

ECE137B Final Exam

6/11/2015, 8-11AM.

There are 4 problems on this exam and you have 3 hours
 There are pages 1-21 in the exam: please make sure all are there.

Do not open this exam until told to do so.

Show all work.

Credit will not be given for correct answers if supporting work is not shown.

Class Crib sheets and 3 pages (front and back → 6 surfaces) of your own notes permitted.

Don't panic.

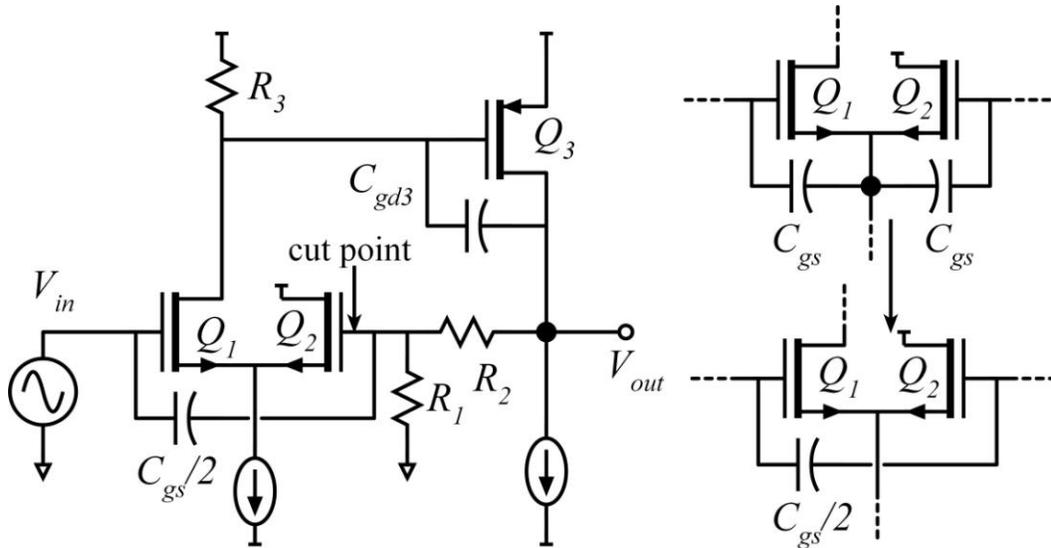
Time function	LaPlace Transform
$\delta(t)$	1
$U(t)$	$1/s$
$e^{-\alpha t} \cdot U(t)$	$\frac{1}{s + \alpha}$ or $\frac{1/\alpha}{1 + s/\alpha}$
$e^{-\alpha t} \cos(\omega_d t) \cdot U(t)$	$\frac{s + \alpha}{(s + \alpha)^2 + \omega_d^2}$
$e^{-\alpha t} \sin(\omega_d t) \cdot U(t)$	$\frac{\omega_d}{(s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

Name: _____

Problem	points	possible	Problem	points	possible
1a		5	2c		5
1b		5	3a		10
1c		15	3b		10
1d		10	4a		10
1e		5	4b		10
2a		5			
2b		10	total		

Problem 1, 40 points

frequency response, negative feedback



In the circuit above $g_{m1} = g_{m2} = 20\text{mS}$. $g_{m3} = 100\text{mS}$, $R_1 = 1\text{k}\Omega$, $R_2 = 9\text{k}\Omega$.

$R_3 = 10\text{k}\Omega$, $R_{DS} = \text{infinity } \Omega$ for all FETs

$C_{gs1} = C_{gs2} = 127\text{fF}$, $C_{gd1} = C_{gd2} = 0\text{fF}$, $C_{gs3} = 0\text{fF}$, $C_{gd3} = 159\text{fF}$.

Note: simplify the problem by using the approximation shown above right.

Part a, 5 points

feedback relationships

In the relationship $A_{CL} = A_{\infty} \frac{T}{1+T}$, what is A_{∞} for this circuit ?

$A_{\infty} =$ _____

Part b, 5 points

feedback relationships

Find the value of the loop transmission at DC and the closed loop gain at DC.

Hint---I recommend using the indicated cut point.

$T =$ _____ $A_{CL} =$ _____

Part c. 15 points

transistor circuit frequency reponse.

