United States Naval Academy
Electrical and Computer Engineering Department
EE 221
Exam 3
10 December 2010

1. You must present your work completely and legibly to receive partial credit. You must show sufficient steps to justify intermediate results as well as final answers.
2. Put all your work on the exam. If you need more space than that provided, ask your instructor for paper. Write your answer clearly and use appropriate units. You have 50 minutes to work this examination.
3. **You are not permitted to discuss the contents of this exam until after 4th period today, Friday 10 December.**

Page	Value	Score
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Total	100	

Name Solution

I have neither given nor received assistance while completing this exam.

Signed and Dated

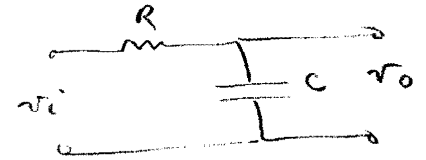
(1) (5 pts) Given a sinusoidal voltage v(t) = 5cos(1000t) V across a resistor, what DC voltage across the resistor would give the same average power absorption as the sinusoidal voltage?

$$V_{DC} = \frac{5}{\sqrt{2}} \text{ V}$$

(2) (5 pts) When we talk about the 3dB point of a filter we are talking about the frequency where the output power is ___ $1/2$ ___ of the input power and the output voltage is ___ $1/\sqrt{2}$ ___ of the input voltage.

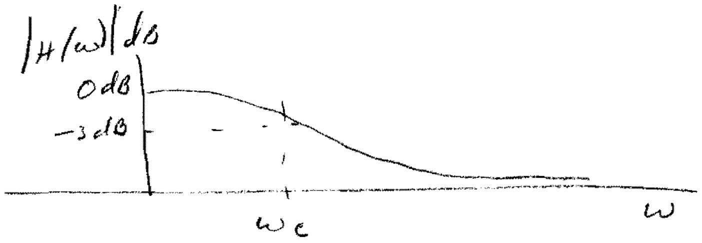
(3) (10 pts)
(a)Sketch a passive low pass filter using one capacitor and one resistor. (No need to use numerical values, using R and C is sufficient.)
(b) What is the transfer function that describes the voltage gain for your design?
(c) Sketch the frequency response of your design.

(a)



(b) $$H(\omega) = \frac{v_o}{v_i} = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{1}{1 + j\omega RC}$$

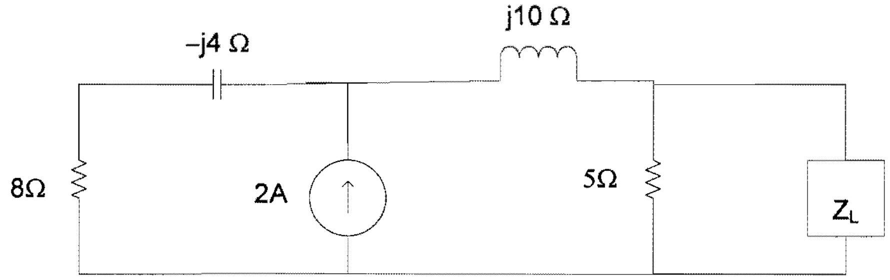
(c)



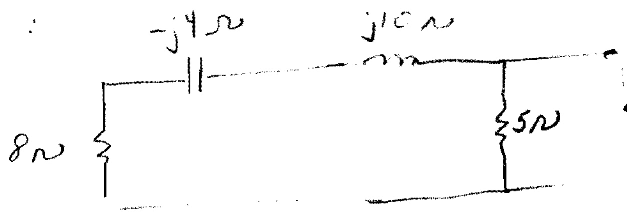
(4)(5 pts) Under what circumstances would we choose to solve for circuit parameters using Laplace transforms(s domain) rather than using the phasor domain?

When we have transient signals or any type of signal beyond AC steady state.

(5) (25 points) Given the circuit shown below, select Z_L so that the load impedance absorbs the maximum average power. What is the value of the average power absorbed by the load?



Z_{TH} :

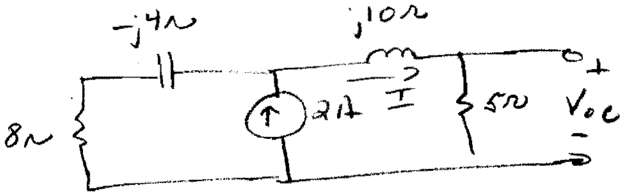


$\Leftarrow Z_{TH} = 5 \parallel (8 + j6)$

$= 3.414 + j\,0.732\,\Omega$

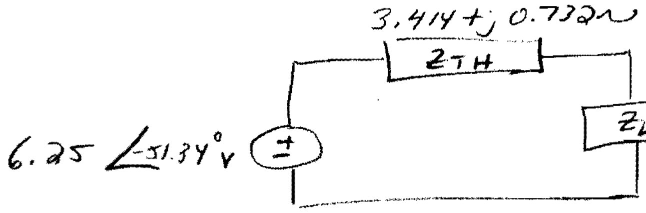
$\Rightarrow Z_L = 3.414 - j\,0.732\,\Omega$

V_{oc} :



$I = 2\left(\frac{8 - 4j}{13 + 6j}\right) = 1.25 \angle -51.34° \text{ A}$

$V_{oc} = IR = (1.25 \angle -51.34°)5 = 6.25 \angle -51.34° \text{ V}$



$Z_L = 3.414 - j\,0.732\,\Omega$

$P_{max} = \frac{1}{2}[P_{source}] = \frac{1}{2}\left[\frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)\right]$ ← 1 since Z_{TOTAL} is purely resistive

$= \frac{1}{2}\left[\frac{1}{2}\frac{V_m^2}{R_T}\right]$

$= \frac{V_m^2}{4R_T} = \frac{(6.25)^2}{4(2)(3.414)} = 1.43 \text{ W}$

$Z_L =$ <u>3.414 − j0.732Ω</u>

Pmax = <u>1.43 W</u>

(6) (25 points) A parallel RLC resonant circuit has an impedance of 40Ω at resonance, quality factor of 80, and a resonant frequency of 200krad/s.
(a) What are the values of R, L and C?
(b) What is the bandwidth and the half power frequencies?
(c) SKETCH the circuit.

