EE 2351 – Circuits II
Test # 4

Aug. 7, 2017

Instructions:

a. **Please keep your cell phone stored in your bag or pocket. No cellphone access during the exam. If you are found using your cellphone, you will be asked to leave the room and will receive a grade of 0 in the test.**

b. **You cannot talk to your classmates during the exam. If you talk to your classmates during the exam, you will be asked to leave the room and will receive a grade of 0 in the test.**

c. **This is a closed book, closed notes, no computer exam. All the formulas are provided for the test in the last page of this exam. DO NOT TEAR ANY PAGES.**

d. **Put the proper units and prefixes with your answers and use the appropriate sign conventions.**

e. **Show all work, including intermediate steps. Failure to do so will be penalized. Explicitly state in your answer when the calculator is used to get the roots of a polynomial or to solve a system of equations.**

f. **Write clearly the answer(s) to each question and highlight them or box them. Do all your work on the pages provided. No scrap paper is permitted. You may also use the back of the paper if you run out of space.**

g. **No bathroom breaks during the exam.**

By signing this exam, you agree that the work presented here represents only your effort.

Name: KEY **Signature:** KEY

UTEP ID: KEY

KEY

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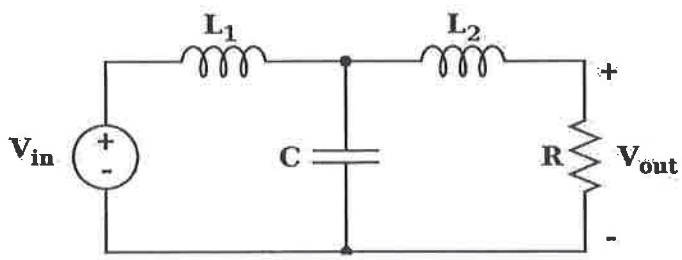
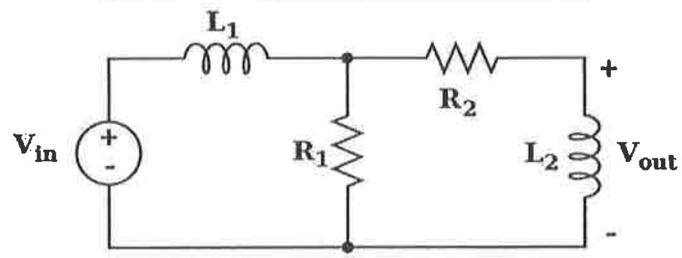
1.- Analysis of Frequency Selective Circuits (20 points)

For the circuits shown below, indicate which type of filter it is (e.g. Low-Pass, High-Pass, or Band-Pass). Use qualitative analysis to explain your answer (e.g. What happens as $\omega \to 0$ and $\omega \to \infty$?) (10 points each)

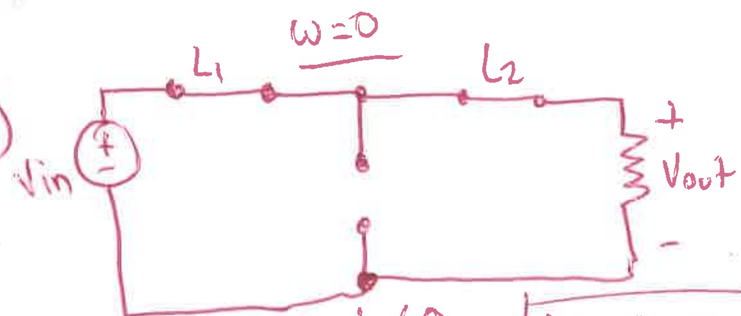
(A)



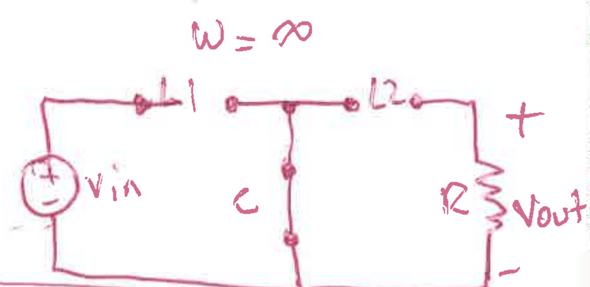
(B)



A)