Find the first two pole frequencies of the loop transmission T .

$$f_{p1} = \text{_____} \quad f_{p2} = \text{_____}$$

Part d, 10 points

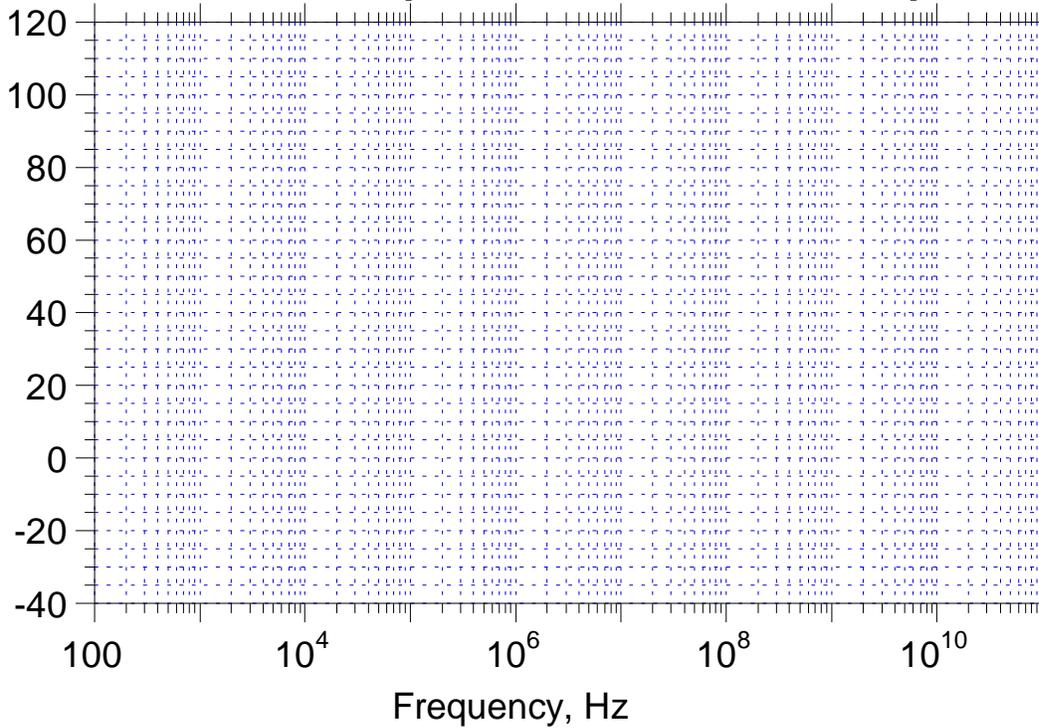
loop bandwidth and stability.

Plot the loop transmission (labels slopes, label critical frequencies)

