Mid-Term Exam, ECE-137B

Tuesday, April 28, 2015

Closed-Book Exam

There are 2 problems on this exam, and you have 75 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.

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

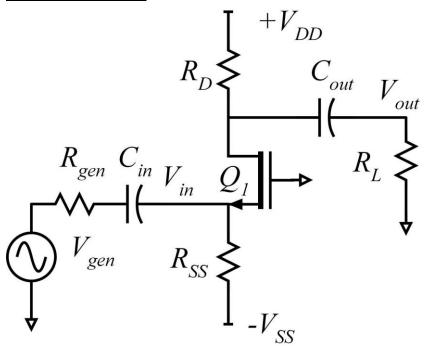
Do not turn over the cover page until requested to do so.

Name: _____

| Time function | LaPlace Transform |
|--------------------------------------|---|
| $\delta(t)$ | 1 |
| U(t) | 1/s |
| $e^{-\alpha t}U(t)$ | |
| | $s + \alpha$ |
| $e^{-\alpha t}\cos(\omega_d t)U(t)$ | $\frac{\mathbf{s} + \alpha}{\left(\mathbf{s} + \alpha\right)^2 + \omega_d^2}$ |
| $e^{-\alpha t}\sin(\omega_{d}t)U(t)$ | $\frac{\omega_{\rm d}}{\left({\rm s}+\alpha\right)^2+\omega_{\rm d}^2}$ |

| 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 |

Problem 1, 60 points



Q1 has 1.0 nm oxide thickness, $\varepsilon_r = 3.8$, 22 nm gate length, and a 0.2 V threshold. Mobility is 400 cm²/(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>: $\varepsilon_r \varepsilon_{ox} / T_{ox} = 3.36 \cdot 10^{-2} \text{ F/m}^2$, $(\mu c_{ox} W_g / 2L_g) = (3.06 \cdot 10^{-2} \text{ A/V}^2) \cdot (W_g / 1 \mu \text{m})$

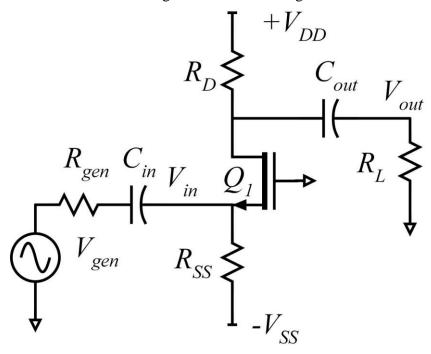
 $(c_{ox}v_{sat}W_g) = (3.36 \cdot 10^{-3} \text{ A/V}^1) \cdot (W_g / 1\mu \text{m}), (v_{sat}L_g / \mu) = 55 \text{mV}.$

The power supplies are +2V and -2V. The drain currents of Q1 is 2 mA. V_{gs} of Q1 is 0.30 V. The drain of Q1 is at +1.0V. R_{gen} =50Ohm. R_L =3· R_D

 $C_{in} = 1 \,\mathrm{nF}, \ C_{out} = 2 \,\mathrm{nF}$

Part a, 6 pointsFind the following: $R_{ss} = _$ $R_g = _$ $R_g = _$ $R_L = _$

Draw all DC node voltages on the circuit diagram below.



3

Part b, 8 points small-signal parameters Find the following

| <i>C</i> _{gs} = | <i>C_{gd}</i> = |
|--------------------------------|-------------------------|
| <i>g</i> _{<i>m</i>} = | f_{τ} = |

 Part c: 8 points

 Mid Band Analysis:

 Find the following:

 $R_{in,Amplifier} =$
 $V_{out}/V_{in} =$
 $V_{in}/V_{gen} =$

a

6

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})

 $f_{p1,HF} = _____ f_{p2,HF} = _____.$

а

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.

 $f_{p1,LF} = _____ f_{p2,LF} = _____.$

а

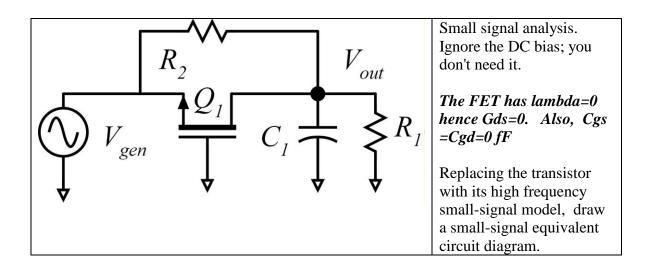
Part f: 10 points

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

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Problem 2, 40 points

Part a 10 points



Part b, 10 points

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

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

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

<u>Part c, 10 points</u> $g_m = 10$ mS. $R_1 = 1$ kOhm, $R_2 = 3$ kOhm, $C_1 = 1$ pF

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 :

 $f_n = \omega_n / 2\pi = \underline{\qquad}, \zeta = \underline{\qquad}$

а

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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