Introduction to Digital Electronics

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7/22/13, Midterm 1

EE42/100, Summer 2013

INSTRUCTIONS

- You have 100 minutes to complete the exam.
- The exam is closed book, closed notes, closed computer, closed calculator, except one hand-written 8.5" x 11" crib sheet of your own creation.
- Mark your answers ON THE EXAM ITSELF, and CIRCLE or BOX the final results
- Arrange your time wisely, move on if you get stuck on one question, and come back later

Last name	Key
First name	Key
SID	
TA & Section Time	
Name of the person to your left	
Name of the person to your right	
All the work on this exam is my own. *(Please sign)*	

For staff use only.

Q. 1	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6	Total
/15	/24	/12	/24	/20	/5	/100

1. Phasors (15 points)

Write the following equations in phaser notation

5 1) $v_1(t) = 4 * \cos(10 \cdot 10^4 t + 10°)$

$V_1 = 4\angle 10°$

$= 4e^{j10°}$

5 2) $v_2(t) = 10 * \sin(3t - 45°)$

$= 10\cos(3t - 45° - 90°)$

$V_2 = 10\angle -135°$

$= 10e^{-j135°}$

5 3) $v_3(t) = 3 * \sin(10 * 10^4 t + 180°)$

$= 3\cos(10 \times 10^4 t + 90°)$

$V_3 = 3\angle 90°$

$= 3e^{j90°}$

both $r\angle\theta$ form and $re^{j\theta}$ form are right

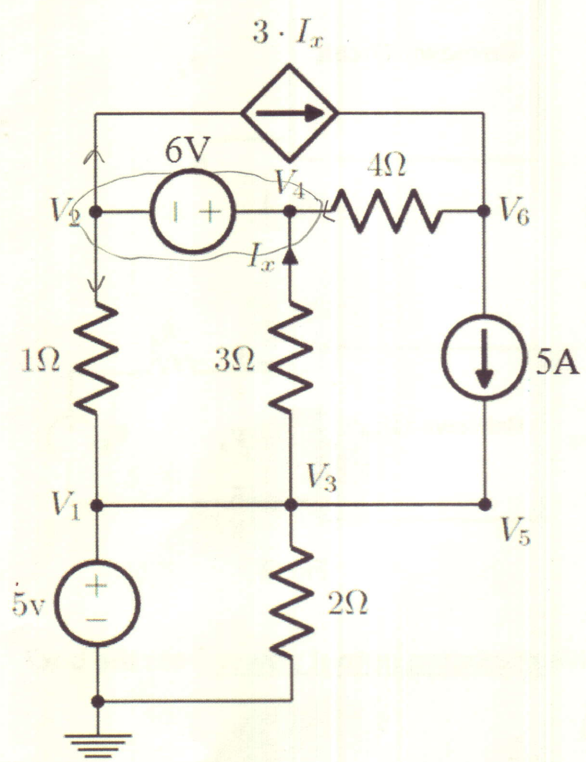
Each: 5 pts for correct mag and phase

3 pts for only one is correct

1 pt for attemption

2. Nodal Analysis (24 points)

Solving the following circuit using NODAL analysis. **Find the value for V_2 (unit is V).**



Node 1, 3, 5 : $V_1 = V_3 = V_5 = 5V$ +2 recoganize same voltage

Node 2 & 4 : supernode   +2 recoganize supernode

$3I_x + \frac{V_2 - 5}{1} = I_x + \frac{V_6 - V_4}{4}$ ① +5 most important function

$V_4 = V_2 + 6$ ② +3

Node 6 : $\frac{V_6 - V_4}{4} + 5 = 3I_x$ ③ +5 2nd important equation

$I_x = \frac{5 - V_4}{3}$ ④ +3 solve for I_x

⇒ ②, ③, ④ substitute into ①

$3I_x + V_2 - 5 = 4I_x - 5$ +2 going to the right direction trying to reduce eqn. to only V_2

$I_x = V_2 = 5-$

$5 - (V_2 + 6) = 3V_2$

$V_2 = -0.25\ V$ +2 . right result

3. Equivalent Circuit (12 points)

Consider the unknown, linear circuit in Fig. 1. The box consists of dependent sources, resistors and independent sources. We measure the voltage V_x before the box is attached to anything else and find $V_x = 2V$.

