Mid-Term Exam, ECE-137B
Tuesday, April 28, 2015

Closed-Book Exam

There are 2 problems on this exam , and you have 75minutes.
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.
Use any, all reasonable approximations. 5% accuracy is fine if the method is correct.

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

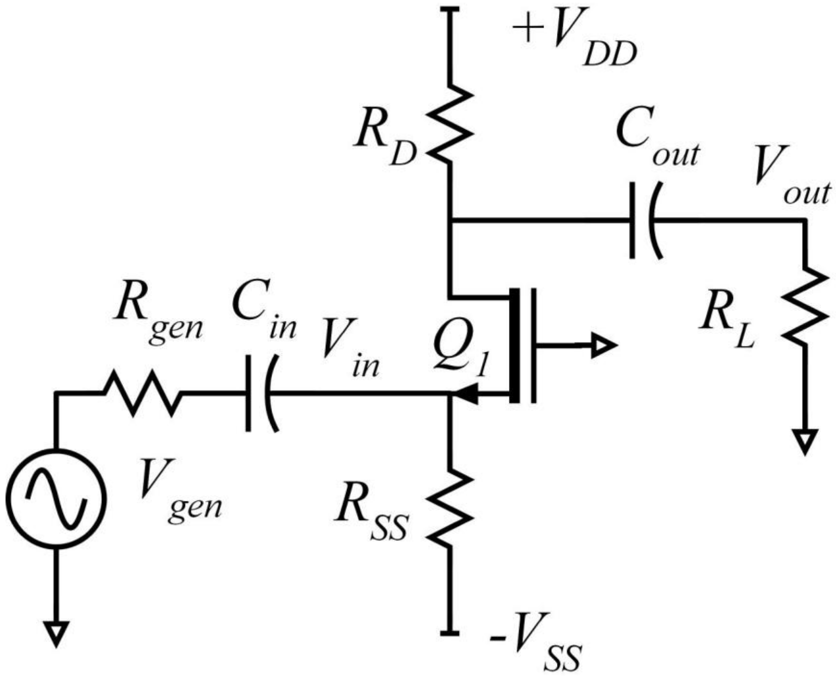
Name: ___________________________________

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		6
1b		8
1c		8
1d		14
1e		14
1f		10
2a		10
2b		10
2c		10
2d		10
total		100

b

Problem 1, 60 points



Q1 has 1.0 nm oxide thickness, ε_r =3.8, 22 nm gate length, and a 0.2 V threshold. Mobility is 400 cm^2/(V-s), saturation drift velocity is 1E7 cm/s, $\lambda = 0$ Volts^{-1},
C_{gs} = $\varepsilon_r \varepsilon_{ox} L_g W_g / T_{ox} + (0.5\text{fF}/\mu\text{m}) \cdot W_g$ and $C_{gd} = (0.5\text{fF}/\mu\text{m}) \cdot W_g$.

<u>Hints</u>:

$\varepsilon_r \varepsilon_{ox} / T_{ox} = 3.36 \cdot 10^{-2}\ \text{F/m}^2$, $(\mu c_{ox} W_g / 2L_g) = (3.06 \cdot 10^{-2}\ \text{A/V}^2) \cdot (W_g / 1\mu\text{m})$

$(c_{ox} v_{sat} W_g) = (3.36 \cdot 10^{-3}\ \text{A/V}^1) \cdot (W_g / 1\mu\text{m})$, $(v_{sat} L_g / \mu)$ =55mV.

The power supplies are +2V and -2V. The drain currents of Q1 is 1mA.
V_{gs} of Q1 is 0.24 V. The drain of Q1 is at +1.0V.
R_{gen}=50Ohm. $R_L = 3 \cdot R_D$
$C_{in} = 1\,\text{nF}$, $C_{out} = 2\,\text{nF}$

b

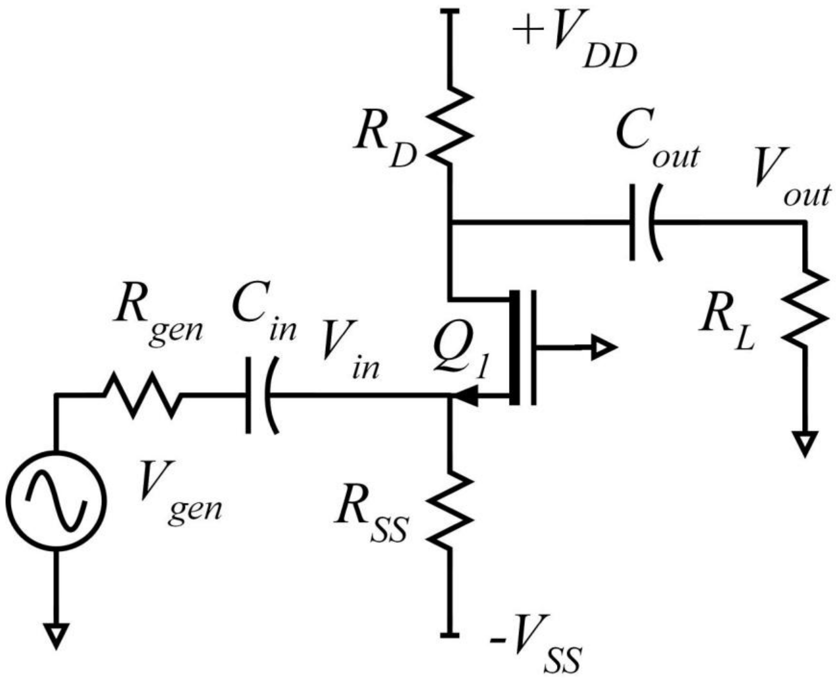
Part a, 6 points

Find the following:

R_{ss} =____________________ R_D =_________________

W_g =______________________ R_L =______________________

Draw all DC node voltages on the circuit diagram below.



b

Part b, 8 points

small-signal parameters

Find the following

$C_{gs}=$________________ $C_{gd}=$______________

$g_m=$_________________ $f_\tau=$_________________

b

Part c: 8 points

Mid Band Analysis:

Find the following:

$R_{in,Amplifier} =$ ____________________ $R_{L,eq} =$ __________________________

$V_{out}/V_{in} =$ _____________________ $V_{in}/V_{gen} =$ _________________________

b

Part d: 14 points

High-Frequency Analysis:

Find the frequencies, in Hz, of the two poles limiting the high-frequency response of the amplifier. Show your analysis (do not simply state that the input pole of a common-gate amplifier is approximately at f_τ)

$f_{p1,HF}$ =______________________ $f_{p2,HF}$ =_________________________.

b

Part e: 14 points

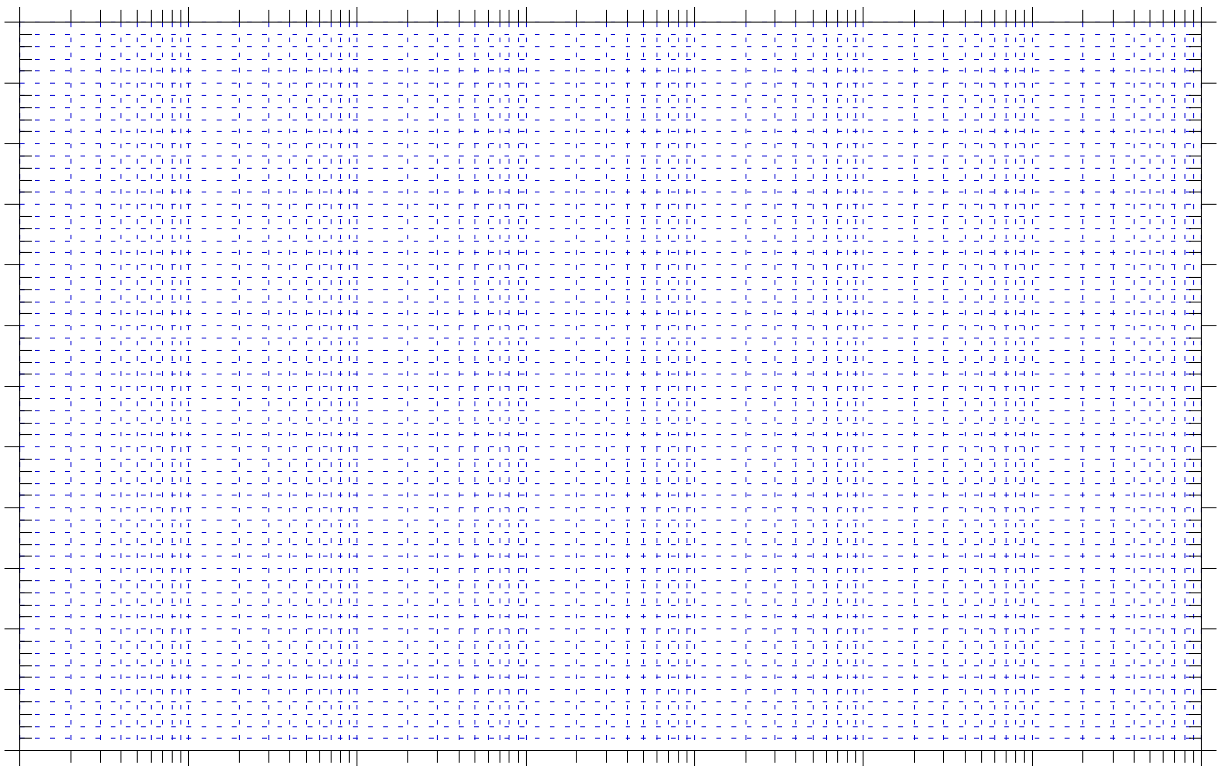
Low-Frequency Analysis:

Find the frequencies, in Hz, of the two poles limiting the low-frequency response of the amplifier. Show your analysis.

$f_{p1,LF}$ =____________________ $f_{p2,LF}$ =_______________________.

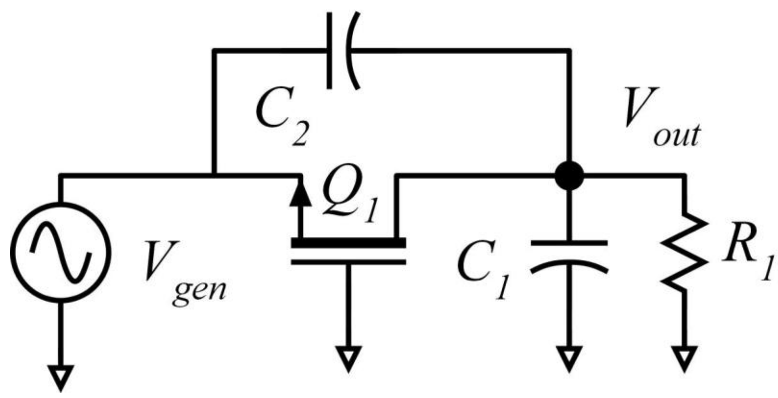
Part f: 10 points

Draw a clean asymptotic Bode Magnitude plot of V_{out}/V_{gen} 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



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.

Part b, 10 points

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

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

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

Part c, 10 points

g_m =10 mS. R_1 =1 kOhm, $C_1 = 1$pF, C_2 =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 =_____________________

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.