

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
ELEG 3023-Z02- Signals and Systems
FALL 2021**

- I. COURSE DESCRIPTION IN ABET FORMAT**
- II ASSESSMENT RESULTS FOR CURRENT AND PAST PERIODS**
Program Outcomes Assessed in Course
Assessment Summary of Class Semester Averages for Outcomes
End of Semester Course Outcomes Assessment Reports
- II. EXAM**
Summary of Topics covered by Test
Original Exam Questions & Master Solution/grading scheme used
(Summary of topics can be a separate page or include on the assignment itself)
Above Average (Graded original work)
Average (Graded original work)
Below Average (Graded original work)
- III. COMPUTER ASSIGNMENT**
Summary of Topics covered by Computer Assignment
Original Homework Questions & Master Solution/grading scheme used
Above Average (Graded original work)
Average (Graded original work)
Below Average (Graded original work)
- IV. PROJECT**
Summary of Topics Covered by Project
Project Problem Statement and Grading Scheme
Above Average (Graded original work)
Average (Graded original work)
Below Average (Graded original work)

Course Description in ABET Format

1.	Course number and name:	ELEG 3302 SIGNALS AND SYSTEMS
2.	Credits and contact hours:	3 credit hours; 3 contact hours * Subject Area: Engineering Topics
3.	Instructor's or course coordinator's name:	Dr. John O. Attia
4.	Text book: Title:	Signals and Systems: A Primer with MATLAB.
	Author:	M.N.O. Sadiku and W.H. Ali,
	Publisher, Year & Edition:	CRC Press, Boca Raton, FL 2016, ISBN: 978-1-4822-6151-6
	a. Other Supplemental material	Hwei P. Hsu, "Signals and Systems: Schaum Outline", McGraw Hill, 4th Edition, 2020.
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	ELEG 3302 Signals and Systems: 3 semester hours. Basic discrete and continuous time signals, properties of systems, linear time invariant systems, Fourier analysis, z-transformers, LaPlace Transform.
	b. Prerequisites or Co-requisites	Prerequisite: ELEG 3301 Co-requisite: None
	c. ** Indicate whether a required, elective, or selected elective (as per definition provided) course in the program	Required
6.	a. Specific goals for the course specific outcomes of instruction (e.g. The student will be able to explain the significance of current research about a particular topic.) <i>Students will be able to :</i>	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course. <i>The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:</i>
	1.1. Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)	Outcome 1 On completion of course the student should have demonstrated an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics.
	2. Solve Complex Engineering Problems by applying the principles of engineering, science and mathematics (Student Outcome 1.2)	

7	Brief list of topics to be covered	1. Introduction to Linear Systems (4.5 hours) 2. Convolution (6 hours) 3. Laplace Transform (6 hours) 4. Fourier Series (4.5 hours) 5. Fourier Transform (5 hours) 6. Discrete Fourier Transform (6.5 hours) 7. Z-Transform (9 hours) 9. Exams (6.5 hours)
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* For all Engineering programs, indicate subject area from the following: **Math, Basic science, Engineering topic or Other**

** **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group

II ASSESSMENT RESULTS FOR CURRENT AND PAST THREE PERIODS

Program Outcomes Assessed in this course

Outcome 1:

An ability to identify, formulate, and solve complex engineering problems (CEP) by applying principles of engineering, science, and mathematics.

Assessment Summary of Class Semester Averages for Outcomes (Should be provided for Spring 2019 through Spring 2022 Assessment Period)

Outcomes	1
Semester	Semester Class Average (%)
Fall 2021	89 (ELEG) / 77 (CPEG)
Spring 2021	92 (ELEG) / No CPEG student
Fall 2020	79 (ELEG) / 82 (CPEG)
Spring 2020	92 (ELEG) / 91 (CPEG)
Spring 2019	91(ELEG) / 81 (CPEG)
Comments on Trend of Data (Improving or deteriorating)	There is no clear trend in the data. However, the outcome values for the semesters are higher than the expected semester class average of 70.

*Expected Semester Class Average = 70% (or as defined by the program)

**End of Semester Course Assessment Reports
Spring 2019 and Last Several Assessment Periods.**

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

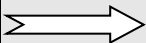
5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

[illegible]

Semester	Analysis Type	Number of Students	Outcome 1.1 Ability to identify and formulate engineering/technical/computing problems using principles of engineering/mathematics/science				Outcome 1.2 Ability to solve complex engineering problems by applying principles of engineering, science, and mathematics.”				Outcome 1 an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics. ,			
			Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2021	Direct	3	70	70	92	100	70	70	65	67	70	70	77	67
Spring 2021	Direct	0	none	none	none	none	none	none	none	none	none	none	none	none
Fall 2020	Direct	2									70	70	82	82
Spring 2020	Direct	4									70	70	91	100
Spring 2019	Direct	6									70	70	81	100
Implementation Summary	Items implemented from previous report or after meeting previous instructor	The following plans were to be implemented during the spring 2021 semester: (a) required all the students to follow the format for writing the project report. (b) taught the students how to obtain resonant frequency and cut-off frequencies from MultiSim magnitude response plots (c) instructed the students how to obtain transfer function from the magnitude plot (d) Discuss with the students how to use the linearity principle to obtain an input signal given an output signal.												
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them	The outcome was satisfied, but one student out of three student score was less than 70. The student had difficulties solving the complex engineering problem using the linearity principle of linear time-invariant systems. In addition, the student was not able to obtain the transfer function of the equivalent passive network.												
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas	The following plan will be implemented the next time the course is taught: teach the students the linearity principle and its application in solving complex engineering problems. In addition, some plans implemented during the fall 2021 semester will be re-implemented. These include (i) requiring all the students to follow the format for writing the project report. (ii) teaching the students how to obtain resonant frequency and cut-off frequencies from MultiSim or MATLAB magnitude response plots; (iii) instructing the students how to obtain transfer function from the magnitude response plot; (iv) how to use the linearity principle or other technique to obtain the input signal that will that came from a particular output signal, (v) to give the students extra incentive to spend more time and energy on the design project, I will increase the current weight of 10% of final course grade to 16%, and decrease the current weight of the class exams from 48% to 42%.												
Overall Trend over Periods	Ascertain if there were improvements over previous semesters	There was no data from spring 2021 semester since no computer engineering student took the class. However, since spring 2019, the outcome #1 average has been trending downwards.												
Were Expectations Met?		YES FOR OUTCOME, BUT NO FOR THE PERCENTAGE OF STUDENTS THAT MET THE EXPECTED AVERAGE												

ELECTRICAL ENGINEERING MAJORS
SPRING 2021 SEMESTER

Report Prepared by: Dr. John O. Attia
Report Date: May 20, 2021

[illegible]

**END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 3023-Z01 SIGNALS AND SYSTEMS**

**COMPUTER ENGINEERING MAJORS
SPRING 2021 SEMESTER**

**Report Prepared by: Dr. John O. Attia
Report Date: May 20, 2021**

THERE WERE NO STUDENTS WITH MAJOR IN COMPUTER ENGINEERING

**END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 3023-Z01 SIGNALS AND SYSTEMS**

**ELECTRICAL ENGINEERING MAJORS
FALL 2020 SEMESTER**

Report Prepared by: Dr. John O. Attia

Report Date: December 21, 2020

Semester	Analysis Type	Number of Students	Outcome 1 an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics.			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2020	Direct	9	70	70	79	100
Spring 2020	Direct	9	70	70	92	100
Spring 2019	Direct	18	70	70	91	100
Implementation Summary	Items implemented from previous report or after meeting previous instructor	The following plans were implemented during the fall 2020 semester: (i) require all the students to follow the format for writing the project report, (ii) go through the project in detail with regard to what is needed to be completed for the project success, (iii) instruct the students on aspects of writing good project report.				
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them	The outcome was satisfied. However, the students could done better in the report : (i) if they properly obtained the transfer function of the unknown system. (ii) if they obtain the center frequency and 3-dB frequencies from MATLAB plots, (iii) if they properly determined the circuits that will realize the transfer function.				
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas	The following plans will be implemented the next time the course is taught: (i) instruct the students how to obtain transfer function from the magnitude plot (ii) teach the students how to obtain resonant frequency and cut-off frequencies from MATLAB magnitude response plots (iii) Discuss with the students some circuits that may be used to realize the system function.				
Overall Trend over Periods	Ascertain if there were improvements over previous semesters	The outcome data obtained during the spring 2019 semester was 91%. The result obtained in the 2020 spring semester was 92, but the outcome average score for the fall 2020 semester is 79. This value is lower than the two previous values. Several problems were identified this semester, which will be rectified during the next time the course is taught.				
Were Expectations Met?		YES				

**END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 3023-Z01 SIGNALS AND SYSTEMS**

**COMPUTER ENGINEERING MAJORS
FALL 2020 SEMESTER**

**Report Prepared by: Dr. John O. Attia
Report Date: December 21, 2020**

Semester	Analysis Type	Number of Students	Outcome 1 an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics.			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2020	Direct	2	70	70	82	82
Spring 2020	Direct	4	70	70	91	100
Spring 2019	Direct	6	70	70	81	100
Implementation Summary	Items implemented from previous report or after meeting previous instructor		The following plans were implemented during the fall 2020 semester: (i) require all the students to follow the format for writing the project report, (ii) go through the project in detail with regard to what is needed to be completed for the project success, (iii) instruct the students on aspects of writing good project report.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them		The outcome was satisfied. However, the students could done better in the report : (i) if they properly obtained the transfer function of the unknown system. (ii) if they obtain the center frequency and 3-dB frequencies from MATLAB plots, (iii) if they properly determined the circuits that will realize the transfer function.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas		The following plans will be implemented the next time the course is taught: (i) instruct the students how to obtain transfer function from the magnitude plot (ii) teach the students how to obtain resonant frequency and cut-off frequencies from MATLAB magnitude response plots (iii) Discuss with the students some circuits that may be used to realize the system function.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters		The outcome data obtained during the spring 2019 semester was 91%. The result obtained in the 2020 spring semester was 92, but the outcome average score for the fall 2020 semester is 82. This value is lower than the two previous values. Several problems were identified this semester, which will be rectified during the next time the course is taught.			
Were Expectations Met?			YES			

**SIGNALS AND SYSTEMS
FALL 2021**

Title of Assignment: EXAM 1

TOPICS COVERED IN EXAM 1

Test 1 covered the following topics:

1. Signal transformation and translation
2. Unit impulse sequences
3. Causal and memoryless systems
4. Convolution (continuous-time and discrete-time)

SIGNALS AND SYSTEMS
FALL 2021

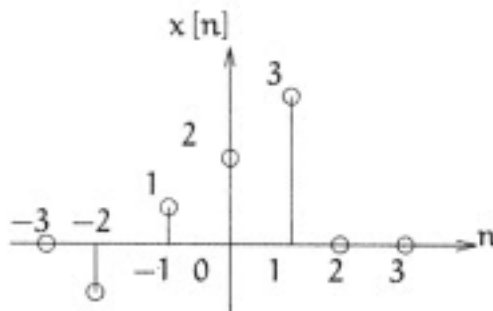
SAMPLE TEST QUESTIONS, SOLUTION,
AND GRADING SCHEME FOR EXAM #1

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS / FALL 2021
EXAM #1

Name: _____

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (14 points) Express the signal $x[n]$, shown below, in terms of unit impulse sequences



$x[n] =$ _____

2. (16 points) the following integrals:

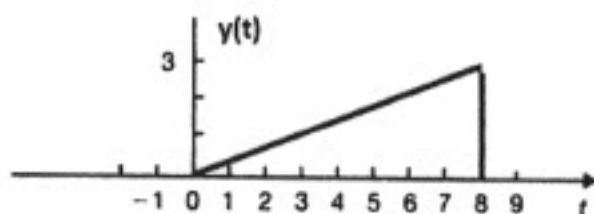
(a) $A = \int_{-\infty}^{\infty} (t^2 + 2t + 2)\delta(t - 2)dt$

$A =$ _____

(b) $B = \int_3^{\infty} \left[\sin\left(t + \frac{\pi}{3}\right) \right] \delta(t) dt$

$B =$ _____

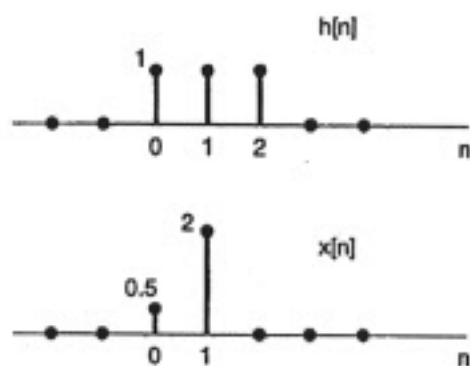
3. (20 points) Given signal $y(t)$ shown below:



(a) Sketch $y(2t)$. Do label the x-axis and y-axis.

(b) Sketch $y(-2t+4)$. Do label the x-axis and y-axis.

4. (25 points) The convolution of $x[n]$ and $h[n]$ is given as $y[n] = x[n] * h[n]$. For $x[n]$ and $h[n]$ shown below, determine $y[n]$:



5. (25 points) Find the convolution of $x(t)$ and $h(t)$, that is $y(t) = x(t) * h(t)$, where $x(t)$ and $h(t)$ are given as $x(t) = u(t) - u(t - 4)$ and $h(t) = e^{-t}u(t)$

ABOVE AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS / FALL 2021
EXAM #1

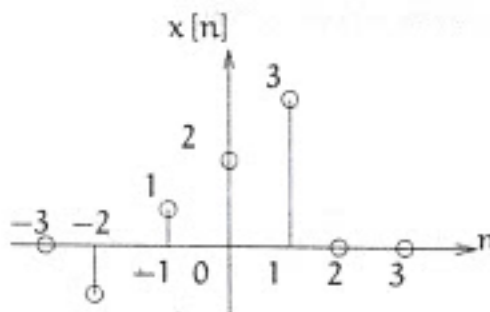
Name: Nasir Rafe

88
+10
98%
Excellent Works

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (14 points) Express the signal $x[n]$, shown below, in terms of unit impulse sequences

14



$$x[n] = 0\delta[n+3] - 1\delta[n+2] + 1\delta[n+1] + 2\delta[n] + 3\delta[n-1] + 0\delta[n-2] + 0\delta[n-3]$$

2. (16 points) the following integrals:

(a) $A = \int_{-\infty}^{\infty} (t^2 + 2t + 2)\delta(t-2)dt$

$$t^2 + 2t + 2 \Big|_{t=2} \rightarrow \frac{4+4+2}{=10}$$

16

A = 10

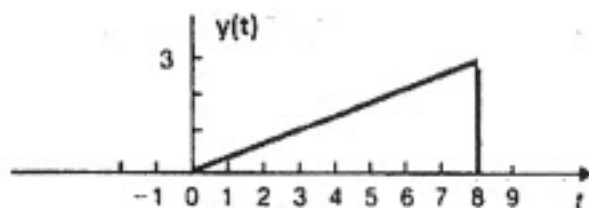
(b) $B = \int_1^{\infty} \left[\sin\left(t + \frac{\pi}{3}\right) \right] \delta(t) dt$

$t=0$

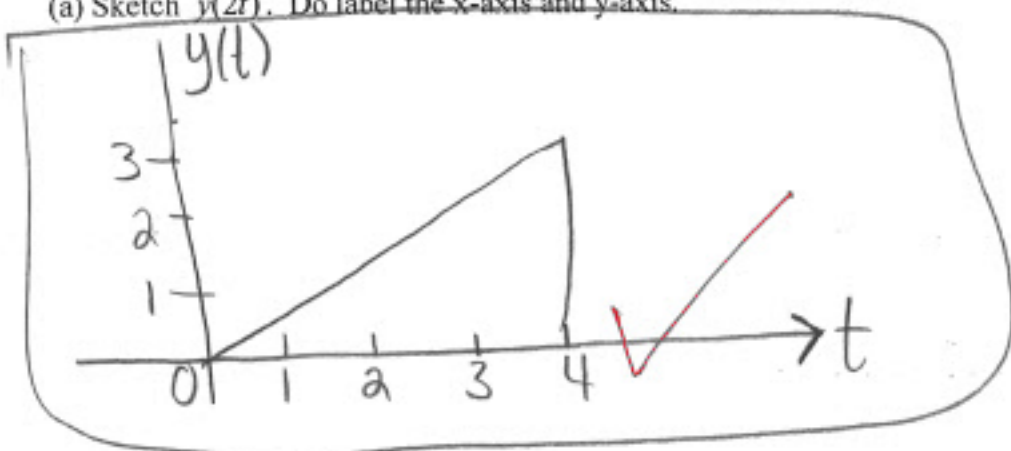
B = 0

3. (20 points) Given signal $y(t)$ shown below:

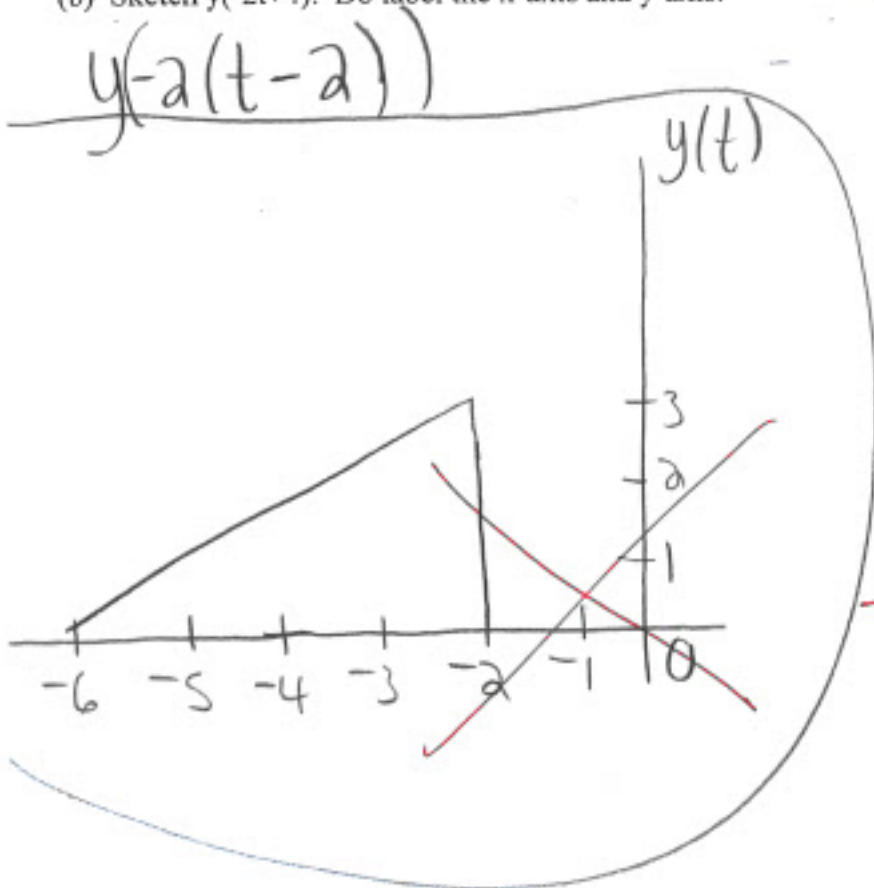
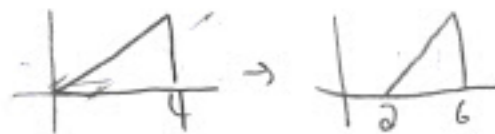
(10)



(a) Sketch $y(2t)$. Do label the x-axis and y-axis.



(b) Sketch $y(-2t+4)$. Do label the x-axis and y-axis.



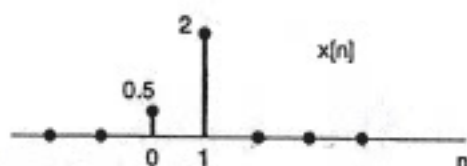
10

4. (25 points) The convolution of $x[n]$ and $h[n]$ is given as $y[n] = x[n] * h[n]$. For $x[n]$ and $h[n]$ shown below, determine $y[n]$:

$$h[n] = \delta[n] + \delta[n-1] + \delta[n-2]$$



$$x[n] = 0.5\delta[n] + 2\delta[n-1]$$



$$y[n] = x[n] * h[n]$$

$$= h[n] * x[n]$$

$$= h[n] * (0.5\delta[n] + 2\delta[n-1]) = 0.5h[n] + 2h[n-1]$$

$$0.5h[n] = 0.5\delta[n] + 0.5\delta[n-1] + 0.5\delta[n-2]$$

$$2h[n-1] = 2\delta[n-1] + 2\delta[n-2] + 2\delta[n-3]$$

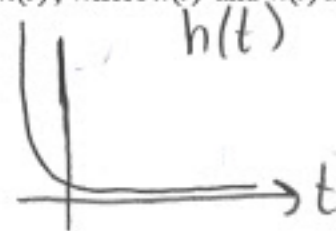
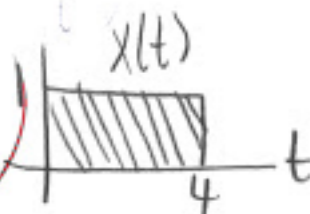
$$y[n] = 0.5\delta[n] + 2.5\delta[n-1] + 2.5\delta[n-2] + 2\delta[n-3]$$

5. (25 points) Find the convolution of $x(t)$ and $h(t)$, that is $y(t) = x(t) * h(t)$, where $x(t)$ and $h(t)$ are given as $x(t) = u(t) - u(t-4)$ and $h(t) = e^{-t}u(t)$

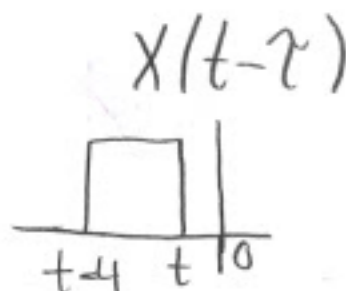
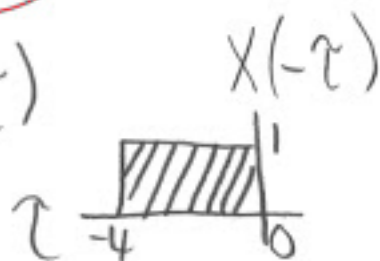
$$x(t) = u(t) - u(t-4)$$

$$h(t) = e^{-t}u(t)$$

23



$$y(t) = h(\tau) * x(t-\tau)$$



$$0 < t < 4$$

$$\int_0^t e^{-\tau} d\tau \rightarrow -e^{-\tau} \Big|_0^t \rightarrow -e^{-t} + e^0 = -e^{-t} + 1$$

$$t > 4$$

$$\int_{t-4}^t e^{-\tau} d\tau \rightarrow -e^{-\tau} \Big|_{t-4}^t \rightarrow -e^{-t} + e^{-(t-4)} = -e^{-t} + e^{-t+4}$$

$$y(t) = -2$$



AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS / FALL 2021
EXAM #1

Name: Xavier Dukes

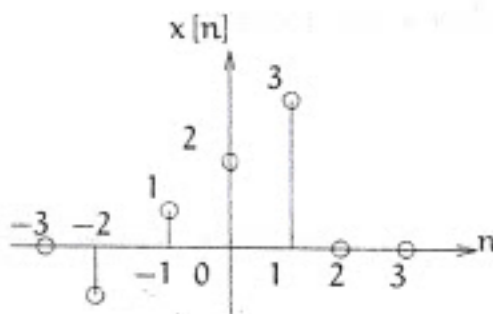
53
+10

63%

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (14 points) Express the signal $x[n]$, shown below, in terms of unit impulse sequences

14



$$x[n] = -\delta[n+2] + \delta[n+1] + 2\delta[n] + 3\delta[n-1]$$

2. (16 points) the following integrals:

(a) $A = \int_{-\infty}^{\infty} (t^2 + 2t + 2)\delta(t-2)dt$ $t^2 + 2t + 2 \big|_{t=2} \rightarrow 2^2 + 2(2) + 2 = 10$

16

$A = 10$

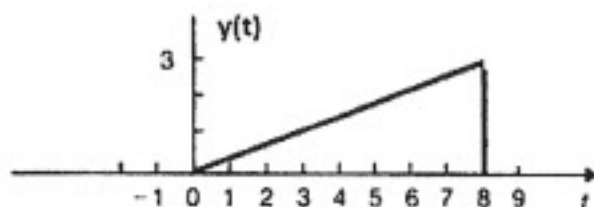
(b) $B = \int_3^{\infty} \left[\sin\left(t + \frac{\pi}{3}\right) \right] \delta(t) dt$

$\int_3^{\infty} \sin\left(t + \frac{\pi}{3}\right) \big|_{t=0}$

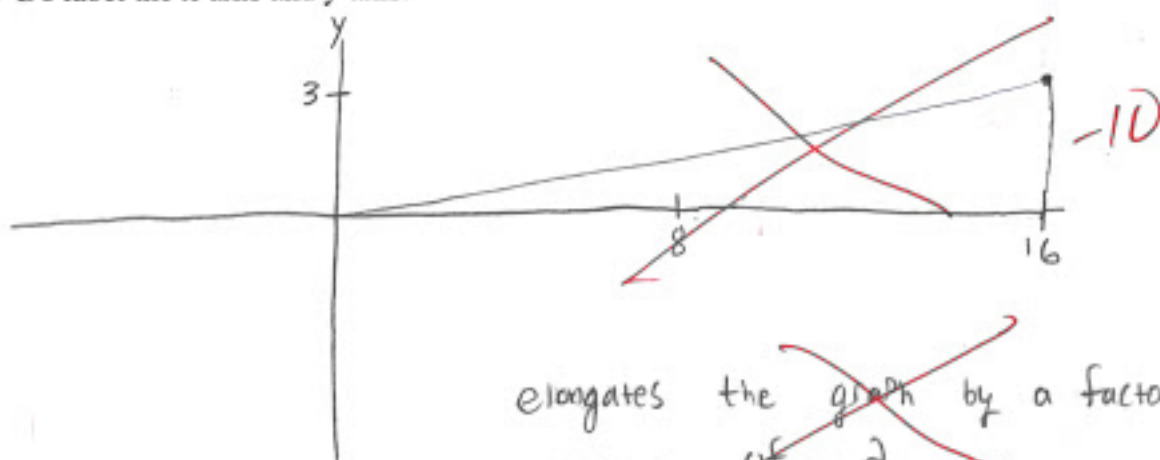
$B = 0$ because impulse is not in interval

3. (20 points) Given signal $y(t)$ shown below:

(0)



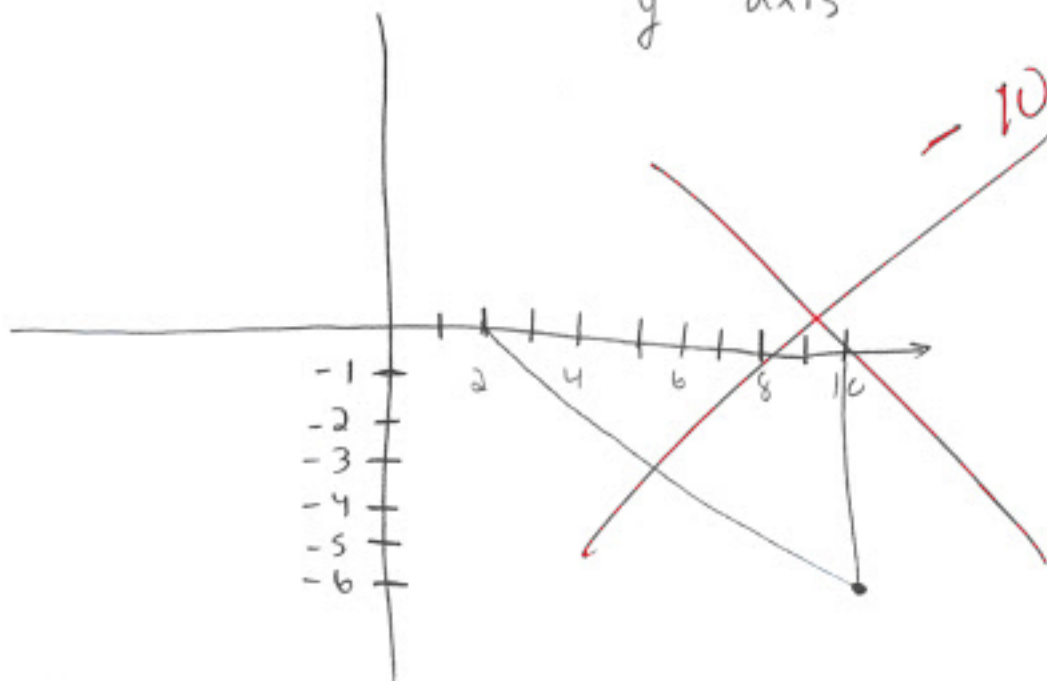
(a) Sketch $y(2t)$. Do label the x-axis and y-axis.



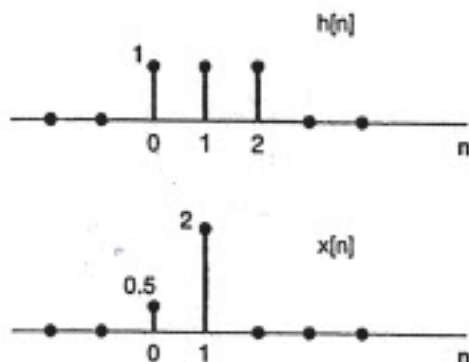
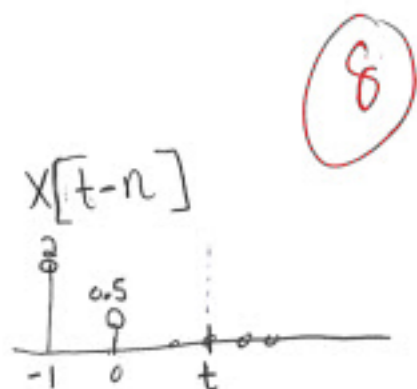
(b) Sketch $y(-2t+4)$. Do label the x-axis and y-axis.

$$y(-2t+4) = y(-2(t-2)) \rightarrow -2(y(t-2))$$

Stretches vertically $\frac{1}{2}$, flips over y axis



4. (25 points) The convolution of $x[n]$ and $h[n]$ is given as $y[n] = x[n] * h[n]$. For $x[n]$ and $h[n]$ shown below, determine $y[n]$:



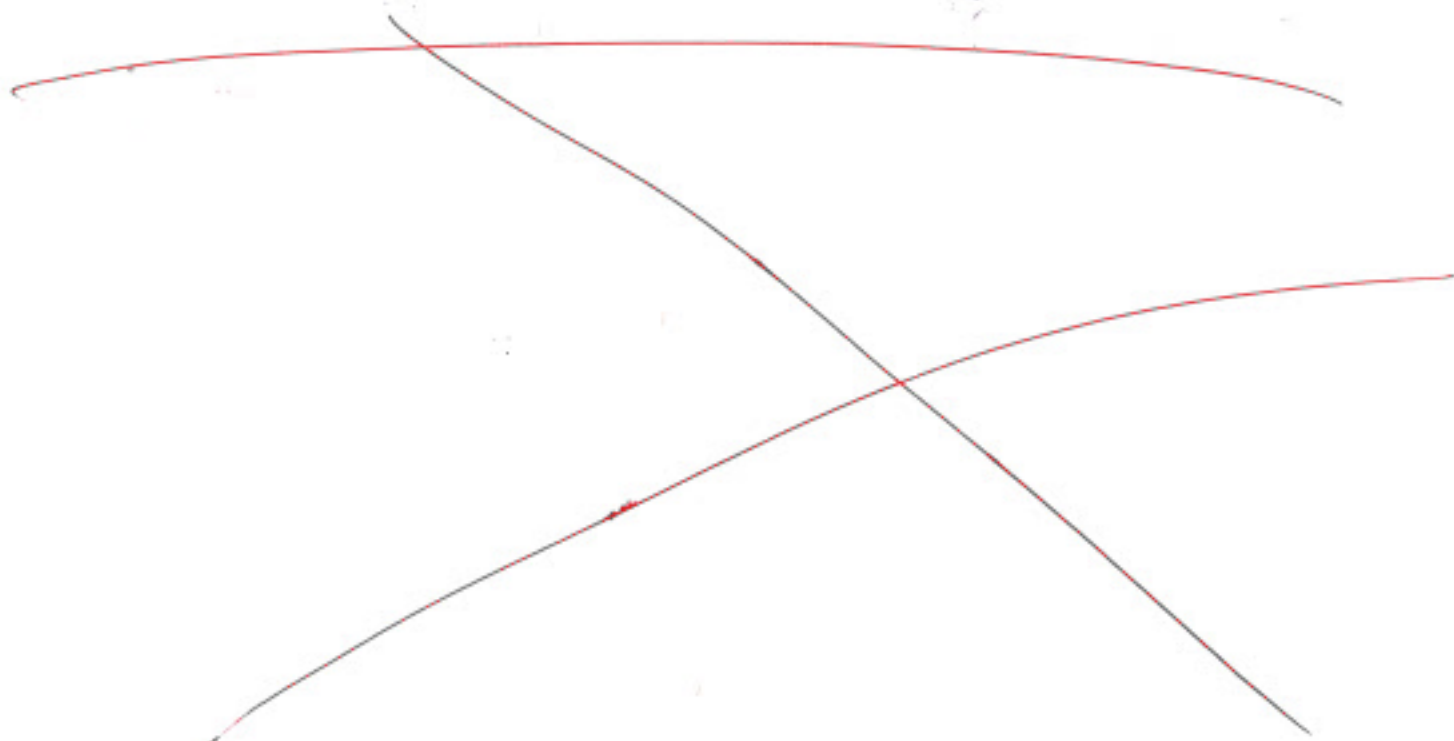
-17

$$y[n] = \{x[n] + h[n]\} = \{1 + 0.5, 1 + 0.5 + 2, 1 + 0.5 + 2\}$$

$$\star \{3.5, 3.5, 1.5\}$$

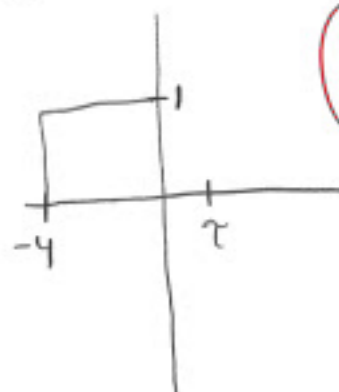
$$h[n] = \{1, 1, 1\}$$

$$x[n] = \{0.5, 2\}$$

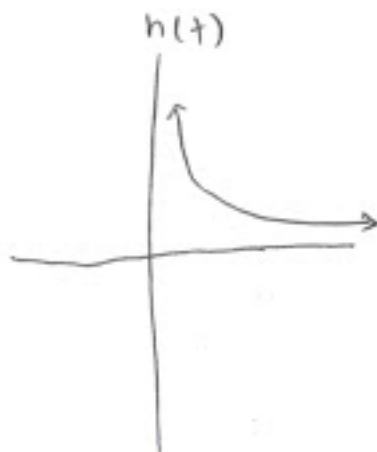


5. (25 points) Find the convolution of $x(t)$ and $h(t)$, that is $y(t) = x(t) * h(t)$, where $x(t)$ and $h(t)$ are given as $x(t) = u(t) - u(t-4)$ and $h(t) = e^{-t}u(t)$

$$x(t) \rightarrow x(\tau - t)$$



15



Partial overlap

$$0 < t < 4$$

$$\int_0^t (1) \cdot e^{-\tau} d\tau \rightarrow \cancel{e^{-\tau}} \Big|_0^t \rightarrow \cancel{te^{-t} - t} \rightarrow \boxed{t(e^{-t} - 1)}$$