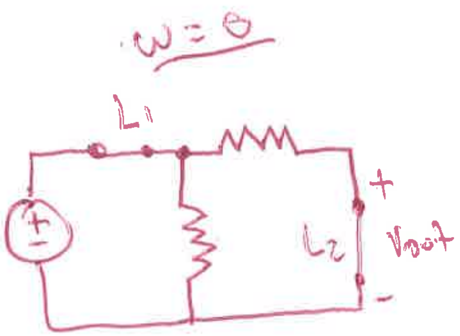
Vout ≠ 0



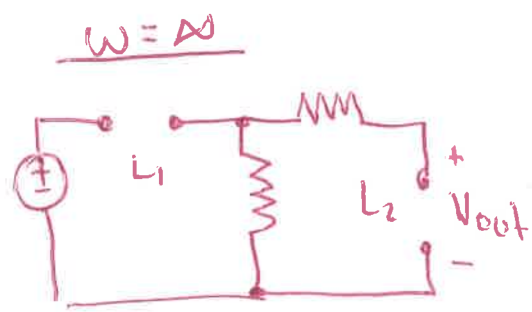
Vout = 0

LOW-PASS FILTER

B)



Vout = 0



Vout = 0

BAND-PASS FILTER

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2. – Frequency Selective Circuits (20 points)

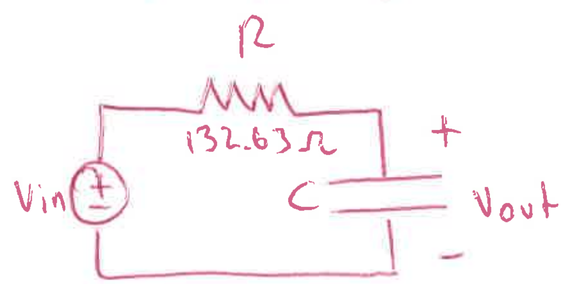
Design a passive RC Low-Pass Filter with a cutoff frequency of 15 KHz, using a 80 nF capacitor. Answer the following questions:

a) What is the cutoff frequency ω_c? (5 points)
b) What is the value of the resistor R? (5 points)
c) Draw the circuit, labeling the component values and output voltage. (10 points)

a) $\omega_c = 2\pi\,(15\ KHz) = \boxed{30K\pi} = \boxed{94{,}247.78\ \frac{rad}{sec}}$

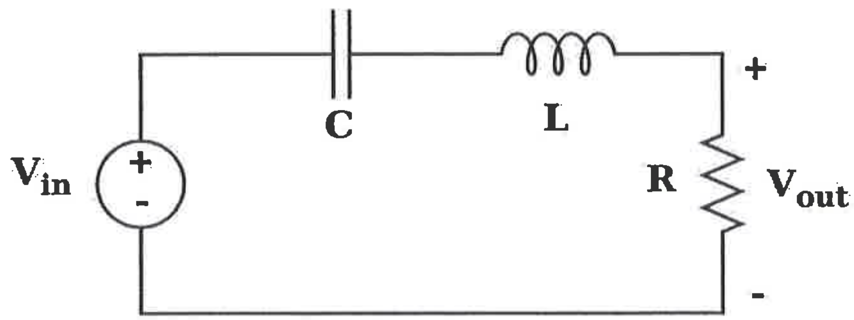
b) $R = \frac{1}{\omega_c C} = \frac{1}{(30{,}000\pi)(80\times10^{-9})} = \boxed{132.63\ \Omega}$

c)



3. – Frequency Selective Circuits (20 points)

The circuit shown below is used to implement a Band-Pass passive filter.



The value for the capacitor is $C = 5\ nF$, and the circuit is designed to have a quality factor Q of 2.
Answer the following questions:

a) Determine the values of R and L so that the resonant frequency is 8 KHz (9 points)
b) Determine the cutoff frequencies f_{c_1} and f_{c_2} in Hertz (9 points)
c) Calculate the bandwidth β (2 points)

$\omega_0^2 = \frac{1}{LC}$. $L = \frac{1}{(16{,}000\pi)^2 (5\times10^{-9})} = 79.16\ mH$

$R = 1989.47\ \Omega$

$Q^2 = \frac{L}{CR^2} \rightarrow R^2 = \frac{L}{CQ^2}$

b) $f_{c1} = 6.25\ KHz$, $f_{c2} = 10.25\ KHz$

c) $\beta = 4\ KHz = 25{,}132\ \frac{rad}{sec}$

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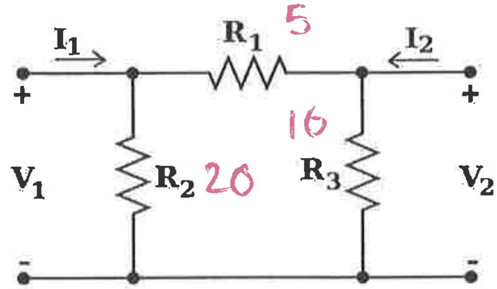
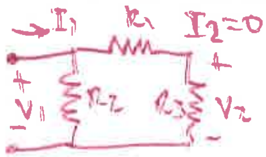
4. – Two-Port Network Parameters (20 points)

