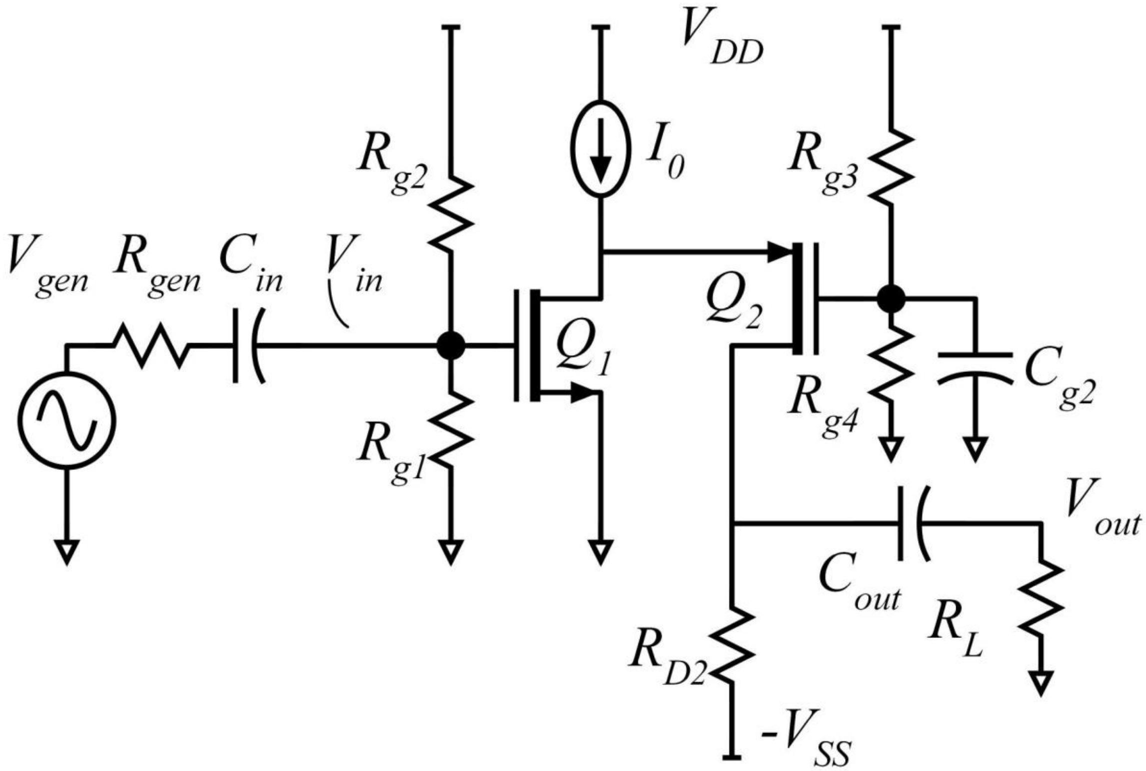
Use any and all reasonable approximations. 5% accuracy is fine if the method is correct.

Time function	LaPlace Transform
$\delta(t)$	1
U(t)	1/s
$e^{-\alpha t}U(t)$	$\frac{1}{s+\alpha}$
$e^{-\alpha t}\cos(\omega_d t)U(t)$	$\frac{s+\alpha}{(s+\alpha)^2+\omega_d^2}$
$e^{-\alpha t}\sin(\omega_d t)U(t)$	$\frac{\omega_d}{(s+\alpha)^2+\omega_d^2}$

Problem	Points Received	Points Possible
1a		10
1b		10
1c		10
1d		20
1e		10
2a		10
2b		10
2c		10
2d		10
total		100

b

Problem 1, 60 points



Q1 and Q2 are mobility-limited FETs with 180nm gate length
Thresholds: +0.3V for the NFETs, -0.3V for the PFETs. $\lambda = 0$ Volts^{-1}
For the NFETs: $I_D = 3.7(\text{mA/V}^2) \cdot (W_g / 1\mu\text{m})(V_{gs} - V_{th})^2$
For the PFETs: $I_D = 3.7(\text{mA/V}^2) \cdot (W_g / 2\mu\text{m})(V_{gs} - V_{th})^2$
The power supplies are +2V and -2V. The drain currents of Q1 and Q2 are both 2mA. Vgs of Q1 is 0.4 V. Vgs of Q2 is -0.4V. The drain of Q1 is at +1.0V. The drain of Q2 is at 0V.