Determine the loop bandwidth and phase margin

$f_{loop} =$ _____, phase margin = _____

Draw the loop transmission T on this plot



Part e, 5 points

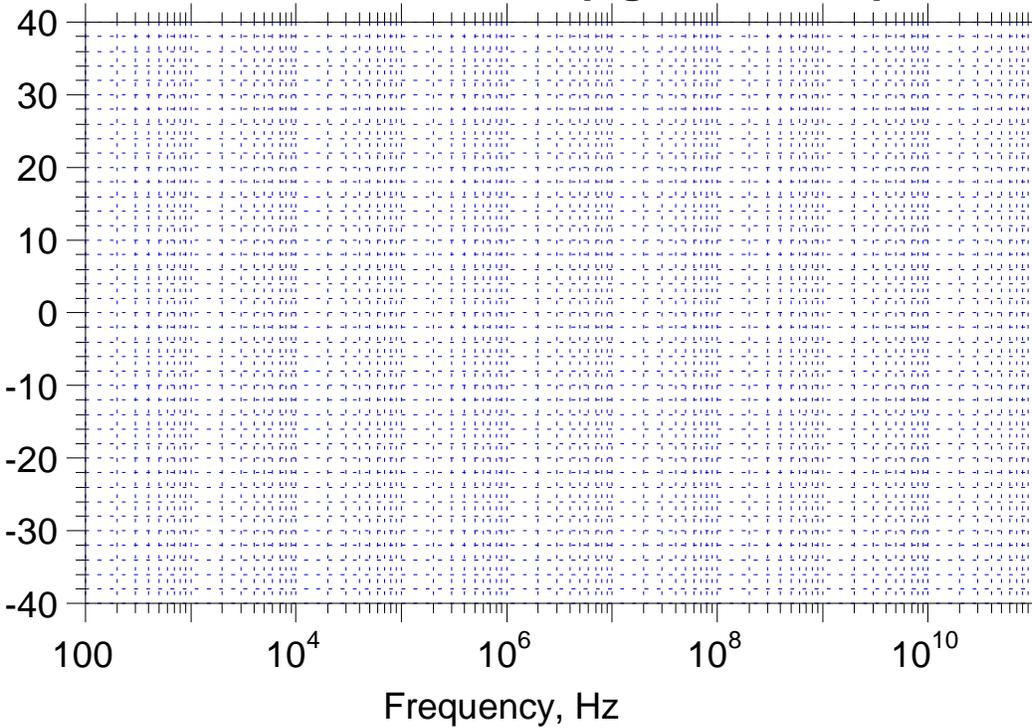
closed-loop bandwidth

Plot the closed-loop gain vs. frequency, estimating the gain peaking at f_{loop}

Estimate the amplifier's closed loop bandwidth

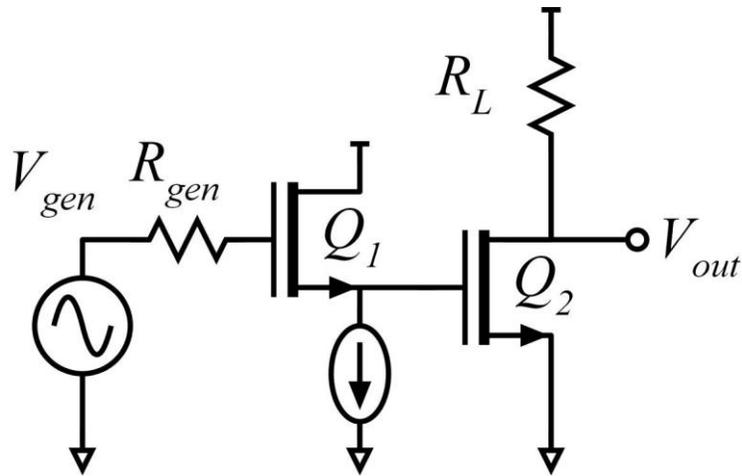
closed-loop bandwidth = _____

Draw the closed loop gain on this plot



Problem 2, 20 points

Circuit frequency response by MOTC.



In the circuit above $g_{m1}=10\text{mS}$, $g_{m2}=50\text{mS}$.

$R_{gen}=1000\ \Omega$, $C_{gs1}=15.9\text{fF}$, $C_{gs2}=79.5\text{fF}$ $C_{gd1}=C_{gd2}=0\text{fF}$.

$R_{DS} = \text{infinity}\ \Omega$ for both FETs

$R_L = 1\ \text{k}\Omega$.

part a, 5 points

midband analysis

find the gain V_{out}/V_{gen} at low frequencies. $V_{out}/V_{gen}=\underline{\hspace{10em}}$

part b, 10 points

frequency response analysis

Find a_1 , a_2 . If the poles are real, find f_{p1} and f_{p2} ; if they are complex, find f_n and ζ

$a_1 =$ _____ $a_2 =$ _____

real poles: $f_{p1} =$ _____ $f_{p2} =$ _____

complex poles $f_n =$ _____ $\zeta =$ _____

part c, 5 points

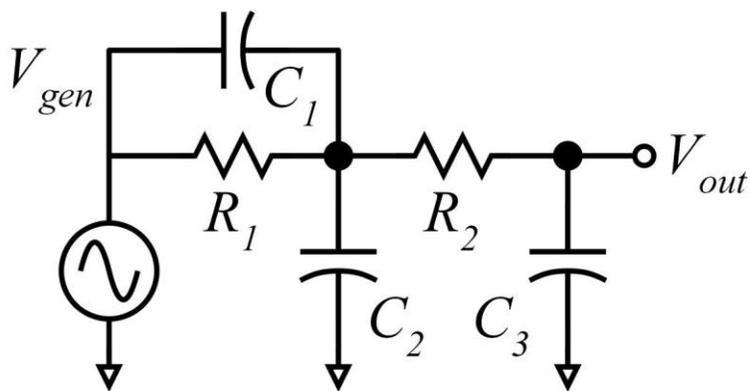
another frequency response analysis

Using any correct method, find the transfer function $V_{out}(s)/V_{gen}(s)$.