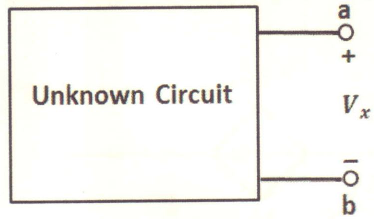


Fig. 1

Next, we connect the box to the circuit on Fig. 2 with $R_s = 500\ \Omega$ and $V_s = 3V$. We measure $i_x = 1mA$:

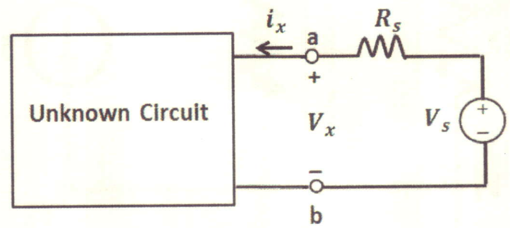
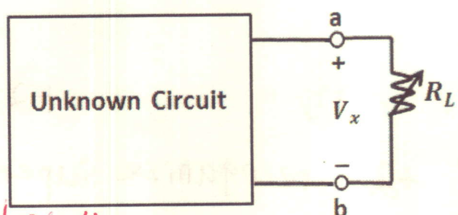


Fig. 2

Now we connect the box to a variable resistor R_L

(a) **What value does R_L** need to be in order to receive **maximum output power** from the box?

(b) What is the maximum output power?



If said to find "thevenin equivalence" without any calculation. +1 only get 1pt.

① $V_{Th} = V_x = 2V$ +2

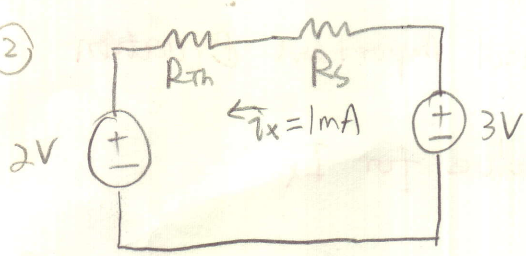
③ 1a) when $R_L = R_{Th} = 500\ \Omega$ +3

(b) $P_{max} = \left(\frac{V_{Th}}{2}\right)^2 / R_L$

$= \frac{1}{0.5k\Omega}$

$= 2mW$ +3

②



$R_{Th} + R_s = \frac{V_s - V_{Th}}{i_x} = \frac{3-2}{1m} = 1k\Omega$

$R_{Th} = 1k\Omega - 0.5k\Omega = 0.5k\Omega$ +4

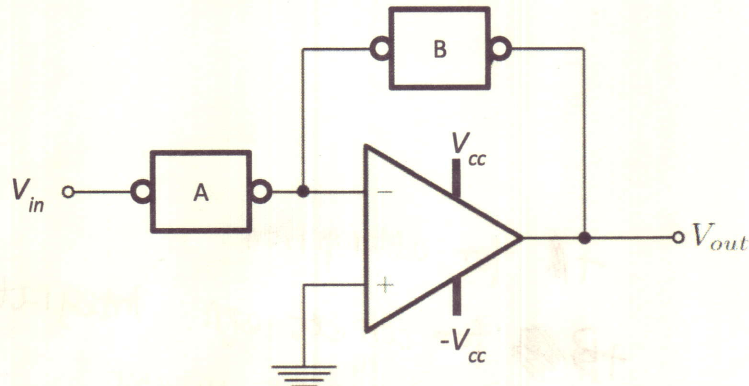
right approach, wrong number −1

4. Operational Amplifiers (24 points)

This problem is about design of an integrator circuit, Figure below. Boxes A and B are unknowns for you to put in.

The input is a 5V unit-step source, $V_{in} = 5u(t)$. And the output, V_{out}, should integrate V_{in} at a rate of -0.2 V/s and **saturates** in 25 seconds.

Vout (0) = 0



6pt (a) What is V_{cc}?

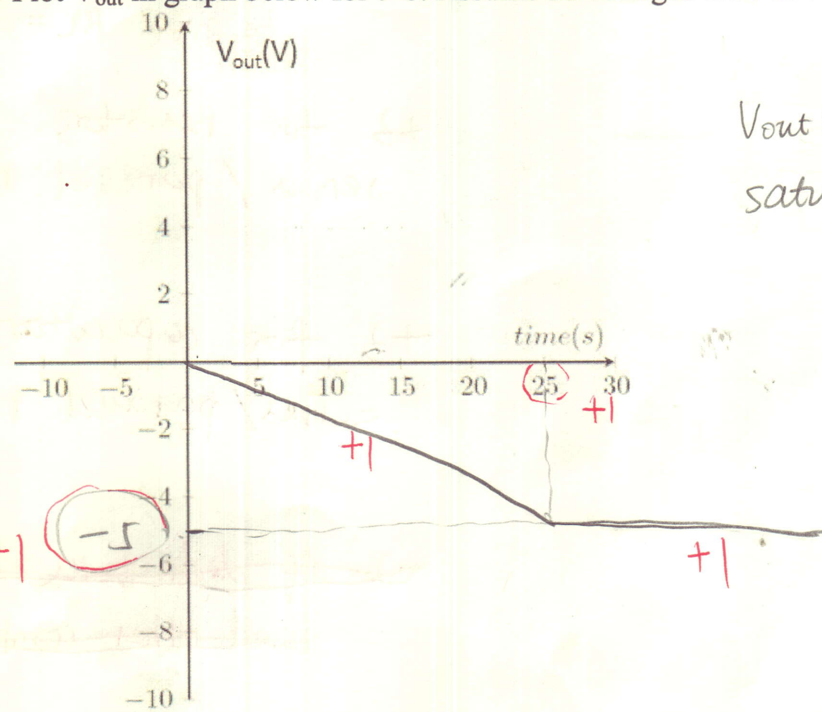
$|V_{out}| \le V_{cc}$ +2

$V_{out} = -0.2\ V/s * t = -0.2t$ +2 understand what -0.2V/s means

$t \le 25$ sec

$V_{out} \le -0.2 \times 25 = -5\ V$ $V_{cc} = 5V$ +2

4pt (b) Plot V_{out} in graph below for t>0. Assume all voltages are 0 at t=0.



$V_{out}(t) = -0.2t$

saturates at -5 V

6pt (c) What is the RC constant needed for boxes A and B?

Integrator

$$V_{out} = -\frac{1}{RC}\int_0^t V_{in}\,dt$$

$$= -\frac{1}{RC}\int_0^t -5\,dt$$

$$= -\frac{5t}{RC}$$

$$= -0.2t$$

$$RC = \frac{5}{0.2} = 25$$

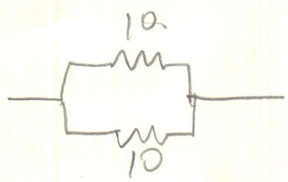
+1 for attemption
+3 for correct eqn. integration
+2 for correct answer

8pt (d) You have an unlimited supply of 10MΩ resistors and 1μF capacitors. How will you use them to get the values needed for boxes A and B?