~~-5~~

full overlap

$$t > 4$$

$$\int_{t-4}^t (1) \cdot e^{-\tau} d\tau \rightarrow \cancel{e^{-\tau}} \Big|_{t-4}^t \rightarrow \cancel{te^{-t} - te^{-(t-4)}} \rightarrow \boxed{4e^{-t}}$$

~~-5~~

BELOW AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS / FALL 2021
EXAM #1

36%

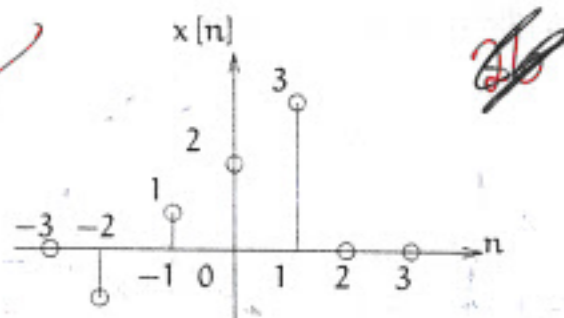
Name: John Owen

26
+ 10

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (14 points) Express the signal $x[n]$, shown below, in terms of unit impulse sequences

~~(Circled 'C' and a large 'X' over the area)~~

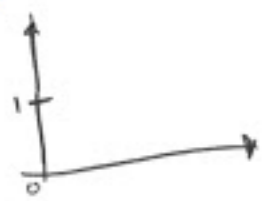
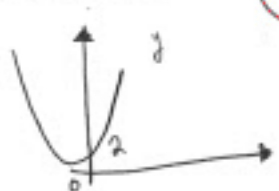


$x[n] = -(\cancel{5n-1}) + (\cancel{3n+1}) - (\cancel{n+3})$ 14

2. (16 points) the following integrals:

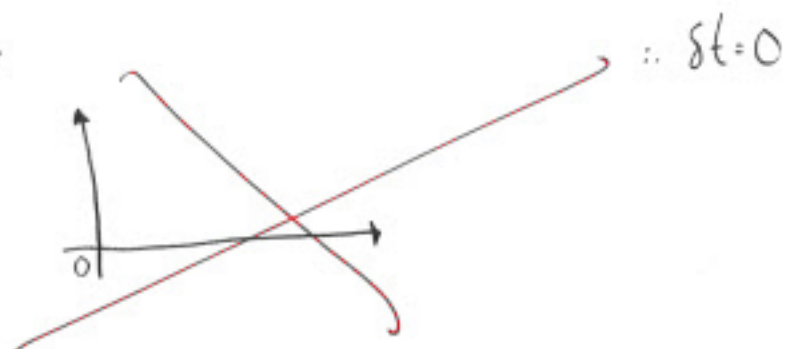
(8)

(a) $A = \int_{-\infty}^{\infty} (t^2 + 2t + 2)\delta(t-2)dt$



$A = 10$ ✓

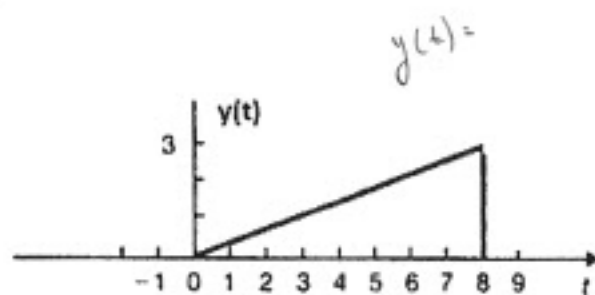
(b) $B = \int_1^{\infty} \left[\sin\left(t + \frac{\pi}{3}\right) \right] \delta(t) dt$



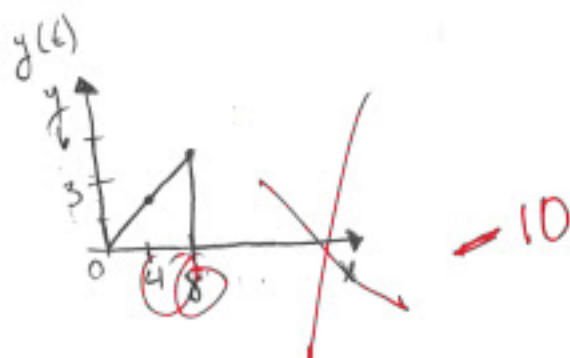
$B = 0$

3. (20 points) Given signal $y(t)$ shown below:

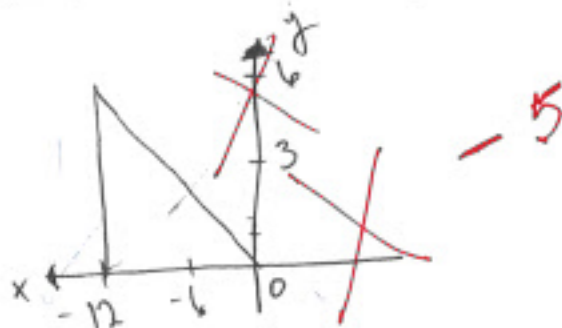
5



(a) Sketch $y(2t)$. Do label the x-axis and y-axis.



(b) Sketch $y(-2t+4)$. Do label the x-axis and y-axis.

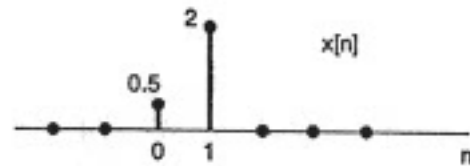
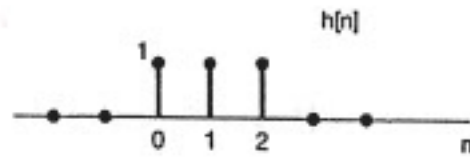


4. (25 points) The convolution of $x[n]$ and $h[n]$ is given as $y[n] = x[n] * h[n]$. For $x[n]$ and $h[n]$ shown below, determine $y[n]$:

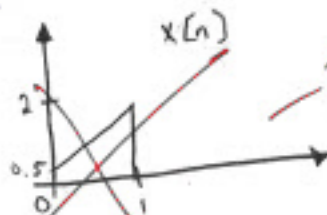
$$h[n] = u[n] - u[n-2]$$

$$x[n] = (n-0.5) - (n-2)$$

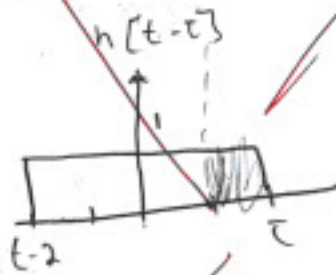
(4)



$$y[n] = x[n] * h[n]$$



-21



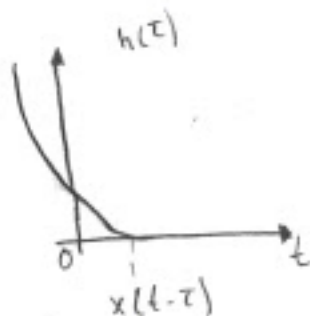
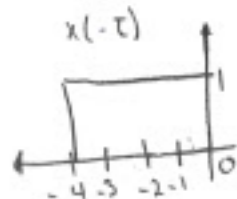
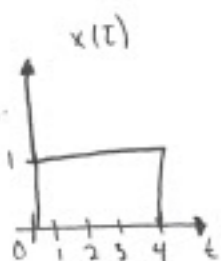
$$\int_{-\infty}^{\infty} x[t-\tau] h[t] d\tau$$

5. (25 points) Find the convolution of $x(t)$ and $h(t)$, that is $y(t) = x(t) * h(t)$, where $x(t)$ and $h(t)$ are given as $x(t) = u(t) - u(t-4)$ and $h(t) = e^{-t}u(t)$

Given: $x(t) = u(t) - u(t-4)$
 $h(t) = e^{-t}u(t)$

(9)

$$y(t) = x(t) * h(t) = \int_{-\infty}^{\infty} h(\tau) x(t-\tau) d\tau$$



$t < 0, y(t) = 0$

for what range

$$\int_0^t e^{-\tau} (1) d\tau = \int_0^t \frac{e^{-\tau}}{-1} = e^{-\tau} \Big|_0^t$$

$$y(t) = e^{-t} + e^0 = \boxed{e^{-t} + 1} \quad \times -4$$

$$y(x) = \begin{cases} \cancel{t-4} & 0 < t \\ e^{-t} + 1 & \end{cases}$$

$t > 4, y(t) = ?$

~~-10~~
-12

**SIGNALS AND SYSTEMS
FALL 2021**

Title of Assignment: EXAM #2

TOPICS COVERED IN EXAM #2

- 1. Stability of system from transfer function**
- 2. Transfer function from system block diagram**
- 3. Solution of linear differential equation with Laplace transform**
- 4. Response of a system using Laplace transform techniques**

**SIGNALS AND SYSTEMS
FALL 2021**

**SAMPLE QUIZ QUESTIONS, SOLUTION,
AND GRADING SCHEME FOR EXAM #2**

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3023-P02 SIGNALS AND SYSTEMS
FALL 2021 / EXAM #2

Name: JOHN ATTIA (KEY)

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (10 points) Determine whether the system with the following transfer function is stable.

$$H_1(s) = \frac{s+2}{s^2+4s-5} = \frac{N(s)}{D(s)}$$

$$D(s) = s^2 + 4s - 5 = (s+5)(s-1) = 0, \quad s = -5, +1$$

$$p_1 = -5, \quad p_2 = 1$$

There is a pole in the RHP ($p_2 = 1$) $\Rightarrow$ system is unstable

$H_1(s)$ is unstable

- 2 (10 points) Given $X(s) = \frac{2s+4}{(s+3)(s+6)}$, determine the initial value of $x(t)$ whose Laplace transform is $X(s)$.

$$x(0) = \lim_{s \rightarrow \infty} sX(s) = \frac{s(2s+4)}{(s+3)(s+6)} = \frac{2s^2 + 4s}{s^2 + 9s + 18}$$

$$= \lim_{s \rightarrow \infty} \frac{2s^2 + 4s}{s^2 + 9s + 18} \cdot \frac{1/s^2}{1/s^2} = \frac{2 + 4/s}{1 + 9/s + 18/s^2}$$

$$= \frac{2}{1} = 2$$

$$X(s) = \frac{2s+4}{(s+3)(s+6)} = \frac{A}{s+3} + \frac{B}{s+6}, \quad A = (s+3)X(s)|_{s=-3} = \frac{2s+4}{s+6}|_{s=-3} = -\frac{2}{3}$$

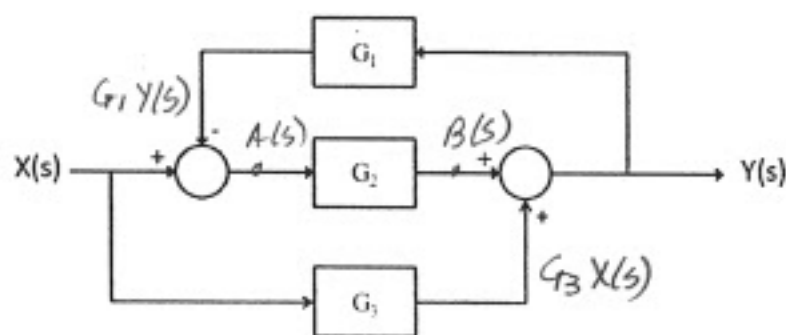
$$B = (s+6)X(s)|_{s=-6} = \frac{2s+4}{(s+3)}|_{s=-6} = \frac{-12+4}{-3} = -\frac{8}{-3} = \frac{8}{3}$$

$$X(s) = \frac{-2/3}{s+3} + \frac{8/3}{s+6} \Rightarrow x(t) = \left[-\frac{2}{3}e^{-3t} + \frac{8}{3}e^{-6t} \right] u(t)$$

$x(0) =$ _____

$$x(0) = -\frac{2}{3} + \frac{8}{3} = \frac{6}{3} = 2$$

3. (20 points) Determine the transfer function, $H(s) = \frac{Y(s)}{X(s)}$, for the system shown below.



$$A(s) = X(s) - G_1 Y(s)$$

$$B(s) = G_2 A(s) = G_2 X(s) - G_1 G_2 Y(s)$$

$$Y(s) = B(s) + G_3 X(s)$$

$$= G_2 X(s) - G_1 G_2 Y(s) + G_3 X(s)$$

$$Y(s) + G_1 G_2 Y(s) = G_2 X(s) + G_3 X(s)$$

$$Y(s) [1 + G_1 G_2] = X(s) [G_2 + G_3]$$

$$\frac{Y(s)}{X(s)} = H(s) = \frac{G_2 + G_3}{1 + G_1 G_2}$$

$$H(s) = \underline{\hspace{2cm}}$$

4. (20 points) The current through a series RLC circuit is given as:

$$\frac{d^2 i(t)}{dt^2} + 6 \frac{di(t)}{dt} + 5i(t) = 10u(t)$$

Assuming zero initial conditions, find $i(t)$.

Taking the Laplace transform
we have

$$s^2 I(s) + 6s I(s) + 5I(s) = \frac{10}{s}$$

$$I(s)(s^2 + 6s + 5) = \frac{10}{s}$$

$$I(s) = \frac{10}{s(s^2 + 6s + 5)} = \frac{10}{s(s+1)(s+5)}$$

$$= \frac{A}{s} + \frac{B}{s+1} + \frac{C}{s+5}$$

Using the Residue method

$$A = sI(s) \Big|_{s=0} = \frac{10}{(s+1)(s+5)} \Big|_{s=0} = \frac{10}{5}$$
$$= 2$$

$$B = (s+1)I(s) \Big|_{s=-1} = \frac{10}{s(s+5)} \Big|_{s=-1}$$
$$= \frac{10}{(-1)(4)} = -2.5$$

$$C = (s+5)I(s) \Big|_{s=-5} = \frac{10}{s(s+1)} \Big|_{s=-5}$$
$$= \frac{10}{(-5)(-4)} = \frac{10}{20} = 0.5$$

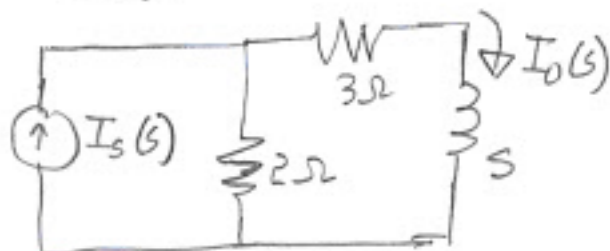
$$I(s) = \frac{2}{s} + \frac{-2.5}{s+1} + \frac{0.5}{s+5}$$

Using the table of Laplace transform
pairs

$$i(t) = [2 - 2.5e^{-t} + 0.5e^{-5t}]u(t)$$

5. (20 points) In the circuit shown below, $R1 = 2 \text{ Ohms}$, $R2 = 3 \text{ Ohms}$, and $L1 = 1 \text{ H}$. Use Laplace transform to find the current $i_o(t)$ if $i_s(t) = 3e^{-2t}u(t) \text{ A}$.

In the s -domain, we have



Using current division

$$I_0(s) = \frac{I_s(2)}{2+3+s} = \frac{2I_s}{s+5}$$

$$I_s(s) = \frac{3}{s+2}$$

Thus

$$I_0(s) = \left(\frac{2}{s+5}\right)\left(\frac{3}{s+2}\right) = \frac{6}{(s+2)(s+5)}$$

$$I_0(s) = \frac{A}{s+2} + \frac{B}{s+5}$$

Using the Residue method

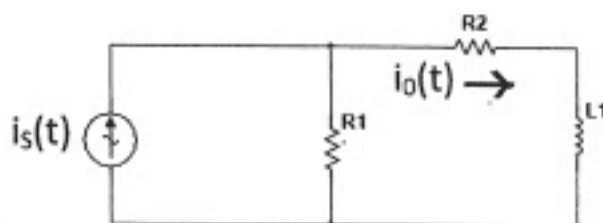
$$A = (s+2)I_0(s) = \frac{6}{s+5} \Big|_{s=-2} = \frac{6}{3} = 2$$

$$B = (s+5)I_0(s) \Big|_{s=-5} = \frac{6}{s+2} \Big|_{s=-5} = \frac{6}{-3} = -2$$

$$I_0(s) = \frac{2}{s+2} - \frac{2}{s+5}$$

$$i_o(t) = 2[e^{-2t} - e^{-5t}]u(t)$$

$$i_o(t) = \underline{\hspace{2cm}}$$



ABOVE AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3023-P02 SIGNALS AND SYSTEMS
FALL 2021 / EXAM #2

Name: John Owens

74 + 93
80 + 5

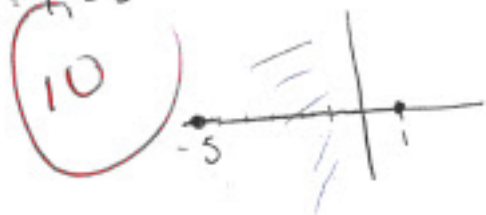
98%

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (10 points) Determine whether the system with the following transfer function is stable.

$$H_1(s) = \frac{s+2}{s^2+4s-5} = \frac{s+2}{(s-1)(s+5)}$$

Poles: $s = -5$



Have to fall on the left side of the y axis to be considered stable

$H_1(s)$ is Unstable

2 (10 points) Given $X(s) = \frac{2s+4}{(s+3)(s+6)}$, determine the initial value of $x(t)$ whose Laplace transform is $X(s)$.

$$X(s) = \frac{2s+4}{(s+3)(s+6)} = \frac{A}{(s+3)} + \frac{B}{(s+6)}$$

5

$$\therefore e^{-at} \rightarrow \frac{1}{s+a}$$

$$A = \frac{2s+4}{s+6} \Big|_{s=-3} = \frac{2(-3)+4}{(-3)+6} = -\frac{2}{3}$$

$$B = \frac{2s+4}{s+3} \Big|_{s=-6} = \frac{2(-6)+4}{(-6)+3} = -\frac{8}{3}$$

$$-\frac{2}{3} + \frac{0}{(s+6)} = -\frac{2}{3}$$

$$f(0) = \lim_{s \rightarrow \infty} F(s) = \lim_{s \rightarrow \infty} \frac{2s+4}{(s+3)(s+6)}$$

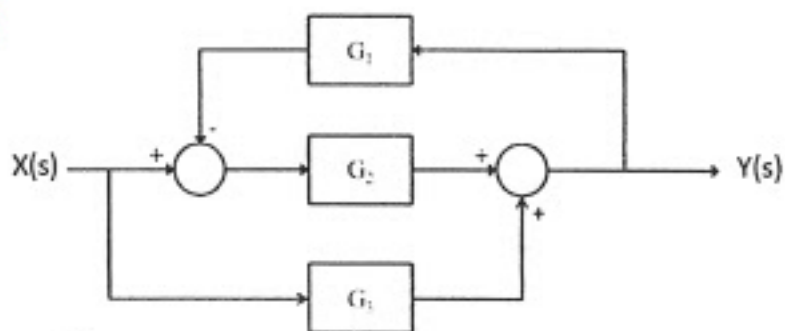
$$\lim_{s \rightarrow \infty} \left[\frac{2s+4}{(s+3)(s+6)} \right] = \frac{2s+4}{s^2+9s+6}$$

$$(10) \lim_{s \rightarrow \infty} = \frac{2(0)+4}{0^2+9(0)+6} = \frac{4}{6} = \frac{2}{3}$$

$x(0) =$ ~~$\frac{2}{3}$~~

3. (20 points) Determine the transfer function, $H(s) = \frac{Y(s)}{X(s)}$, for the system shown below.

20



Find $h(s) = y(s)$

Number of forward paths = 2

P_1 = path 1 forward path gain = h_2

P_2 = path 2 forward path gain = h_3

Number of loops = 1

Loop gain = $-h_1 h_2$

$$\Delta = 1 - (\text{loop gain}) = 1 - (-h_1 h_2) = 1 + h_1 h_2$$

As the loop touches both forward paths

$$\Delta_1 = 2$$

$$\Delta_2 = 1$$

The transfer function

$$\frac{Y(s)}{X(s)} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

$$\frac{Y(s)}{X(s)} = \frac{h_2 \cdot 2 + h_3 \cdot 1}{1 + h_1 h_2}$$

$$= \frac{h_2 + h_3}{1 + h_1 h_2}$$

$$H(s) = \frac{Y(s)}{X(s)} = \frac{h_2 + h_3}{1 + h_1 h_2}$$

4. (20 points) The current through a series RLC circuit is given as:

$$\frac{d^2 i(t)}{dt^2} + 6 \frac{di(t)}{dt} + 5i(t) = 10u(t) \quad (19) \quad \therefore (u(t)) = \frac{1}{s}$$

$$= \frac{10}{s}$$

Assuming zero initial conditions, find $i(t)$.

Using Laplace Transform Both sides

$$s^2 I(s) + 6s I(s) + 5 I(s) = \frac{10}{s}$$

$$I(s) [s^2 + 6s + 5] = \frac{10}{s}$$

$$= \frac{10}{s(s^2 + 6s + 5)} = \frac{10}{s(s+1)(s+5)}$$

$$\frac{A}{s} + \frac{B}{(s+1)} + \frac{C}{(s+5)}$$

$$A = \frac{10}{(s+1)(s+5)} \Big|_{s=0} = \frac{10}{(0+1)(0+5)} = \frac{10}{5} = 2$$

$$B = \frac{10}{s(s+5)} \Big|_{s=-1} = \frac{10}{(-1)(-1+5)} = \frac{10}{-4} = -\frac{5}{2}$$

$$C = \frac{10}{s(s+1)} \Big|_{s=-5} = \frac{10}{(-5)(-5+1)} = \frac{10}{20} = \frac{1}{2}$$

$$\frac{2}{s} + \frac{-\frac{5}{2}}{(s+1)} + \frac{\frac{1}{2}}{(s+5)}$$

$$\left\{ 2 - \frac{5}{2} e^{-t} + \frac{1}{2} e^{-5t} \right\} u(t)$$

5. (20 points) In the circuit shown below, $R_1 = 2 \text{ Ohms}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 1 \text{ H}$. Use Laplace transform to find the current $i_o(t)$ if $i_s(t) = 3e^{-2t}u(t) \text{ A}$.

Time Domain	s-Domain
R	R
L	sL
C	$\frac{1}{sC}$

$\therefore e^{-at} \rightarrow \frac{1}{s+a}$

$i_s(t) = 3e^{-2t}u(t) \text{ A}$

Laplace equivalent circuit

$I(s) = \frac{3}{s+2}$

Current Division Rule

$I_o(s) = \frac{2}{2+3+s} \times \frac{3}{s+2}$

$I_o(s) = \frac{2/s}{s+5} \times \frac{3}{s+2} = \frac{6}{(s+2)(s+5)}$

$\frac{A}{(s+2)} + \frac{B}{(s+5)}$

$A = \frac{6}{(s+5)} \Big|_{s=-2} = \frac{6}{(-2+5)} = \frac{6}{3} = 2$

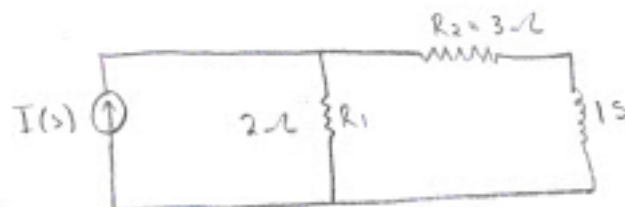
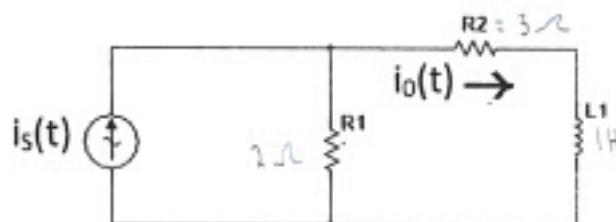
$B = \frac{6}{(s+2)} \Big|_{s=-5} = \frac{6}{(-5+2)} = \frac{6}{-3} = -2$

$\frac{2}{(s+2)} + \frac{-2}{(s+5)}$

$2e^{-2t} - 2e^{-5t}u(t)$

$i_o(t) = 2(e^{-2t} - e^{-5t})u(t)$

20



AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3023-P02 SIGNALS AND SYSTEMS
FALL 2021 / EXAM #2

Name: Xavier Dukes

59/80 + 74%
+ 5 = 79%

79%

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

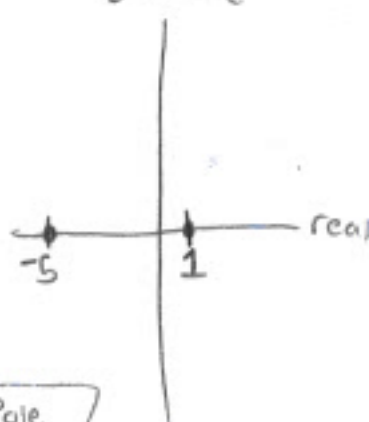
1. (10 points) Determine whether the system with the following transfer function is stable.

$$H_1(s) = \frac{s+2}{s^2+4s-5}$$

$$\frac{s+2}{(s+5)(s-1)}$$

Poles: $s = -5, 1$

S-Plane



Unstable

$H_1(s)$ is ~~M marginally~~ Stable as only one pole is in the right of the S-Plane & the other is not Imaginary

2 (10 points) Given $X(s) = \frac{2s+4}{(s+3)(s+6)}$, determine the initial value of $x(t)$ whose Laplace transform is $X(s)$.

$$\frac{2(s+2)}{(s+3)(s+6)} = \frac{A}{s+3} + \frac{B}{s+6} \rightarrow 5 A(s+6) + B(s+3) = 2(s+2)$$

when $s = -6$: $0 + B(-3) = 2(-4) \rightarrow B = \frac{8}{3}$

when $s = -3$: $A(3) + 0 = 2(5) = 10 \rightarrow A = \frac{10}{3}$

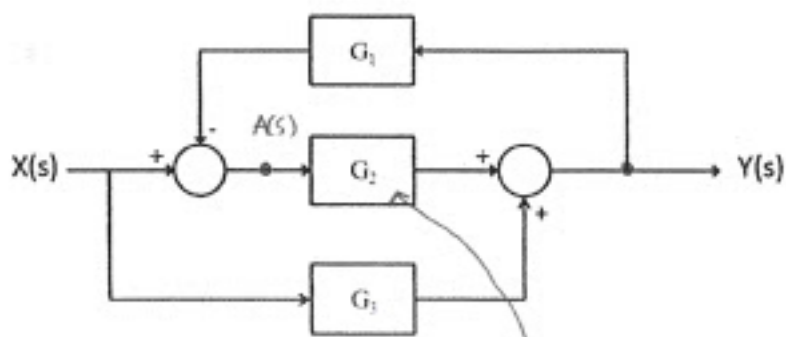
$$\left[\frac{10}{3} \frac{1}{s+3} + \frac{8}{3} \frac{1}{s+6} \right] = 2^{-1} [X(s)] = x(t) = \left[\frac{10}{3} e^{-3t} + \frac{8}{3} e^{-6t} \right] u(t) = x(t)$$

$x(0) =$ _____

$$x(0) = \frac{10}{3} + \frac{8}{3} = \frac{18}{3} = 6$$

3. (20 points) Determine the transfer function, $H(s) = \frac{Y(s)}{X(s)}$, for the system shown below.

15



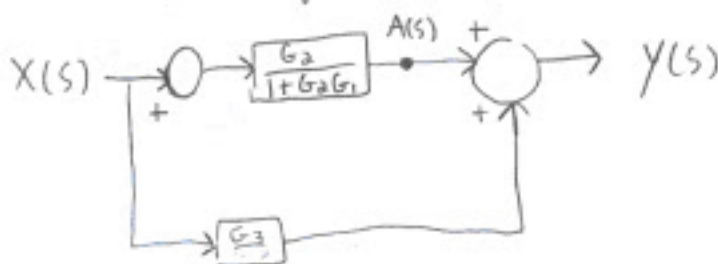
$$A(s) = \frac{G_2}{1 + G_1 G_2} X(s)$$

$$Y(s) = A(s) + X(s) G_3$$

G_2

$$1 + G_1 G_2$$

* Simplify block diagram *



$$X(s) = Y(s) - Y(s) G_1$$

$$Y(s) = A(s) G_2 + X(s) G_3$$

$$Y(s) = [X(s) - Y(s) G_1] G_2 + X(s) G_3 \rightarrow G_2 (X(s) - Y(s) G_1) + X(s) G_3$$

simplify -5

$$H(s) = \frac{G_2}{1 + G_1 G_2} + G_3$$

4. (20 points) The current through a series RLC circuit is given as:

$$\frac{d^2 i(t)}{dt^2} + 6 \frac{di(t)}{dt} + 5i(t) = 10u(t)$$

19

Assuming zero initial conditions, find $i(t)$.

$$s^2 \tilde{i}(s) - s i(0) - \dot{i}(0) + 6[s i(s) - i(0)] + 5 \tilde{i}(s)$$

$$i(0) = 0$$

$$\dot{i}(0) = 0$$

$$s^2 \tilde{i}(s) - 0 - 0 + 6[s i(s) - 0] + 5 \tilde{i}(s)$$

$$s^2 \tilde{i}(s) + 6 \tilde{i}(s) + 5 \tilde{i}(s) \rightarrow \tilde{i}(s) [s^2 + 6s + 5] = \frac{10}{s}$$

$$\frac{10}{s} \cdot \frac{1}{s^2 + 6s + 5} = \tilde{i}(s) \rightarrow \frac{10}{s(s+1)(s+5)} \rightarrow \frac{A}{s} + \frac{B}{s+1} + \frac{C}{s+5}$$

$$10 = A(s+1)(s+5) + B(s)(s+5) + C(s)(s+1)$$

$$\text{When } s=0: 10 = A(5)(1) + 0 + 0 \rightarrow A=2$$

$$\text{When } s=-1: 10 = 0 + B(-1)(4) + 0 \rightarrow B = -\frac{10}{4}$$

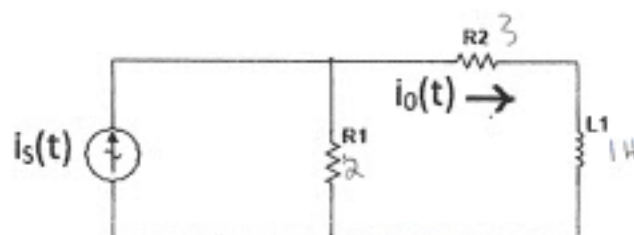
$$\text{When } s=-5: 10 = 0 + 0 + C(-4)(-5) \rightarrow C = \frac{1}{2}$$

-4

$$\mathcal{L}^{-1} \left[\frac{2}{s} + \frac{-10/4}{s+1} + \frac{1/2}{s+5} \right] \rightarrow 2u(t) - \frac{10}{4} e^{-t} u(t) + \frac{1}{2} e^{-5t} u(t)$$

5. (20 points) In the circuit shown below, $R_1 = 2 \text{ Ohms}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 1 \text{ H}$. Use Laplace transform to find the current $i_o(t)$ if $i_s(t) = 3e^{-2t}u(t) \text{ A}$.

(20)



$$I_s(s) = \frac{3}{s+2}$$

$$L_1 = 1 \cdot s = s$$

* Apply Current Divider

$$\frac{3}{s+2} \left(\frac{2\Omega}{2+3+s} \right) \rightarrow \frac{6}{(s+2)(s+5)} \rightarrow \frac{A}{s+2} + \frac{B}{s+5} = 6 = \hat{I}_o(s)$$

$$6 = A(s+5) + B(s+2)$$

When $s = -5$: $0 + B(-3) = 6 \rightarrow B = -2$

When $s = -2$: $A(3) + 0 = 6 \rightarrow A = 2$

$$\mathcal{L}^{-1} \left[\frac{2}{s+2} - \frac{2}{s+5} \right] = \mathcal{L}^{-1} [\hat{I}_o(s)] = I_o(t) = [2e^{-2t} - 2e^{-5t}]u(t) = \hat{I}_o$$

$$i_o(t) = [2e^{-2t} - 2e^{-5t}]u(t)$$

BELOW AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3023-P02 SIGNALS AND SYSTEMS
FALL 2021 / EXAM #2

Name: Breland Walker

$22 \frac{2}{3} \rightarrow 28\% + 5$

33%

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (10 points) Determine whether the system with the following transfer function is stable.

$H_1(s) = \frac{s+2}{s^2+4s-5}$ $H_1(s) = \frac{s+2}{s^2+4s-5} = \frac{s+2}{s^2+5s-s-5} = \frac{s+2}{s(s+5)-1(s+5)} =$
 $H_1(s) = \frac{s+2}{(s+5)(s-1)}$

stable or not stable
-10

$H_1(s)$ is $\frac{s+2}{(s+5)(s-1)}$

- 2 (10 points) Given $X(s) = \frac{2s+4}{(s+3)(s+6)}$, determine the initial value of $x(t)$ whose Laplace transform is $X(s)$.

$X(s) = \frac{2s+4}{(s+3)(s+6)}$ 0

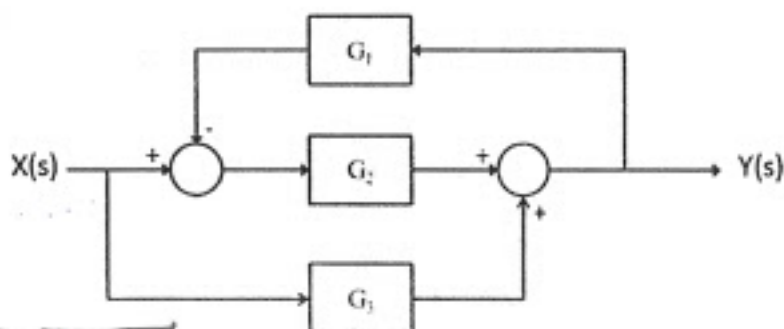
A
B
C

$x(0) =$ _____

-10

3. (20 points) Determine the transfer function, $H(s) = \frac{Y(s)}{X(s)}$, for the system shown below.