The answer must be in standard form $\frac{V_{out}(s)}{V_{gen}(s)} = \frac{V_{out}}{V_{gen}} \Big|_{DC} \frac{1 + b_1s}{1 + a_1s + a_2s^2}$

Hint: Nodal analysis will be slow and painful.

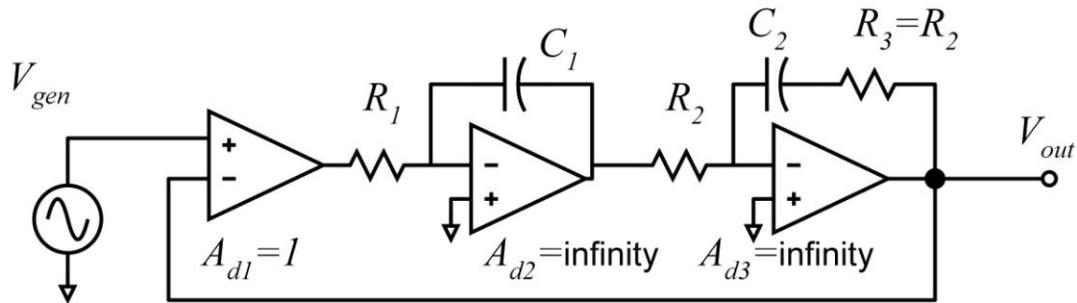
$R_1=1k\Omega$, $R_2=1k\Omega$, $C_1=1nF$, $C_2=2nF$, $C_3=3nF$



$$\frac{V_{out}}{V_{gen}} \Big|_{DC} = \underline{\hspace{2cm}}, \quad a_1 = \underline{\hspace{2cm}}, \quad a_2 = \underline{\hspace{2cm}}$$
$$b_1 = \underline{\hspace{2cm}}$$

Problem 3: 20 points

negative feedback and stability



In the circuit above, A_{d2} and A_{d3} are ideal, infinite-gain op-amps.

A_{d1} is a differential amplifier with a voltage gain of 1.

$R_1 = 1 \text{ k}\Omega$, $R_2 = 4 \text{ k}\Omega$, $C_1 = 15.9 \text{ pF}$, $C_2 = 15.9 \text{ pF}$.

Part a, 10 points

simple nodal analysis

find the loop transmission $T(s)$.

The answer must be in standard form: $T(s) = T_{DC} \frac{1 + b_1s + b_2s^2 + \dots}{1 + a_1s + a_2s^2 + \dots}$,

or if there are N poles at DC, $T(s) = \frac{1}{(s\tau)^N} \frac{1 + b_1s + b_2s^2 + \dots}{1 + a_1s + a_2s^2 + \dots}$