(a) $Q = \omega_0 RC$

$80 = (200k)(40)(C)$

$C = 10\mu F$

$Q = \frac{R}{\omega_0 L}$

$80 = \frac{40}{(200k)(L)}$

$L = 2.5\mu H$

Check: $\omega_0 = \frac{1}{\sqrt{LC}}$
$= \frac{1}{\sqrt{(2.5\mu)(10\mu)}}$
$= 200K \frac{rad}{sec}$

$Q = \frac{\omega_0}{B}$

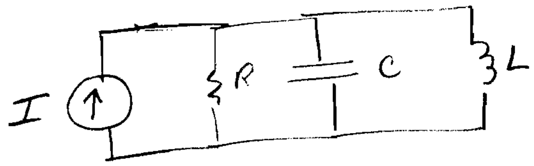
$80 = \frac{200k}{B}$

$B = 2.5$ Krad/sec

(b)
$\omega_1 = \omega_0 - \frac{B}{2}$
$= 200k - \frac{2.5k}{2}$
$= 198.75$ Krad/sec

$\omega_2 = \omega_1 + 2.5K$
$= 201.25$ Krad/sec

(c)



R = 40Ω

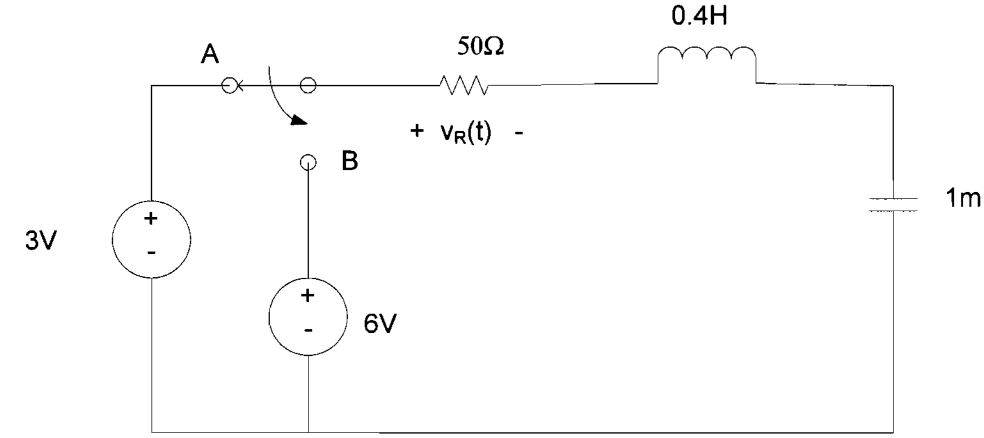
L= 2.5μE

C= 10μF

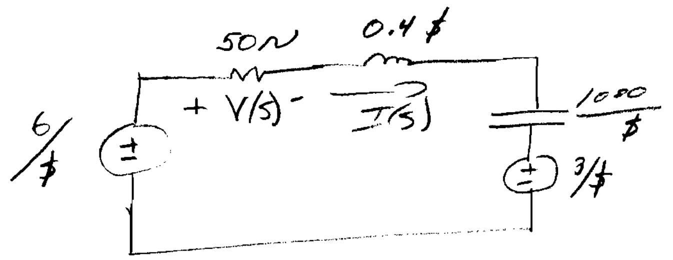
Bandwidth = 2.5 Krad/sec

Half Power Frequencies = $\omega_1 = 198.75$ Krad/sec
$\omega_2 = 201.25$ Krad/sec

(8) (25 points)The switch in the circuit below has been closed for a long time at position A. At t=0 the switch moves from position A to position B. Find the voltage across **the resistor $v_R(t)$ for t>0** using Laplace transforms.



$v(0) = 3V,\quad i(0) = 0A \qquad 1/sC = \frac{1}{s(0.001)} = \frac{1000}{s}$



$$\frac{6}{s} - \frac{3}{s} = \left(50 + 0.4s + \frac{1000}{s}\right) I(s)$$

$$I(s) = \frac{3/s}{50 + 0.4s + \frac{1000}{s}}$$

$$V_R(s) = \frac{50\left(3/s\right)}{50 + 0.4s + \frac{1000}{s}} = \frac{150}{0.4s^2 + 50s + 1000}$$

$$= \frac{375}{s^2 + 125s + 2500} = \frac{375}{(s+25)(s+100)}$$

$$= \frac{A}{s+25} + \frac{B}{s+100} = \frac{5}{s+25} + \frac{-5}{s+100}$$

$$A = \left.\left(\frac{375}{s+100}\right)\right|_{s=-25} = 5$$

$$B = \left.\left(\frac{375}{s+25}\right)\right|_{s=-100} = -5$$

$v_R(t) = \left(5e^{-25t} - 5e^{-100t}\right)u(t)$ V