10



$$= \frac{P_1 + D_1 + P_2 + D_2}{1 - D}$$

$$D_1 = 1 - (0) = 1$$

$$D_2 = 1 - (0) = 1$$

$$D = 1 - (G_1 G_2 - G_1 G_3)$$

$$H(s) = \frac{G_2 + G_3}{1 + G_1 G_2 + G_1 G_3}$$

10

$$H(s) = \frac{G_2 + G_3}{1 + G_1 G_2 + G_1 G_3}$$

4. (20 points) The current through a series RLC circuit is given as:



$$\frac{d^2 i(t)}{dt^2} + 6 \frac{di(t)}{dt} + 5i(t) = 10u(t)$$

Assuming zero initial conditions, find $i(t)$.

$$\frac{d^2 i(t)}{dt^2} + 6 \frac{di(t)}{dt} + 5i(t) = 10u(t)$$

-20

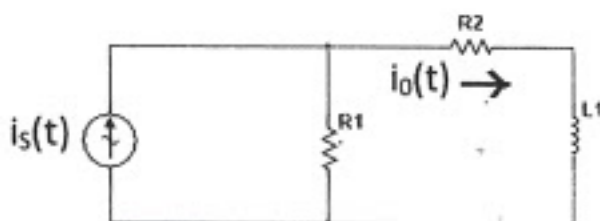
5. (20 points) In the circuit shown below, $R_1 = 2 \text{ Ohms}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 1 \text{ H}$. Use Laplace transform to find the current $i_o(t)$ if $i_s(t) = 3e^{-2t}u(t) \text{ A}$.

$$R_1 = 2 \Omega$$

$$R_2 = 3 \Omega$$

$$L_1 = 1 \text{ H}$$

(12)



$$i_s(t) = 3e^{-2t}u(t)$$

$$I_{os} = \frac{2}{2+3+s} \times \frac{3}{s+2} = \frac{6}{(s+1)(s+5)}$$

$$\frac{6}{(s+1)(s+5)} = \frac{A}{s+1} + \frac{B}{s+5}$$

$$6 = A(s+5) + B(s+1)$$

$$s = -1 \text{ in } \textcircled{1} = A = 1$$

$$s = -5 \text{ in } \textcircled{1} = B = 1$$

$$A = \frac{6}{s+5} \Big|_{s=-1} = 1$$

$$B = \frac{6}{s+1} \Big|_{s=-5} = -1$$

$$I_o(s) = \frac{1}{s+1} - \frac{1}{s+5}$$

$$i_o(t) = (e^{-t} - e^{-5t})u(t)$$

$$i_o(t) = (e^{-t} - e^{-5t})u(t)$$

**SIGNALS AND SYSTEMS
FALL 2021**

EXAM #3

TOPICS COVERED IN EXAM #3

- 1. Fourier Series**
- 2. Fourier transform**

**SIGNALS AND SYSTEMS
FALL 2021**

EXAM #3 QUESTIONS

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
EXAM #3 - FALL 2021

Name: JOHN ATTIA (KEY)

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (25 points) A periodic signal is given by $x(t) = \sum_{n=1}^{\infty} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \cos(600n\pi t)$

- (a) Compute the period T
- (b) Determine the fundamental frequency ω_0 .
- (c) Identify the Fourier series coefficients a_n .
- (d) Identify the Fourier series coefficients b_n .
- (e) Find the amplitude of the third harmonic.

$$x(t) = \sum_{n=1}^{\infty} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \cos(600n\pi t)$$

$$= \sum_{n=1}^{\infty} a_n \cos n\omega_0 t, \text{ with}$$

$$a_0 = 0, \text{ and } b_n = 0$$

$$n\omega_0 t = 600n\pi t$$

$$\omega_0 = 600\pi$$

$$a) \omega_0 = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega_0}$$

$$T = \frac{2\pi}{600\pi} = \frac{1}{300} \text{ s}$$

$$b) \omega_0 = 600\pi$$

$$(c) a_n = \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right)$$

$$(d) b_n = 0$$

$$(e) a_3 = \frac{2}{3} \cos^2\left(\frac{3\pi}{2}\right)$$

$$= \frac{2}{3} (0)^2 = 0$$

$$T = \frac{1}{300} \text{ s} = 3.33 \times 10^{-3}$$

$$\omega_0 = 600\pi \quad a_n = \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right)$$

$$b_n = 0$$

$$\text{magnitude of 3rd harmonic} = 0$$

5pts each

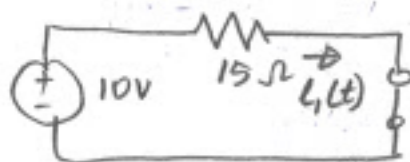
2. (25 points) For the circuit shown below, $R = 15 \text{ Ohms}$, $L = 10 \text{ mH}$. If the periodic signal $v_s(t)$ is given as:

$$V_s(t) = 10 + 5 \cos(500t + 30^\circ) + 2 \cos(1500t - 50^\circ) \text{ V}$$

(a) Determine the current $i(t)$ flowing through the resistor R , (b) determine the average power dissipated in the resistor R .

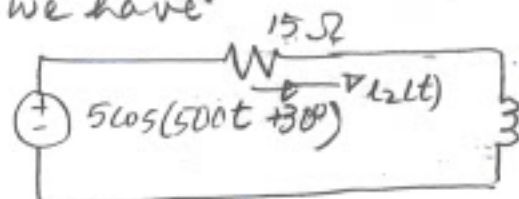
Using superposition, we have

(i) considering 10 V source, we have with $\omega = 0$



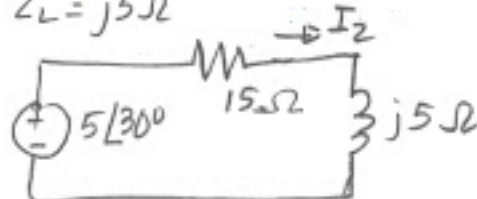
$$i_1(t) = 10/15 = 2/3 = 0.667 \text{ A}$$

(ii) considering the $5 \cos(500t + 30^\circ)$ we have



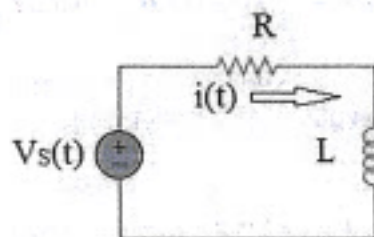
$$\omega = 500 \text{ rad/s}, Z_L = j\omega L = j(500)(10 \times 10^{-3})$$

$$Z_L = j5 \Omega$$

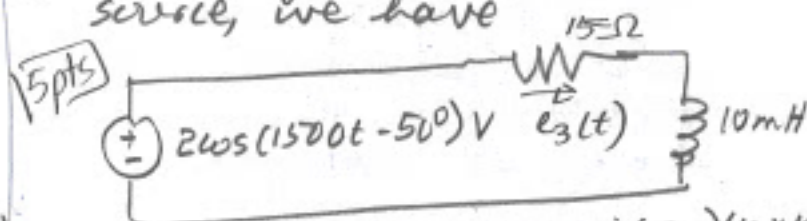


$$I_2 = \frac{5 \angle 30^\circ}{15 + j5} = 0.32 \angle 11.56^\circ$$

$$i_2(t) = 0.32 \cos(500t + 11.56^\circ) \text{ A}$$

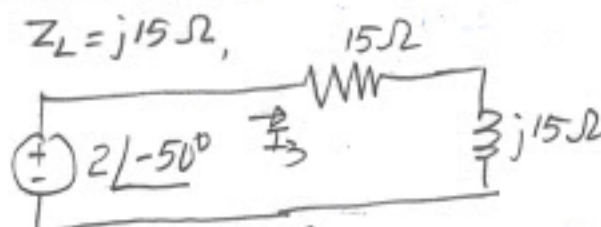


(iii) considering the $2 \cos(1500t - 50^\circ)$ V source, we have



$$\omega = 1500 \text{ rad/s}, Z_L = j\omega L = j(1500)(10 \times 10^{-3})$$

$$Z_L = j15 \Omega$$



$$I_3 = \frac{2 \angle -50^\circ}{15 + j15} = 0.09 \angle -95^\circ$$

$$i_3(t) = 0.09 \cos(1500t - 95^\circ)$$

Thus,

$$i(t) = i_1(t) + i_2(t) + i_3(t)$$

$$i(t) = 0.67 + 0.32 \cos(500t + 11.56^\circ) + 0.09 \cos(1500t - 95^\circ)$$

(3pts)

$$P = \left[(0.67)^2 + \left(\frac{0.32}{\sqrt{2}} \right)^2 + \left(\frac{0.09}{\sqrt{2}} \right)^2 \right] \times 15$$

$$= [0.445 + 0.0512 + 0.004] \times 15$$

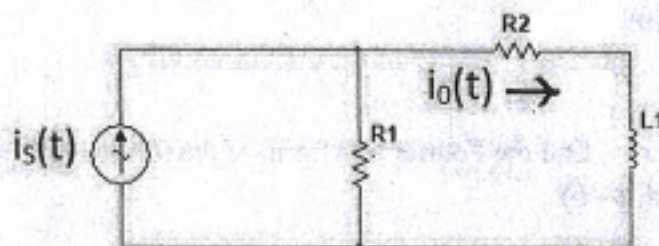
$$= 0.500 \times 15 = 7.5 \text{ W}$$

(7pts)

average power = _____

$$i(t) = 0.67 + 0.32 \cos(500t + 11.56^\circ) + 0.09 \cos(1500t - 95^\circ)$$

3. (25 points) In the circuit shown below, $R_1 = 1 \text{ Ohm}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 2 \text{ H}$, Find the current $i_o(t)$ if $i_s(t) = 3e^{-5t}u(t) \text{ A}$.



In the $j\omega$ -domain, we have



$$Z_L = j\omega L = j2\Omega$$

Using current division

$$I_o(\omega) = I_s(\omega) \frac{1}{1 + 3 + j2\omega}$$

$$I_o(\omega) = I_s(\omega) \frac{1}{4 + j2\omega}$$

$$I_s(\omega) = \frac{3}{j\omega + 5}$$

$$I_o(\omega) = \left(\frac{1}{4 + j2\omega} \right) \left(\frac{3}{j\omega + 5} \right)$$

$$= \frac{1.5}{(j\omega + 2)(j\omega + 5)}$$

$$I_o(s) = \frac{1.5}{(s+2)(s+5)} = \frac{A}{s+2} + \frac{B}{s+5}$$

$$A = I_o(s)(s+2) \Big|_{s=-2} = \frac{1.5}{(s+5)} \Big|_{s=-2}$$

$$A = \frac{1.5}{3} = 0.5$$

$$B = I_o(s)(s+5) \Big|_{s=-5} = \frac{1.5}{(s+2)} \Big|_{s=-5}$$

$$B = \frac{1.5}{-3} = -0.5$$

$$I_o(s) = \frac{0.5}{s+2} - \frac{0.5}{s+5}$$

$$I_o(\omega) = \frac{0.5}{j\omega + 2} - \frac{0.5}{j\omega + 5}$$

Using Table of Fourier transform

$$i_o(t) = 0.5[e^{-2t} - e^{-5t}]u(t)$$

[5pts]

$$i_o(t) = \underline{0.5[e^{-2t} - e^{-5t}]u(t)}$$

4. (25 points) A signal $x(t)$ has a Fourier transform given by

$$X(\omega) = \frac{(8 + j\omega)}{4 + 5j\omega - \omega^2}$$

Without finding $x(t)$, find the Fourier transform of the following:

(a) $x_1(t) = x(3t - 6)$

(b) $x_2(t) = e^{-j7t} x(t)$

(c) $x_3(t) = x(-t)$

a) $x_1(t) = x(3t - 6)$
 $= x[3(t - 2)]$

[9pts] Thus, we have time-shift of 2 and time-scaling of 3.

Thus,
 $X_1(\omega) = e^{-j\omega(2)} \times \frac{1}{3} X\left(\frac{\omega}{3}\right)$

$$X_1(\omega) = \frac{1}{3} e^{-j2\omega} \left[\frac{8 + j(\omega/3)}{4 + 5j(\omega/3) - (\omega/3)^2} \right]$$

(b) $x_2(t) = e^{-j7t} x(t)$

[8pts] This is frequency shifting property, where

$$e^{j\omega_0 t} x(t) \Rightarrow X(\omega - \omega_0)$$

$$X_2(\omega) = \frac{8 + j(\omega + 7)}{4 + 5j(\omega + 7) - (\omega + 7)^2}$$

(c) $x_3(t) = x(-t)$
 $= x[-1(t)]$

The time scaling property says

$$x(at) \Rightarrow \frac{1}{|a|} X\left(\frac{\omega}{a}\right),$$

$a = -1$
 $X_3(\omega) = \frac{1}{1} X(-\omega)$

$$X_3(\omega) = \frac{8 + j(-\omega)}{4 + 5j(-\omega) - (-\omega)^2}$$

$$= \frac{8 - j\omega}{4 - j5\omega - \omega^2}$$

[8pts]

$X_1(\omega) = \underline{\hspace{2cm}}$ $X_2(\omega) = \underline{\hspace{2cm}}$ $X_3(\omega) = \underline{\hspace{2cm}}$

ABOVE AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
EXAM #3 - FALL 2021

91+9 = 100%

Name: Ben Nguyen

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

23

1. (25 points) A periodic signal is given by $x(t) = \sum_{n=1}^{\infty} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \cos(600n\pi t)$

- (a) Compute the period T
- (b) Determine the fundamental frequency ω_0 .
- (c) Identify the Fourier series coefficients a_n .
- (d) Identify the Fourier series coefficients b_n .
- (e) Find the amplitude of the third harmonic.

• $\omega_0 = 600\pi$

• $T = \frac{2\pi}{\omega_0} = \frac{2\pi}{600\pi} = \frac{1}{300}$

$$x(t) = a_0 + \sum_{n=1}^N a_n \cos n\omega_0 t + \sum_{n=1}^N b_n \sin n\omega_0 t$$

• $a_n = \frac{2}{n} \cdot \cos^2\left(\frac{n\pi}{2}\right)$ ✓

• $b_n = 0$ ✓

• $x_3(t) = \frac{2}{3} \cdot \cos^2\left(\frac{3\pi}{2}\right) \cos(600 \cdot 3 \cdot \pi \cdot t)$

$x_3(t) = \frac{2}{3} \cdot \cos^2\left(\frac{3\pi}{2}\right) \cdot \cos(1800\pi t)$

$T = \frac{1}{300}$ ✓

$b_n = 0$ ✓

$\omega_0 = 600\pi$ ✓

$a_n = \frac{2}{n} \cdot \cos^2\left(\frac{n\pi}{2}\right)$

magnitude of 3rd harmonic = $\frac{2}{3} \cdot \cos^2\left(\frac{3\pi}{2}\right) \cdot \cos(1800\pi t)$
-2

2. (25 points) For the circuit shown below, $R = 15 \text{ Ohms}$, $L = 10 \text{ mH}$. If the periodic signal $v_s(t)$ is given as:

$$V_s(t) = 10 + 5 \cos(500t + 30^\circ) + 2 \cos(1500t - 50^\circ) \text{ V}$$

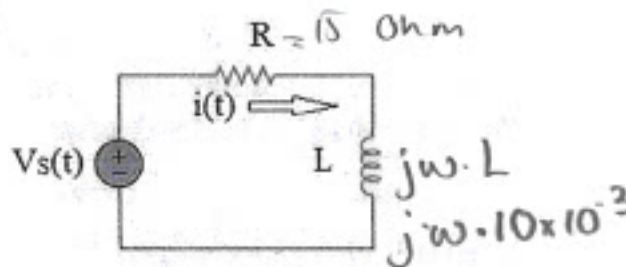
(a) Determine the current $i(t)$ flowing through the resistor R , (b) determine the average power dissipated in the resistor R .

$$\omega_0 = 500$$

$$i(t) = \frac{V_s}{R + X_L}$$

$$R + X_L = 15 + j\omega \cdot 10 \times 10^{-3} = 15 + 5j$$

$$18$$



$$i_1(t) = \frac{10}{15} = \frac{2}{3}$$

$$i_2(t) = \frac{5 \angle 30^\circ}{15 + 5j} = \frac{5 \angle 30^\circ}{15.81 \angle 18.4349^\circ} = 0.316 \cos(500t + 11.5651^\circ)$$

$$i_3(t) = \frac{2 \angle -50^\circ}{15 + 5j} = \frac{2 \angle -50^\circ}{15.81 \angle 18.4349^\circ} = 0.1265 \cos(1500t - 68.4349^\circ)$$

for $\omega = 500 \text{ rad/s}$

$$\rightarrow i(t) = \frac{2}{3} + 0.316 \cos(500t + 11.5651^\circ) + 0.1265 \cos(1500t - 68.4349^\circ) \text{ (A)}$$

$$P_{\text{avg}} = A_0^2 + \left(\frac{A_1}{\sqrt{2}}\right)^2 + \left(\frac{A_2}{\sqrt{2}}\right)^2$$

$$= \left[\left(\frac{2}{3}\right)^2 + \left(\frac{0.316}{\sqrt{2}}\right)^2 + \left(\frac{0.1265}{\sqrt{2}}\right)^2 \right] \times 15$$

$$= 114.5 \text{ (W)}$$

$$i(t) = \frac{2}{3} + 0.316 \cos(500t + 11.5651^\circ) + 0.1265 \cos(1500t - 68.4349^\circ) \text{ A}$$

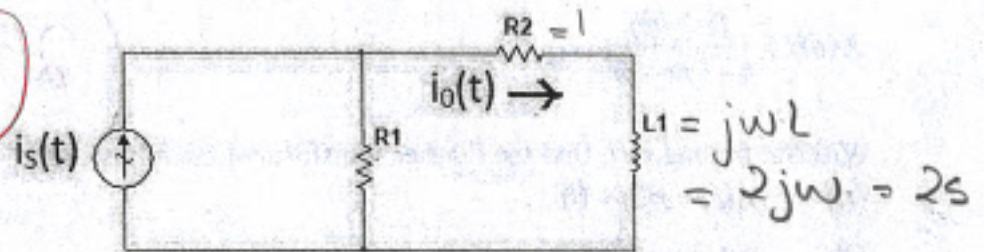
$$\text{average power} = 114.5 \text{ W}$$

$$\frac{1}{s} \cdot (s+2) = \frac{1}{s} \cdot \frac{1}{s+2}$$

3. (25 points) In the circuit shown below, $R_1 = 1 \text{ Ohm}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 2 \text{ H}$, Find the current $i_o(t)$ if $i_s(t) = 3e^{-5t}u(t) \text{ A}$.

$$I_s(j\omega) = \frac{3}{5+j\omega}$$

(25)



$$I_o(\omega) = \frac{I_s \cdot R_1}{R_1 + R_2 + X_L} = \frac{3 \cdot 1}{5+j\omega} \cdot \frac{1}{4+2j\omega} \quad (A)$$

$$s = j\omega \Rightarrow I_o(s) = \frac{3}{5+s} \cdot \frac{1}{s+2} = \frac{A}{5+s} + \frac{B}{s+2} \quad A.$$

$$A = (5+s) \cdot I_o(s) \Big|_{s=-5} = \frac{3 \cdot \frac{1}{2}}{-5+2} = -0.5$$

$$B = (s+2) \cdot I_o(s) \Big|_{s=-2} = \frac{3 \cdot \frac{1}{2}}{5-2} = 0.5$$

$$I_o(s) = \frac{-0.5}{5+s} + \frac{0.5}{s+2} \quad (A)$$

$$I_o(j\omega) = \frac{-0.5}{5+j\omega} + \frac{0.5}{2+j\omega} \quad (A)$$

$$i_o(t) = [-0.5e^{-5t} + 0.5e^{-2t}] \cdot u(t) = 0.5u(t) \cdot [e^{-2t} - e^{-5t}] \quad (A)$$

$$i_o(t) = 0.5u(t) \cdot [e^{-2t} - e^{-5t}] \quad (A)$$

4. (25 points) A signal $x(t)$ has a Fourier transform given by

$$X(\omega) = \frac{(8 + j\omega)}{4 + 5j\omega - \omega^2}$$

25

Without finding $x(t)$, find the Fourier transform of the following:

(a) $x_1(t) = x(3t - 6)$

(b) $x_2(t) = e^{-j7t} x(t)$

(c) $x_3(t) = x(-t)$

(a) $x_1(t) = x[3(t - 2)]$

$$X_1(\omega) = e^{-j\omega \cdot 2} \cdot \frac{1}{3} \cdot X\left(\frac{\omega}{3}\right) = e^{-j\omega \cdot 2} \cdot \frac{1}{3} \cdot \frac{(8 + j\frac{\omega}{3})}{4 + 5j\frac{\omega}{3} - (\frac{\omega}{3})^2}$$

(b) $X_2(\omega) = X(\omega + 7)$

$$\Rightarrow X_2(\omega) = \frac{8 + j(\omega + 7)}{4 + 5j(\omega + 7) - (\omega + 7)^2}$$

(c) $X_3(\omega) = X(-\omega)$

$$\Rightarrow X_3(\omega) = \frac{8 - j\omega}{4 - 5j\omega - (-\omega)^2} = \frac{8 - j\omega}{4 - 5j\omega - \omega^2}$$

$$X_1(\omega) = \frac{1}{3} e^{-j\omega \cdot 2} \cdot \frac{(8 + j\frac{\omega}{3})}{4 + 5j\frac{\omega}{3} - (\frac{\omega}{3})^2} \quad X_2(\omega) = \frac{8 + j(\omega + 7)}{4 + 5j(\omega + 7) - (\omega + 7)^2} \quad X_3(\omega) = \frac{8 - j\omega}{4 - 5j\omega - \omega^2}$$

AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
EXAM #3 - FALL 2021

Name: Trevor Johnson

60+9

69%

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

1. (25 points) A periodic signal is given by $x(t) = \sum_{n=-\infty}^{\infty} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \cos(600n\pi t)$

- Compute the period T
- Determine the fundamental frequency ω_0 .
- Identify the Fourier series coefficients a_n .
- Identify the Fourier series coefficients b_n .
- Find the amplitude of the third harmonic.

~~$\omega_0 = 600\pi$~~

$\omega_0 = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega_0}$

$T = \frac{2\pi}{600} = 0.01$

11

$a_n = \frac{2}{T} \int_0^T x(t) \cos(n\omega_0 t) dt$

$\frac{2}{0.01} \int_0^{0.01} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \cos(600n\pi t) dt$

$\frac{4}{0.01n} \cos^2\left(\frac{n\pi}{2}\right) \left(\frac{-\sin(600n\pi t)}{600n\pi} \right) \Big|_0^{0.01}$

$a_n = \frac{400}{n} \cos^2\left(\frac{n\pi}{2}\right) \left(\frac{-\sin(6\pi n)}{600n\pi} \right)$

$b_n = \frac{2}{T} \int_0^T x(t) \sin(n\omega_0 t) dt$
 $= \frac{2}{0.01} \int_0^{0.01} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \sin(600n\pi t) dt$
 $= \frac{4}{0.01n} \cos^2\left(\frac{n\pi}{2}\right) \left(\frac{-\cos(600n\pi t)}{600n\pi} \right) \Big|_0^{0.01}$

$b_n = \frac{400}{n} \cos^2\left(\frac{n\pi}{2}\right) \left(\frac{\cos(6\pi n) - 1}{600n\pi} \right)$

~~$T = 10^{-4} \times 10^3$~~ -3

~~$b_n =$~~ -5

~~$\omega_0 = 600\pi$~~ -2

~~$a_n =$~~ -4

magnitude of 3rd harmonic = 0 ✓

2. (25 points) For the circuit shown below, $R = 15 \text{ Ohms}$, $L = 10 \text{ mH}$. If the periodic signal $v_s(t)$ is given as:

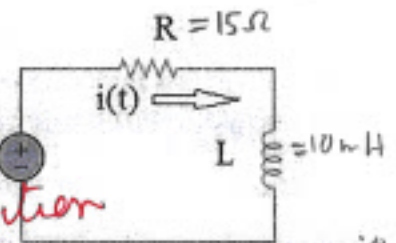
$$v_s(t) = 10 + 5 \cos(500t + 30^\circ) + 2 \cos(1500t - 50^\circ) \text{ V}$$

(a) Determine the current $i(t)$ flowing through the resistor R , (b) determine the average power dissipated in the resistor R .

$$a) \quad V_s(t) = i(t) (Z) = i(t) (15 + j10 \times 10^{-3})$$

$$i(t) = \frac{V_s(t)}{Z} = \frac{10 + 5 \cos(500t + 30^\circ) + 2 \cos(1500t - 50^\circ)}{15 + j0.01}$$

$$i(t) = \frac{10 + \frac{5}{2}(e^{j30} - e^{-j30}) + (e^{-j50} - e^{j50})}{15 + j0.01} = 0.66 - j0.29 \text{ Vs}(t)$$



$$\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$$

$$P = V^2 I = (10^2 + (\frac{5}{\sqrt{2}})^2 + (\frac{2}{\sqrt{2}})^2) (0.66 - j0.29)$$

$$= 75.57 - j33.2 \text{ W}$$

the superposition theorem

-25

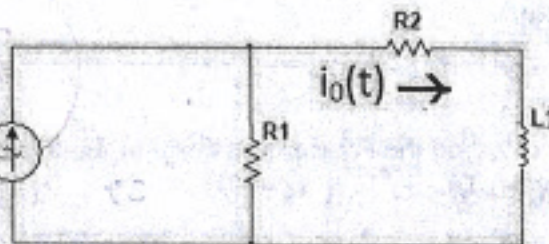
$$i(t) = 0.66 - j0.29 \text{ A}$$

$$\text{average power} = 75.57 - j33.2$$

3. (25 points) In the circuit shown below, $R_1 = 1 \text{ Ohm}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 2 \text{ H}$, Find the current $i_o(t)$ if $i_s(t) = 3e^{-5t}u(t) \text{ A}$.

$$i_o(s) = \frac{R_1}{R_1 + Z} \cdot i_s(s)$$

(25)



$$Z = R_2 + j\omega L_1 = 3 + j2$$

$$i_o(s) = \frac{1}{1 + 3 + j2} \cdot \frac{3}{s + 5} = \frac{3}{(4 + j2)(s + 5)}$$

$$= \frac{3}{2(j\omega + 2)(j\omega + 5)} = \frac{A}{2(j\omega + 2)} + \frac{B}{j\omega + 5}$$

$$3 = A(j\omega + 5) + B2(j\omega + 2)$$

$$\begin{aligned} \omega = -2 &\Rightarrow 3 = 3A + 0 \Rightarrow A = 1 \\ \omega = -5 &\Rightarrow 3 = -6B \Rightarrow B = -1/2 \end{aligned}$$

$$\frac{1}{2(j\omega + 2)} - \frac{1/2}{j\omega + 5} = \frac{1/2}{(j\omega + 2)} - \frac{1/2}{j\omega + 5} = i_o(j\omega)$$

$$i_o(t) = F^{-1}[i_o(j\omega)] = \boxed{\frac{1}{2} [e^{-2t} - e^{-5t}] u(t)}$$

$$i_o(t) = 0.5 (e^{-2t} - e^{-5t}) u(t)$$

4. (25 points) A signal $x(t)$ has a Fourier transform given by

$$X(\omega) = \frac{(8 + j\omega)}{4 + 5j\omega - \omega^2}$$

24

Without finding $x(t)$, find the Fourier transform of the following:

(a) $x_1(t) = x(3t - 6) = x(3(t - 2)) \Rightarrow \frac{1}{3} e^{-j2\omega} X\left(\frac{\omega}{3}\right)$

(b) $x_2(t) = e^{-j7t} x(t) \Rightarrow X(\omega - 7) = X(\omega - 7)$

(c) $x_3(t) = x(-t) \Rightarrow X(-\omega)$

a) $\frac{1}{3} e^{-j2\omega} \left[\frac{8 + j(\frac{\omega}{3})}{4 + 5j(\frac{\omega}{3}) - (\frac{\omega}{3})^2} \right] = \boxed{e^{-j2\omega} \left(\frac{8 + j(\frac{\omega}{3})}{12 + 15j(\frac{\omega}{3}) - \frac{\omega^2}{9}} \right)}$

b) $X(\omega - 7) = \boxed{\frac{8 + j(\omega - 7)}{4 + 5j(\omega - 7) - (\omega - 7)^2}}$

c) $X(-\omega) = \boxed{\frac{8 - j\omega}{4 - 5j\omega - \omega^2}} - 1$

$X_1(\omega) = \underline{\hspace{2cm}} \quad X_2(\omega) = \underline{\hspace{2cm}} \quad X_3(\omega) = \underline{\hspace{2cm}}$

BELOW AVERAGE

$\frac{600 \times 36}{2} = 10800$
 $18 \times 300 = 5400$
 $300 \times 18 = 5400$

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
 ELEG 3302-P01 SIGNALS AND SYSTEMS
 EXAM #3 - FALL 2021

44 + 9 → 53%

Name: Brandon Belkowitz

Note: All the steps leading to the solution of the problems should be shown. In addition, put your answers in blanks, if provided.

5

1. (25 points) A periodic signal is given by $x(t) = \sum_{n=1}^{\infty} \frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right) \cos(600n\pi t)$

- (a) Compute the period T
- (b) Determine the fundamental frequency ω_0 .
- (c) Identify the Fourier series coefficients a_n .
- (d) Identify the Fourier series coefficients b_n .
- (e) Find the amplitude of the third harmonic.

$(b) \omega_0 = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi$

$(a) \omega_0 = \frac{2\pi}{T} \checkmark \quad T = \frac{2\pi}{\omega_0}$

$\omega_0 = \frac{\pi}{2}$

$T = \frac{2\pi}{\frac{\pi}{2}} = 4$

$T = 2 \times 2 = 4$

$(c) a_n = \frac{2}{T} \int_0^{T/2} \cos^2\left(\frac{n\pi}{2}\right) dt$

$= \frac{2}{4} \left[-\cos^2\left(\frac{n\pi}{2}\right) t \right]_0^2$
 $= \frac{1}{2} \cdot -\cos^2\left(\frac{n\pi}{2}\right) 2 = -\cos^2(n\pi)$

$(d) b_n = \frac{2}{T} \int_0^{T/2} \cos(600n\pi t) dt$

$= \frac{1}{2} \left[-\sin(600n\pi) \frac{t}{2} \right]_0^2$
 $= \frac{-\sin(600n\pi)}{2} \cdot \frac{2}{2} = -\frac{\sin(600n\pi)}{2}$

$\omega_0 = \frac{\pi}{2} \quad a_n = -\cos^2(n\pi)$

magnitude of 3rd harmonic = $\frac{1}{2}$

$\sqrt{\left(\frac{1}{2}\right)^2 + \left(-\frac{1}{2}\right)^2}$
 $= \sqrt{\frac{1}{4} + \frac{1}{4}} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$

$T = 4$

$b_n = \frac{-\sin(600n\pi)}{2} = -\frac{\sin(600n\pi)}{2}$

$\frac{2}{n} \cos^2\left(\frac{n\pi}{2}\right)$

2. (25 points) For the circuit shown below, $R = 15 \text{ Ohms}$, $L = 10 \text{ mH}$. If the periodic signal $v_s(t)$ is given as:

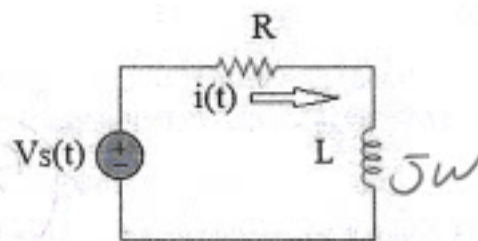
$$V_s(t) = 10 + 5 \cos(500t + 30^\circ) + 2 \cos(1500t - 50^\circ) \text{ V}$$

(a) Determine the current $i(t)$ flowing through the resistor R , (b) determine the average power dissipated in the resistor R .

$V_s(t)$
 $R + L$

$\frac{V}{R} = I$

$10 \cdot 10^{-3}$



$$V_s(t) = V_s(\omega) = 10 \pi \delta(\omega) + 5 \pi [e^{-j30^\circ} \delta(\omega + 500) + e^{j30^\circ} \delta(\omega - 500)]$$

$$V_s(t) + 2 \pi [e^{-j50^\circ} \delta(\omega + 1500) + e^{j50^\circ} \delta(\omega - 1500)]$$

Use superposition theorem

$$V_0 = \frac{15 \cdot 3}{20 + j\omega} V_s(\omega)$$

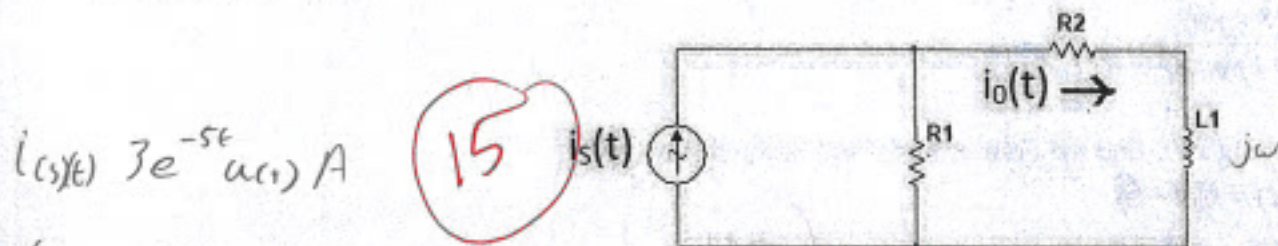
-25

$$V_0 = \frac{45}{20 + j\omega} V_s(\omega)$$

$i(t) =$

average power =

3. (25 points) In the circuit shown below, $R_1 = 1 \text{ Ohm}$, $R_2 = 3 \text{ Ohms}$, and $L_1 = 2 \text{ H}$. Find the current $i_o(t)$ if $i_s(t) = 3e^{-5t}u(t) \text{ A}$.



$i(s) = 3e^{-5t}u(t) \text{ A}$

$I(s) = \frac{3}{s+5}$

convert into the
jw-domain
and use current
division
 $R_1 = 1 \text{ ohm}$
 $R_2 = 3 \text{ ohm}$
 $L_1 = 2 \text{ H}$

$I(s) = \frac{3}{s+5}$

$s = j\omega$

$I_o(s) = \frac{I_s \cdot 3}{s+2(1+3)} = \frac{I_s \cdot 3}{s+8} = \left(\frac{3}{s+5} \right) \cdot \left(\frac{3}{s+8} \right) = \frac{9}{(s+5)(s+8)}$

$= \frac{9}{(s+5)(s+8)} = \frac{A}{s+5} + \frac{B}{s+8}$

$A = I_o(s)(s+5)|_{s=-5} = \frac{9}{s+8}|_{s=-5} = \frac{9}{3} = 3$

$B = I_o(s)(s+8)|_{s=-8} = \frac{9}{s+5}|_{s=-8} = \frac{9}{-3} = -3$

$I_o(s) = I_o(j\omega) = \frac{3}{s+5} - \frac{3}{s+8} = s + \frac{3}{\omega}$

$i_o(t) = 3(e^{-5t} - e^{-8t})u(t)$

~~$\frac{3}{s+5} = I_o(t) = 3(e^{-5t} - e^{-8t})u(t)$~~

~~$X(t) \Rightarrow X(\omega)$~~

~~$\frac{1}{u+j\omega}$~~

4. (25 points) A signal $x(t)$ has a Fourier transform given by

$$X(\omega) = \frac{(8 + j\omega)}{4 + 5j\omega - \omega^2}$$

Without finding $x(t)$, find the Fourier transform of the following:

(a) $x_1(t) = x(3t - 6)$

(b) $x_2(t) = e^{-j\pi t} x(t)$

(c) $x_3(t) = x(-t)$

24

(a) Scaling and Time shift $x_1(t) = x(3t - 6) = X(\omega) = \frac{1}{3} X\left(\frac{\omega}{3}\right) e^{-j\omega 6}$
 $\frac{1}{|a|} X\left(\frac{\omega}{a}\right) e^{-j\omega a} X(\omega) = \frac{1}{3} \left[\frac{8 + j\frac{\omega}{3}}{4 + 5j\frac{\omega}{3} - \left(\frac{\omega}{3}\right)^2} \right] e^{-j\omega 6}$

(b) Frequency Shift $x_2(t) = e^{-j\pi t} x(t) = X(\omega) = X(\omega - (-\pi)) = X(\omega + \pi)$
 $X(\omega - \omega_0) = \left[\frac{8 + j(\omega + \pi)}{4 + 5j(\omega + \pi) - (\omega + \pi)^2} \right]$

(c) Time reversal $x_3(t) = x(-t) = X(-\omega) = \frac{8 + j(-\omega)}{4 + 5j(-\omega) - (-\omega)^2}$
 $X(-\omega)$

$$X_3(\omega) = \frac{8 - j\omega}{4 - 5j\omega + \omega^2}$$

$$X_1(\omega) = \frac{1}{3} \left[\frac{8 + j\frac{\omega}{3}}{4 + 5j\frac{\omega}{3} - \left(\frac{\omega}{3}\right)^2} \right] e^{-j\omega 6} \quad X_2(\omega) = \frac{8 + j(\omega + \pi)}{4 + 5j(\omega + \pi) - (\omega + \pi)^2} \quad X_3(\omega) = \frac{8 - j\omega}{4 - 5j\omega + \omega^2} \quad -1$$

**SIGNALS AND SYSTEMS
FALL 2021**

EXAM #4 (FINAL EXAM)

TOPICS COVERED IN FINAL EXAM

- 1. Discrete Fourier Transform**
- 2. Z-Transform**

**SIGNALS AND SYSTEMS
FALL 2021**

FINAL EXAM QUESTIONS

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
FINAL EXAM (FALL 2021)

Name: JOHN ATTIA (KEY)

Note: All the steps that lead to your answer should be shown.