$T(s)$ _____

Part a, 10 points

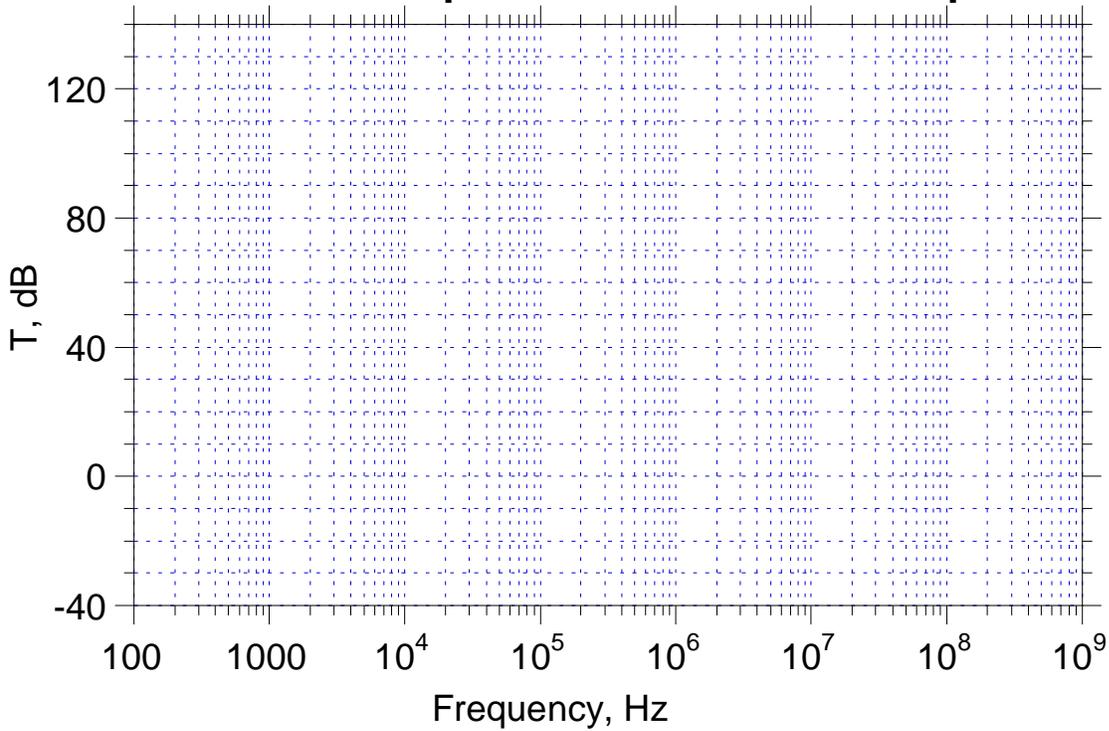
feedback stability analysis

Plot the loop transmission (labels slopes, label critical frequencies)

Determine the loop bandwidth and phase margin

$f_{loop} =$ _____, phase margin = _____

Draw the loop transmission T on this plot



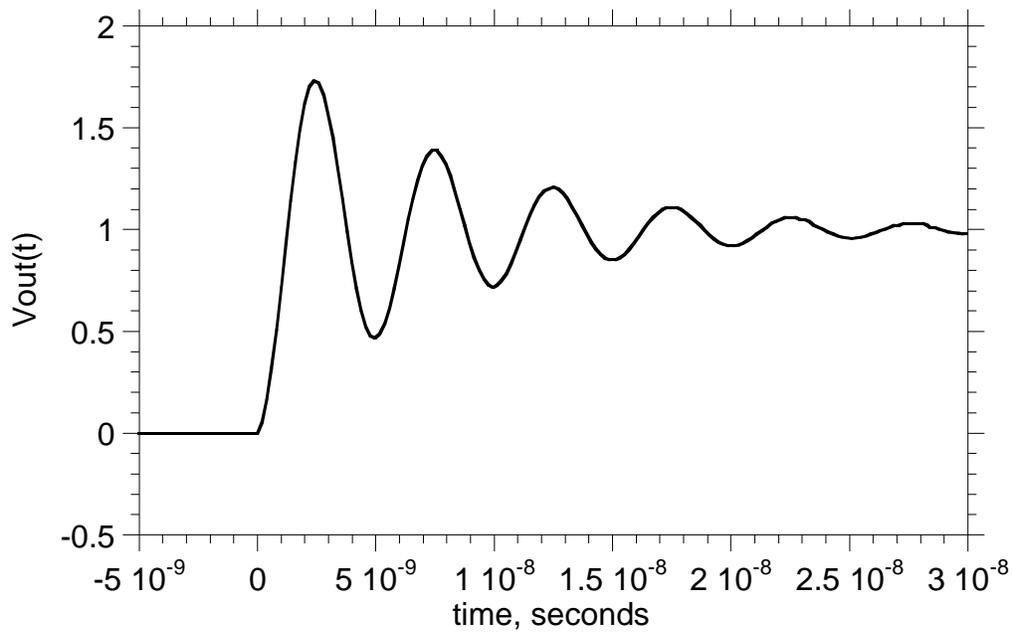
Problem 4, 20 points

frequency and transient response

part a, 10 points

transient response

A circuit has the response to a 1V step-function input:

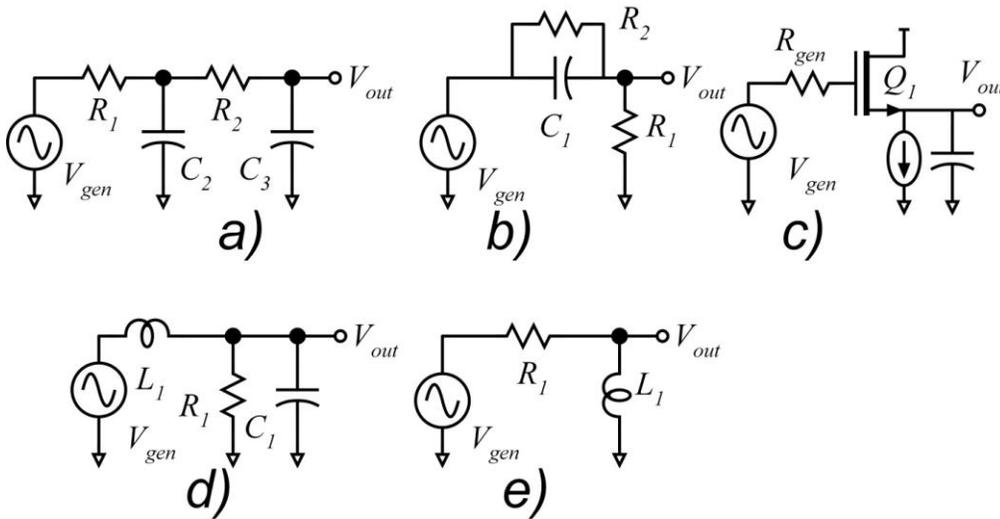
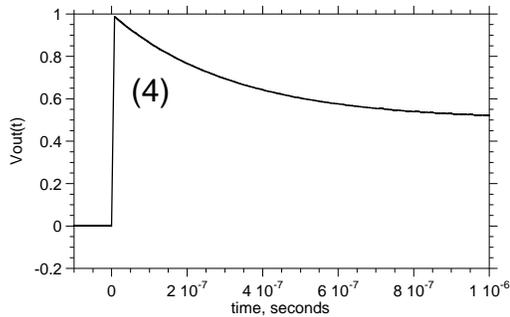
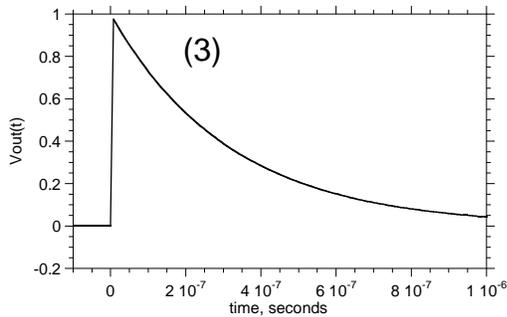
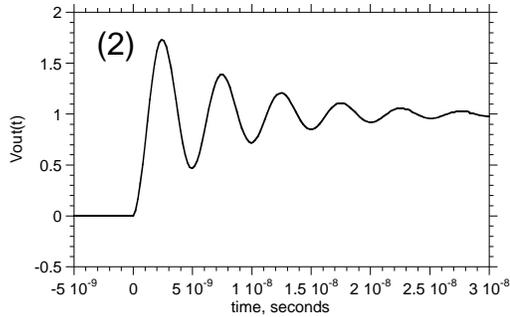
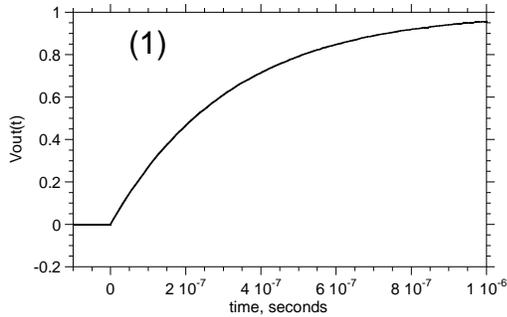


Determine the frequency and damping factor of the dominant poles of the transfer function.

Natural resonant frequency = _____ Hz

estimated damping factor = _____

part b, 10 points
transient response



You have four unknown circuits (1-4) whose response to a 1V step-function is as above. For each, you must identify, giving your reasons clearly, which possible circuits (a-e) **might** give this observed response. (Consider the possibility that some elements in the circuits a-e might have negligible values)

response #1: circuits _____

why:

response #2: circuits _____

why:

response #3: circuits _____

why:

response #4: circuits _____

why:

