Name: Solution Key

ECE 202 Circuits and Systems II

Fall 2007

Examination III

November 16, 2007

Problem	Points	Score
1	21	21
2	19	19
3	30	30
4	30	30
Total:	100	100

V.G.!!

Notes:

1) You have 50 minutes to complete this examination.
2) This exam has 4 problems and a total of 8 pages.
3) Please write your name in the space provided on each page.
4) Please draw a box around to clearly indicate each answer.
5) You must show your work to receive full or partial credit (where applicable).
6) Some questions may have little or no partial credit.
7) *Please, please, please check and double-check your work and calculations!!*
8) All answers must have units where appropriate, and be in proper engineering notation.

Name: S. K.

1. [24 pts] Answer the following questions:

(a) [ ] For a series RLC bandpass filter, which element would you adjust, and by how much, to double the bandwidth without changing the center frequency?

$\omega_o = \frac{1}{\sqrt{LC}}$

$B = \frac{R}{L}$

Double R to 2R changes B but not ω_o

(b) [ ] For a system with transfer function $H(s) = \frac{s+1}{(s-2)(s+3)}$, determine whether this system is stable or not. Explain why.

The pole at s=2 is in the Right-half plane, thus causing the system to be unstable

(c) [pts] For the transfer function $H(s) = \frac{2}{(s+3)(s+1)}$, what is the Laplace domain response, *G(s)*, of the circuit due to a time-domain unit step input?

$$G(s) = \frac{H(s)}{s} = \frac{2}{s(s+3)(s+1)}$$

Name: S. K.

2. [19 pts] Write a PSPICE netlist file that maybe used to generate the Bode plots for the circuit in Figure 1. Let C = 20 nF, R = 500 , and L = 50 uH. Scan your frequency from 10 kHz to 10 MHz, with 20 steps per decade.