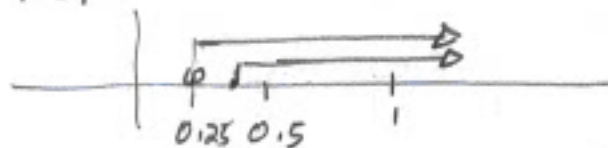
1. (10 points) Find the ROC of the z-transform of $x[n] = \left(\left(\frac{1}{4} \right)^n - \left(\frac{1}{3} \right)^n \right) u[n]$

$$Z\{a^n u[n]\} = \frac{z}{z-a} \quad |z| > |a|$$

$$Z\left\{\left(\frac{1}{4}\right)^n u[n]\right\} = \frac{z}{z - \frac{1}{4}} \quad |z| > \left|\frac{1}{4}\right|$$

$$Z\left\{\left(\frac{1}{3}\right)^n u[n]\right\} = \frac{z}{z - \frac{1}{3}} \quad |z| > \left|\frac{1}{3}\right|$$

$$\text{ROC: } \left|\frac{1}{4}\right| \cap \left|\frac{1}{3}\right|$$

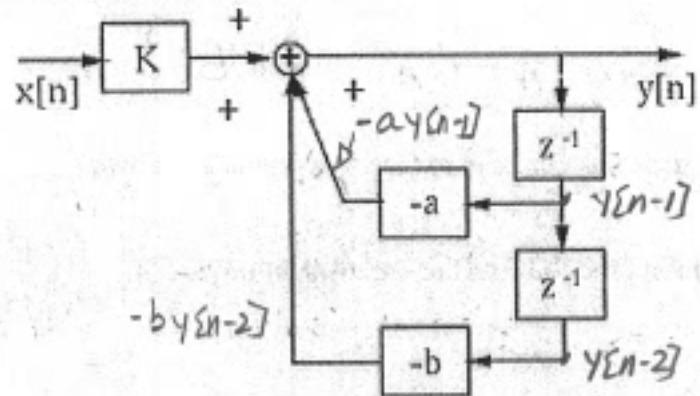


$$\text{ROC is } |z| > \left|\frac{1}{3}\right|$$

ROC is: _____

KEY

2. (10 points) A discrete-time linear system is shown below, $K=4$, $a=3$ and $b=2$, (a) find its difference equation that describe the system;



$$y[n] = Kx[n] + (-by[n-2]) + (-ay[n-1])$$

Thus

$$y[n] + ay[n-1] + by[n-2] = Kx[n]$$

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

Difference equation is: _____

KEY

3. (20 points) A discrete-time linear system is described by the difference equation:

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

(a) Determine the transfer function $H(z)$ of the system, (b) find the impulse response $h[n]$.

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

Taking the z -transform, we get

$$Y(z) + 3z^{-1}Y(z) + 2z^{-2}Y(z) = 4X(z)$$

$$Y(z)(1 + 3z^{-1} + 2z^{-2}) = 4X(z)$$

10pts $\frac{Y(z)}{X(z)} = H(z) = \frac{4}{1 + 3z^{-1} + 2z^{-2}} = \frac{4z^2}{z^2 + 3z + 2}$

$$h[n] = Z^{-1}[H(z)]$$

$$\frac{H(z)}{z} = H_1(z) = \frac{4z}{z^2 + 3z + 2} = \frac{4z}{(z+1)(z+2)} = \frac{A}{z+1} + \frac{B}{z+2}$$

$$A = H_1(z)(z+1) \Big|_{z=-1} = \frac{4z}{z+2} = \frac{4(-1)}{-1+2} = \frac{-4}{1} = -4$$

$$B = H_1(z)(z+2) \Big|_{z=-2} = \frac{4z}{(z+1)} = \frac{4(-2)}{-2+1} = \frac{-8}{-1} = 8$$

$$\frac{H(z)}{z} = \frac{-4}{z+1} + \frac{8}{z+2} \Rightarrow H(z) = \frac{8z}{z+2} - \frac{4z}{z+1}$$

10pts Thus, $h[n] = [8(-2)^n - 4(-1)^n]u[n]$

$$H(z) = \underline{\hspace{2cm}}$$

$$h[n] = \underline{\hspace{2cm}}$$

KEY

4. (20 points) A discrete-time system is described by the difference equation

$$y[n] - 2y[n-1] = (4)^n; \quad y[-1] = 1; \quad \text{Find the response } y[n].$$

Taking the z -transform of the difference equation, we have

$$Y(z) - 2[z^{-1}Y(z) + y[-1]] = \frac{z}{z-4}$$

$$Y(z) - 2z^{-1}Y(z) - 2(1) = \frac{z}{z-4}$$

$$Y(z)(1 - 2z^{-1}) = \frac{z}{z-4} + 2$$

$$= \frac{z + 2z - 8}{z-4}$$

$$Y(z)(1 - 2z^{-1}) = \frac{3z - 8}{z-4}$$

10pts $Y(z) = \left(\frac{3z - 8}{z-4} \right) \frac{1}{(1 - 2z^{-1})}$

$$= \frac{3z - 8}{(z-4)} \cdot \left(\frac{z}{z-2} \right)$$

$$\frac{Y(z)}{z} = \frac{3z - 8}{(z-2)(z-4)} = \frac{A}{z-2} + \frac{B}{z-4}$$

$$A = \frac{Y(z)(z-2)}{z} \Big|_{z=2} = \frac{3z - 8}{z-4} \Big|_{z=2}$$

$$= \frac{6 - 8}{2 - 4} = \frac{-2}{-2} = 1$$

$$B = \frac{Y(z)(z-4)}{z} \Big|_{z=4} = \frac{3z - 8}{z-2} \Big|_{z=4}$$

$$= \frac{12 - 8}{4 - 2} = \frac{4}{2} = 2$$

$$\frac{Y(z)}{z} = \frac{1}{z-2} + \frac{2}{z-4}$$

$$Y(z) = \frac{z}{z-2} + \frac{2z}{z-4}$$

$$y[n] = [(2)^n + 2(4)^n] u[n]$$

10pts

$$y[n] = \underline{\hspace{2cm}}$$

KEY

5. (20 points) Calculate the DFT of the following discrete-time signal with: $x[0] = 2$, $x[1] = -1$, $x[2] = 3$, $x[3] = -2$. The DFT values of $X(0)$, $X(1)$, $X(2)$ and $X(3)$ are required for this question.

The DFT of $x[n]$ is given as:

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j2\pi nk/N}$$

$N=4$, thus $X[k]$ is given as

$$X[k] = \sum_{n=0}^3 x[n] e^{-j\pi nk/2}$$

$$X(0) = \sum_{n=0}^3 x[n] e^0 = 2 - 1 + 3 - 2 = 2$$

$$X(1) = \sum_{n=0}^3 x[n] e^{-j\pi n/2}$$

$$X(1) = x[0]e^0 + x[1]e^{-j\pi/2} + x[2]e^{-j\pi/2} + x[3]e^{-j3\pi/2}$$

$$= 2 + (-1)(-j) + 3(-1) - (2)(j)$$

$$= 2 + j - 3 - j2 = -1 - j1$$

$$X(2) = \sum_{n=0}^3 x[n] e^{-j2\pi n/2}$$

$$= \sum_{n=0}^3 x[n] e^{-j\pi n}$$

$$= x[0]e^0 + x[1]e^{-j\pi} + x[2]e^{-j2\pi} + x[3]e^{-j3\pi}$$

$$X(2) = 2 + (-1)(-1) + 3(1) + (-2)(-1)$$

$$X(2) = 2 + 1 + 3 + 2 = 8$$

$$X(3) = \sum_{n=0}^3 x[n] e^{-j3\pi n/2}$$

$$X(3) = x[0]e^0 + x[1]e^{-j3\pi/2} + x[2]e^{-j3\pi} + x[3]e^{-j9\pi/2}$$

$$X(3) = 2 + (-1)(j) + (3)(-1) + (-2)(-j)$$

$$X(3) = 2 - j - 3 + j2 = -1 + j1$$

5pts $X(0) = 2$

$X(1) = -1 - j1$

5pts

$X(2) = 8$ 5pts

$X(3) = -1 + j1$

5pts

KEY

6. (20 points) The discrete-time Fourier transform (DTFT) of a signal $x[n]$ is

$$X(\Omega) = \frac{2}{3 + e^{-j\Omega}}$$

Find the DTFT of the following signals.

(a) $y[n] = x[-n]$; (b) $z[n] = x[n]e^{j6n}$; (c) $w[n] = x[n] + x[n-1]$

Us
a) From the properties of DTFT

$$x[-n] \Leftrightarrow X(-\Omega)$$

Thus, $Y(\Omega) = \frac{2}{3 + e^{-j(-\Omega)}}$

$$= \frac{2}{3 + e^{j\Omega}}$$

6pts

$$W(\Omega) = \frac{2}{3 + e^{-j\Omega}} + \frac{2e^{-j\Omega}}{3 + e^{-j\Omega}}$$

$$W(\Omega) = \frac{2 + 2e^{-j\Omega}}{3 + e^{-j\Omega}}$$

b) Using the frequency modulation property

$$e^{j\Omega_0 n} x[n] \Leftrightarrow X(\Omega - \Omega_0)$$

$$e^{j6n} x[n] \Leftrightarrow X(\Omega - 6)$$

$$Z(\Omega) = \frac{2}{3 + e^{-j(\Omega - 6)}}$$

7pts

(c) Using the time-shifting and linearity property we have

$$w[n] = x[n] + x[n-1]$$

$$W(\Omega) = \frac{2}{3 + e^{-j\Omega}} + e^{-j\Omega} \cdot \frac{2}{3 + e^{-j\Omega}} = \frac{2}{3 + e^{-j\Omega}} [1 + e^{-j\Omega}]$$

7pts

$$Y(\Omega) = \frac{2}{3 + e^{j\Omega}}$$

$$Z(\Omega) = \frac{2}{3 + e^{-j(\Omega - 6)}}$$

$$W(\Omega) = \frac{2}{3 + e^{-j\Omega}} + e^{-j\Omega} \cdot \frac{2}{3 + e^{-j\Omega}}$$

ABOVE AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
FINAL EXAM (FALL 2021)

Name: Ben Nguyen

Note: All the steps that lead to your answer should be shown.

1. (10 points) Find the ROC of the z-transform of $x[n] = \left[\left(\frac{1}{4} \right)^n - \left(\frac{1}{3} \right)^n \right] u[n]$

$$z_1 = \left(\frac{1}{4} \right)^n \Leftrightarrow \frac{z}{z - \frac{1}{4}} \quad z > \frac{1}{4}$$

$$z_2 = \left(\frac{1}{3} \right)^n \Leftrightarrow \frac{z}{z - \frac{1}{3}} \quad z > \frac{1}{3}$$

$$\Rightarrow z = z_1 - z_2 = \frac{z}{z - \frac{1}{4}} - \frac{z}{z - \frac{1}{3}}$$

$$\Rightarrow \text{ROC is } z > \frac{1}{3}$$

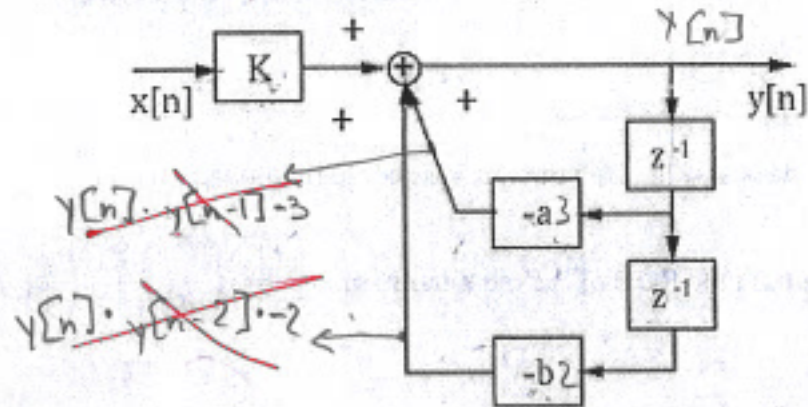
93+7
 $\Rightarrow$ (100%)
Excellent

ROC is:

$$z > \frac{1}{3}$$

2. (10 points) A discrete-time linear system is shown below, $K=4$, $a=3$ and $b=2$, (a) find its difference equation that describe the system;

3



$$\Rightarrow y[n] = 4x[n] + y[n] \cdot y[n-1] \cdot -3 + y[n] \cdot y[n-2] \cdot -2$$

$$y[n] + 3y[n] \cdot y[n-1] + 2y[n] \cdot y[n-2] = 4x[n] \quad (*)$$

$$y[n] \{1 + 3y[n-1] + 2y[n-2]\} = 4x[n] \quad -7$$

$$H[n] = \frac{y[n]}{x[n]} = \frac{4}{1 + 3y[n-1] + 2y[n-2]} = \frac{4}{1 + 3z^{-1} + 2z^{-2}} = H[z]$$

$$\Rightarrow H'[z] = \frac{H[z]}{z} = \frac{4 \cdot z}{z^2 + 3z + 2} = \frac{4 \cdot z}{(z+1)(z+2)} = \frac{A}{z+1} + \frac{B}{z+2}$$

$$A = H'[z] \cdot (z+1) \Big|_{z=-1} = \frac{4 \cdot (-1)}{(-1)+2} = -4$$

$$B = H'[z] \cdot (z+2) \Big|_{z=-2} = \frac{4 \cdot (-2)}{(-2)+1} = 8$$

$$H[z] = \frac{-4z}{z+1} + \frac{8z}{z+2} \Rightarrow h[n] = [-4(-1)^n + 8(2)^n] u[n]$$

→ Impulse response

Difference equation is: ~~$y[n] + 3y[n] \cdot y[n-1] + 2y[n] \cdot y[n-2] = 4x[n]$~~

3. (20 points) A discrete-time linear system is described by the difference equation:

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

(a) Determine the transfer function $H(z)$ of the system, (b) find the impulse response $h[n]$.

$$\left. \begin{aligned} y[n] &= Y[z] \\ 3y[n-1] &= 3z^{-1}Y[z] \\ 2y[n-2] &= 2z^{-2}Y[z] \\ 4x[n] &= 4X[z] \end{aligned} \right\} \rightarrow \begin{aligned} Y[z] + 3z^{-1}Y[z] + 2z^{-2}Y[z] &= 4X[z] \\ Y[z](1 + 3z^{-1} + 2z^{-2}) &= 4X[z] \end{aligned}$$

$$\rightarrow H[z] = \frac{Y[z]}{X[z]} = \frac{4}{1 + 3z^{-1} + 2z^{-2}} = \frac{4z^2}{z^2 + 3z + 2}$$

$$H'[z] = \frac{H[z]}{z} = \frac{4z}{z^2 + 3z + 2} = \frac{4z}{(z+1)(z+2)} = \frac{A}{z+1} + \frac{B}{z+2}$$

$$A = H'[z] \cdot (z+1) \Big|_{z=-1} = \frac{4 \cdot (-1)}{-1 + 2} = -4$$

$$B = H'[z] \cdot (z+2) \Big|_{z=-2} = \frac{4 \cdot (-2)}{-2 + 1} = 8$$

$$\Rightarrow H[z] = \frac{-4z}{z+1} + \frac{8z}{z+2}$$

$$\Rightarrow h[n] = [-4(-1)^n + 8(-2)^n] \cdot u[n]$$

$$H(z) = \frac{4}{1 + 3z^{-1} + 2z^{-2}} = \frac{4z^2}{z^2 + 3z + 2}$$

$$h[n] = [-4(-1)^n + 8(-2)^n] \cdot u[n]$$

4. (20 points) A discrete-time system is described by the difference equation

$$y[n] - 2y[n-1] = (4)^n; \quad y[-1] = 1; \quad \text{Find the response } y[n].$$

$$y[n] = Y(z).$$

$$z \{ 2y[n-1] \} = z^{-1} Y(z) + y[-1].$$

$$(4)^n = \frac{z}{z-4}$$

$$\Rightarrow Y(z) - 2 \cdot (z^{-1} Y(z) + 1) = \frac{z}{z-4}$$

$$Y(z) - 2z^{-1} Y(z) - 2 = \frac{z}{z-4}$$

$$Y(z) (1 - 2z^{-1}) = \frac{z - 2(z-4)}{z-4}$$

$$Y(z) = \frac{z - 2z + 8}{(z-4)(1-2z^{-1})} = \frac{-z + 8}{z - 2 - 4 + 8z^{-1}}$$

$$= \frac{z^1 \cdot (-z + 8)}{z^1 \cdot (z + 8z^{-1} - 6)}$$

$$= \frac{z \cdot (-z + 8)}{z^2 - 6z - 8}$$

$$\Rightarrow Y'(z) = \frac{Y(z)}{z} = \frac{-z + 8}{(z-2)(z-4)} = \frac{A}{z-2} + \frac{B}{z-4}$$

$$A = Y'(z) \cdot (z-2) \Big|_{z=2} = \frac{-2+8}{2-4} = -3$$

$$B = Y'(z) \cdot (z-4) \Big|_{z=4} = \frac{-4+8}{4-2} = 2$$

$$\Rightarrow Y(z) = \frac{-3z}{z-2} + \frac{2z}{z-4}$$

$$\Rightarrow y[n] = [-3(2)^n + 2(4)^n] \cdot u[n]$$

$$y[n] = [-3(2)^n + 2(4)^n] \cdot u[n]$$

-4

5. (20 points) Calculate the DFT of the following discrete-time signal with: $x[0] = 2$, $x[1] = -1$, $x[2] = 3$, $x[3] = -2$. The DFT values of $X(0)$, $X(1)$, $X(2)$ and $X(3)$ are required for this question.

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j \frac{2\pi nk}{N}}$$

$$N = 4$$

14

$$X[k] = \sum_{n=0}^3 x[n] e^{-j \frac{1}{2} n k}$$

$$X[0] = \sum_{n=0}^3 x[n] e^{-0} = \sum_{n=0}^3 x[n]$$

$$\begin{aligned} X[0] &= x[0] + x[1] + x[2] + x[3] \\ &= 2 + (-1) + 3 + (-2) \\ &= 2 \end{aligned}$$

$$X[1] = \sum_{n=0}^3 x[n] e^{-j \frac{1}{2} n}$$

$$\begin{aligned} &= x[0] e^0 + x[1] e^{-j \frac{\pi}{2}} + x[2] e^{-j \pi} + x[3] e^{-j \frac{3\pi}{2}} \\ &= 2 + (-1) \cdot (-j) + 3 \cdot (-1) + (-2) \cdot j \end{aligned}$$

$$\begin{aligned} &= 2 + (-1) \cdot (-j) + 3 \cdot (-1) + (-2) \cdot j \\ &= 2 + j - 3 - 2j \\ &= -1 - j \end{aligned}$$

$$= -1 - j$$

$$X[2] = \sum_{n=0}^3 x[n] e^{-j \pi n}$$

$$\begin{aligned} &= x[0] e^0 + x[1] e^{-j \pi} + x[2] e^{-j 2\pi} + x[3] e^{-j 3\pi} \\ &= 2 + (-1) \cdot (-1) + 3 \cdot (1) + (-2) \cdot (-1) \\ &= 2 + 1 + 3 + 2 = 8 \end{aligned}$$

$$X[3] = \sum_{n=0}^3 x[n] e^{-j \frac{3}{2} n}$$

$$\begin{aligned} &= x[0] e^0 + x[1] e^{-j \frac{3\pi}{2}} + x[2] e^{-j 3\pi} + x[3] e^{-j \frac{9\pi}{2}} \\ &= 2 + (-1) \cdot j + 3 \cdot (-1) + (-2) \cdot j \\ &= 2 - j - 3 - 2j = -1 - 3j \end{aligned}$$

$$= -1 - 3j$$

$$X(0) = 2$$

$$X(1) = -1 - j$$

$$X(2) = 8$$

$$X(3) = -1 - 3j$$

6. (20 points) The discrete-time Fourier transform (DTFT) of a signal $x[n]$ is

$$X(\Omega) = \frac{2}{3 + e^{-j\Omega}}$$

Find the DTFT of the following signals.

(a) $y[n] = x[-n]$; (b) $z[n] = x[n]e^{j6n}$; (c) $w[n] = x[n] + x[n-1]$

(20)

(a) $y[n] = x[-n] \Rightarrow X(-\Omega) = \frac{2}{3 + e^{j\Omega}}$

(b) $z[n] = x[n]e^{j6n} \Rightarrow X(\Omega - 6) = \frac{2}{3 + e^{-j(\Omega - 6)}}$
 $\Omega_0 = 6$

(c) $w[n] = x[n] + x[n-1] \Rightarrow X(\Omega) + e^{-j\Omega} X(\Omega)$
 $k=1$
 $= \frac{2}{3 + e^{-j\Omega}} + e^{-j\Omega} \cdot \frac{2}{3 + e^{-j\Omega}}$

$$Y(\Omega) = \frac{2}{3 + e^{j\Omega}}$$

$$W(\Omega) = \frac{2}{3 + e^{-j\Omega}} + e^{-j\Omega} \cdot \frac{2}{3 + e^{-j\Omega}}$$

$$Z(\Omega) = \frac{2}{3 + e^{-j(\Omega - 6)}} = \frac{2}{3 + e^{-j\Omega + 6j}}$$

AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
FINAL EXAM (FALL 2021)

Name: Nasir Pate

65 + 7
⇒ (72%)

Note: All the steps that lead to your answer should be shown.

1. (10 points) Find the ROC of the z-transform of $x[n] = \left[\left(\frac{1}{4} \right)^n - \left(\frac{1}{3} \right)^n \right] u[n]$

(10) $X(z) = \frac{z}{z - 1/4} - \frac{z}{z - 1/3}$ $1/3 = 0.33$
 $1/4 = 0.25$

$X(z) = \frac{z}{z - 1/4} - \frac{z}{z - 1/3} \quad |z| > 0.33 = \text{ROC}$

ROC is:

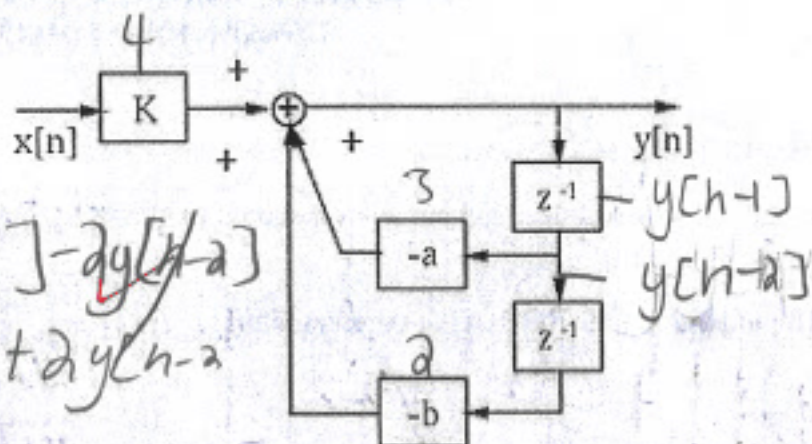
$|z| > 0.33$

2. (10 points) A discrete-time linear system is shown below, $K=4$, $a=3$ and $b=2$, (a) find its difference equation that describe the system;

10

$$y[n] = 4x[n] - 3y[n-1] - 2y[n-2]$$

$$+ 3y[n-1] + 2y[n-2]$$



$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

Difference equation is:

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

3. (20 points) A discrete-time linear system is described by the difference equation:

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

(a) Determine the transfer function $H(z)$ of the system, (b) (c) find the impulse response $h[n]$.

$$y(z) + 3z^{-1}y(z) + 2z^{-2}y(z) = 4x(z)$$

18

$$\frac{y(z)}{x(z)} \frac{1 + 3z^{-1} + 2z^{-2}}{1 + 3z^{-1} + 2z^{-2}} = \frac{4x(z)}{1 + 3z^{-1} + 2z^{-2}}$$

$$\frac{y(z)}{x(z)} = \frac{4}{1 + 3z^{-1} + 2z^{-2}} \cdot \frac{(z^2)}{(z^2)} \rightarrow \frac{4z^2}{z^2 + 3z + 2} = \frac{Az}{(z+1)} + \frac{Bz}{(z+2)}$$

$$A = \frac{4z}{z+2} \Big|_{z=-2} = \frac{4(-2)}{-2+1} = \frac{-8}{-1} \rightarrow A = 8$$

$$B = \frac{4z}{z+1} \Big|_{z=-1} = \frac{4(-1)}{-1+2} = \frac{-4}{1} \rightarrow B = -4$$

$$H(z) = -\frac{4z}{(z+1)} + \frac{8z}{(z+2)}$$

$$h[n] = [-4(1)^n + 8(2)^n] u[n]$$

-2

$$H(z) = -\frac{4z}{(z+1)} + \frac{8z}{(z+2)}$$

$$h[n] = [-4(1)^n + 8(2)^n] u[n]$$

4. (20 points) A discrete-time system is described by the difference equation

$$y[n] - 2y[n-1] = (4)^n; \quad y[-1] = 1; \quad \text{Find the response } y[n].$$

z^{-m} negative

$$y(z) - 2z^{-1}y(z) = \frac{z}{z-4} + z$$

-2 positive

$$y(z) - 2z^{-1}y(z) = \frac{z + z^2 - 4z}{z-4}$$

-20

$$y(z) \frac{1 - 2z^{-1}}{1 - 2z^{-1}} = \frac{z^2 - 3z}{(z-4)(1-2z^{-1})} = \frac{z^2 - 3z}{z^2 - 2 - 4 + 2z^{-1}}$$

$$\frac{z^2 - 3z}{0}$$

$$y[n] =$$

$$N=4$$

5. (20 points) Calculate the DFT of the following discrete-time signal with: $x[0] = 2$, $x[1] = -1$, $x[2] = 3$, $x[3] = -2$. The DFT values of $X(0)$, $X(1)$, $X(2)$ and $X(3)$ are required for this question.

$$X[0] = 2, X[1] = -1, X[2] = 3, X[3] = -2$$

19

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j2\pi nk/N} = \sum_{n=0}^3 x[n] e^{-j2\pi nk/4}$$

$$X[0] = x[n] e^{-j2\pi n(0)/4} = x[n] e^0$$

$$X[0] = x[0]e^0 + x[1]e^0 + x[2]e^0 + x[3]e^0 = 2 - 1 + 3 - 2$$

$$X[0] = 2$$

$$X[1] = x[n] e^{-j2\pi n(1)/4} = x[n] e^{-j\pi n/2}$$

$$X[1] = x[0]e^{-j\pi(0)/2} + x[1]e^{-j\pi(1)/2} + x[2]e^{-j\pi(2)/2} + x[3]e^{-j\pi(3)/2} = 2 + j - 3 - 2j$$

$$X[1] = -j - 1$$

$$X[2] = x[n] e^{-j2\pi n(2)/4} = x[n] e^{-j\pi n}$$

$$X[2] = x[0]e^{-j\pi(0)} + x[1]e^{-j\pi(1)} + x[2]e^{-j\pi(2)} + x[3]e^{-j\pi(3)}$$

$$= 2 - 1 + 3 - 2$$

$$X[2] = 8$$

$$X[3] = x[n] e^{-j2\pi n(3)/4} = x[n] e^{-j3\pi n/2}$$

$$X[3] = x[0]e^{-j3\pi(0)/2} + x[1]e^{-j3\pi(1)/2} + x[2]e^{-j3\pi(2)/2} + x[3]e^{-j3\pi(3)/2}$$

$$= 2 - j - 3 + j2$$

$$X[3] = j + 5$$

-1

$$X(0) = 2$$

$$X(2) = 8$$

$$X(1) = -j - 1$$

$$X(3) = j + 5$$

6. (20 points) The discrete-time Fourier transform (DTFT) of a signal $x[n]$ is

$$X(\Omega) = \frac{2}{3 + e^{-j\Omega}}$$

8

Find the DTFT of the following signals.

(a) $y[n] = x[-n]$; (b) $z[n] = x[n]e^{j6n}$; (c) $w[n] = x[n] + x[n-1]$

a) $y[n] = x[-n]$

$$y(\Omega) = X(-\Omega) = \frac{2}{3 + e^{-j(-\Omega)}} = \frac{2}{3 + e^{j\Omega}}$$

replace Ω by $(-\Omega)$

-4

b) $z[n] = x[n]e^{j6n}$

$$z(\Omega) = X(\Omega - 6) = \frac{2}{3 + e^{-j(\Omega - 6)}} = \frac{2}{3 + e^{-j\Omega}e^{j6}} = \frac{2}{3 + e^{-j\Omega}}$$

$$z(\Omega) = \frac{2 - 1.5 - 0.5e^{-j\Omega}}{3 + e^{-j\Omega}} =$$

replace Ω by $(\Omega - 6)$

$$Z(\Omega) = \frac{0.5e^{-j\Omega} + 0.5}{3 + e^{-j\Omega}}$$

-5

c) $w[n] = \frac{2}{3 + e^{-j\Omega}} + \frac{2}{3 + e^{-j(\Omega - 2\pi)}}$

$$w(\Omega) = \frac{2}{3 + e^{-j\Omega}} + 0.67 \rightarrow w(\Omega) = \frac{2 + 2.01 + 0.67e^{-j\Omega}}{3 + e^{-j\Omega}}$$

-3

$$Y(\Omega) = \frac{2}{3 + e^{-j\Omega}}$$

$$W(\Omega) = \frac{4.01 + 0.67e^{-j\Omega}}{3 + e^{-j\Omega}}$$

$$Z(\Omega) = \frac{-0.5e^{-j\Omega} + 0.5}{3 + e^{-j\Omega}}$$

BELOW AVERAGE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
FINAL EXAM (FALL 2021)

Name: Arthur Quinney

41 + 7
⇒ 48%

Note: All the steps that lead to your answer should be shown.

ROC $z \neq 0$

1. (10 points) Find the ROC of the z-transform of $x[n] = \left(\left(\frac{1}{4} \right)^n - \left(\frac{1}{3} \right)^n \right) u[n]$ Given

$a^n u[n] = \left(\frac{1}{4} \right)^n - \left(\frac{1}{3} \right)^n u[n]$

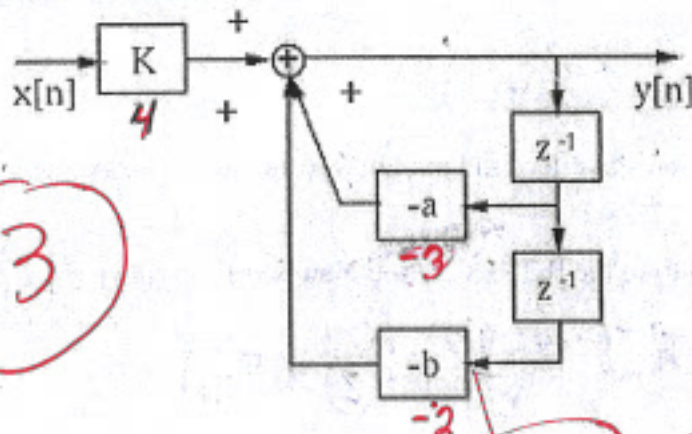
0

-10

ROC is:

X

2. (10 points) A discrete-time linear system is shown below, $K=4$, $a=3$ and $b=2$, (a) find its difference equation that describe the system;



~~$$Y[n] = X[n] - Y[n-2]$$~~

~~$$X[n] = Y[n] + Y[n-2]$$~~

3

~~$$Y(z) = X(z) - z^{-2}Y(z)$$~~

~~$$Y(z) + z^{-2}Y(z) = X(z)$$~~

~~$$Y(z)(1 + z^{-2}) = X(z)$$~~

~~$$H(z) = \frac{Y(z)}{X(z)} = \frac{1}{1 + z^{-2}}$$~~

~~$$Y[n] + Y[n-2] = 4X[n]$$~~

Difference equation is: _____

3. (20 points) A discrete-time linear system is described by the difference equation:

$$y[n] + 3y[n-1] + 2y[n-2] = 4x[n]$$

12

(a) Determine the transfer function $H(z)$ of the system, (b) (c) find the impulse response $h[n]$.

$$Y(z) + 3Yz^{-1} + 2Yz^{-2} = 4X(z)$$

$$\frac{Y(z)}{X(z)} = H(z) = \frac{1}{3 + 2z^{-2} + 1} = \frac{z^2}{z^2 + 3z + 2}$$

$$H(z) = \frac{z^2}{z^2 + 3z + 2} = \frac{z^2}{(z+1)(z+2)} = \frac{Az}{z+1} + \frac{Bz}{z+2}$$

$$H(z) = \frac{A}{z-1} + \frac{B}{z-2} = \frac{z}{z^2 + 3z + 2} = \frac{z}{(z+1)(z+2)}$$

$$A = \frac{H(z)(z-1)}{z} \Big|_{z=1} = \frac{z}{(z-1)} \Big|_{z=1} = \frac{1}{1} = 1$$

$$B = \frac{H(z)(z-2)}{z} \Big|_{z=2} = \frac{z}{z-2} \Big|_{z=2} = \frac{2}{-2} = -1$$

$$H(z) = \frac{z}{z-1} - \frac{z}{z-2}$$

$$h[n] = 2^n u[n] - 2^{n-1} u[n-1]$$

$$H(z) = \underline{\hspace{2cm}}$$

$$h[n] = \underline{\hspace{2cm}}$$

$$y[n+1] - 2y[n] = 4^n, \quad y[0] = 1$$

4. (20 points) A discrete-time system is described by the difference equation

$$y[n] - 2y[n-1] = (4)^n; \quad y[-1] = 1; \quad \text{Find the response } y[n].$$

(12)

$$zY(z) - 2Y(z) = \frac{z}{z-4}$$

$$Y(z)(z-2) = \frac{z}{z-4} \Rightarrow Y(z) = \frac{z}{(z-2)(z-4)}$$

$$Y(z) = \frac{z}{(z-2)(z-4)}$$

$$Y_1(z) = \frac{Y(z)}{z} = \frac{1}{(z-2)(z-4)} = \frac{A}{z-2} + \frac{B}{z-4}$$

$$A = Y_1(z)(z-2) \Big|_{z=2} = \frac{1}{z-4} \Big|_{z=2} = -\frac{1}{2}$$

$$B = Y_1(z)(z-4) \Big|_{z=4} = \frac{1}{z-2} \Big|_{z=4} = \frac{1}{2}$$

$$Y(z) = \frac{-\frac{1}{2}}{z-2} + \frac{\frac{1}{2}}{z-4}$$

$$y[n] = \left[-\frac{1}{2}(2)^n + \frac{1}{2}(4)^n \right] u[n]$$

-8

$$y[n] = \underline{\hspace{2cm}}$$

$$2-1+3-2$$

5. (20 points) Calculate the DFT of the following discrete-time signal with: $x[0] = 2$, $x[1] = -1$, $x[2] = 3$, $x[3] = -2$. The DFT values of $X(0)$, $X(1)$, $X(2)$ and $X(3)$ are required for this question.

