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.

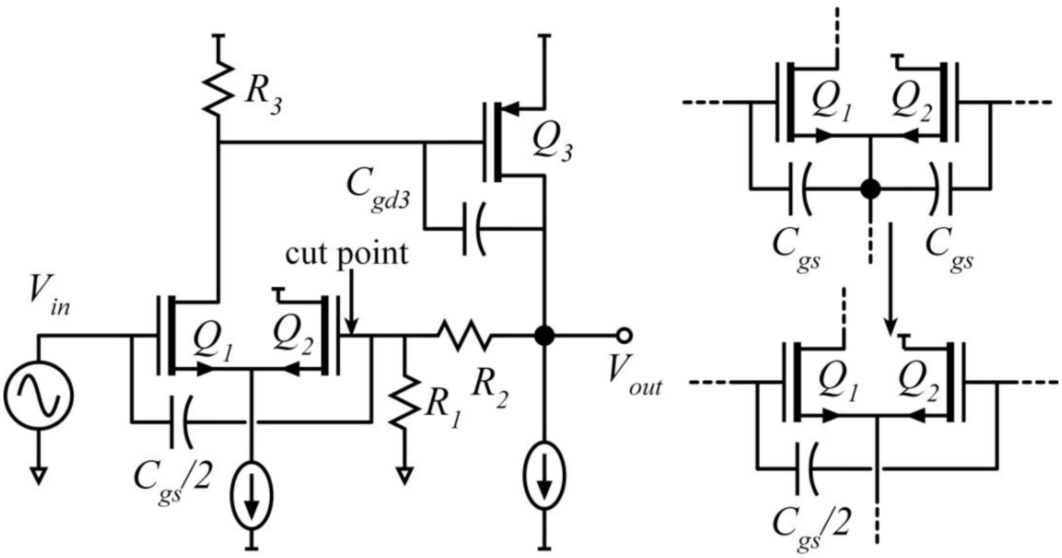
Time function	LaPlace Transform
$\delta(t)$	1
U(t)	1/s
$e^{-\alpha t}\cdot U(t)$	$\frac{1}{s+\alpha}$ or $\frac{1/\alpha}{1+s/\alpha}$
$e^{-\alpha t}\cos(\omega_d t)\cdot U(t)$	$\frac{s+\alpha}{(s+\alpha)^2+\omega_d^2}$
$e^{-\alpha t}\sin(\omega_d t)\cdot U(t)$	$\frac{\omega_d}{(s+\alpha)^2+\omega_d^2}$

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		

b

Problem 1, 40 points
frequency reponse, negative feedback



In the circuit above $g_{m1} = g_{m2}$ =20mS. $g_{m3} = 100$mS, R_1 =1kΩ , $R_2 = 9$ kΩ.
$R_3 = 10$ kΩ, R_{DS} = infinity Ω for all FETs
$C_{gs1} = C_{gs2} = 31.8$ fF, $C_{gd1} = C_{gd2} = 0$fF, $C_{gs3} = 0$ fF, C_{gd3}=31.8fF.
Note: simplify the problem by using the approximation shown above right.

<u>Part a, 5 points</u>
feedback relationships

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

A_∞ =__________________

b

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} =____________________ f_{p2} =____________________