$R = 5\ M\Omega$, $C = 5\ uF$

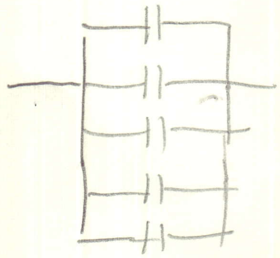
+2. for correct R and C to give $RC = 25$

A:



+3 for resistors series / parallel relation

B



+3 for capacitors series / parallel relation

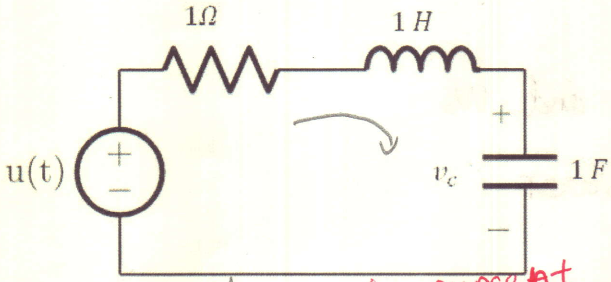
~~-2 if didn't use 10MΩ / 1uF used other combinations~~

only get 4 pts if ~~~~ RC = 25 and used R . C ~~~~ in the right position, but single R . C

5. RLC Circuits (20 points)

(a) A RLC series circuit is connected to a unit step input u(t). Use KVL and write a second order equation of $V_c(t)$ in response to the input.

8 pt



$i = i_C = C\frac{dv_c}{dt}$ +2 for current

$V_R + V_L + V_c = u(t)$, +2 KCL

$i_c \times 1 + L\frac{di}{dt} + V_c = u(t)$ +2 for V_L

$C\frac{dV_c}{dt} + LC\frac{d^2V_c}{dt} + V_c = u(t)$ +2 final form

$\frac{d^2V_c}{dt} + \frac{dV_c}{dt} + V_c = 1$ okay if $u(t) = 1$

(b) What is α, ω_0?

4 pt

$\alpha = \frac{R}{2L} = \frac{1\Omega}{2H} = 0.5$ Np/sec +2

$\omega_0 = \sqrt{\frac{1}{LC}} = 1$ rad/sec +2

unit missing −0.5

(C) Is this overdamped, underdamped, or critically damped?

4 pt

$\alpha < \omega_0$

underdamped

+2 if compare α and ω_0

+2 if correct answer

(d) What is the value of $V_c(\infty)$ as time goes to ∞ ?

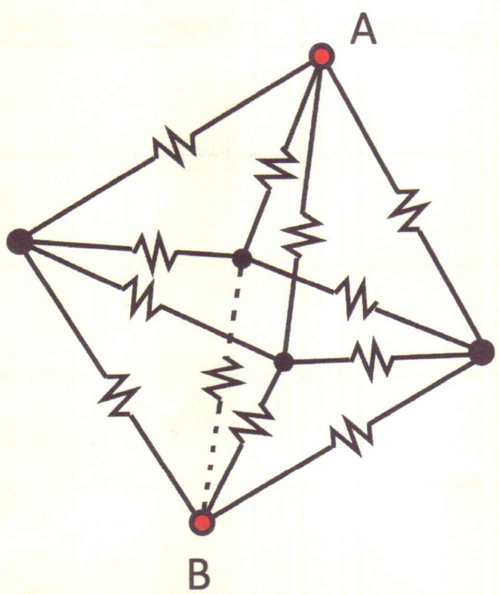
4 pt

open circuit +2 for right direction

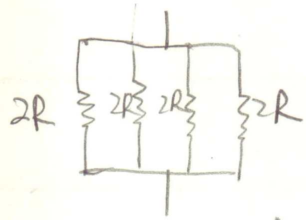
$V_c(\infty) = V(t) = 1\,V$ +2 for correct answer

6. Resistor Networks (5 points)

A regular octahedron is a Platonic solid composed of eight equilateral triangles, four of which meet at each vertex.
Consider a resistor network connected in the form of octahedron with identical resistors of resistance R. What is the equivalent resistance between points A and B, which are opposite corners of an octahedron?
Hint: **Think about Wheatstone bridge. It should NOT include complex calculations.**



4 resistors in between no use, no current flowing across laterally +2 recognize Wheatstone bridge



+1 equivalence

$R_{eq} = \frac{2R}{4} = \frac{R}{2}$ +2 correct answer