FALL 2014 **Name _____**
ECEN 457 (ESS)

FINAL EXAM

This is a closed book and notes exam. This exam is worth 20% of your total grade.

Problem	Maximum	Yours
1	4	
2	4	
3	4	
4	4	
5	4	
Extra Credit*	1	
Total	21	

*Provide the list of five fundamental concepts learned in the course.

Problem 1. Design an active-RC circuit, using only one op amp, capable to yield an output voltage for four inputs equals to

$$V_o = 3V_1 - 4V_2 + \frac{10^6}{s}V_3 - 10^{-6}sV_4$$

Provide the topology and all the component values.

Hint. Consider a fully balanced circuit with a feedback load of a resistor (R_F) and a capacitor (C_F) in series.

Problem 2. The relation between GB and ω_u which the frequency at which $A(j\omega_u) = 1$ is given by

$$\omega_u = \left\{GBH^2 - \omega_{3db}^2\right\}^{1/2} = \left\{A_o^2 - 1\right\}^{1/2} \omega_{3dB}$$
$$\omega_u\Big|_{A_{>>1}} \cong A_o\omega_{3db} = GB$$

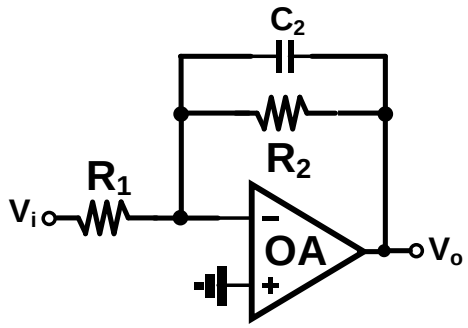
This is valid for

$$A(s) = \frac{A_o\omega_{3db}}{s + \omega_{3db}} = \frac{A_o}{1 + s/\omega_{3db}}$$

Assume A_0 is very large. Obtain ω_u when

$$A(s) = \frac{A_0}{\left(1 + \frac{s}{\omega_d}\right)\left(1 + \frac{s}{\omega_{nd}}\right)}$$

Problem 3. Given the active-RC low pass filter show below:



a) Determine the transfer function and $V_o(s)$ when $V_{in}(s) = \frac{V_m}{s}$. Assume the open loop gain of the op amp is characterized by GB/s.

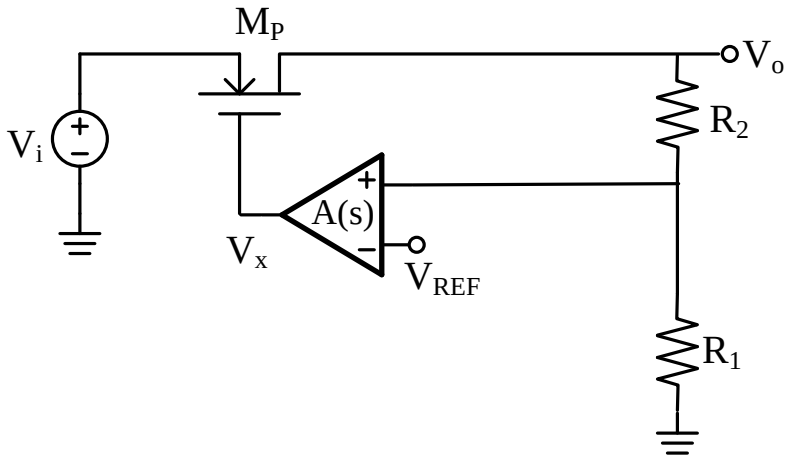
b) When the above transfer function's Q is set to $\frac{1}{\sqrt{2}}$, determine the maximum $\left|\frac{dv_o(t)}{dt}\right|$ for a step (V_m) input. Assume $v_o(0)=0$.

Hint. Use the following relations (Laplace transforms and trigonometric equations):

$$\mathcal{L}\left[\frac{df(t)}{dt}\right] = sF(s) - f(0), \quad \mathcal{L}[e^{-at}sin(\omega_0 t)] = \frac{\omega_0}{(s+a)^2 + \omega_0^2}$$

$$Asin(\omega_0 t) - Bcos(\omega_0 t) = \sqrt{A^2 + B^2}sin(\omega_0 t - \phi) \; where \; tan(\phi) = \frac{B}{A}$$

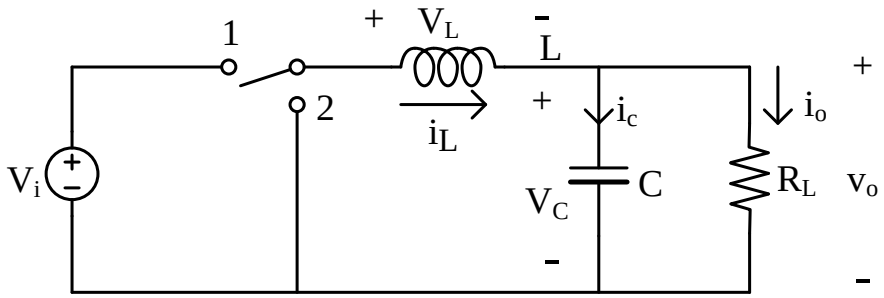
Problem 4. Obtain the approximated expression of $V_o(s)$ for the LDO shown below



Note that the pass transistor M_p is a PMOS transistor. In its model assume

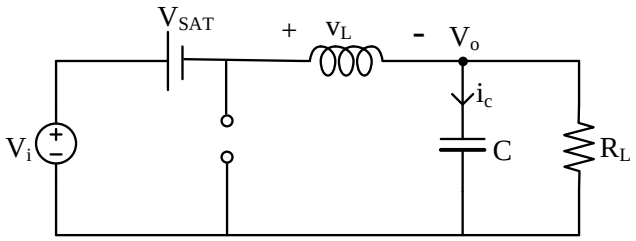
$R_{in} \to \infty$ and $R_0 = r_o$.

Problem 5. The basic buck converter is illustrated below



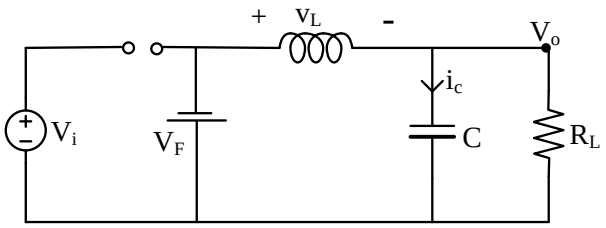
Next we show the equivalent circuits, with some non-idealities, during Phase 1 and 2, respectively.

Recall that $v_L = L\frac{diL}{dt}$, if v_i and v_o do not change during a switch cycle, the expression of v_L can be approximated as $v_L = L\frac{\Delta i}{\Delta t}$.



During Switch 1 (2)

On (Off)



During Switch 1 (2)

Off (On)

i) Determine the inductor ripple current Δi_L
ii) The output voltage expression in steady state
iii) Δi_L and v_o for $V_F = V_{SAT} = 0$

EXTRA CREDIT

List the five most fundamental concepts you learned in this course, write in one line for each concept why it is important.

1.

2.

3.

4.

5.