Part d, 10 points

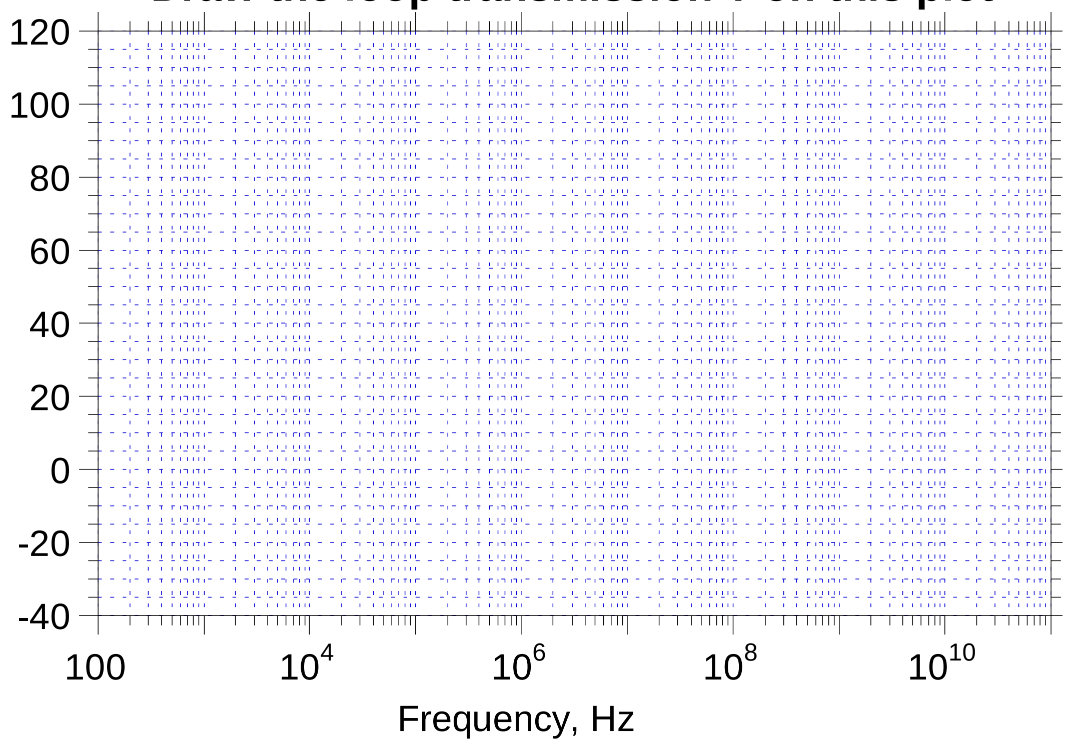
loop bandwidth and stablity.

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



b

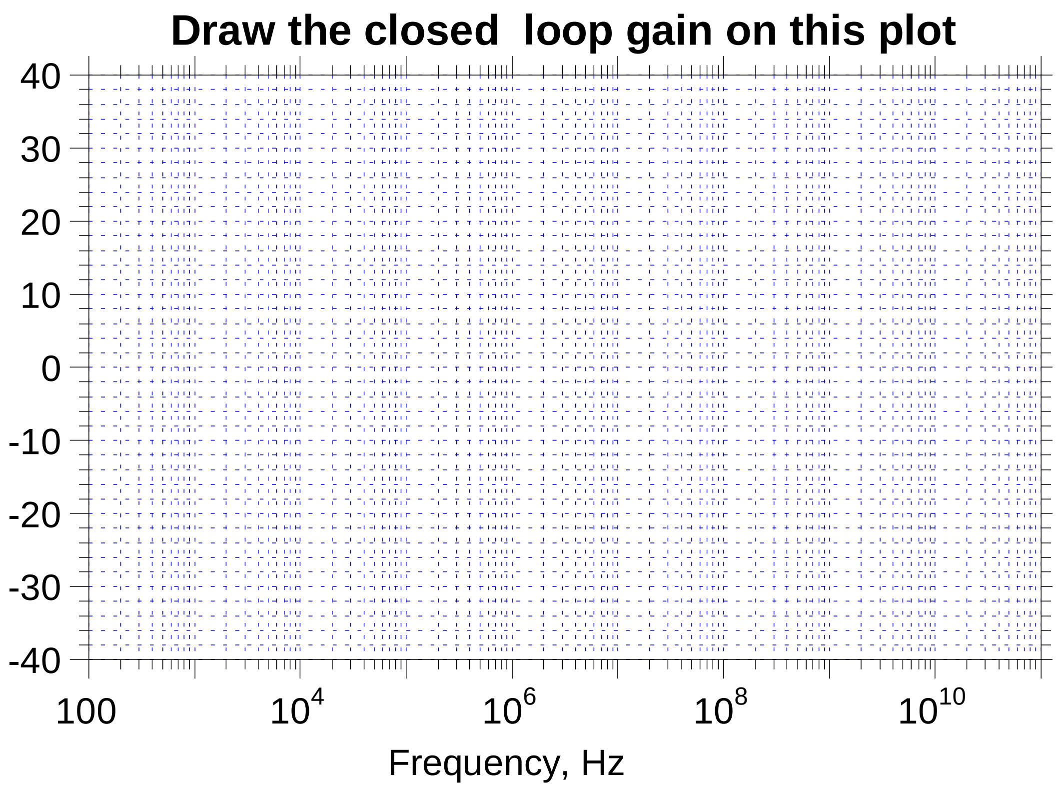
Part e, 5 points

closed-loop bandwidth

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

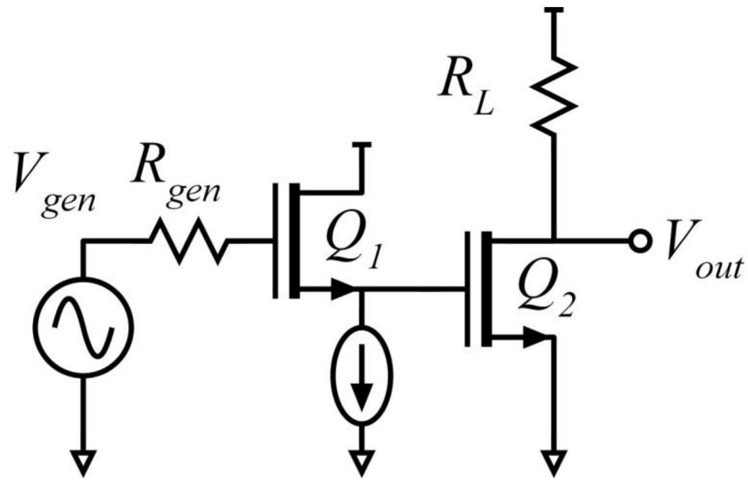
Estimate the amplifier's closed loop bandwidth

closed-loop bandwidth =______________________



b

Problem 2, 20 points
Circiut frequency response by MOTC.



In the circuit above g_{m1}=10mS, g_{m2}=50mS.
R_{gen}=1000 Ω , C_{gs1}=15.9fF, C_{gs2}=79.5fF $C_{gd1} = C_{gd2} = 0$fF.
R_{DS} = infinity Ω for both FETs
$R_L = 1$ kΩ.

<u>part a, 5 points</u>
midband analysis

find the gain Vout/Vgen at low frequencies. Vout/Vgen=_____________________

b

part b, 10 points

frequency reponse 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 =_____________________ ζ =_______________

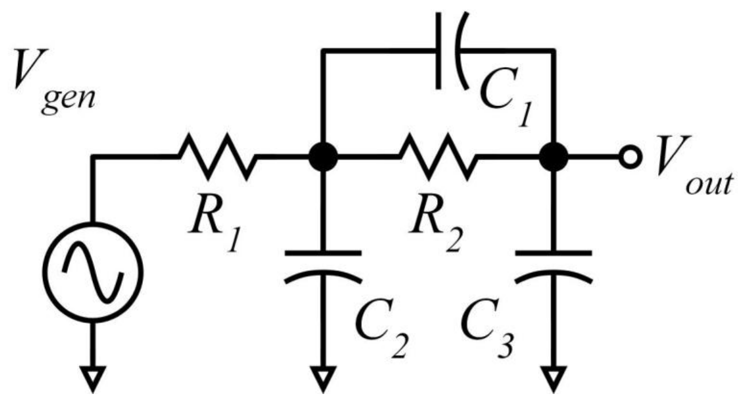
part c, 5 points
another frequency reponse analysis

Using any correct method, find the transfer function Vout(s)/Vgen(s).