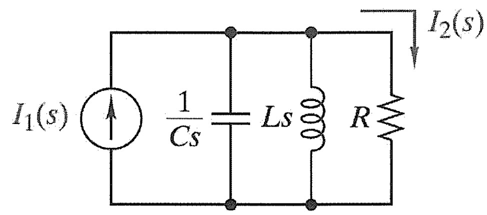

Figure 1 Circuit for Problem 2

5 pts

optional

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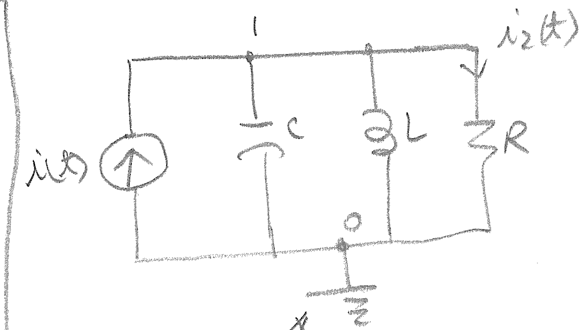
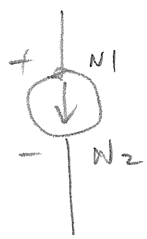
1  *Exam III Problem 2
8  I1  0  1   AC   1Aac   DC 0Adc
1  C1  1  0   20n
1  L1  1  0   50u
1  R1  1  0   500
1  .probe
5  .ac  dec  20   10000   10000000
1  .end
```

or [1k 10meg]



add grounding to diagram

for current source



current flows from N1 to N2

Name: S.K.

3. [30 pts] For the waveform in Figure 1:

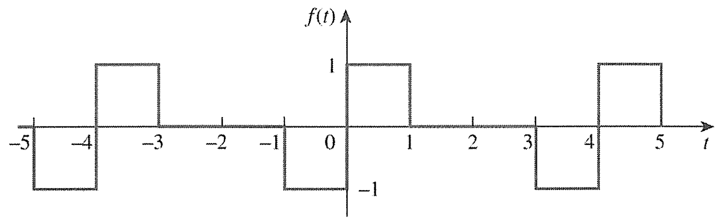


Figure 2 Waveform for Problem 3

(a) [6 pts] Identify all symmetry properties for *f(t)*. Briefly explain your reasoning.

$\boxed{f(t) = -f(-t) \Rightarrow \text{odd symmetry.}}$

3 3

(b) [24 pts] Find the Fourier series representation of *f(t)* in **closed** form (i.e., the expression of *f(t)* should use the summation symbol and contain no "a_n"s, "b_n"s or ellipsis "…").

Odd symmetry :

$$\boxed{\begin{aligned} a_0 &= 0 \\ a_n &= 0. \end{aligned}}$$

4 4

$T = 4$

$$b_n = \frac{2}{T}\left[\int_{-1}^{0}(-1)\sin\left(\frac{2\pi n}{T}t\right)dt + \int_{0}^{1}(1)\sin\left(\frac{2\pi n}{T}t\right)dt\right]$$

$$= \frac{2}{T}\left[\frac{T}{2\pi n}\cos\left(\frac{2\pi n}{T}t\right)\Big|_{-1}^{0} - \frac{T}{2\pi n}\cos\left(\frac{2\pi n}{T}t\right)\Big|_{0}^{1}\right]$$

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3. Cont'd (work space)

$$= \frac{1}{\pi n}\left[1 - \cos\left(\frac{2\pi n}{T}\cdot -1\right) - \cos\left(\frac{2\pi n}{T}\cdot 1\right) + 1\right]$$

$$b_n = \frac{2}{\pi n}\left[1 - \cos\left(\frac{2\pi n}{T}\right)\right]$$

Recall $T=4$

$$\therefore \; b_n = \frac{2}{\pi n}\left[1 - \cos\left(\frac{\pi n}{2}\right)\right]$$

$$\boxed{\therefore \; f(t) = \frac{2}{\pi}\sum_{n=1}^{\infty}\frac{1}{n}\left[1-\cos\left(\frac{\pi n}{2}\right)\right]\sin\left(\frac{\pi n}{2}t\right)}$$

3 1 3 3 3 3

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4. [30 pts] For the RC circuit in Figure 3(b), the response $v_o(t)$ is due to the excitation shown in Figure 3(a). (Note: there are 3 parts to this problem; part (c) is on the next page)

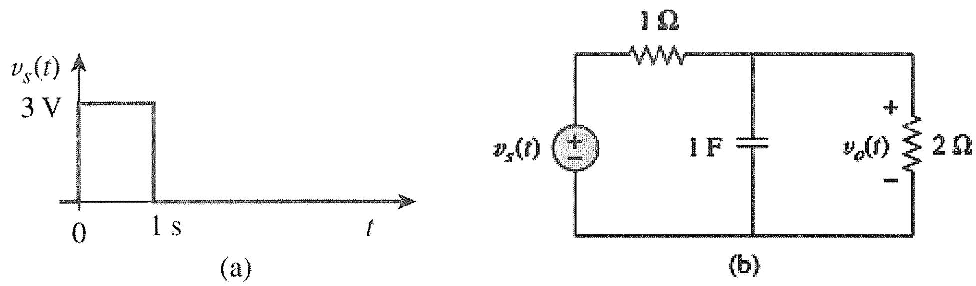
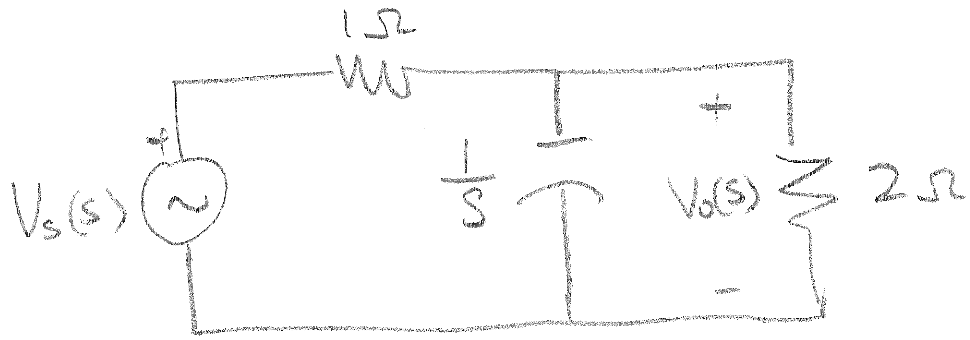


Figure 3 Input signal (a) and circuit diagram (b) for Problem 4

(a) [10] Draw and fully label the Laplace domain circuit diagram.