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j2\pi nk/N} = \sum_{n=0}^{3} x[n] e^{-j2\pi nk/4}$$

$$14$$

$$X[0] = \sum_{n=0}^3 x[n] e^{-j2\pi n \cdot 0/4} = x[0] + x[1] + x[2] + x[3]$$

$$= \sum_{n=0}^3 x[n] = 2 - 1 + 3 - 2 = 2$$

$$X[1] = \sum_{n=0}^3 x[n] e^{-j2\pi n \cdot 1/4}$$

$$= \sum_{n=0}^3 x[n] e^{-j\pi n/2}$$

$$= \sum_{n=0}^3 x[n] e^{-j\pi n/2}$$

$$(2)e^{-j0\pi/2} - 1e^{-j\pi/2} + 3e^{-j\pi} - 2e^{-j3\pi/2}$$

$$X[1] = 2 - j2 - 1 - j2 = -2$$

$$X[2] = \sum_{n=0}^3 x[n] e^{-j2\pi n \cdot 2/4}$$

$$= \sum_{n=0}^3 x[n] e^{-j\pi n}$$

$$X[2] = \sum_{n=0}^3 x[n] e^{-j\pi n}$$

$$X[2] = (2)e^0 + 2e^{-j\pi} + 3e^{-j2\pi} - 2e^{-j3\pi} = (2 - 1 + 3 - 2) = 2$$

$$X[3] = \sum_{n=0}^3 x[n] e^{-j2\pi n \cdot 3/4}$$

$$X[3] = \sum_{n=0}^3 x[n] e^{-j3\pi n/2}$$

$$X[3] = 1e^0 + 2e^{-j3\pi/2}$$

$$X(0) = X[3] = 2 - 1e^{j3\pi/2} + 3e^{-j3\pi} - 2e^{-j3\pi/2} = 2 - j2 - 3 - j2 = -2$$

$$X(2) =$$

$$X(3) =$$

6. (20 points) The discrete-time Fourier transform (DTFT) of a signal $x[n]$ is

$$X(\Omega) = \frac{2}{3 + e^{-j\Omega}}$$

Find the DTFT of the following signals.

(a) $y[n] = x[-n]$; (b) $z[n] = x[n]e^{j6n}$; (c) $w[n] = x[n] + x[n-1]$

$Y(\Omega) =$ _____

$W(\Omega) =$ _____

$Z(\Omega) =$ _____

-20

**SIGNALS AND SYSTEMS SEMESTER PROJECT
FALL 2021**

COMPUTER ASSIGNMENT

TOPICS COVERED IN COMPUTER ASSIGNMENT

- 1. Convolution**
- 2. Impulse and Step Response**
- 3. Fourier Transform**

**SIGNALS AND SYSTEMS
SEMESTER PROJECT
FALL 2021**

COMPUTER ASSIGNMENT QUESTIONS

**PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 SIGNALS AND SYSTEMS
FALL 2021**

COMPUTER ASSIGNMENT

Due Date: Wednesday, November 10, 2021

Problems are from the Class Textbook, "Signals and Systems: A Primer with MATLAB" by M.N.O. Sadiku and W.H. Ali

1. Problem 2.37 (a)
2. Problem 3.50 (b)
3. Problem 5.50 (b)

**SIGNALS AND SYSTEMS
FALL 2021**

DETAILED COMPUTER GRADING SCHEME

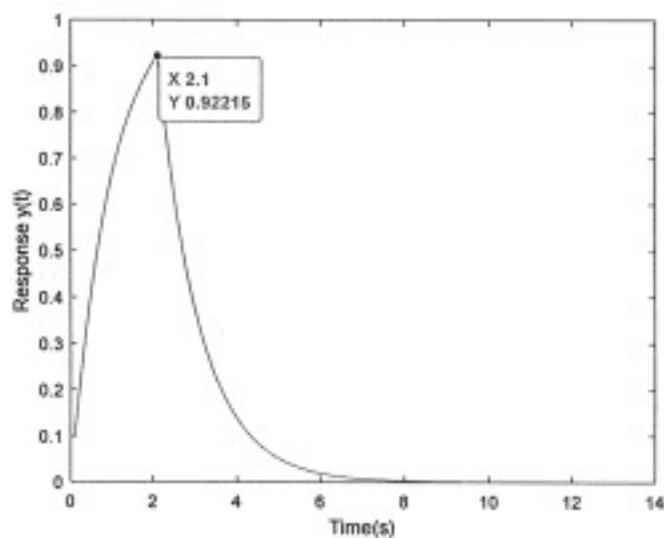
**ELEG 3302-P01 SIGNALS AND SYSTEMS
COMPUTER ASSIGNMENT
FALL 2021**

SOLUTION TO COMPUTER ASSIGNMENT

1. Solution to Problem 2.37(a)

MATLAB Script:

```
% solution to ELEG 3023 Computer Assignment #1
T = 0.1; %sampling period
t = 0:T:10;
t1 = 0:T:2;
len1 = max(size(t1));
x = ones(len1, 1); % calculates x(t)
h = exp(-t); % calculates h(t)
y = T*conv(x,h); % calculates the convolution of x(t) and h(t)
len2 = max(size(y));
t0 = (1:len2)*T;
plot(t0,y) % plot y(t)
xlabel('Time(s)')
ylabel('Response y(t)')
```



2. Solution to Problem 3.44 (c)

MATLAB Program

```
syms s t
x = sin(2*t)*exp(-t);
X = laplace(x)
```

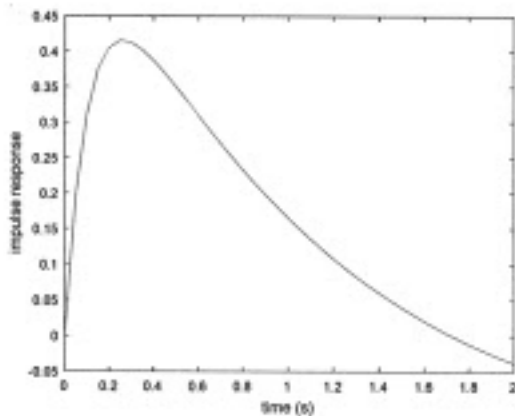
SOLUTION

$$X = 2/((s + 1)^2 + 4)$$

3. Solution to Problem 3.50 (b)

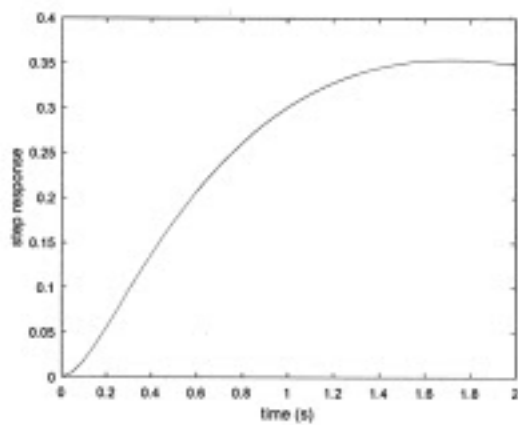
MATLAB Program (Impulse Response)

```
num = [ 5 0 ];
den = [1 10 10 4];
t = 0:0.05:2;
y=impz(num,den,t)
plot(t,y)
xlabel('time (s)')
ylabel('impulse response')
```



MATLAB Program (Step Response)

```
num = [ 5 0 ];
den = [1 10 10 4];
t = 0:0.05:2;
y=step(num,den,t)
plot(t,y)
xlabel('time (s)')
ylabel('step response')
```



4. Solution to Problem 5.50 (b)

```
% problem 5_50b Comp. Assgn #3
syms y t
y = ( exp(-2*t) - exp(-t) )*heaviside(t);
Y = fourier(y)
pretty(Y)
```

Solution:

```
>> pr_5_50b
```

Y =

- 1/(1 + w*1i) + 1/(2 + w*1i)

$$= \frac{1}{1 + w \, 1i} + \frac{1}{2 + w \, 1i}$$

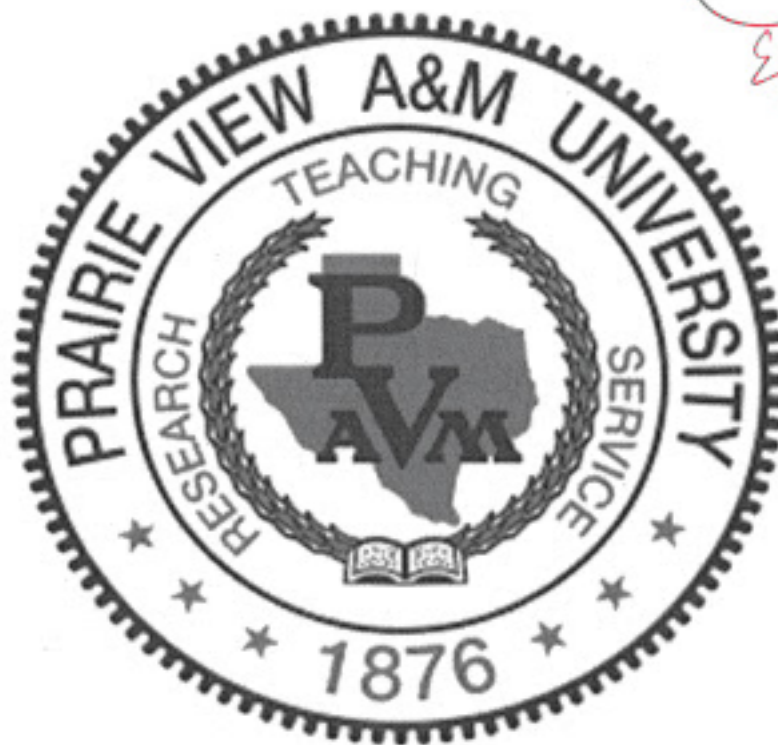
ABOVE AVERAGE

ELEG 3302
Signals and Systems:
Computer Assignment

Dr. Attia
Xavier Dukes

100%

Excellent



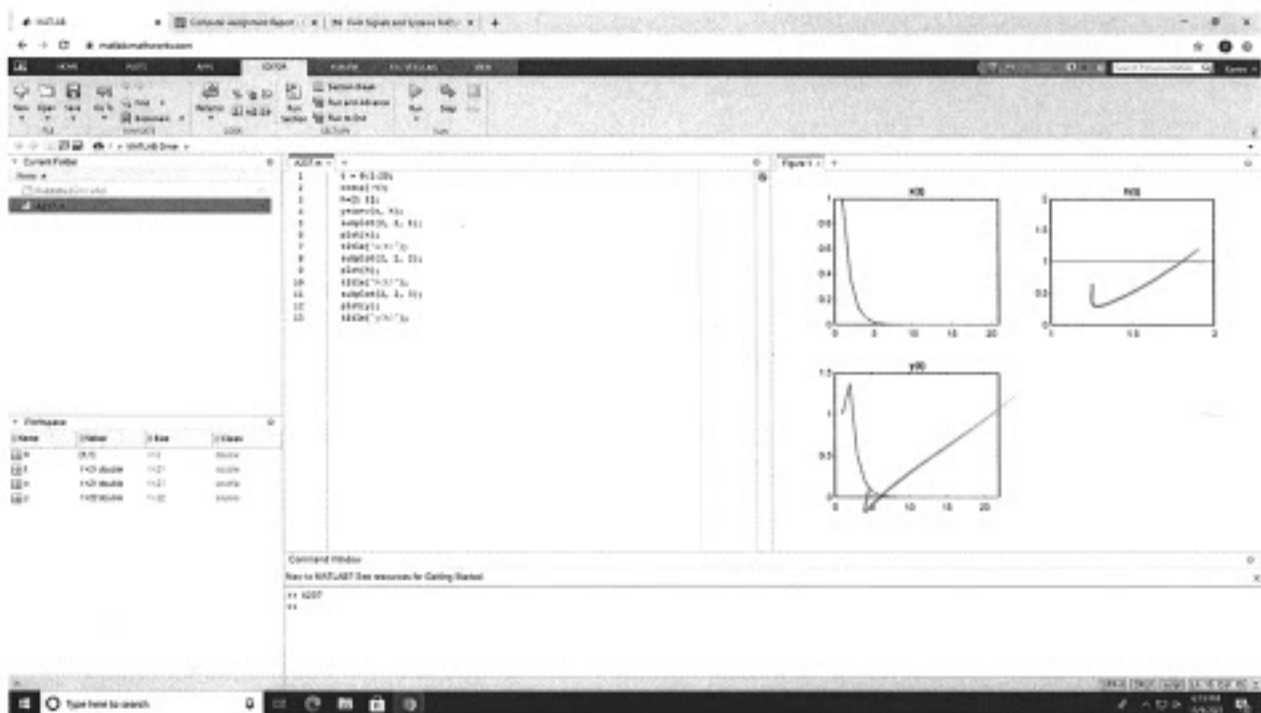
Problem 2.37:

Code:

```
t = 0:1:20;  
x=exp(-t);  
h=[1 1];  
y=conv(x, h);  
subplot(2, 2, 1);  
plot(x);  
title('x(t)');  
subplot(2, 2, 2);  
plot(h);  
title('h(t)');  
subplot(2, 2, 3);  
plot(y);  
title('y(t)');
```



Results:



The code above convolves the function and outputs the results in a graphical format once the code is run. ✓

Problem 3.50:

Code:

`syms H`

`H = tf([5 0], [1 10 10 4]);`

`subplot(2, 1, 1);`

`step(H);`

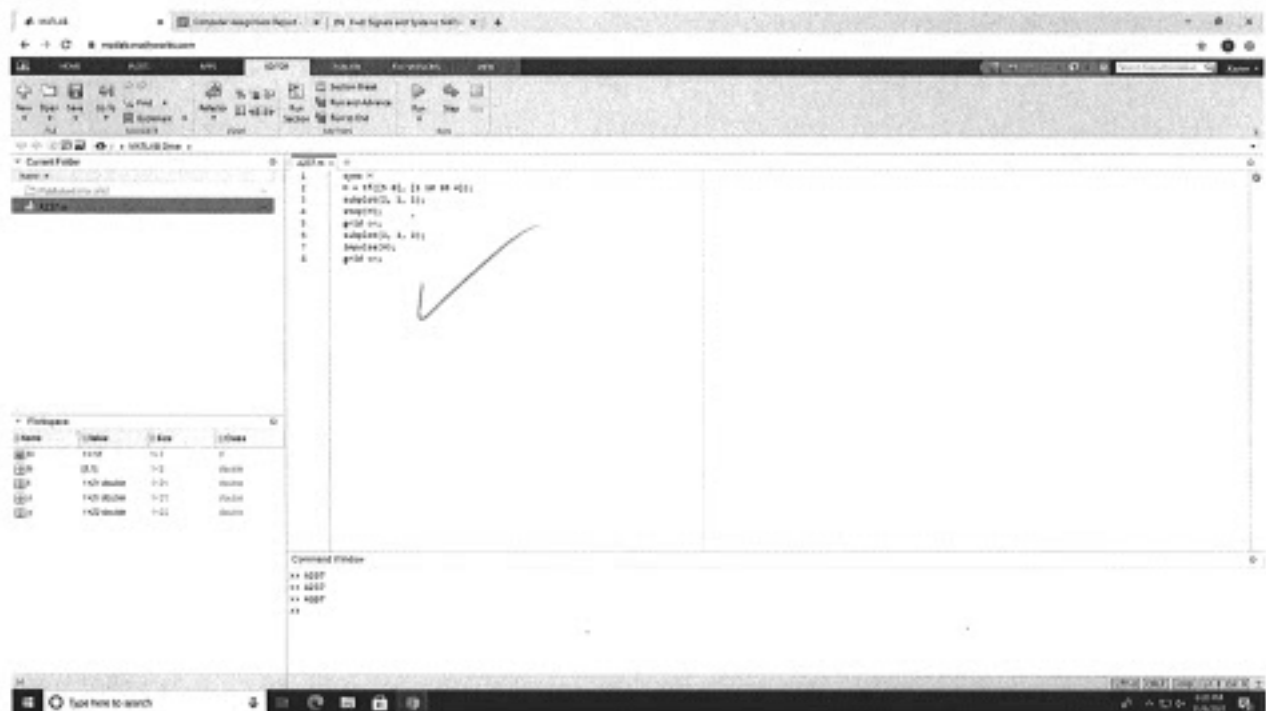
`grid on;`

`subplot(2, 1, 2);`

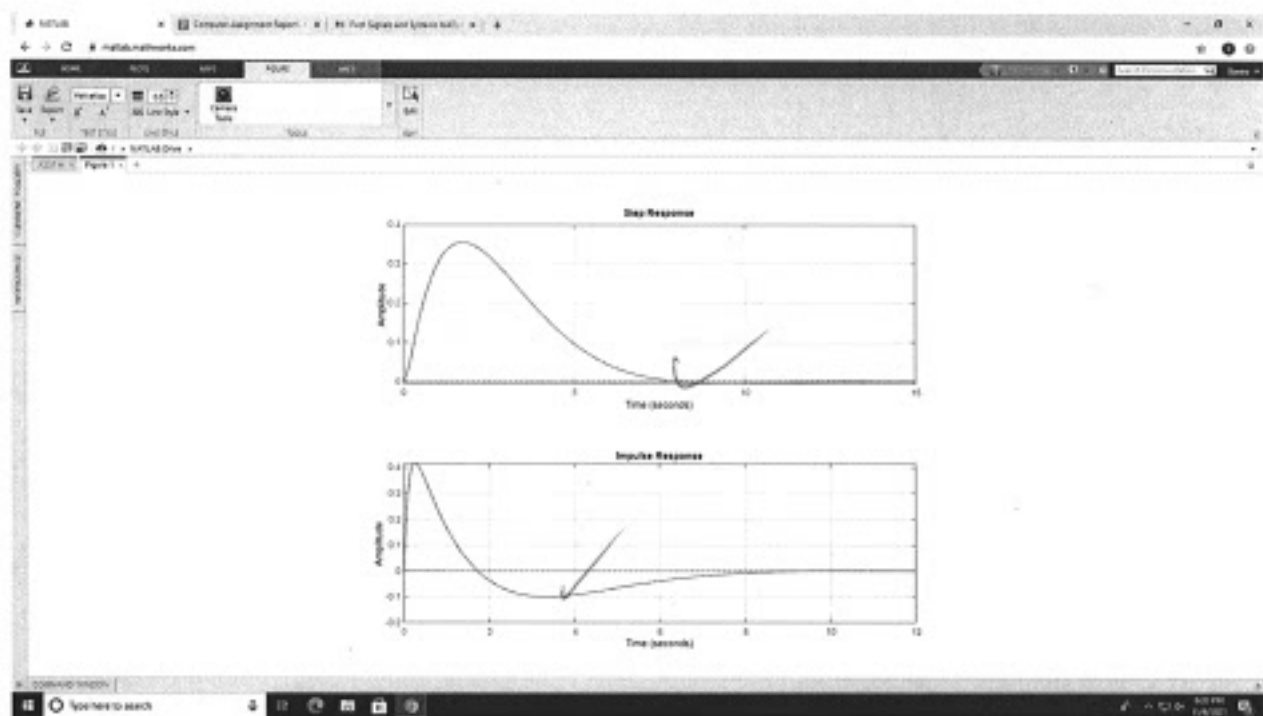
`impz(H);`

`grid on;`

Results:



This code segment finds the unit response of given functions and plots them on graphs.



Problem 5.50:

Code:

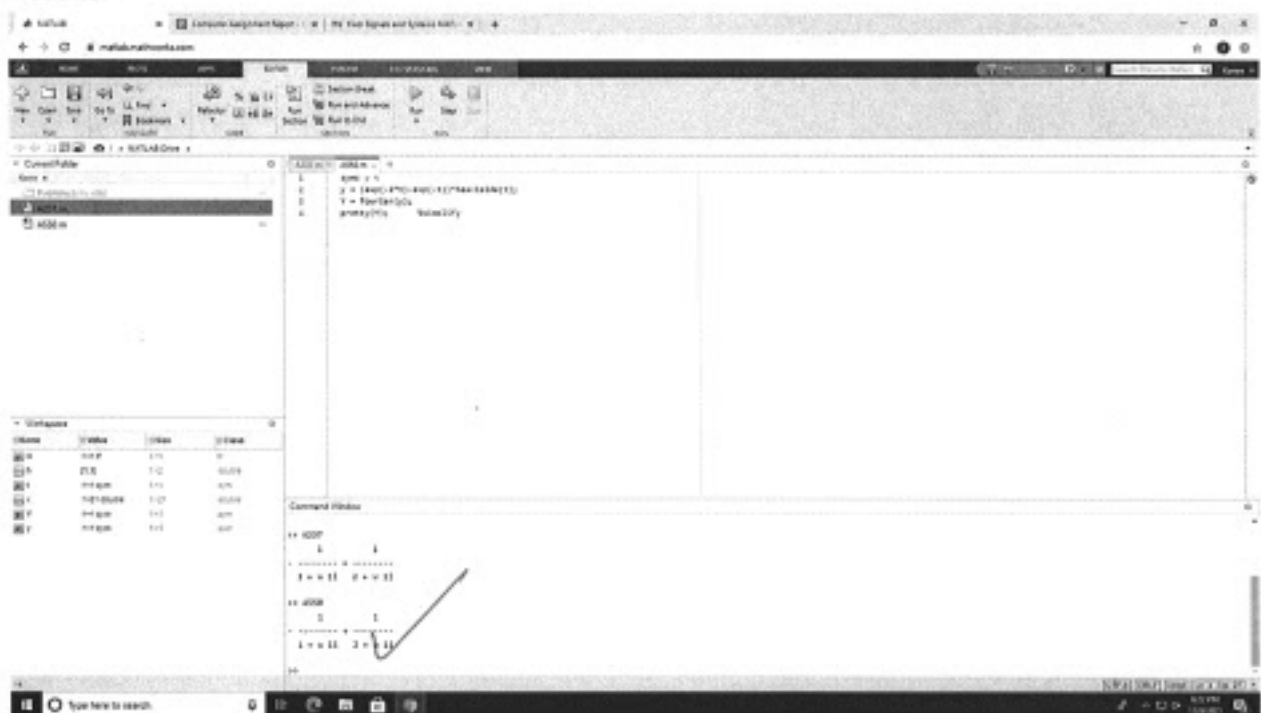
```
syms y t
```

```
y = (exp(-2*t)-exp(-t))*heaviside(t);
```

```
Y = fourier(y);
```

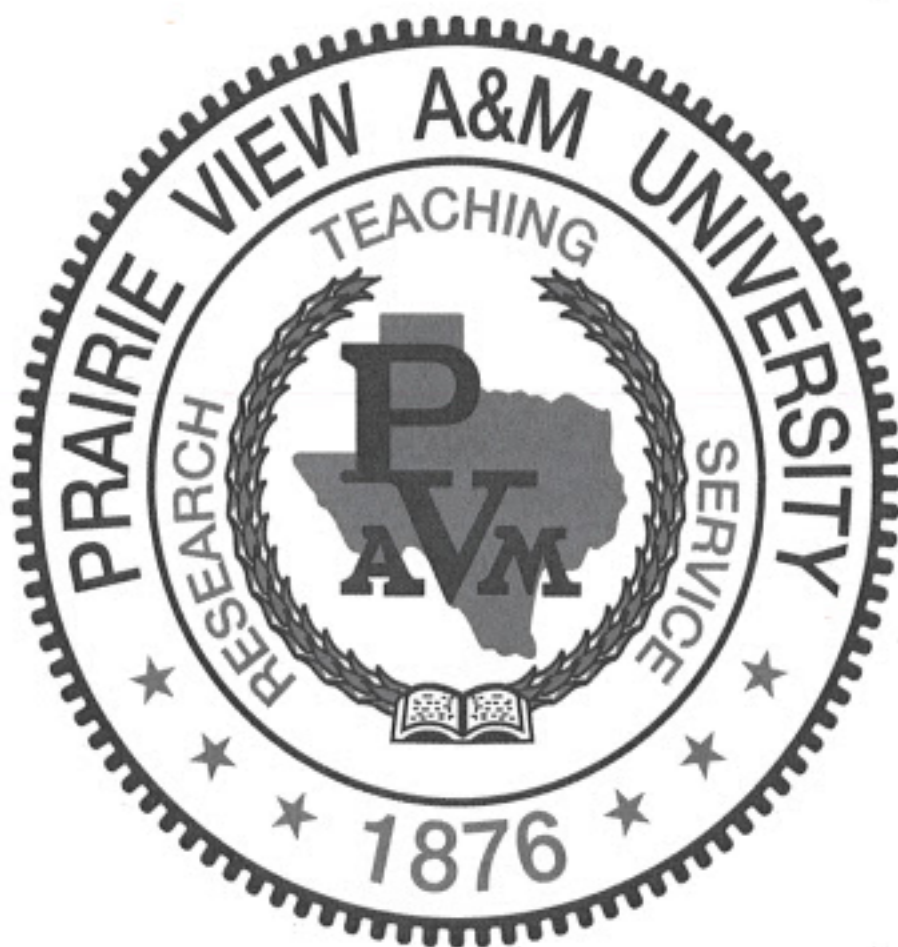
```
pretty(Y); %simplify
```

Results:



This code finds the fourier transform of a function using the following code. Once the program is executed the fourier transform of the given function is output in the command window.

AVERAGE



95%

ELEG 3302: Signal System

Computer Assignment

November 10, 2021

Brandon R Beckwith

Objective:

Case 1: Use MATLAB a program to convolve the impulse response

Case 2: Use MATLAB to obtain the Fourier transform of the given signals

Case 3: Find the impulse response and the step response for each of the following systems:

Source Material:

Problems 2.37(a), 3.50(b) and 5.50 (b)

Sadiku, M.N.O., & Ali, W.H. (2015). Signals and Systems: A Primer with MATLAB (1st ed.). CRC Press. <https://doi.org/10.1201/b19285> pg. 103,169 and 268.

Equipment & Software

Matlab Online - <https://matlab.mathworks.com>

Written Program Code Design:

Case 1: Solve for the Convolution of the given impulse response

Utilizing the 'conv' function of MATLAB to obtain the results.

$$x(t) = e^{-t}u(t)$$

$$h(t) = u(t) - u(t - 2)$$

```
%Brandon Beckwith
%ELEG3302-P01 Signals and Systems Fall 2021
% Problem 2.37(a) MATLAB writing a program to Convolve
% x(t) = e^-t*u(t)
% h(t) = u(t)-u(t-2)
T = 0.1; % sampling period
t = 0:T:10;
x = exp(-t); %calculates x(t)
h = t - (t-2);
y = T*conv(x,h); %this contains Lx+Lh -1
t0=(0:200)*T;
plot(t0,y);
xlabel('Time(s)');
ylabel('Response y(t)');
```

Case 2: Solve and Generate a plot of both the impulse and step responses

Utilitizing the 'step', 'impulse' and 'plot' functions of MATLAB to obtain the results.

$$H(s) = \frac{5s}{(s^3 + 10s^2 + 10s + 4)}$$

```
%%Brandon Beckwith
%ELEG3302-P01 Signals and Systems Fall 2021
% Problem 3.50(b) MATLAB writing a program to find the impulse response
% and the step response
% H(s) = 5(s) / s^3+10s^2+10s+4

num = [5];
den = [1 10 10 4];
t = 0: 0.1: 20;
y = impulse(num,den,t);
```

```

w = step(num,den,t);
%plot(t,y,t,w); % plot y and w%
plot(t,y,'m-');
hold on
plot(t,w,'b');
legend(['Impulse Response'],'Step Response');

```

Case 3: Obtain Fourier Transform of the give signal
Utilizing the 'fourier' function in MATLAB to obtain the results.

$$y(t) = (e^{-2t} - e^{-t}) u(t)$$

```

%Brandon Beckwith
%ELEG3302-P01 Signals and Systems Fall 2021
% Problem 5.50(b) Obtain the fourier Transform of the
% following signals:  $y(t) = (e^{-2t} - e^{-t})u(t)$ 
syms y t
y = heaviside(t)*(exp(-2*t)-exp(-t)); % define the signal
Y = fourier(y);
pretty(Y); % simplify

```

Results:

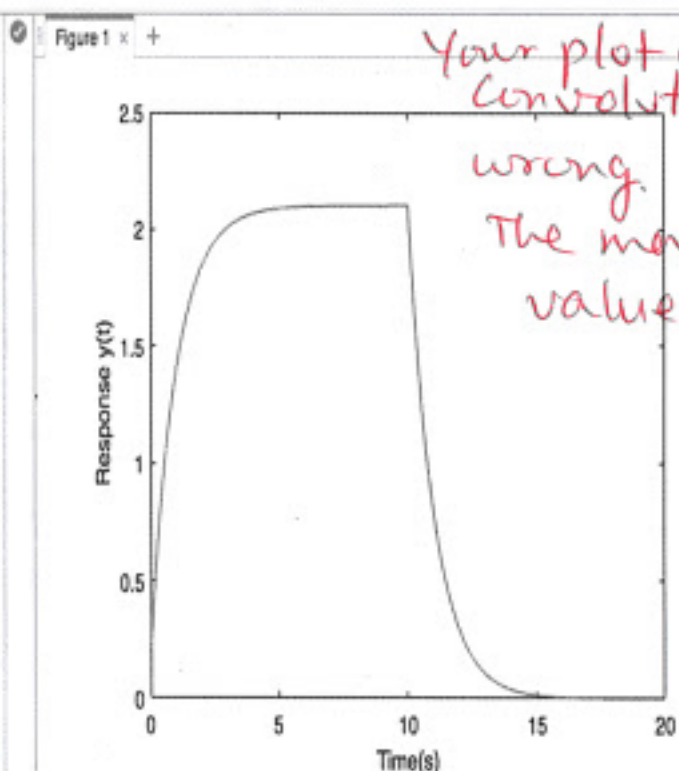
Case 1:

/ > MATLAB Drive >

```

1 %Brandon Beckwith
2 %ELEG3302-P01 Signals and Systems Fall 2021
3 % Problem 2.37(a) MATLAB writing a program to Convolve
4 %  $x(t) = e^{-t}u(t)$ 
5 %  $h(t) = u(t) - u(t-2)$ 
6
7 T = 0.1; % sampling period
8 t = 0:T:20;
9 x = exp(-t); %calculates x(t)
10 h = t - (t-2);
11 y = T*conv(x,h); %this contains Lx+Lh -1
12 t0=(0:200)*T;
13 plot(t0,y);
14 xlabel('Time(s)');
15 ylabel('Response y(t)');
16
17

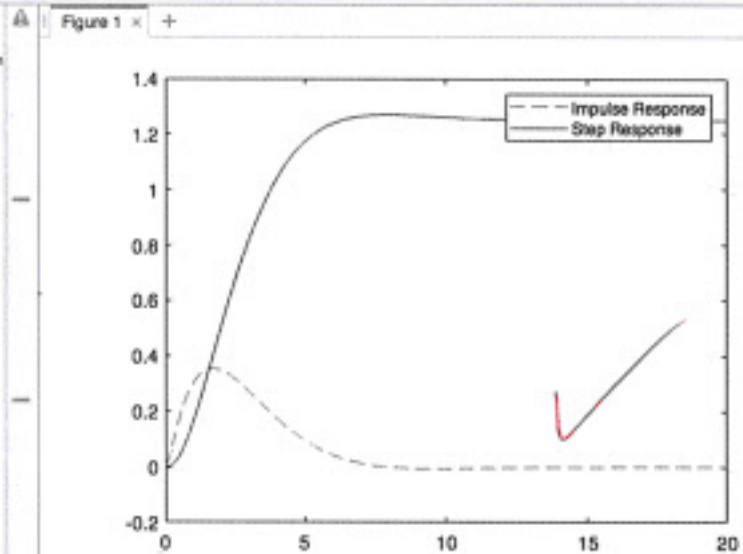
```



Case 2: Impulse Response and Step Resonse

```
%Brandon Beckwith
%ELEG3382-P01 Signals and Systems Fall 2021
% Problem 3.58(b) MATLAB writing a program to find the im
% and the step response
% H(s) = 5(s) / s^3+10s^2+10s+4

num = [5];
den = [1 10 10 4];
t = 0: 0.1: 20;
y = impulse(num,den,t);
w = stepnum,den,t);
subplot(t,y, t,w); % plot y and w
plot(t,y, 'm--');
hold on
plot(t,w, 'b');
legend(['Impulse Response','Step Response']);
```



Case 3: Fourier Transform

Problem5_50.m x

```
1 %Brandon Beckwith
2 %ELEG3382-P01 Signals and Systems Fall 2021
3 % Problem 5.58(b) Obtain the fourier Transform of the
4 % following signals:  $y(t) = (e^{-2t} - e^{-t})u(t)$ 
5 syms y t
6 y = heaviside(t)*(exp(-2*t)-exp(-t)); % define the signal
7 Y = fourier(y);
8 pretty(Y); % simplify
9
10
```