The blocking and bypass capacitors (Cin, Cout, Cg) are all extremely large.
R_{gen}=1kOhm. R_L=300 Ohms. R_{g1}= R_{g4}=1 MOhm.

b

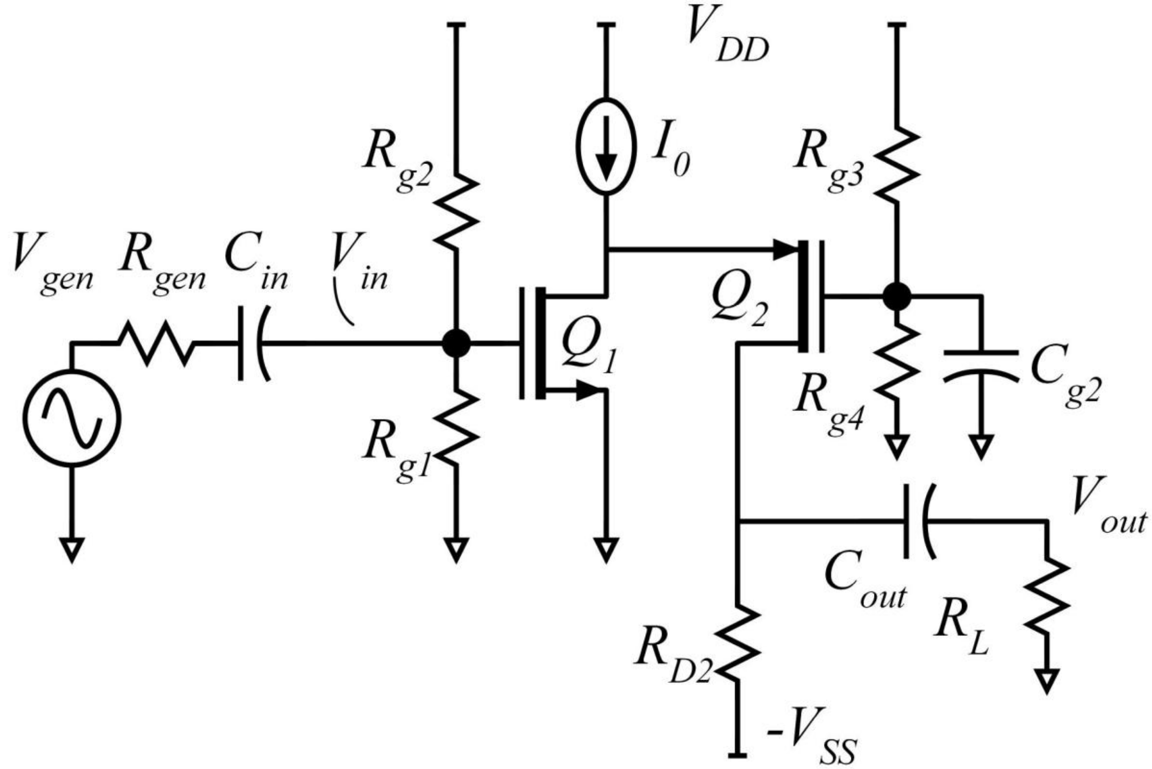
Part a, 10 points

Find the following:

R_{g2}=____________________ R_{g3}=________________

R_{D2}=______________________________ I_0=______________________

Draw all DC node voltages on the circuit diagram below.



b

Part b, 10 points

Mid Band Analysis:
Find the following:
transconductance of Q1=______________ transconductance of Q2=_____________
Voltage gain of Q2=V_{d2}/V_{s2}=__________ input impedance of Q2=______________
Voltage gain of Q1=V_{d1}/V_{g1}=__________ amplifier input impedance=______________
Vout/Vin=__________________ Vout/Vgen=_____________________

b

Part c: 10 points

The FETs have an oxide thickness of 1nm, have SiO2 ($\varepsilon_r = 3.8$) as the gate dielectric. Recalling that $\varepsilon_0 = 8.854 \cdot 10^{-12} F/m$, and assuming that $C_{gs} = c_{ox} L_g W_g$, find Cgs of Q1 and Q2. Using the over-simplified relationship $C_{gd} = (1 fF/\mu m) \cdot W_g$, find Cds of Q1 and Q2.