(2 pts for each label)

[10]

(b) [4] What is the impulse response of this circuit in time domain?

impulse response = $h(t) \longleftrightarrow H(s)$ = transfer fn.

Let $Z = \frac{1}{s} \| 2 = \dfrac{\frac{2}{s}}{2+\frac{1}{s}} = \dfrac{1}{s+\frac{1}{2}}$

$$V_o(s) = V_s(s) \cdot \frac{Z}{Z+1} = \frac{\frac{1}{s+\frac{1}{2}}}{\frac{1}{s+\frac{1}{2}}+1} = \frac{1}{1+s+\frac{1}{2}} = \frac{1}{s+\frac{3}{2}}$$

$\therefore H(s) = \dfrac{V_o(s)}{V_s(s)} = \dfrac{1}{s+1.5}$

Thus $\boxed{h(t) = e^{-1.5t}\,u(t) \quad \text{or} \quad h(t) = e^{-\frac{3}{2}t}\,u(t)}$

(4)

(c) [This part is on the next page]

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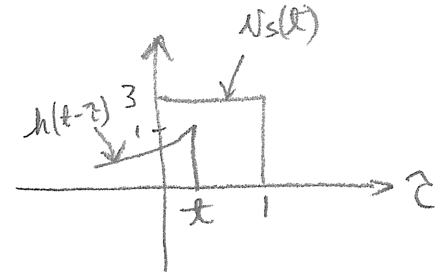
4 (c) [16 pts] Using convolution integrals, find the zero-state response for $t > 0$.

Zero-state response $= v_o(t)$

$$v_o(t) = v_s(t) * h(t)$$

$$v_s(t) = 3\left[u(t) - u(t-1)\right]$$

$$h(t) = e^{-\frac{3}{2}t}\, u(t)$$



for $0 \le t < 1$

$$v_o(t) = \int_0^t 3 \cdot e^{-\frac{3}{2}(t-\tau)}\, d\tau$$

$$= 3 \cdot e^{-\frac{3}{2}t} \int_0^t e^{+\frac{3}{2}\tau}\, d\tau$$

$$= 3 \cdot e^{-\frac{3}{2}t} \left(\frac{2}{3}\right) \left[e^{\frac{3}{2}\tau}\right]_0^t$$

$$= 2e^{-\frac{3}{2}t}\left[e^{\frac{3}{2}t} - 1\right] = 2\left[1 - e^{-\frac{3}{2}t}\right]$$

$0 \le t < 1$

for $t > 1$

$$v_o(t) = \int_0^1 3 \cdot e^{-\frac{3}{2}(t-\tau)}\, d\tau$$

$$= 3e^{-\frac{3}{2}t}\left(\frac{2}{3}\right)\left[e^{\frac{3}{2}\tau}\right]_0^1 = 2e^{-\frac{3}{2}t}\left[e^{\frac{3}{2}} - 1\right]$$

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4. Cont'd (work space)

$$\boxed{v_o(t) = \begin{cases} 2\left[1-e^{-\frac{3}{2}t}\right] & 0 \le t < 1 \\ 2e^{-\frac{3}{2}t}\left[e^{\frac{3}{2}}-1\right] & t > 1 \end{cases} \quad \text{Volts}}$$

[16]

Optionally:

$$v_o(t) = 2\left[1-e^{-\frac{3}{2}t}\right]\left[u(t)-u(t-1)\right] + 2e^{-\frac{3}{2}t}\left[e^{\frac{3}{2}}-1\right]u(t-1)$$

$$= 2\left(1-e^{-\frac{3}{2}t}\right)u(t) - 2\left(1-e^{-\frac{3}{2}t}\right)u(t-1)$$

$$+ 2e^{-\frac{3}{2}t}e^{\frac{3}{2}}u(t-1) - 2e^{-\frac{3}{2}t}u(t-1)$$

$$= 2u(t) - 2e^{-\frac{3}{2}t}u(t) - 2u(t-1) + \cancel{2e^{-\frac{3}{2}t}u(t-1)}$$

$$+ 2e^{-\frac{3}{2}(t-1)}u(t-1) - \cancel{2e^{-\frac{3}{2}t}u(t-1)}$$

$$\boxed{v_o(t) = 2\left[1-e^{-\frac{3}{2}t}\right]u(t) - 2\left[1-e^{-\frac{3}{2}(t-1)}\right]u(t-1) \text{ V}}$$

[16]