The answer must be in standard form $\frac{V_{out}(s)}{V_{gen}(s)} = \left.\frac{V_{out}}{V_{gen}}\right|_{DC} \frac{1+b_1 s.}{1+a_1 s + a_2 s^2}$

R_1 =1kΩ, R_2 =1kΩ, C_1 =1nF, C_2 =2nF, C_3 =3nF

Hint: Nodal analysis will be slow and painful.

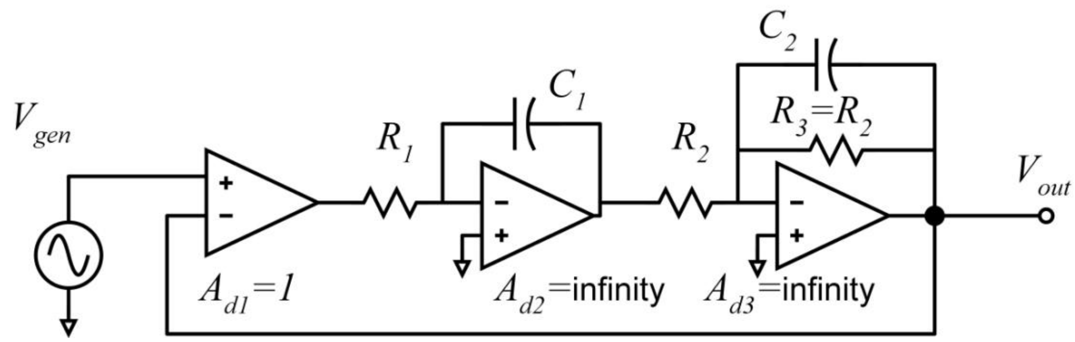


$\left.\frac{V_{out}}{V_{gen}}\right|_{DC}$ = ____________________ , a_1 = ____________________ , a_2 = ____________________

b_1 = ____________________

b

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 kΩ, R_2 =0.5kΩ , C_1 =15.9pF, C_2 =15.9pF.

Part a, 10 points
simple nodal analysis

find the loop transmission $T(s)$.

The answer must be in standard form: $T(s) = T_{DC} \frac{1 + b_1 s + b_2 s^2 + ...}{1 + a_1 s + a_2 s^2 + ...}$,

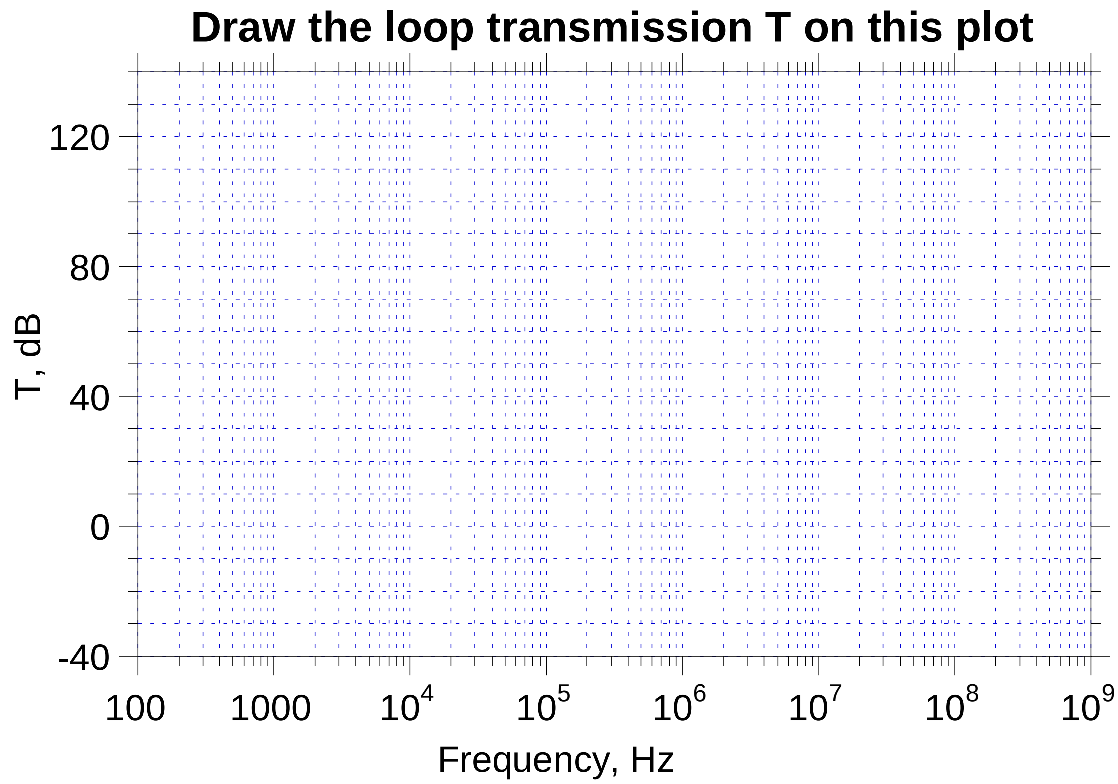
or if there are N poles at DC, $T(s) = \frac{1}{(s\tau)^N} \frac{1 + b_1 s + b_2 s^2 + ...}{1 + a_1 s + a_2 s^2 + ...}$

$T(s) =$ ____

b

Part a, 10 points
feeback stability analysis

Plot the loop transmission (labels slopes, label critical frequencies)
Determine the loop bandwidth and phase margin
f_{loop} =______________________, phase margin =______________________



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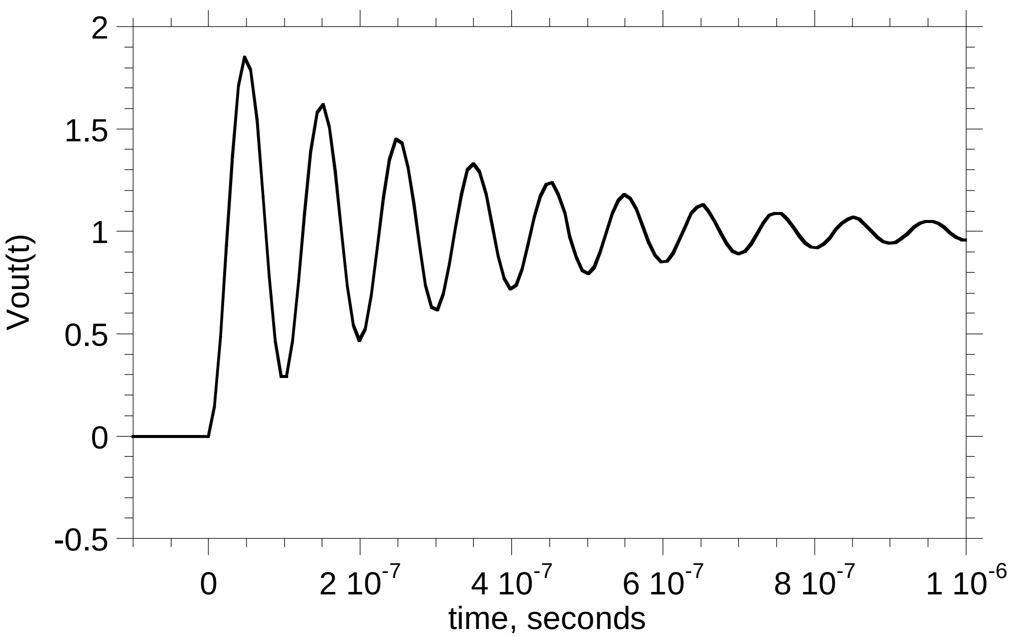
Problem 4, 20 points
frequency and transient response