For the two-port circuit shown below, $R_1 = 5\Omega,\ R_2 = 20\Omega,\ R_3 = 10\Omega.$



Determine the g-parameters $g_{11}, g_{12}, g_{21}, g_{22}$ (5 points each)

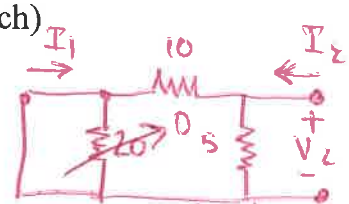


g_{11} – admittance seen from port 1

$g_{11} = \frac{1}{20} + \frac{1}{15} = \frac{7}{60} = \boxed{0.11667}$

$g_{21} = \frac{V_2}{V_1} = \left(\frac{10}{15}\right) = \boxed{0.667}$

voltage divider



current divider

$g_{12} = -\frac{I_1}{I_2}\left(\frac{10}{15}\right) = \boxed{-0.667}$

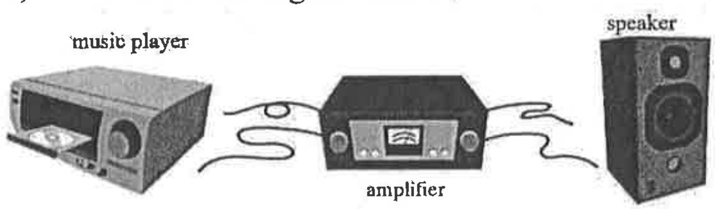
g_{22} – impedance seen from port 1

(20 Ω resistance doesn't count)

$5 \,||\, 10 = \frac{50}{15} = \boxed{3.333 = g_{22}}$

5. – Terminated Two-Port Networks (20 points)

Suppose you buy an amplifier circuit from a second-hand store to connect your music player and a speaker, as shown in the figure below.



The amplifier can be modeled as a black-box 2-port circuit, since you don't know what components are inside. The music player has a voltage source output of $15\ V$ and an impedance of $50\ \Omega$. The speaker has a $8\ \Omega$ internal resistance with a maximum power output of $64\ W$.

To obtain the circuit behavior of the amplifier, two direct measurements were done:

1.- With Port 2 open, a voltage of $10\ V$ is applied to Port 1. The measured voltage across Port 2 is $-40\ V$, and the measured current across Port 1 is $0.3\ mA$.

2.- With Port 2 short-circuited, a voltage of $1\ V$ is applied to Port 1. The measured current across Port 2 is $300\ mA$, and the current across Port 1 is $200\ \mu A$.

Answer the following questions:

a) Which two-port circuit parameter is easier to compute from these measurements? (1 point)
b) From the answer obtained in part (a), obtain the required two-port parameters. (7 points)
c) From the parameters obtained in part (b), calculate the output voltage gain $\frac{V_2}{V_1}$ from the amplifier. (3 points)
d) From the parameters obtained in part (b), obtain the output current from the amplifier to the speaker when connected to the music player (I_2) (8 points)
e) From the current in part (d), calculate the average power delivered to the 8Ω speaker. Is it safe to connect the amplifier to the speaker? (1 point)

$Z_g = 50\,\Omega$ $Z_L = 8\,\Omega$ KEY

$V_g = 15\,V$ Power = 64 W

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Problem 5: Terminated 2-port networks

Measurements

① $I_2 = 0$
$I_1 = 0.3\times10^{-3}$
$V_2 = -40\,V$
$V_1 = 10\,V$

② $V_2 = 0$
$V_1 = 1V$
$I_1 = 200\times10^{-6}\,A$
$I_2 = 0.3\,A$

a) a-parameters

b) $a_{11} = \left.\frac{V_1}{V_2}\right|_{I_2=0} = -0.25$ $a_{12} = \left.-\frac{V_1}{I_2}\right|_{V_2=0} = -3.333\,\Omega$

$a_{21} = \left.\frac{I_1}{V_2}\right|_{I_2=0} = -7.5\times10^{-6}\,S$ $a_{22} = \left.-\frac{I_1}{I_2}\right|_{V_2=0} = \frac{-200\times10^{-6}}{0.3} = -6.667\times10^{-4}$

c) $\frac{V_2}{V_1} = \frac{Z_L}{a_{11}Z_L + a_{12}} = \frac{8}{(-0.25)(8) + (-3.333)} = -1.5 = \frac{V_2}{V_1}$

d) $I_2 = \frac{-V_g}{a_{11}Z_L + a_{12} + a_{21}Z_gZ_L + a_{22}Z_g} = \frac{-15}{-2-3.333-0.003-0.0333} = \frac{-15}{-5.37}$

$I_2 = 2.79366\,A$

e) $P = I^2R = (2.79366)^2(8) =$ 62.436 W < 64 W
So it is safe to connect