Command Window

>> Problem5_50

```
1 1
----- + -----
1 + w 1i 2 + w 1i
```

Conclusion

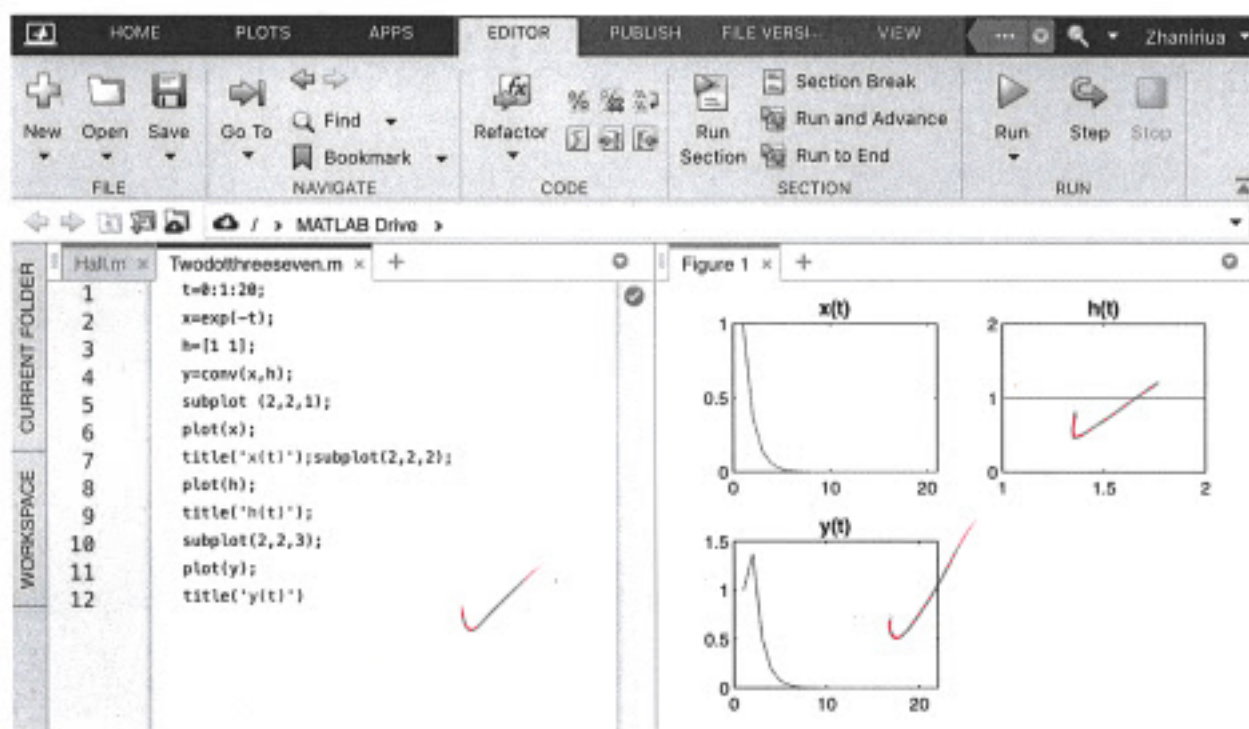
Upon completion of assignment, All program code function successfully. Some syntax error occurred during simulation runs of the programs which were missing ';' or ' '. Thus, resulting an incomplete statement. In Case 3, an additional ';' placed at the end of the 'syms' line caused program to return the value of the initialize integer. As the removal of that ';' allow to program code to run fully as written. Each program produce it particular function as it was written. ✓

BELOW AVERAGE

Zhaniriua Hall
 PRAIRIE VIEW A&M UNIVERSITY
 DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
 ELEG 3302-P01 SIGNALS AND SYSTEMS
 FALL 2021
 COMPUTER ASSIGNMENT

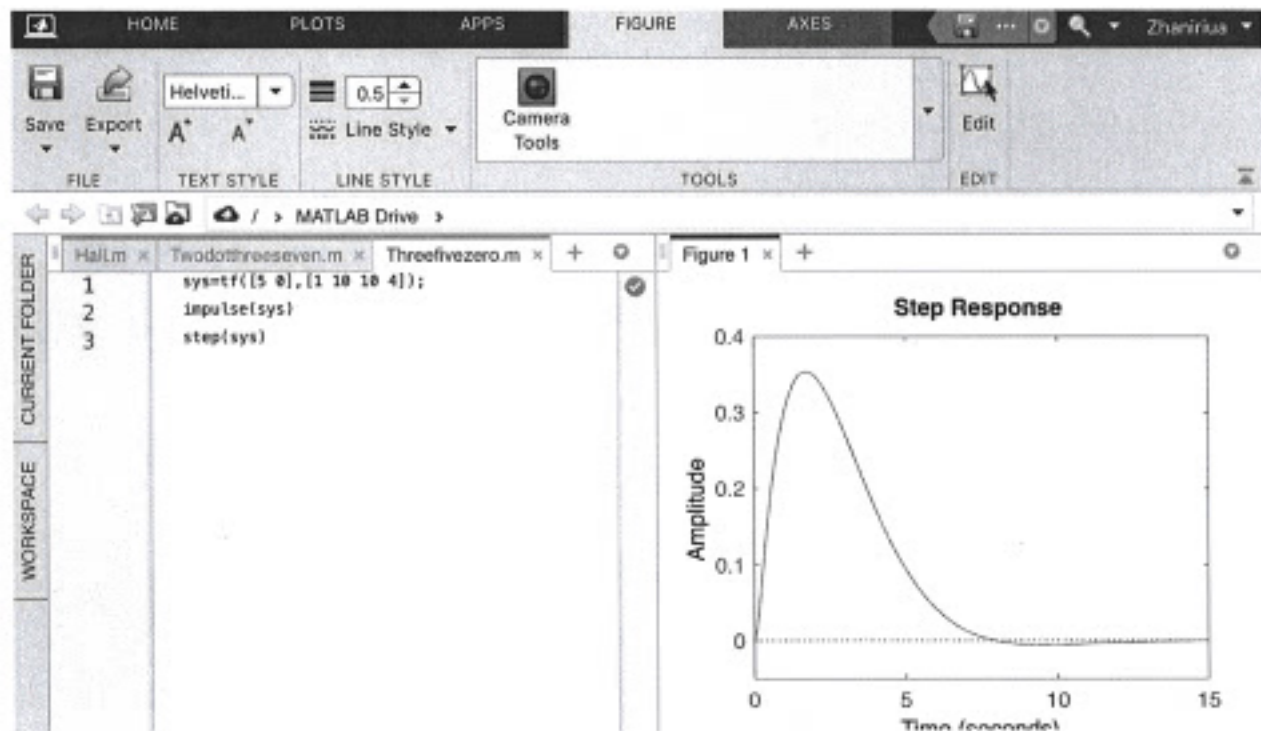
90%

1. Problem 2.37 (a) Using MATLAB, write a program to convolve $x(t) = e^{-t}u(t)$ and $h(t) = u(t) - u(t - 2)$



Using MATLAB to find the graphic solutions for this problem was fairly easy. First you set the y boundaries for each graph, then you set the boundaries for each graph. In the middle of doing that, you tell the program where to plot the points. Then the last thing you have to do is name each graph .

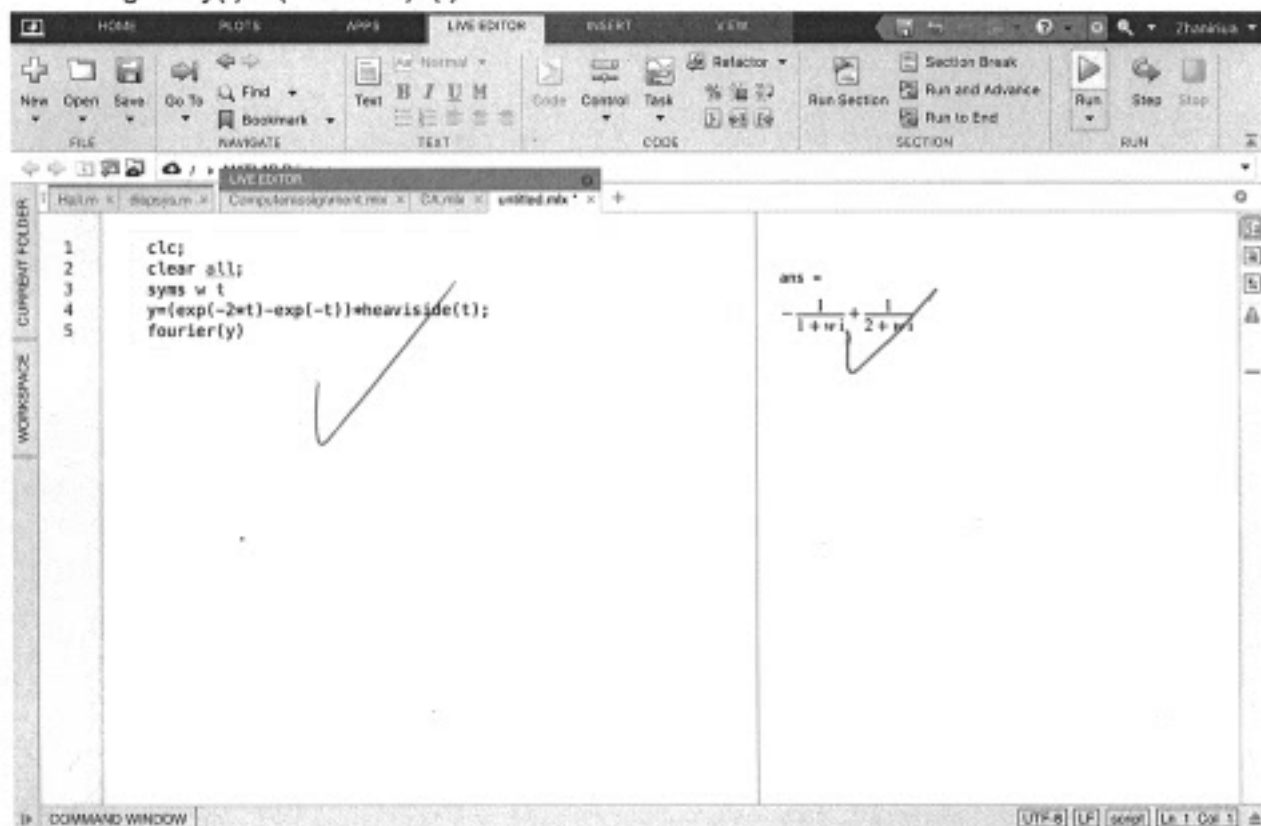
2. Problem 3.50 (b) Find the impulse response and the step response for each of the following systems: $H(s) = \frac{5s}{s^3 + 10s^2 + 10s + 4}$



While using MATLAB to solve this equation, I realized that the coefficients of the equations are needed. When inputting this code you have to identify the coefficients, list them under systems, then set the boundaries.

The impulse response was not provided. -10

3. Problem 5.50 (b) Use MATLAB to obtain the Fourier transform of the following signals: $y(t) = (e^{-2t} - e^{-t})u(t)$



In the problem given they state what y of t equals. The expression given for y of t is input into MATLAB and ran.

**SIGNALS AND SYSTEMS
SEMESTER PROJECT
FALL 2021**

PROJECT TITLE: MODELING AN ACTIVE NETWORK

TOPICS COVERED IN PROJECT

- 1. Active Network**
- 2. Passive Network Model of Active Network**
- 3. Applications of MultiSim**
- 4. Transfer Function of a Network**
- 5. Application of Linearity Principle for obtaining an input signal that will give a particular output signal or the Use of Phasors, Ohm's Law and KVL to obtain the input signal given a particular output voltage**

**SIGNALS AND SYSTEMS
SEMESTER PROJECT
FALL 2021**

**DETAILED PROJECT PROBLEM STATEMENT
AND REQUIREMENTS**

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302-P01 – FALL 2021
CLASS PROJECT: MODELING AN ACTIVE NETWORK

In this project, a team consisting of about two students must determine a possible circuit that can be used to model an active network shown figure 1.

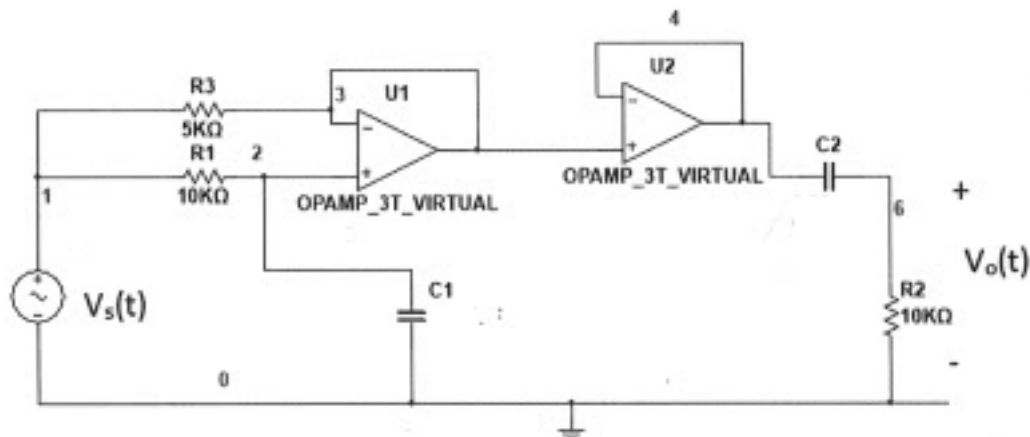


Figure 1: Active Network

For groups 1 to 5, the component values are shown in Table 1:

Table 1: Component Values and Frequency (freq_X)

Group	R1	C1	R2	C2	R3	freq_X (Hz)
1	1.00E+04	5.00E-07	1.00E+04	5.00E-07	5.00E+03	5.00E+01
2	1.00E+04	5.00E-08	1.00E+04	5.00E-08	5.00E+03	5.00E+02
3	1.00E+04	5.00E-09	1.00E+04	5.00E-09	5.00E+03	5.00E+03
4	1.00E+04	5.00E-10	1.00E+04	5.00E-10	5.00E+03	5.00E+04
5	1.00E+04	5.00E-11	1.00E+04	5.00E-11	5.00E+03	5.00E+05

- Use MultiSim to determine the frequency response of the active network
- Obtain an equivalent passive network, with its element values, that will have the same frequency response as that obtained in part (a).
- Use MultiSim to determine the frequency response of the passive network obtained in part (b)
- Compare the center frequencies and bandwidths of the frequency responses obtained in parts (a) and (c).
- Determine the transfer function equation of the passive network obtained in part (b)
- Given that the output signal is $v_o(t) = 0.1 \cos(2\pi * \text{freq_X} * t)$, find the input signal $v_s(t)$ of the passive network obtained in part (b).

Content of Your Report

Your report must have the following sections:

- (i) Title of project
- (ii) Problem Statement
- (iii) Frequency Response of the Active Filter Network – use MultiSim to determine the frequency response of the active filter network
- (iv) Equivalent Passive Network - obtaining an equivalent passive network, with its element values, that will have the same frequency response as the active network.
- (v) Frequency Response of Equivalent Passive Network - use MultiSim to determine the frequency response of the passive network
- (vi) Comparison Between Frequency Responses of Active and Passive Networks - compare the center frequencies and bandwidths of the frequency responses obtained for the active and passive networks.
- (vii) Transfer Function of the Passive Network - determine the transfer function of the passive network
- (viii) An Application of the Model – determine the input signal $v_s(t)$ of the passive network if the output signal is given as $v_o(t) = 0.1 \cos(2\pi * freq_X * t)$
- (ix) Discussion of Results – discuss the results of this project
- (x) Conclusions - provide the major conclusions of this project

Note: The report should be carefully written, with proper grammar and spelling. You are advised to make use of well-designed tables and graphs to present your design and results. Each figure and table should have a numbered caption, and they should be referenced in the text of the report.

Indicate in your report the amount of work done by each member in your group. Signatures of the members in your group indicating they participated actively in the project are required.

Submission (Two Submissions)

- (i) **Each team member must submit a copy of the team project to Ecourse on Thursday, November 18, 2021 by 11:59 p.m.**
- (ii) Each member of a team must submit a softcopy of the project to Taskstream: ELEG 3302-P01, Assignment (outcome 1) on **Thursday, November 18, 2021 by 11:59 p.m.**

SIGNALS AND SYSTEMS FALL 2021

DETAILED PROJECT GRADING SCHEME

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302 SIGNALS AND SYSTEMS
RUBRICS FOR GRADING SOLVING COMPLEX ENGINEERING PROBLEM
FALL 2021

GROUP NUMBER: _____

GROUP MEMBERS: 1. _____
 2. _____

RUBRICS FOR GRADING DESIGN PROJECT

ITEMS	POINTS ACHIEVED	MAXIMUM POINTS
1. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> Obtain passive circuit characteristics that models the active circuit.		20
2. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> Identify element values of the passive circuit for modeling the active circuit.		20
3. <i>Solve Engineering Problem by Using MultiSim (Student Outcome 1.2)</i> Use MultiSim to determine the frequency response of the identified passive network.		10
4. <i>Solve Engineering Problem – Evaluate and Interpret Results (Student Outcome 1.2)</i> Compare the magnitude responses obtained for both the active and passive networks.		10
5. <i>Solve Engineering Problem – Determine Transfer Function of Passive Network (Student Outcome 1.2)</i> Use appropriate equation to determine transfer function of the passive network.		10
6. <i>Solve Engineering Problem – Determine the Input Signal Given an Output Signal (Student Outcome 1.2)</i> Use an appropriate method to determine the input signal for a given output signal.		10
7. <i>Discussion of Results and Conclusions (Student Outcome 1.2)</i> Draw conclusions using appropriate engineering judgement.		10
8. <i>General Write-up of Report</i> (i) Grammar and Adequacy of plots and figures, (ii) Proper labeling of graphs and tables, (iii) Proper references to graphs and tables, (iv) Clear and meaningful sentences, and (v) Organized report		10
9. <i>Composite Report Grade</i>		100
10. <i>Grade for ABET Student Outcome 1.1 (Items #1, 2)</i>		40
11. <i>Grade for ABET Student Outcome 1.1 (Normalized to 100%)</i>		100
12. <i>Grade for ABET Student Outcome 1.2 (Items # 3, 4, 5, 6 and 7)</i>		50
13. <i>Grade for ABET Student Outcome 1.2 (Normalized to 100%)</i>		100
14. <i>Grade for ABET Student Outcome 1 (Items #1, 2, 3, 4, 5, 6, and 7)</i>		90
15. <i>Grade for ABET Student Outcome 1 (Normalized to 100%)</i>		100

ABOVE AVERAGE

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302 SIGNALS AND SYSTEMS
RUBRICS FOR GRADING SOLVING COMPLEX ENGINEERING PROBLEM
FALL 2021

GROUP NUMBER:

4

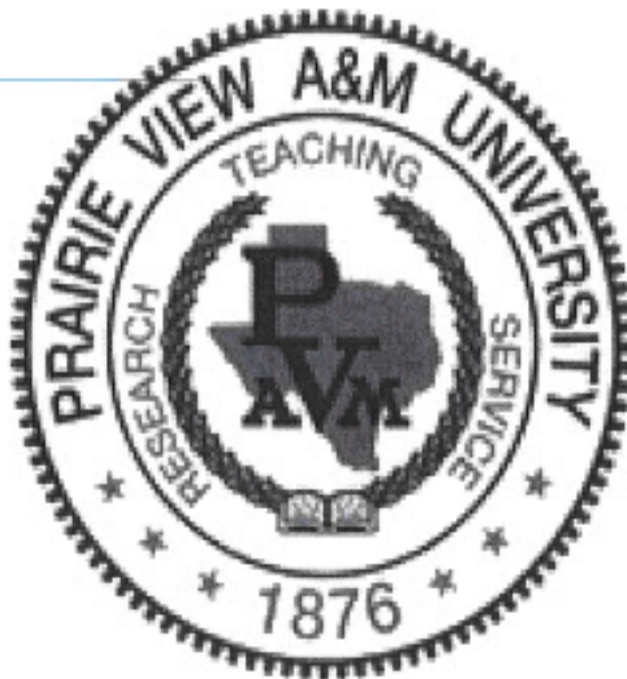
GROUP MEMBERS:

1. Ben Nguyen ✓
2. Abel Mendoza ✓

RUBRICS FOR GRADING DESIGN PROJECT

ITEMS	POINTS ACHIEVED	MAXIMUM POINTS
1. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> • Obtain passive circuit characteristics that models the active circuit.	20	20
2. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> • Identify element values of the passive circuit for modeling the active circuit.	20	20
3. <i>Solve Engineering Problem by Using MultiSim (Student Outcome 1.2)</i> • Use MultiSim to determine the frequency response of the identified passive network.	10	10
4. <i>Solve Engineering Problem – Evaluate and Interpret Results (Student Outcome 1.2)</i> • Compare the magnitude responses obtained for both the active and passive networks.	10	10
5. <i>Solve Engineering Problem – Determine Transfer Function of Passive Network (Student Outcome 1.2)</i> • Use appropriate equation to determine transfer function of the passive network.	10	10
6. <i>Solve Engineering Problem – Determine the Input Signal Given an Output Signal (Student Outcome 1.2)</i> • Use an appropriate method to determine the input signal for a given output signal.	8	10
7. <i>Discussion of Results and Conclusions (Student Outcome 1.2)</i> • Draw conclusions using appropriate engineering judgement.	10	10
8. <i>General Write-up of Report</i> (i) Grammar and Adequacy of plots and figures, (ii) Proper labeling of graphs and tables, (iii) Proper references to graphs and tables, (iv) Clear and meaningful sentences, and (v) Organized report	9	10
9. <i>Composite Report Grade</i>	97	100
10. <i>Grade for ABET Student Outcome 1.1 (Items #1, 2)</i>	40	40
11. <i>Grade for ABET Student Outcome 1.1 (Normalized to 100%)</i>	100	100
12. <i>Grade for ABET Student Outcome 1.2 (Items # 3, 4, 5, 6 and 7)</i>	48	50
13. <i>Grade for ABET Student Outcome 1.2 (Normalized to 100%)</i>	98	100
14. <i>Grade for ABET Student Outcome 1 (Items #1, 2, 3, 4, 5, 6, and 7)</i>	88	90
15. <i>Grade for ABET Student Outcome 1 (Normalized to 100%)</i>	98	100

**ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**



**ELEG 3302: Signal and System
Fall 2021**

Project Report

Dr. Attia

Modeling an Active Network

Group 4

Ben Nguyen *BN*
Abel Mendoza *AM*

50% work from each

Submitted on:
November 23rd, 2021

Objective

Based on a given active network, designing an equivalent passive network that produced a similar frequency response. ✓

Procedure

The values of the active network were given in the table below.

Table (i): Group 4 Active Circuit Given Values

	R1	C1	R2	C2	R3	Freq (Hz)
Group 4	1.00E+04	5.00E-10	1.00E+4	5.00E-11	5.00E+03	5.00E+05

By using Multisim, the frequency response of the active circuit would be determined. Using the results of center, upper and lower frequencies, values of the inductors, capacitors and resistors for the passive network were calculated using the provided formula. Lastly, the transfer function of the network would need to be obtained.

Results

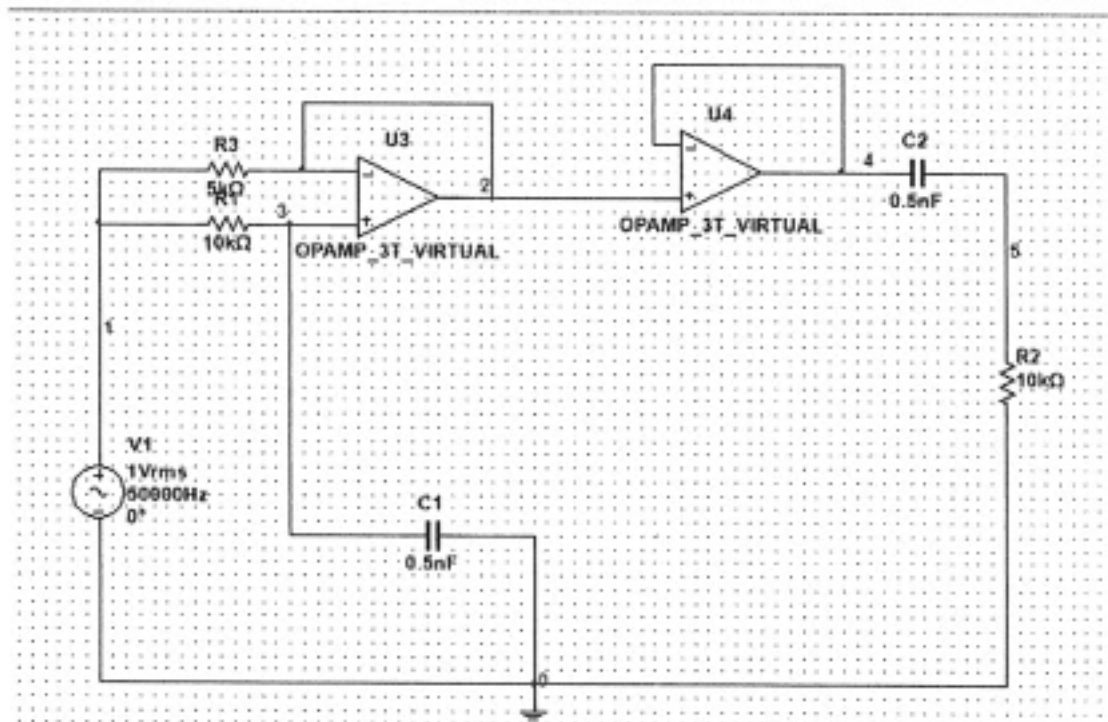


Figure 1: Active Circuit on Multisim

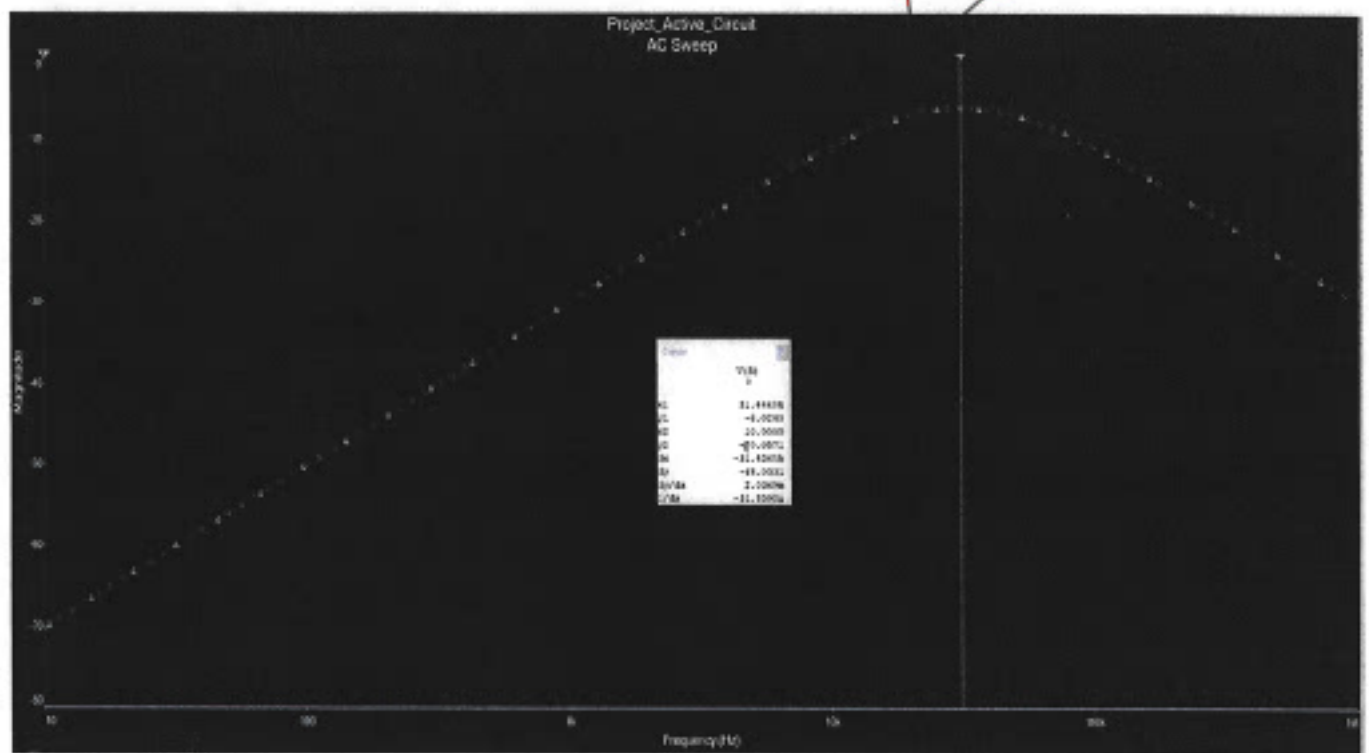


Figure 2: Active Network Frequency Response and Center Frequency

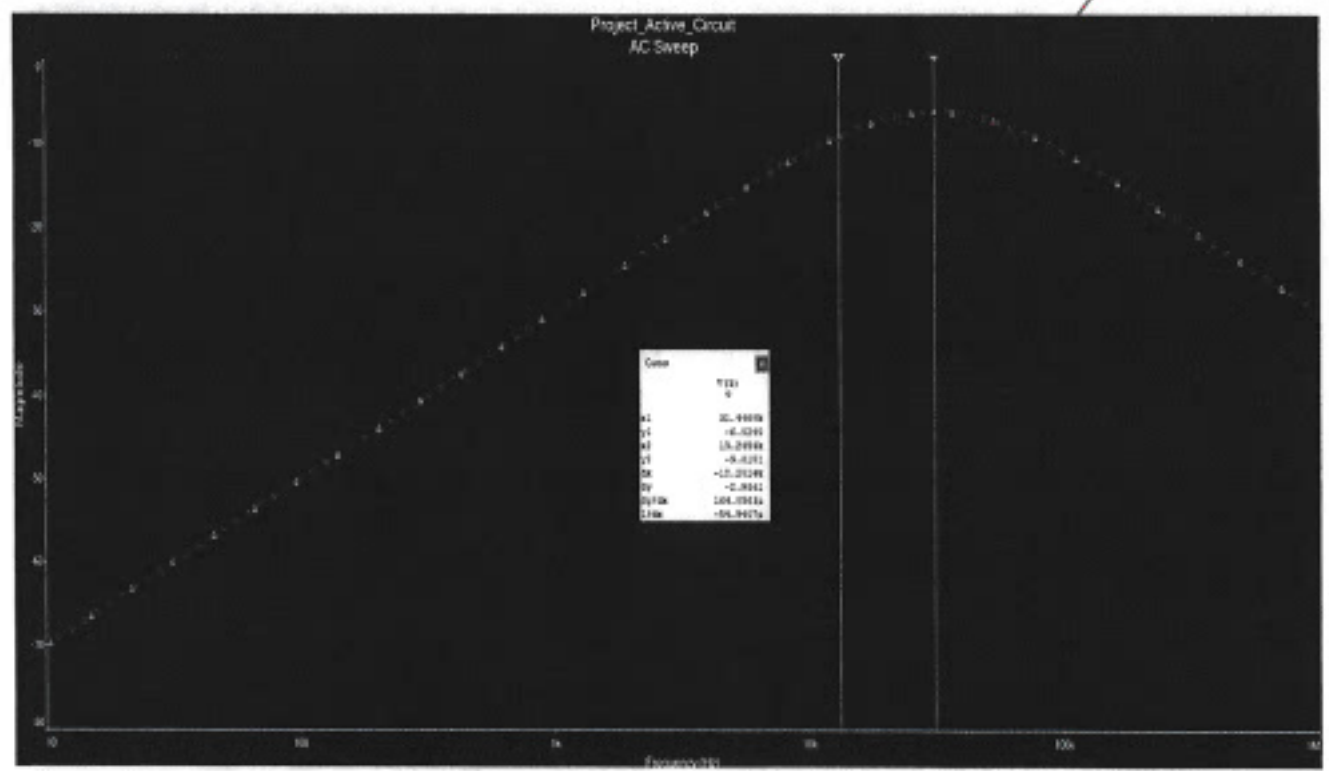


Figure 3: Active Network Lower Cut-off Frequency

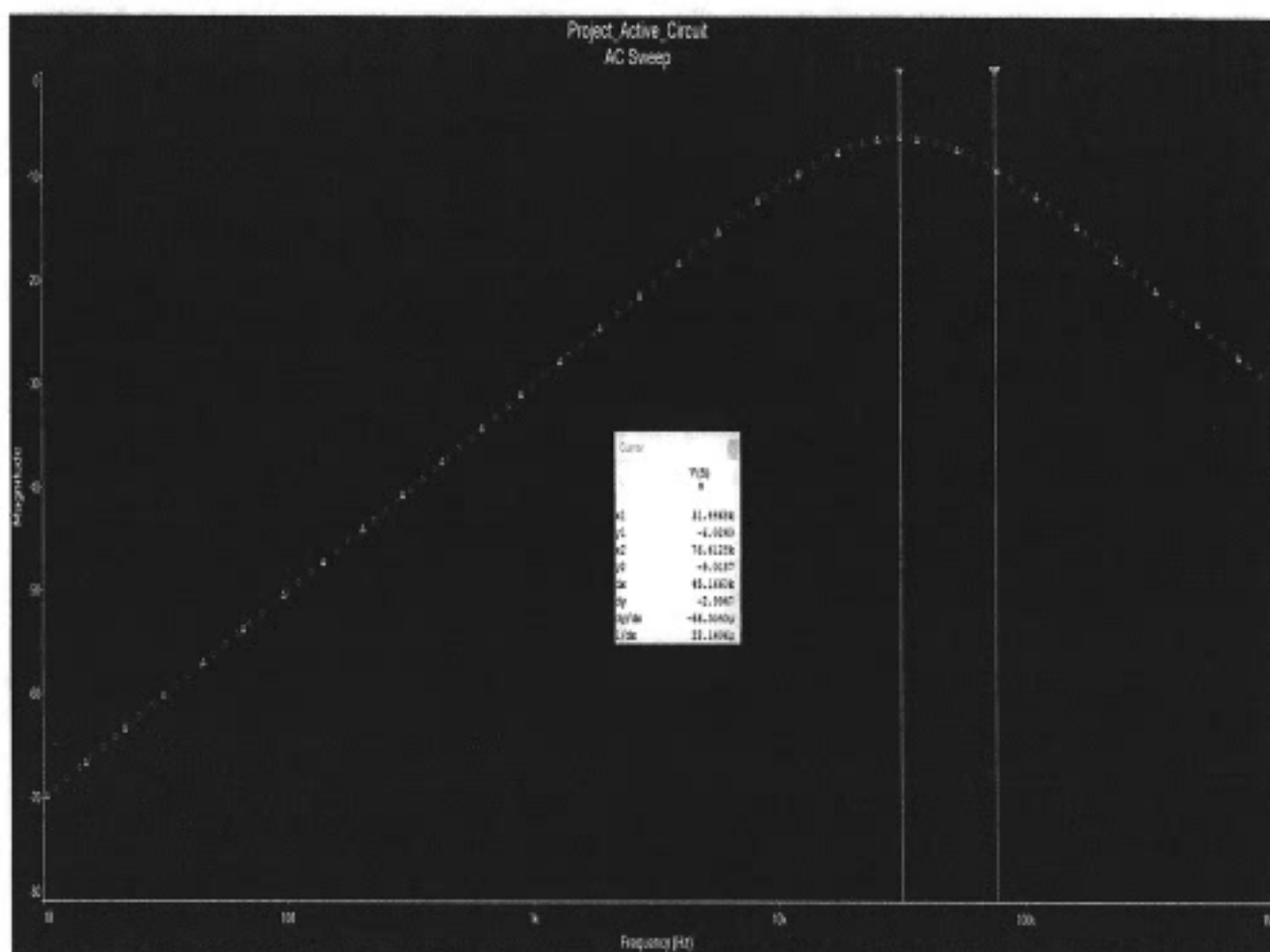


Figure 4: Active Network Upper Cut-off Frequency

Table (ii): Active Network Measured Frequency Values

	Measured
Center Frequency	31.4468 kHz
Lower Frequency	13.2454 kHz
Upper Frequency	76.6128 kHz

$$f_0 = 31.4468 \text{ kHz}$$

$$f_1 = 13.2454 \text{ kHz}$$

$$f_2 = 76.6128 \text{ kHz}$$

$$Q = \frac{f_0}{f_2 - f_1} = \frac{31.4468}{76.6128 - 13.2454} = 0.4963$$

$$\omega_0 = 2\pi \cdot f_0 = 2\pi \cdot 31.4468 \text{ kHz}$$

$$= 197586.0717 \text{ rad/s}$$

$$B = \frac{\omega_0}{Q} = \frac{197586.0717}{0.4963} = 398149.1166 \text{ Hz}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} \Rightarrow C = \left(\frac{1}{\omega_0}\right)^2 / L$$

$$\text{picked } L = 10 \mu\text{H} \checkmark$$

$$= \frac{1}{197586.0717^2 \cdot 10 \times 10^{-6}}$$

$$= 2.5615 \text{ nF} \checkmark$$

$$Q = \frac{\omega_0 \cdot L}{R} \Rightarrow R = \frac{\omega_0 \cdot L}{Q} \checkmark$$

$$= \frac{197586.0717 \cdot 10 \times 10^{-6}}{0.4963}$$

$$= 3.9812 \Omega \checkmark$$

Figure 5: Passive Network Components Hand Calculations

Table (iii): Passive Network Components Values

Components	Calculated Values
Inductor (L)	10 microH
Capacitor (C)	2.5615 microF
Resistor (R)	3.9812 Ohm