part a, 10 points
transient response

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



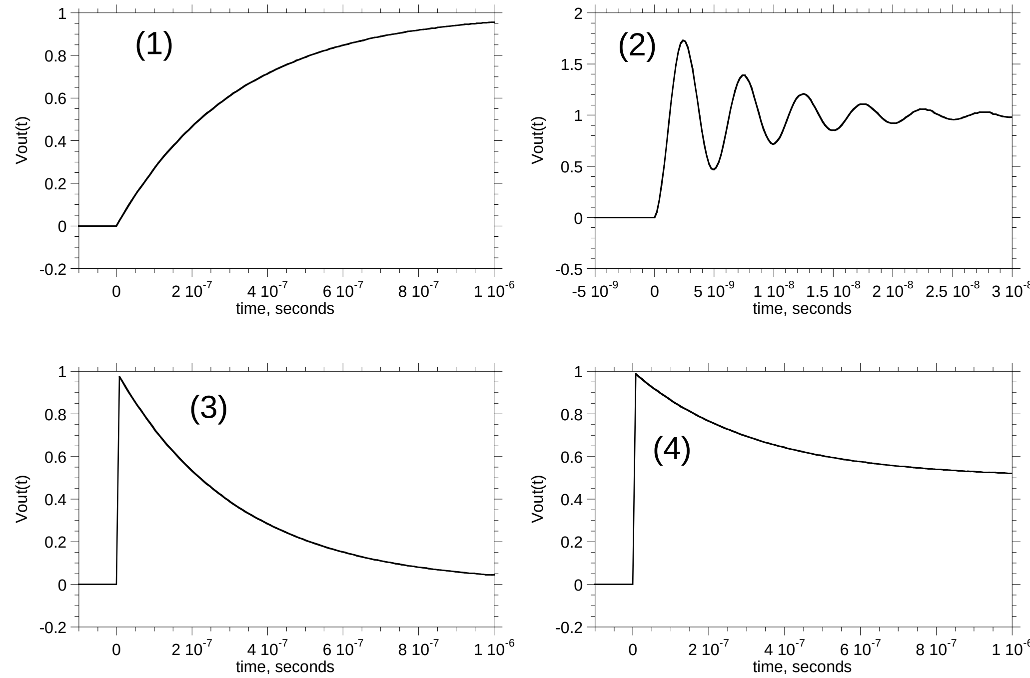
Determine the frequency and damping factor of the dominant poles of the transfer function.

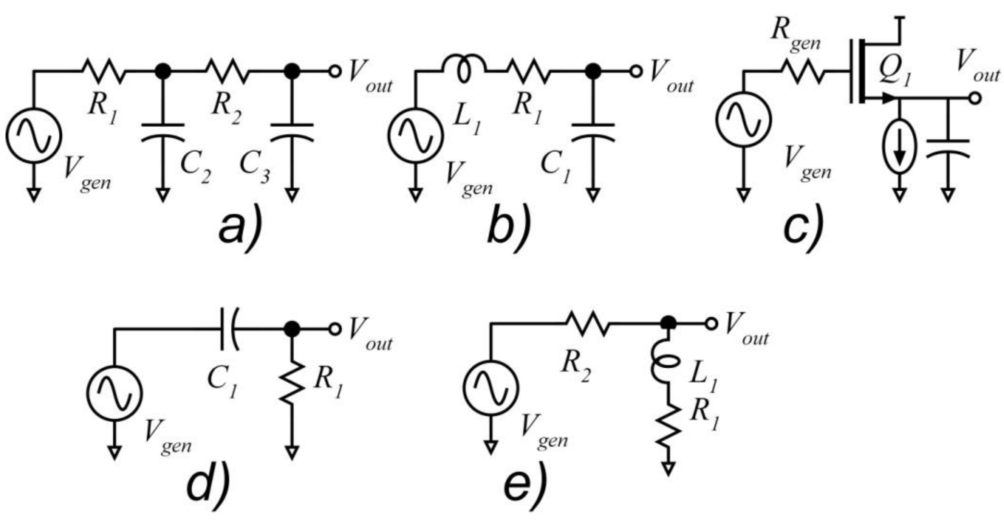
Natural resonant frequency = _______________ Hz
estimated damping factor = ___________________

b

spart 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 resonse. (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:

b