Cgs1=______________________ Cgs2=______________

Cgd1=______________________ Cgd2=______________

b

Part d: 20 points

USING either MOTC or the results of single-stage nodal analysis, find all ***three*** pole frequencies, and the zero frequency, of the transfer function V_{out}/V_{gen}. Give the frequencies of these in Hz. Feel free to use the separated-pole approximation *if* it is justified.

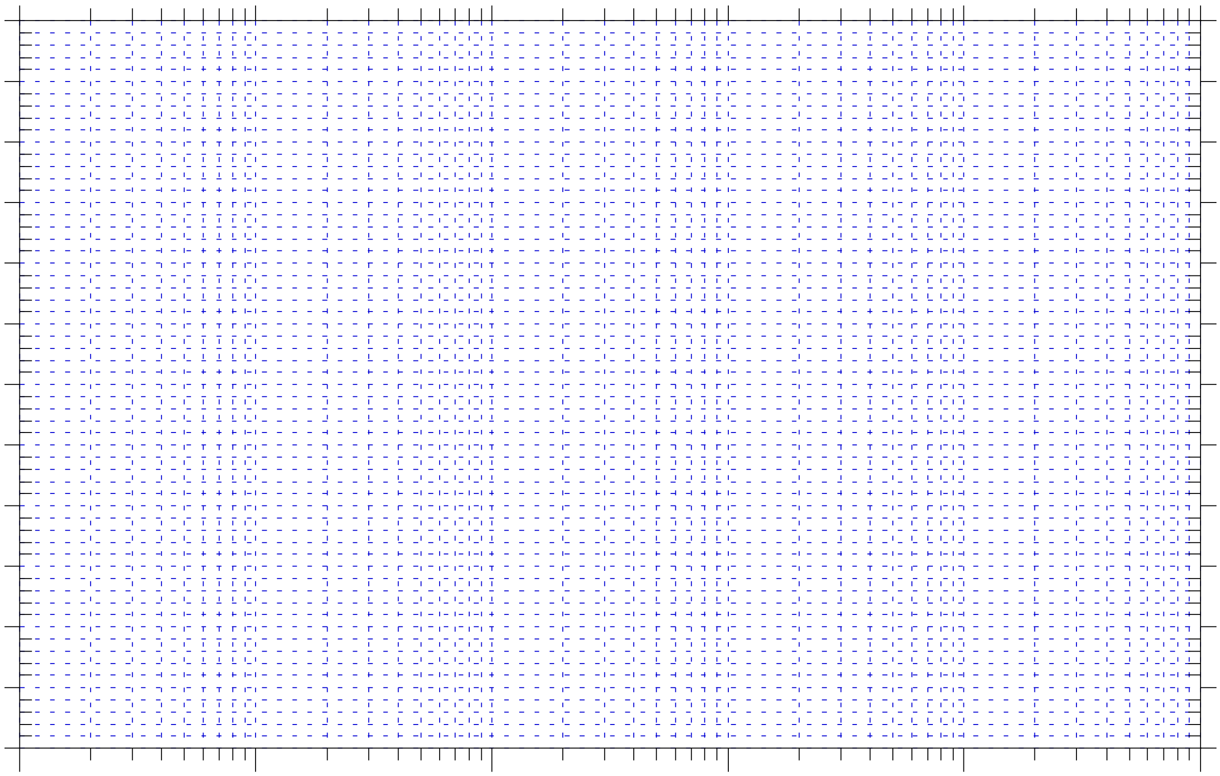
f_{p1} =______________ , f_{p2} =__________________, f_{p3} =__________________

f_{z1} =______________

b

Part e: 10 points

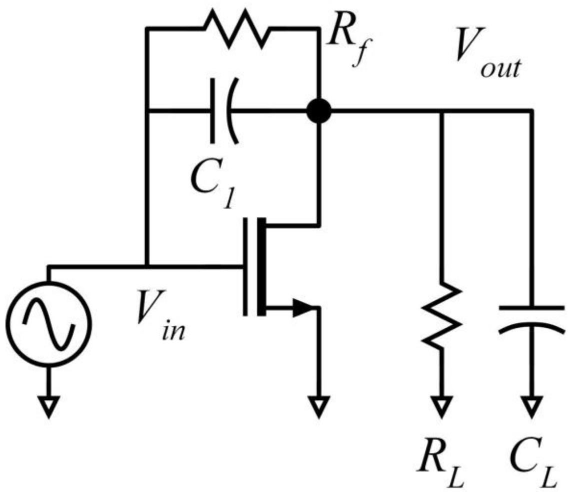
Draw a clean asymptotic Bode Magnitude plot of Vout/Vgen as a function of frequency in Hz. Be sure to label and dimension the axes clearly, label pole and zero frequencies and gain slopes. Be sure to use the semi-log paper correctly