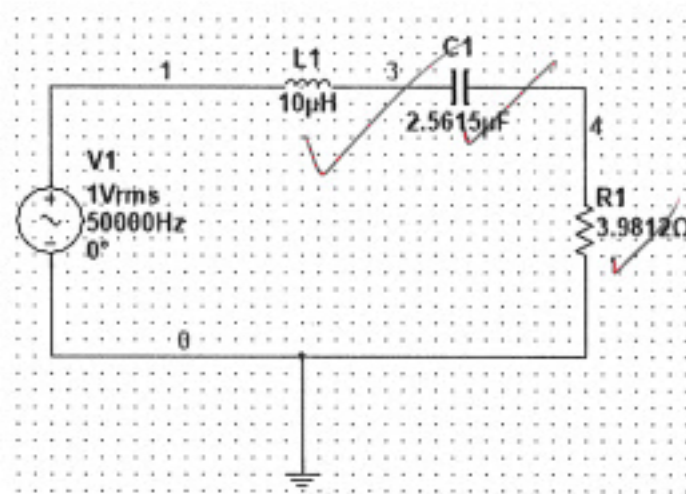


Figure 6: Passive Network Circuit on Multisim; Series RLC Circuit

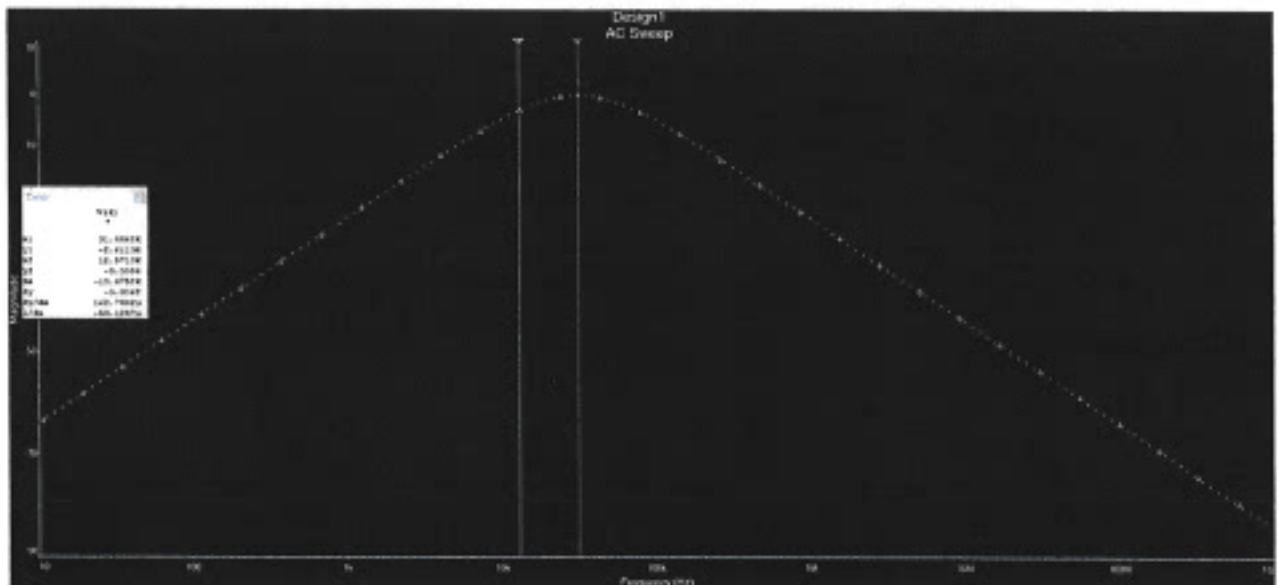


Figure 7: Passive Network Frequency Response, Lower Cut-off, and Center Frequencies

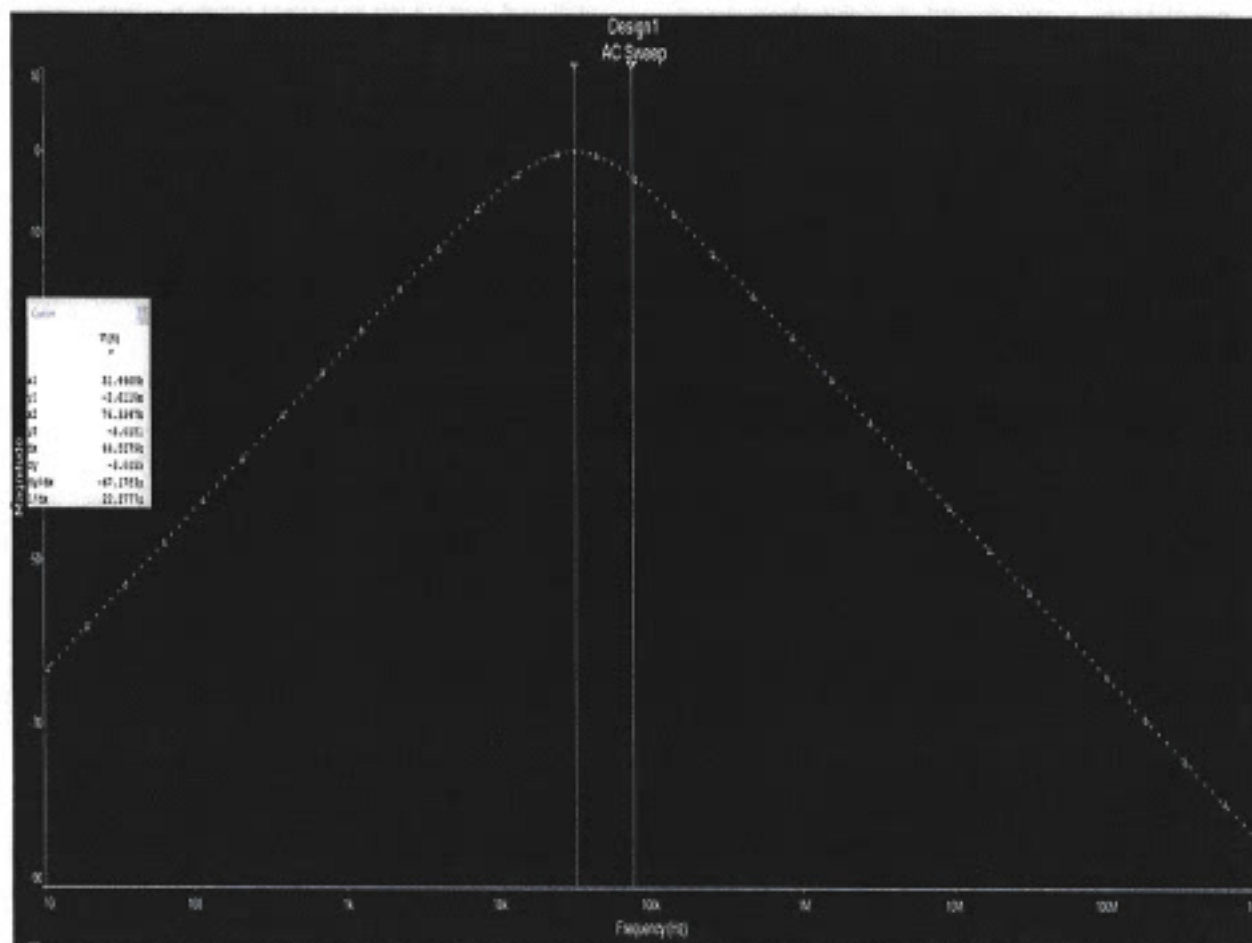


Figure 8: Passive Network Upper Cut-off Frequencies

Table (iv): Frequency Response Comparison of Active and Passive Networks

Values	Active Network	Passive Network
Center Frequency	31.4468 kHz ✓	31.1751 kHz ✓
Lower Cut-off Frequency	13.2454 kHz ✓	13.2366 kHz ✓
Upper Cut-off Frequency	76.6128 kHz ✓	76.6626 kHz ✓
Bandwidth	398149.166 Hz ✓	✓ 398120 Hz

Transfer function

$$\omega_0 = \frac{1}{\sqrt{L \cdot C}} = \frac{1}{\sqrt{10 \times 10^{-6} \cdot 2.5616 \times 10^{-6}}}$$

$$= 197580.6195 \text{ rad/s}$$

$$Q = \frac{\omega_0 \cdot L}{R} = \frac{197580.6195 \cdot 10 \times 10^{-6}}{3.9812}$$

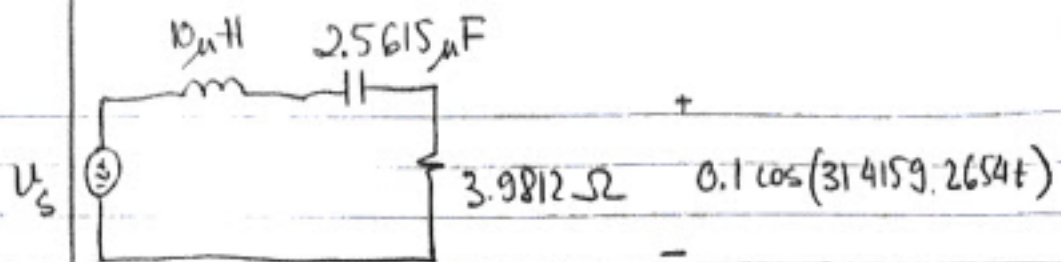
$$= .49628$$

$$H(s) = \frac{H_0 \cdot \frac{\omega_0}{Q} s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$$

$$= \frac{197580.6195 / 0.49628 s}{s^2 + \frac{197580.6195}{0.49628} s + (197580.6195)^2}$$

$$= \frac{398120.0001 s}{s^2 + 398120.0001 s + 3.9038 \times 10^{10}}$$

Figure 9: Passive Network Transfer Function



$$X_L = j \cdot \omega \cdot L = j \cdot 10 \times 10^{-6} \cdot 314159.2654 \cdot \cancel{1000} \\ = 3.1416j \checkmark$$

$$X_C = \frac{-j}{\omega \cdot C} = \frac{-j}{314159.2659 \cdot 2.5615 \times 10^{-6}} \\ = 1.2427j \checkmark$$

$$Z_{eq} = R + X_L + X_C \\ = 3.9812 + \cancel{4.3843j} (3.14 - 1.24)$$

$$\cancel{u_s} u_o = \frac{u_s \cdot R}{Z_{eq}} \Rightarrow u_s = \frac{u_o \cdot Z_{eq}}{R} \\ = \frac{0.1 \cdot (3.9812 + \cancel{4.3843j})}{3.9812}$$

$$= 0.1485 / 47.75^\circ$$

$$\rightarrow u_s = 0.1485 \cos(314159.2654t + 47.75^\circ) \text{ V}$$

a little high

Figure 10: Passive Network Calculating (V) Source

Discussion

In this class project, Modeling an Active Network, we were assigned an active network and values in **Figure 1** and **Table (i)**. We simulated this active network in Multisim with AC sweep and obtained the center frequency to be 31.4468 kHz, the high cut off frequency to be 13.2454 kHz, and the low cut off frequency with a value of 76.6128 kHz/as indicated in **Figures 2-4**.

After those values were confirmed by the instructor, we moved on to find equivalent passive network values to model the passive network circuit. We utilized the equation of $\omega_0 = 2\pi(F_0)$ to calculate a value of 197586.0717 rad/s. We also needed to find the quality factor which was possible by using the equation $Q = F_0/(F_2-F_1)$, this gave us a value of 0.4963. After these values were calculated, we continued to obtain the values of the resistor and capacitor by choosing the value of the inductor at 10 microH. In order to find the value of the capacitor, the following equation $\omega_0 = 1/\sqrt{L \cdot C}$. Capacitor value could be rewritten as $C = (1/\omega_0)^2/L$. As a result, C was calculated to be 2.5615 microFarad. The next needed value would be the resistor which could be obtained with the following equation of quality factor $Q = \omega_0 \cdot L/R$. By isolating R, we would get $R = \omega_0 \cdot L/Q$ and the value of R was determined to be 3.9812 Ohm. With all the values identified, the equivalent passive network could be assembled in Multisim.

The equivalent passive network circuit was simulated in Multisim and an AC sweep was performed to obtain the center frequency with a value of $(F_0) = 31.1751$ kHz, the low cut off frequency of $(F_1) = 13.2366$ kHz, and the high cutoff frequency of $(F_2) = 76.6626$ kHz.

After the equivalent passive network circuit simulation was run, the values were compared to the active network circuit. The center frequency of the active network was at 31.4468 kHz and the passive network was at 31.1751 kHz. The bandwidth for the active network had a value of 398149.166 Hz, while the passive network had a value of 398120 Hz. That meant the passive network produced similar values to the active network. Also, it confirmed the calculating and designing processes were done correctly. **Table (iv)** showed the comparison of two circuits.

After that was confirmed, the transfer function was calculated using the following formula $H(s) = (H_0 \cdot (\omega_0/Q)s)/(s^2 + k_2s + \omega_0^2)$. The result came out to be $H(s) = 398120.001s/(s^2 + 398120.001s - 3.9038 \cdot 10^{10})$. The calculation was shown in **Figure 9**.

Moving to the last part of the project, we needed to determine the input signal $V_s(t)$ of the passive network with a given output voltage $V_o(t)$. The source voltage was calculated to be $V_s(t) = 0.1485 \cos(314159.2654t + 47.75 \text{ degree})$ as **Figure 10** had shown. ✓

Conclusion

Through the completion of this project, we were able to learn how to utilize the given active network's frequency response to obtain the components values of the passive network by using Multisim. The passive circuit had also shown to produce similar frequency response values. With the components values, we were able to achieve the transfer function and determine the input signal $V_s(t)$ successfully. We ran into a few issues and concerns along the way. However, the problems were addressed and resolved by discussing among the team members and consulting with the instructor.

Very Good Report
Well written.

AVERAGE

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302 SIGNALS AND SYSTEMS
RUBRICS FOR GRADING SOLVING COMPLEX ENGINEERING PROBLEM
FALL 2021

GROUP NUMBER:

2

GROUP MEMBERS:

1. Xavier Dukes ✓
2. Arthur Quinney ✓

RUBRICS FOR GRADING DESIGN PROJECT

ITEMS	POINTS ACHIEVED	MAXIMUM POINTS
1. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> Obtain passive circuit characteristics that models the active circuit.	20	20
2. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> Identify element values of the passive circuit for modeling the active circuit.	20	20
3. <i>Solve Engineering Problem by Using MultiSim (Student Outcome 1.2)</i> Use MultiSim to determine the frequency response of the identified passive network.	10	10
4. <i>Solve Engineering Problem – Evaluate and Interpret Results (Student Outcome 1.2)</i> Compare the magnitude responses obtained for both the active and passive networks.	10	10
5. <i>Solve Engineering Problem – Determine Transfer Function of Passive Network (Student Outcome 1.2)</i> Use appropriate equation to determine transfer function of the passive network.	0	10
6. <i>Solve Engineering Problem – Determine the Input Signal Given an Output Signal (Student Outcome 1.2)</i> Use an appropriate method to determine the input signal for a given output signal.	7	10
7. <i>Discussion of Results and Conclusions (Student Outcome 1.2)</i> Draw conclusions using appropriate engineering judgement.	8	10
8. <i>General Write-up of Report</i> (i) Grammar and Adequacy of plots and figures, (ii) Proper labeling of graphs and tables, (iii) Proper references to graphs and tables, (iv) Clear and meaningful sentences, and (v) Organized report	9	10
9. <i>Composite Report Grade</i>	84	100
10. <i>Grade for ABET Student Outcome 1.1 (Items #1, 2)</i>	40	40
11. <i>Grade for ABET Student Outcome 1.1 (Normalized to 100%)</i>	100	100
12. <i>Grade for ABET Student Outcome 1.2 (Items # 3, 4, 5, 6 and 7)</i>	35	50
13. <i>Grade for ABET Student Outcome 1.2 (Normalized to 100%)</i>	70	100
14. <i>Grade for ABET Student Outcome 1 (Items #1, 2, 3, 4, 5, 6, and 7)</i>	75	90
15. <i>Grade for ABET Student Outcome 1 (Normalized to 100%)</i>	83	100

PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING



Course Number: ELEG 3023 Signals & Systems

Course Topic: Modeling an Active Network

Submitted by Group 2

Arthur Quinney, Xavier Dukes

Instructor: Dr. John Attia

Date: 11/18/2021

(1) Class Project: Modeling An Active Network

(2) Problem Statement

The purpose of the project was for students to determine a possible passive RLC circuit that can be used to model an active circuit which is shown below in Figure 1. The passive network should have the same frequency values as the active network depicted below. The element values of the passive circuit will be calculated via the results from multisim from the active network. ✓

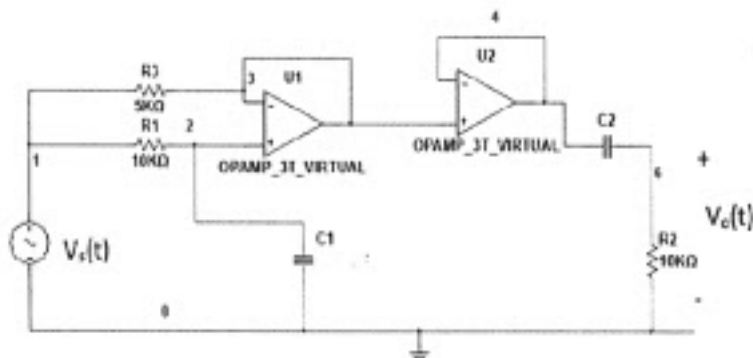
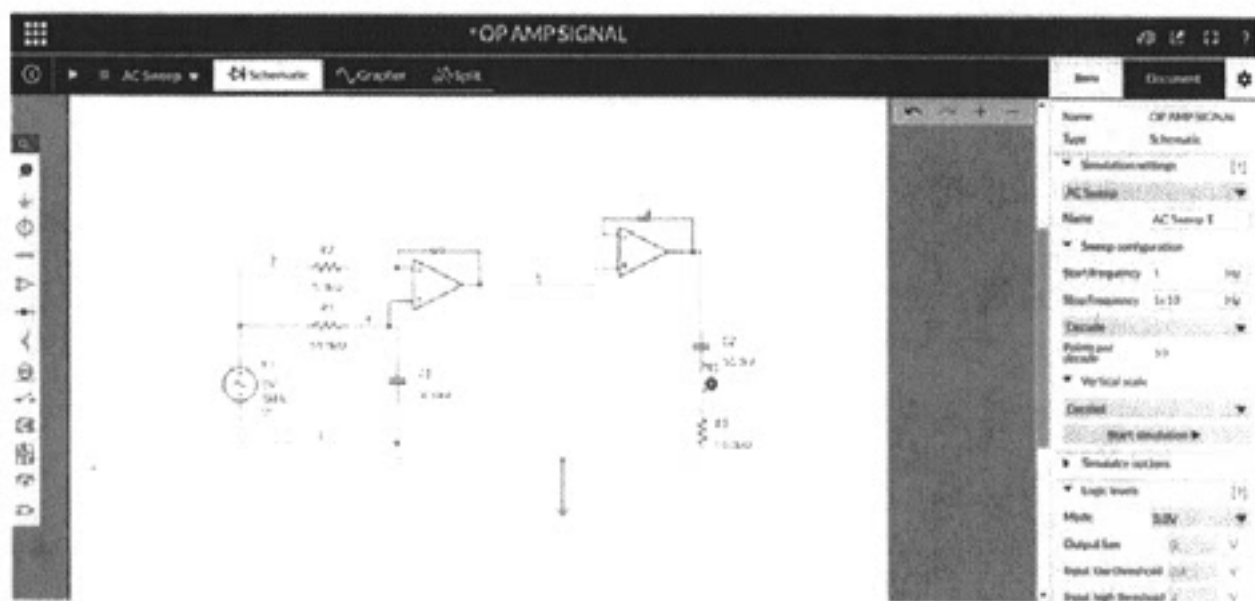


Figure 1: Active Network

With the following values:

$R1 = 10\text{ k}\Omega$, $R2 = 10\text{ k}\Omega$, $R3 = 50\text{ k}\Omega$, $C1 = 50\text{ nF}$, $C2 = 50\text{ nF}$, Frequency = 500 Hz ✓



(3) Frequency response of the active filter network

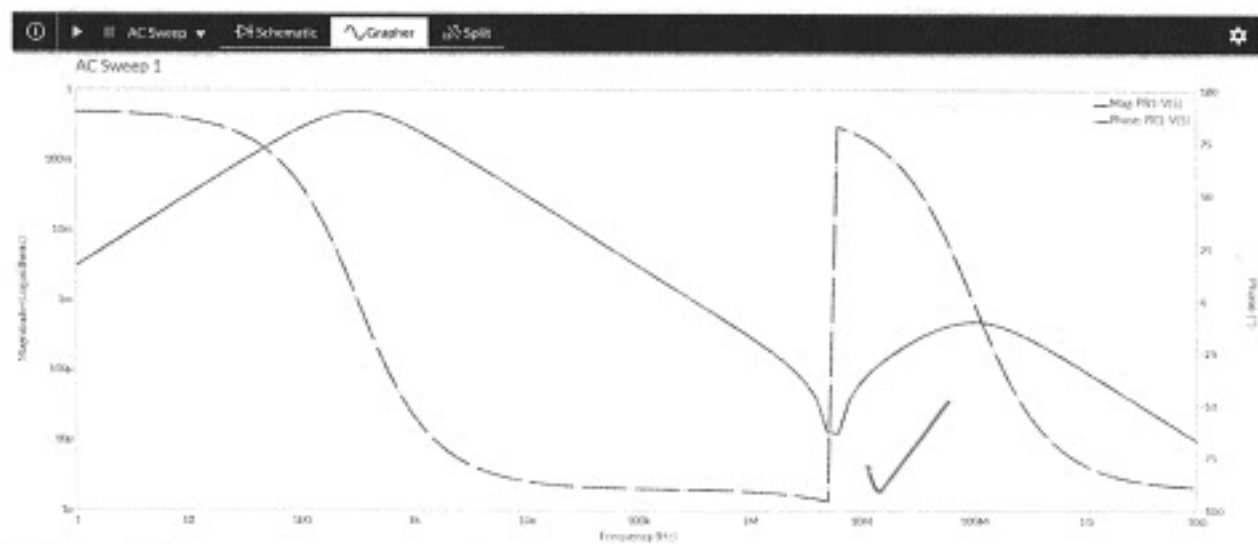


Figure 2: Frequency response from 1 Hz to 10 GHz

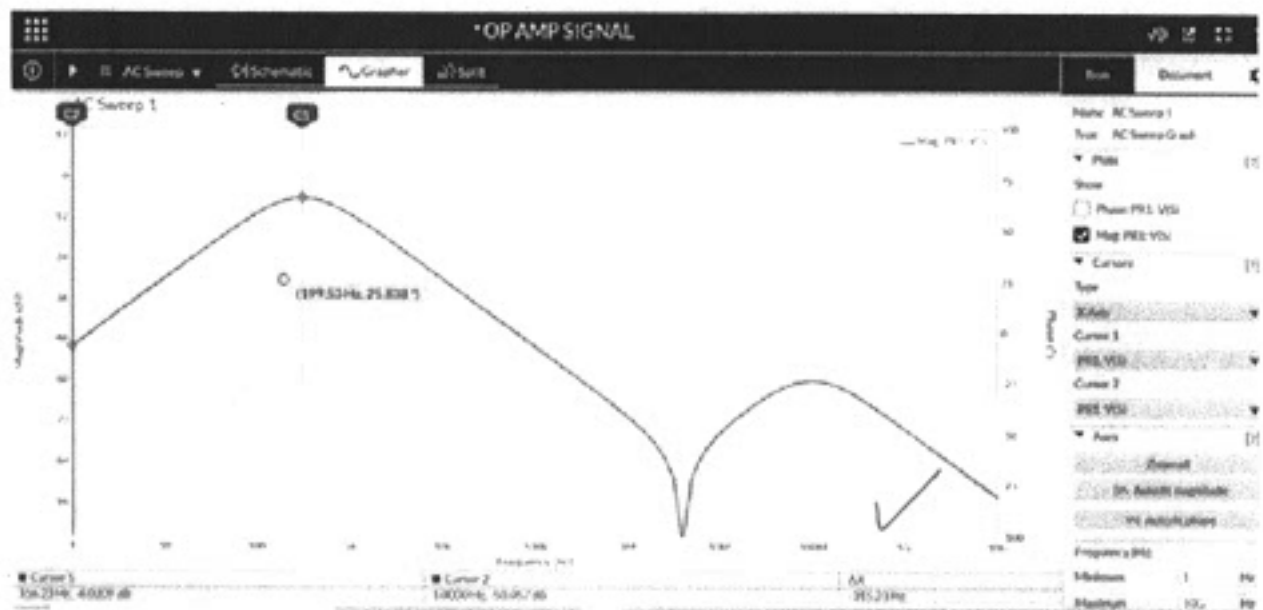


Figure 3: Max Response Point

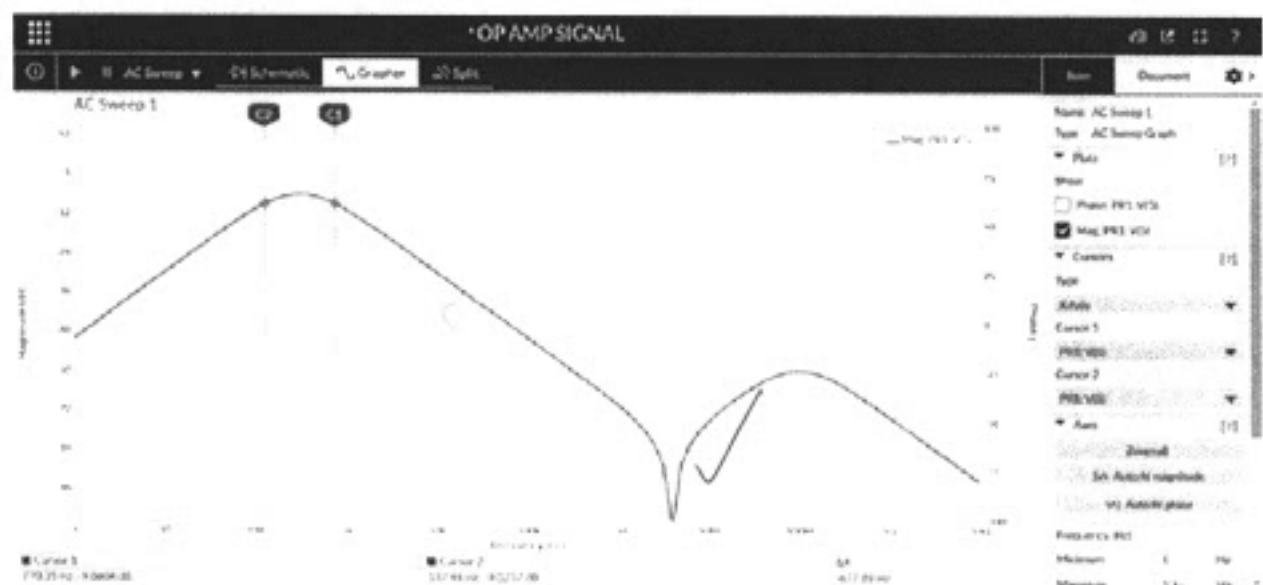


Figure 4: Low-Cutoff & High-Cutoff Points

From the data points per decade the values captured in the response curve were determined and listed below, and we are also able to find the value of Q of the circuit.

Center Frequency = 316.23 Hz

Low-Cutoff $\approx 132.53\text{Hz}$

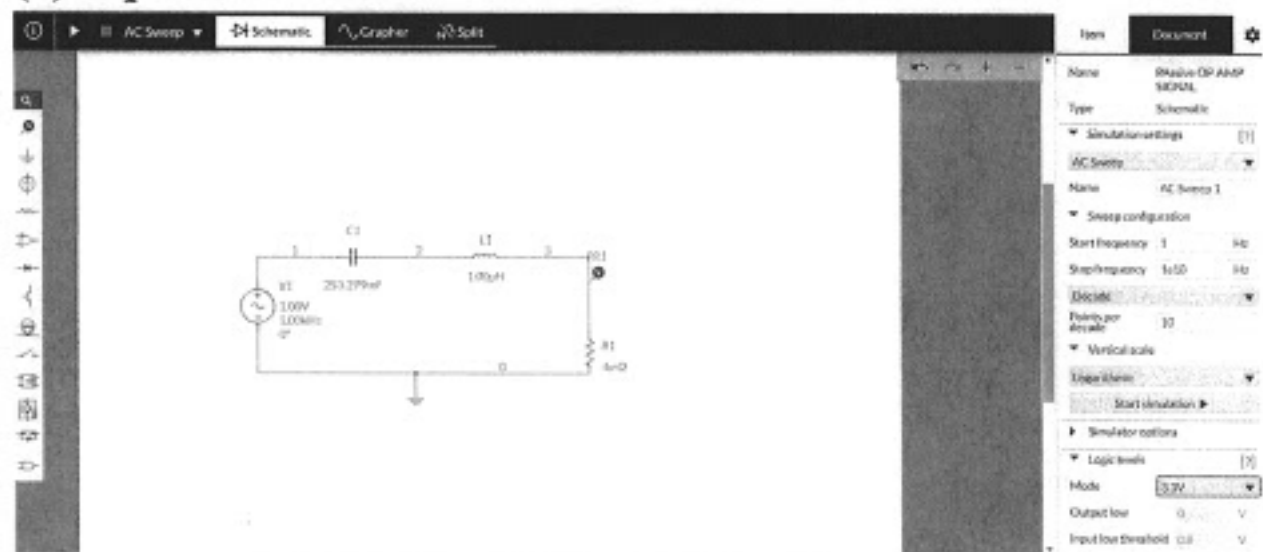
High-Cutoff $\approx 770.35\text{Hz}$

Bandwidth $\approx 637.82\text{Hz}$

$Q \approx 0.49574378$

$\omega_0 \approx 2\pi * 316.23 = 1986.9317$

(4) Equivalent Passive Network



(5) Frequency of passive network and element values

$$\omega_0 = \frac{1}{\sqrt{LC}}, \text{ let } L=1\mu\text{H}$$

$$\omega_0 = 1986.9317 = \frac{1}{\sqrt{(1\mu\text{H})C}}$$

$$\therefore C = 253.29939 \text{ nF}$$

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

$$R = \frac{1986.9317(1\mu\text{H})}{0.49574378} = 4\text{m}\Omega$$

Figure 5: Passive Equivalent Circuit

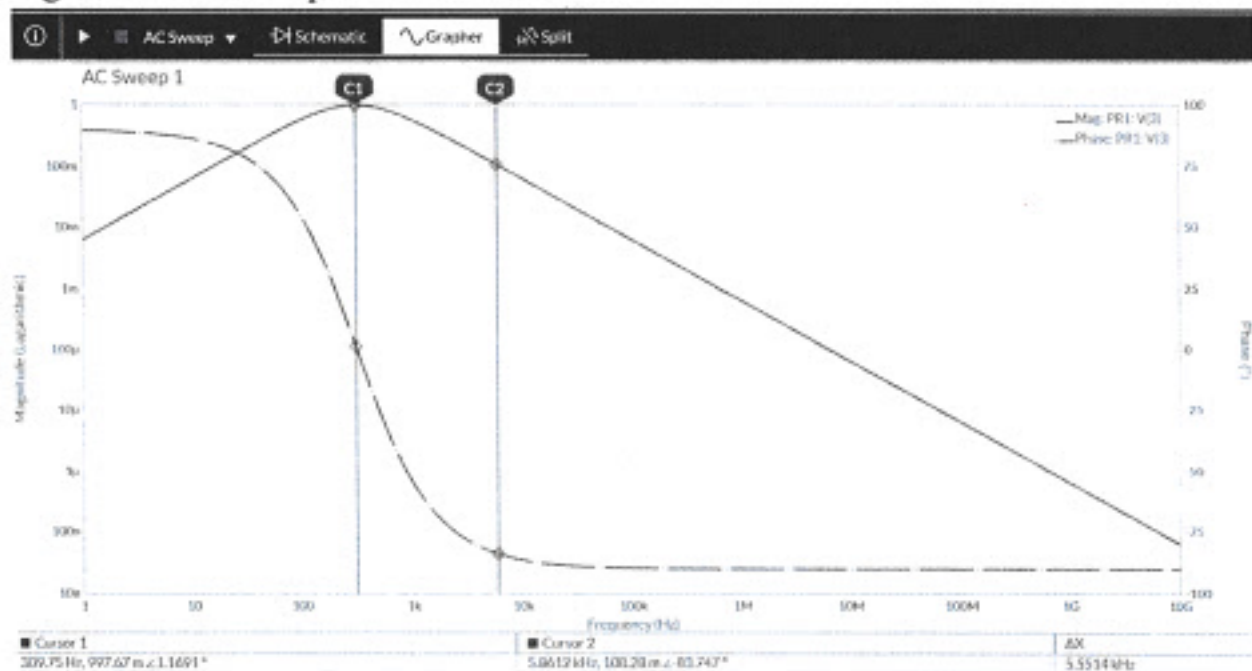


Figure 6: Center Frequency

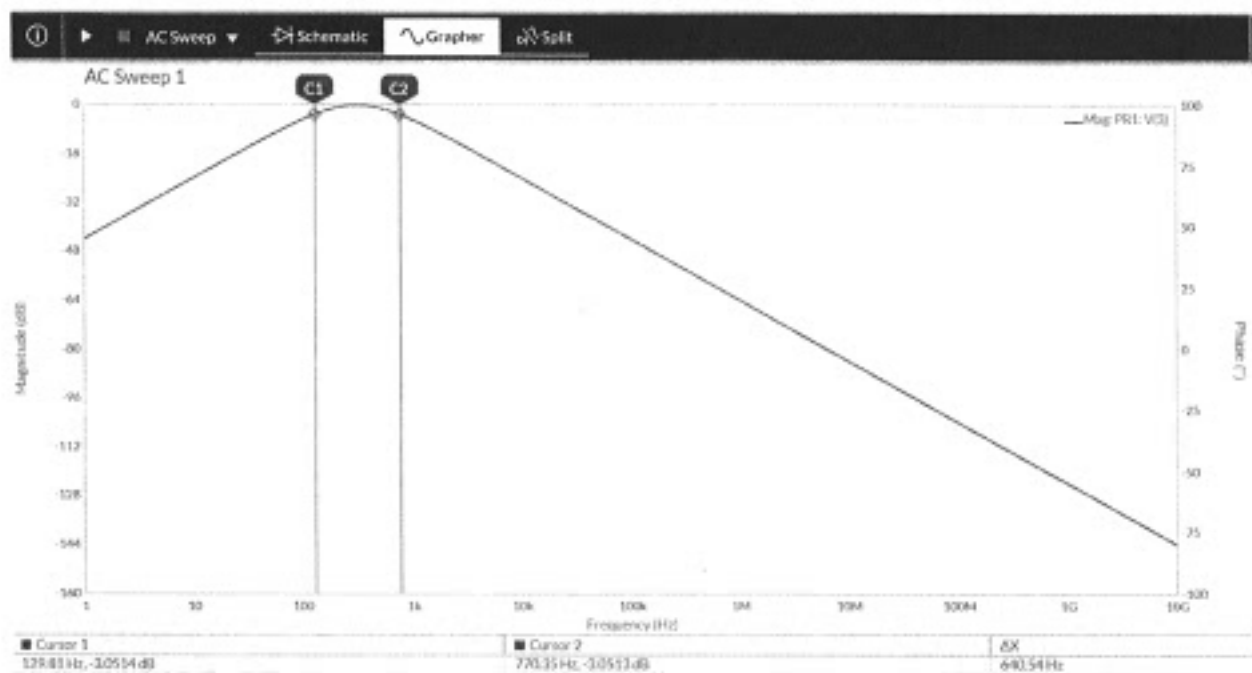


Figure 7: Bandwidth

From Figure 6 we can see that the center frequency of the passive RLC network is equivalent to be at 309.75 Hz. Then from Figure 7 we can see the low-cutoff frequency is at 129.81 Hz and the high-cutoff frequency is at 770.35 Hz. This allows us to find the bandwidth which is the high-cutoff frequency minus the low-cutoff frequency and is equal to 640.54 Hz. Obtaining the calculation of the bandwidth the 'Q' of the circuit can be calculated by dividing the center frequency by the bandwidth this gives the value of 0.4835.