Frequency, Hz

Problem 2, 40 points

Part a 10 points

	Small signal analysis. Ignore the DC bias; you don't need it. ***The FET has lambda=0 hence Gds=0. Also, Cgs =Cgd=0 fF*** Replacing the transistor with its high frequency small-signal model, draw a small-signal equivalent circuit diagram.

b

Part b, 10 points

USING NODAL ANALYSIS, compute Vout(s)/Vgen(s) in ratio-of-polynomials form:

$$\frac{V_{out}(s)}{V_{gen}(s)} = \left.\frac{V_{out}}{V_{gen}}\right|_{mid-band} \times (s\tau)^m \times \frac{1+b_1 s + b_2 s^2 + \ldots}{1+a_1 s + a_2 s^2 + \ldots} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

here m, an integer, can be positive or negative or zero

Part c, 10 points

gm= 10 mS. R_L =1000 Ohm, R_f =2000 Ohm, C1=1pF, CL=2pF.

Find the frequencies of any zeros (there may be zero, one or two present) in the transfer function:
f_{z1} =______________, f_{z2} =________________, ...

There may be either 1 or 2 poles of the transfer function.

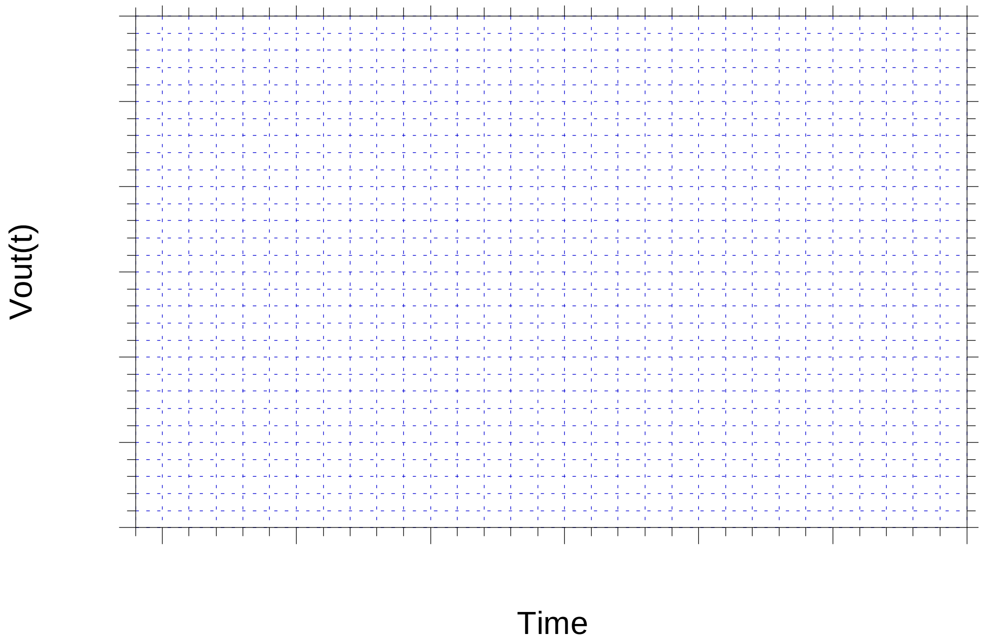
If the poles are real, give the 1 or 2 pole frequencies in Hz:
f_{p1} =______________ , f_{p2} =_________________

If there are 2 poles, and they are complex, give $f_n = \omega_n / 2\pi$ and the damping factor ζ :
$f_n = \omega_n / 2\pi$ =________________, ζ =____________________

b

Part d, 10 points

If Vin(t) is a 100mV step-function, find and plot Vout(t). Be sure to label and dimension the axes clearly, and to clearly label key features of the time waveform.



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