Center Frequency ≈ 309.75 Hz ✓

High Cutoff Frequency ≈ 770.35 Hz

Low Cutoff ≈ 129.81 Hz ✓

With these values we can calculate the bandwidth and Q. Bandwidth ≈ 640.54 Hz

Q ≈ 0.4835 ✓

(6) Comparison values for active and passive networks

$$f_{c\text{-active}} = 316.23 \text{ Hz} \quad \checkmark$$

$$f_{c\text{-passive}} = 309.75 \text{ Hz} \quad \checkmark$$

This is about a 6.48 Hz difference in the center frequency which is acceptable for a standard value conversion of a circuit.

$$B_{\text{active}} = 637.82 \text{ Hz} \quad \checkmark$$

$$B_{\text{passive}} = 640.54 \text{ Hz} \quad \checkmark$$

This is a 2.72 Hz difference. This tolerance on real components can be seen as an acceptable range of deviation.

(7) Transfer function for the passive network

$$\frac{R}{R + j\left(\omega L - \frac{1}{\omega C}\right)} = H(s)$$

$$\frac{4 \text{ m}\Omega}{4 \text{ m}\Omega + j\left(500 * (1 \mu\text{H}) - \frac{1}{500 * (253.29939 \text{ mF})}\right)} = H(s)$$

$$H(s) = \frac{\frac{\omega_0}{Q} s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$$

(8) Determination of the input signal of the passive network if the output signal is given as $V_0(t) = 0.1\cos(2\pi \cdot \text{freq}_x \cdot t)$

$$0.1\cos(2\pi \cdot 500 \cdot t) = 0.1\angle 0$$

$$\frac{V_0}{\square(\square)} = V_I = (0.1\angle 0) / (0.22632 + 0.41845j)$$

$$0.1 - 0.18489487j = 0.21020 \angle -61.593354$$

$$V_i = 0.21020\cos(2\pi \cdot 500 \cdot t - 61.593354) \quad \text{should be high}$$

(9) Discussion of Results

The results of the passive circuit went as expected, the two circuits had very similar values and frequency curves. In this initial test 2 designs were tested. The two designs tested were a passive RLC circuit and an active network with op amps. Out of the 2 tested the active network gave the best results. At this point, the values of the components needed to be calculated to match the active networks cutoff and bandwidth values. The active network values were within tolerance range for the real valued components in the circuit. The calculations that were obtained were desired results, with minimal issues.

(10) Conclusion

During this project we utilized Multisim to determine the differences between the passive and active networks. Utilization of this software was simple and very user friendly. The transfer function and other calculations were within expected values, which made the comparisons extremely easier than expected. We complied with each directive as instructed in this assignment. As a result all figures were utilized to illustrate the results effectively.

Member Roles

Xavier Dukes - Ensured proper calculations and mainly worked on multisim live demonstration and obtaining values

Arthur Quinney - Assisted with calculations and formatted and report ✓

BELOW AVERAGE

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3302 SIGNALS AND SYSTEMS
RUBRICS FOR GRADING SOLVING COMPLEX ENGINEERING PROBLEM
FALL 2021

GROUP NUMBER:

5

GROUP MEMBERS:

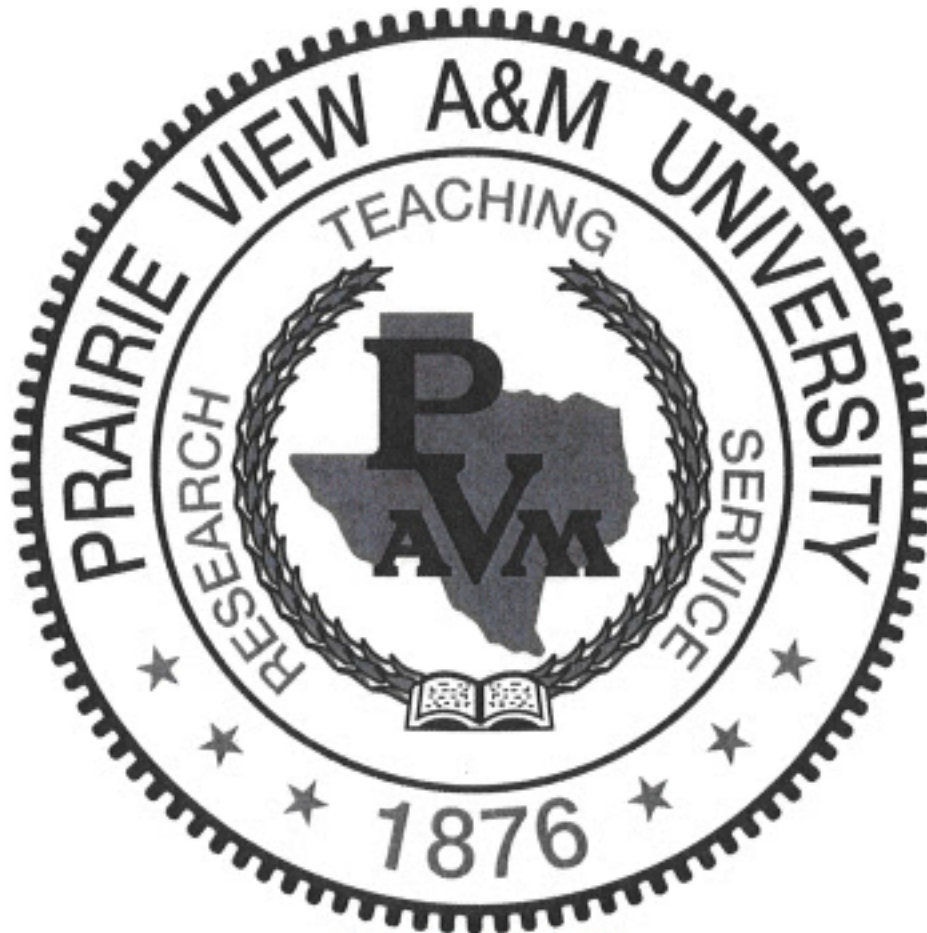
1. Nasir Pate ✓
2. Breland Walker

RUBRICS FOR GRADING DESIGN PROJECT

ITEMS	POINTS ACHIEVED	MAXIMUM POINTS
1. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> • Obtain passive circuit characteristics that models the active circuit.	20	20
2. <i>Identify and Formulate Complex Engineering Problem by Applying the Principles of Engineering (Student Outcome 1.1)</i> • Identify element values of the passive circuit for modeling the active circuit.	18	20
3. <i>Solve Engineering Problem by Using MultiSim (Student Outcome 1.2)</i> • Use MultiSim to determine the frequency response of the identified passive network.	8	10
4. <i>Solve Engineering Problem – Evaluate and Interpret Results (Student Outcome 1.2)</i> • Compare the magnitude responses obtained for both the active and passive networks.	7	10
5. <i>Solve Engineering Problem – Determine Transfer Function of Passive Network (Student Outcome 1.2)</i> • Use appropriate equation to determine transfer function of the passive network.	6	10
6. <i>Solve Engineering Problem – Determine the Input Signal Given an Output Signal (Student Outcome 1.2)</i> • Use an appropriate method to determine the input signal for a given output signal.	0	10
7. <i>Discussion of Results and Conclusions (Student Outcome 1.2)</i> • Draw conclusions using appropriate engineering judgement.	7	10
8. <i>General Write-up of Report</i> (i) Grammar and Adequacy of plots and figures, (ii) Proper labeling of graphs and tables, (iii) Proper references to graphs and tables, (iv) Clear and meaningful sentences, and (v) Organized report	7	10
9. <i>Composite Report Grade</i>	65	100
10. <i>Grade for ABET Student Outcome 1.1 (Items #1, 2)</i>	30	40
11. <i>Grade for ABET Student Outcome 1.1 (Normalized to 100%)</i>	75	100
12. <i>Grade for ABET Student Outcome 1.2 (Items # 3, 4, 5, 6 and 7)</i>	28	50
13. <i>Grade for ABET Student Outcome 1.2 (Normalized to 100%)</i>	56	100
14. <i>Grade for ABET Student Outcome 1 (Items #1, 2, 3, 4, 5, 6, and 7)</i>	58	90
15. <i>Grade for ABET Student Outcome 1 (Normalized to 100%)</i>	64	100

Prairie View A&M University

Signals & System
Engineering Economics (~~CHEG 2308~~) Group Project



Group #5

Members: Nasir Pate & Breland Walker

Date Submitted: 11/23/21

Date Performed: 11/23/21

Introduction

-To start the project we must first use multisim to demonstrate our ability to use build a circuit and use it measure the frequency response. We will later obtain the passive network using its calculated element values solved by hand calculations. With the measured values of the bandwidths and center frequencies from both frequency responses we will compare and contrast the values.

Problem Statement (ii)

-Use multisim to determine the frequency response of the active network as well as measure and calculate the bandwidth and center frequency

Measuring the frequency response of the Active filter network (iii)

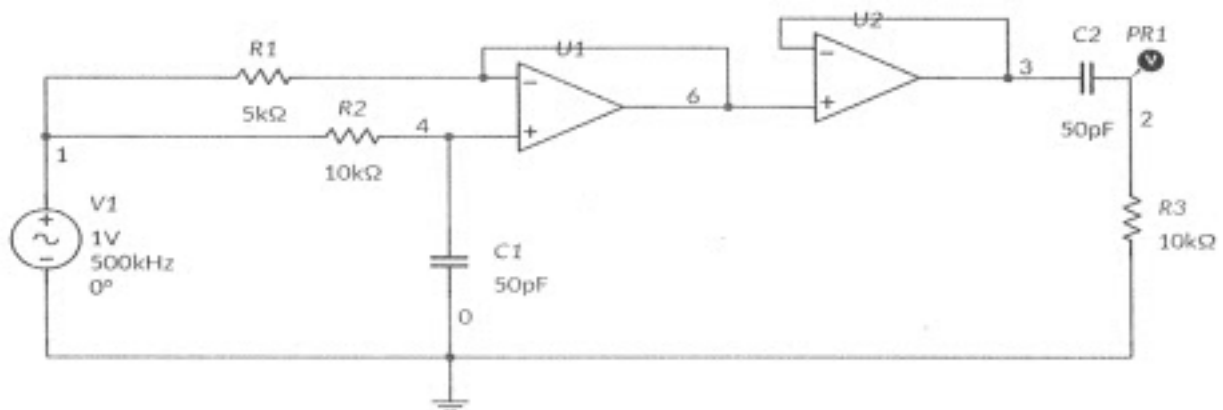


Figure 1: Active network circuit

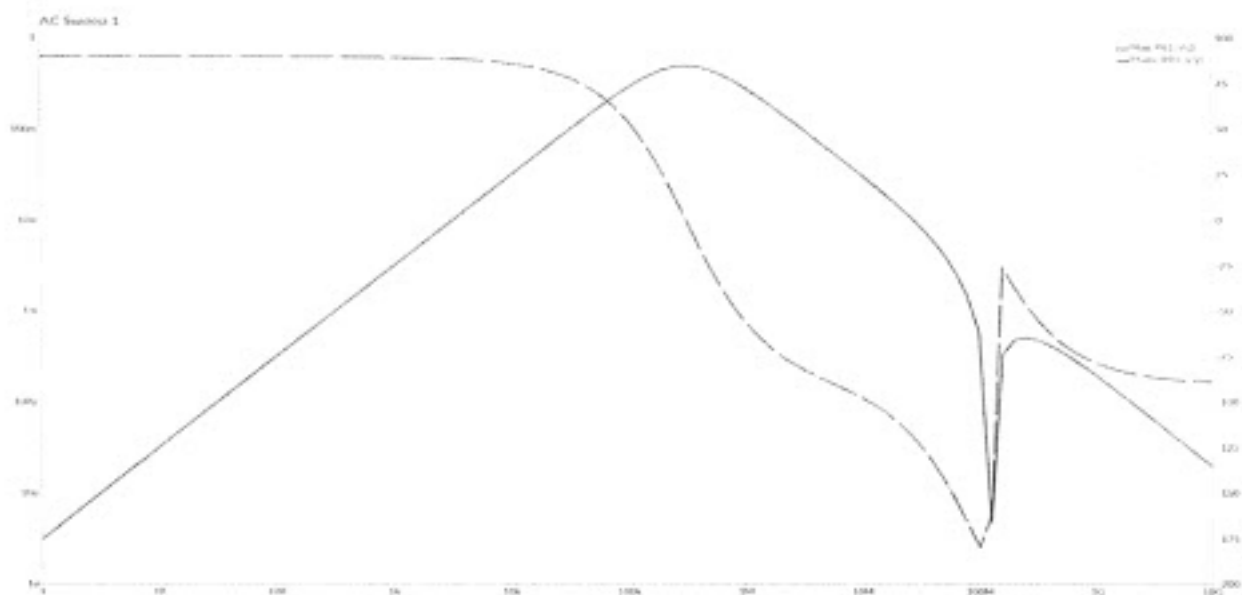


Figure 2: Active Network Frequency Response graph

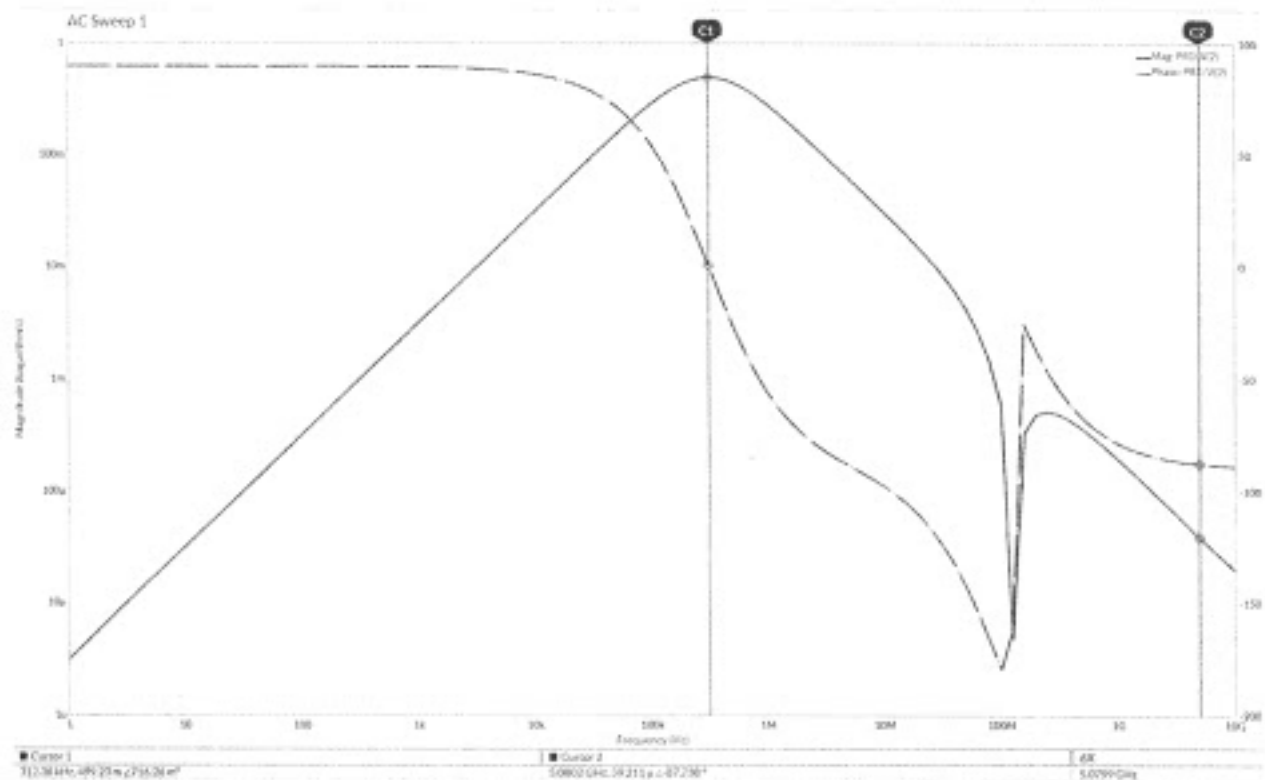


Figure 3: Center frequency of Active network 312.36 kHz ✓

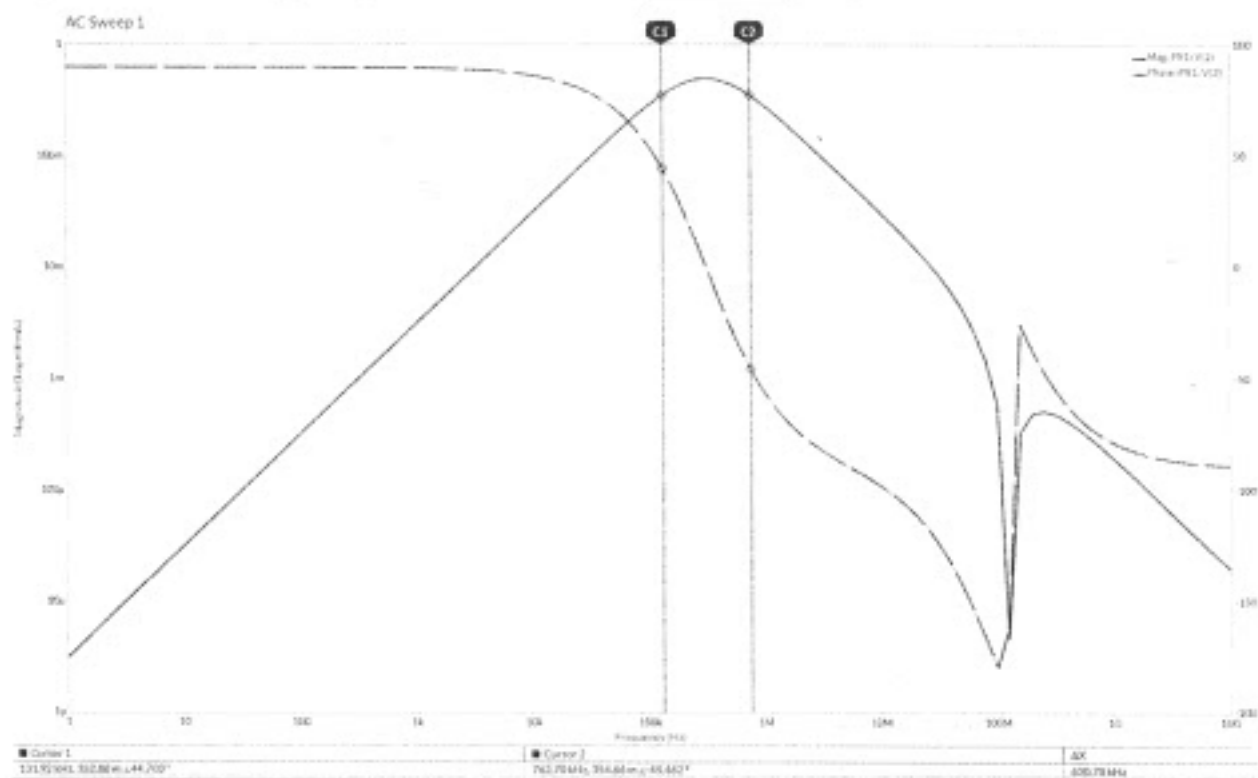


Figure 4: Frequency Response high and low cutoff ✓

Hand calculations

$$\begin{aligned}W_0 &= 2\pi f_0 \\&= 2\pi(312.59) \\ \boxed{W_0} &= \boxed{1964.06}\end{aligned}$$
$$\begin{aligned}f_0 &= 312.59 \text{ kHz} \checkmark \\f_1 &= 132.37 \text{ kHz} \checkmark \\f_2 &= 766.68 \text{ kHz} \checkmark\end{aligned}$$
$$Q = \frac{f_0}{f_2 - f_1} = \frac{312.59}{766.68 - 132.37} \checkmark$$
$$\boxed{Q} = \boxed{0.49} \checkmark$$

Obtaining the equivalent passive network with its element values (iv)

$$B = \frac{W_0}{Q} = \frac{1964.06}{0.49}$$
$$B = 4008.29$$
$$Q = \frac{W_0 L}{R} \rightarrow L = \frac{QR}{W_0} = \frac{(0.49)(10000)}{4008.29}$$
$$\boxed{L = 2.49 \text{ H}} \checkmark$$
$$W_0 = \frac{1}{\sqrt{LC}} \rightarrow \sqrt{(2.49)C} = \frac{1}{1964.06} \rightarrow (\sqrt{(2.49)C})^2 = (5.09 \times 10^{-4})^2$$
$$\frac{(2.49)C}{2.49} = \frac{(2.59 \times 10^{-7})}{2.49}$$
$$\boxed{C = 1.04 \times 10^{-7}} \checkmark$$

If you choose $L = 2.49 \text{ H}$
then $C = 1.0 \times 10^{-7} \text{ F}$
and $R = 9.93 \times 10^6 \text{ Ohms}$

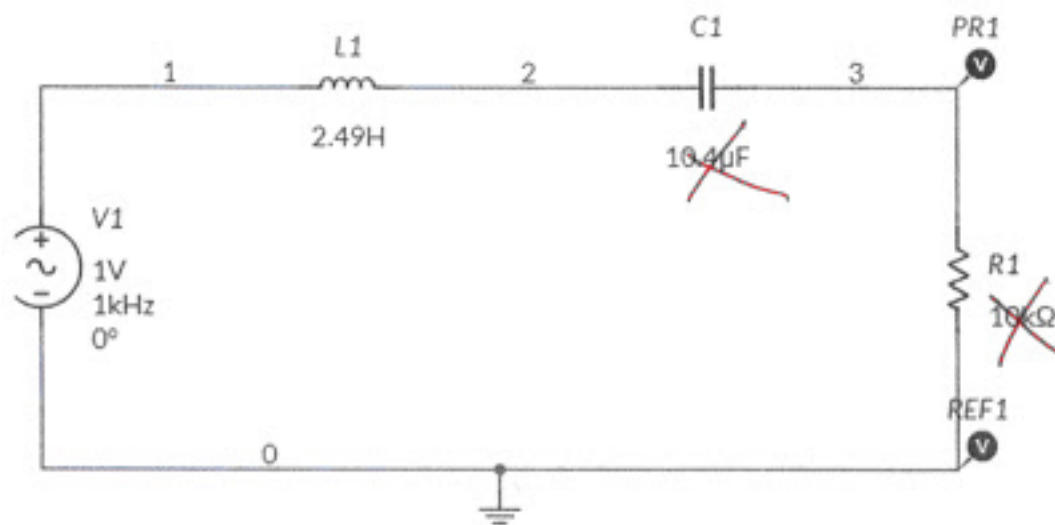


Figure 5: Passive network circuit

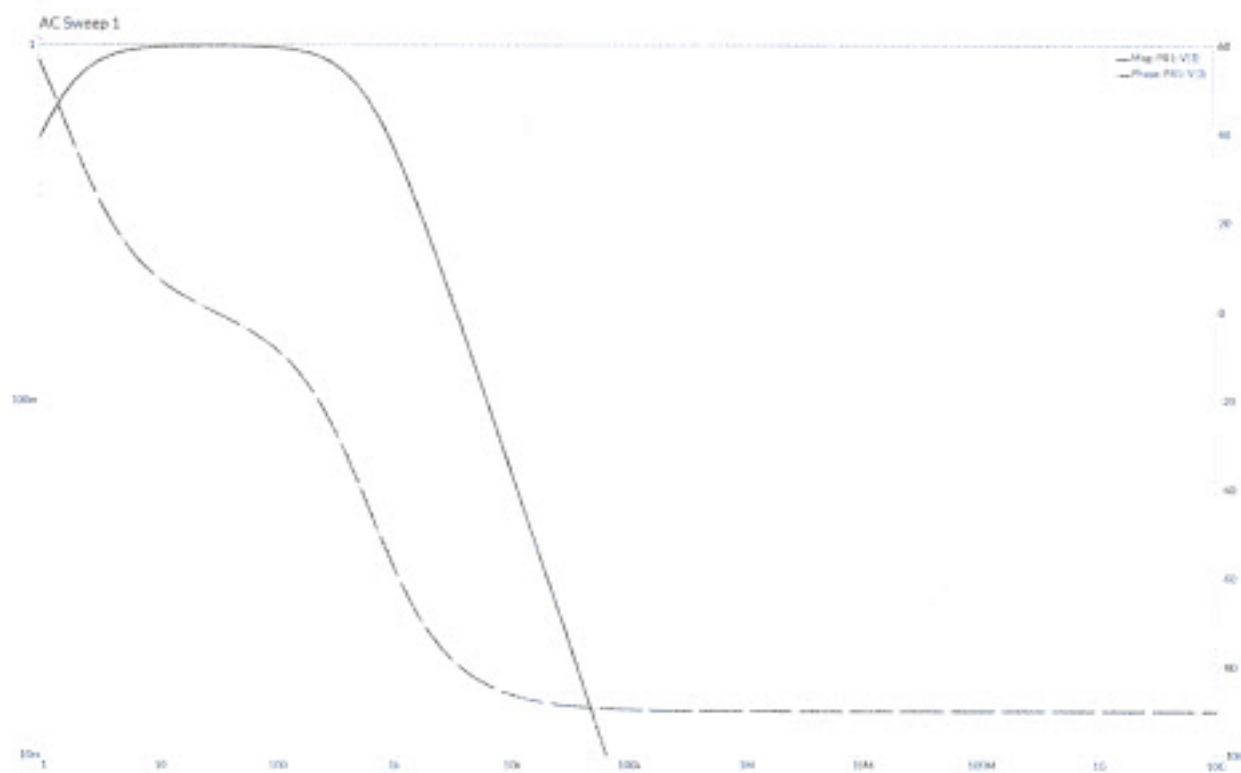


Figure 6: Passive network frequency response

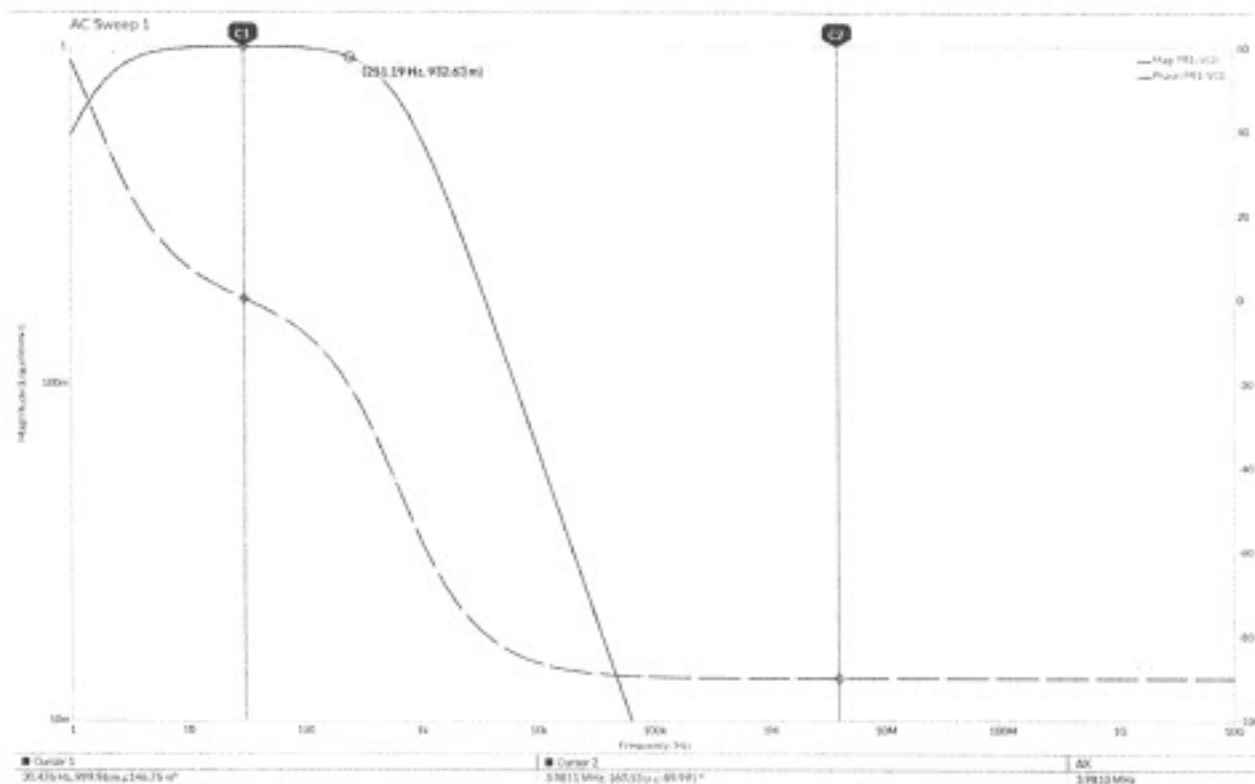


Figure 7: Passive network center frequency 30.47 Hz

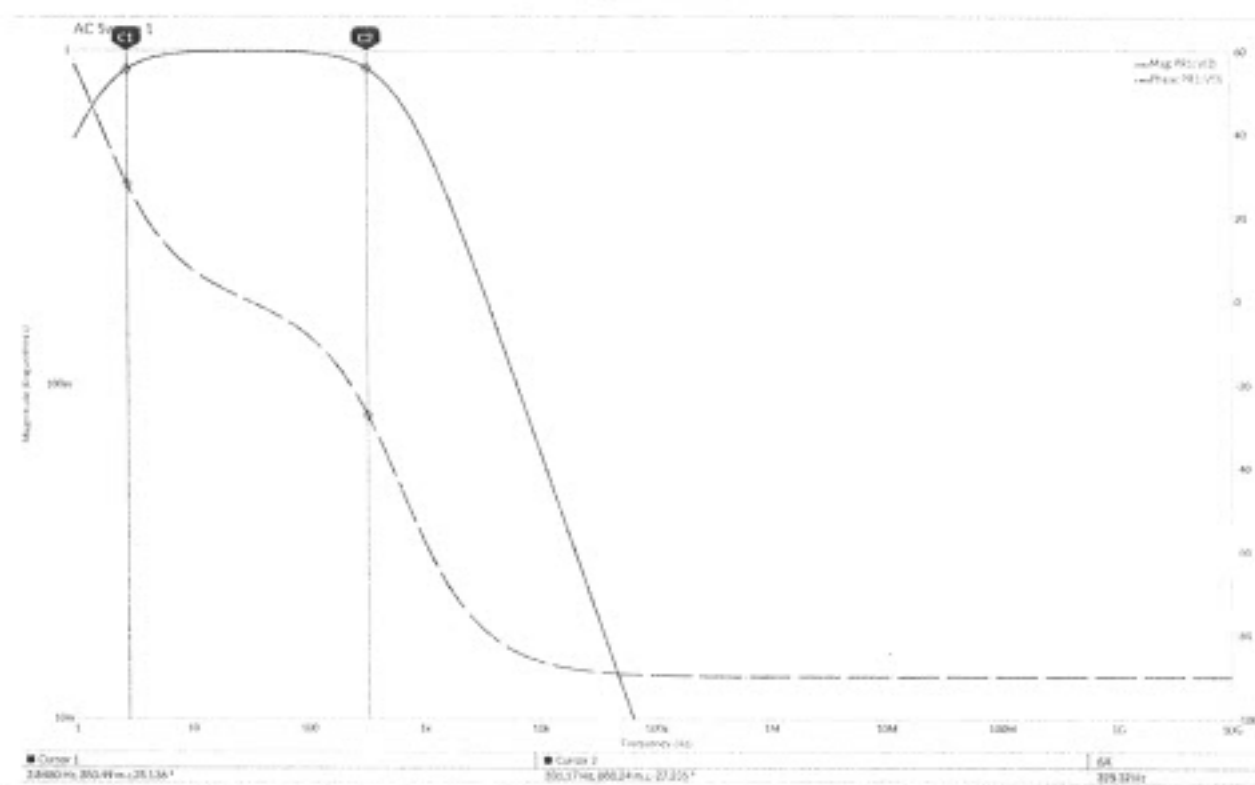


Figure 8: Passive network high and low points

Comparison between frequency responses of Active and Passive networks (vi)

	Active network	Passive network
Center Frequency	312.36 kHz	30.47 Hz
Bandwidth	634.31 kHz	328.32 Hz

Table1: Comparison of Active and Passive frequencies

Not in agreement because of wrong ~~element~~ calculation of element values

-The difference between the Active and Passive network center frequency and bandwidth differ tremendously and it shown in the table above

Obtain the transfer function of the Passive network (vii)

$$H(s) = \frac{H_0 \frac{\omega_0}{Q} s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2} = \quad H_0 = 1$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(2.41)(1.04 \times 10^{-7})}} = 1965.09$$

$$Q = \frac{\omega_0 L}{R} = \frac{(1965.09)(2.41)}{10,000} = 0.49$$

$$H(s) = \frac{4010.39 s}{s^2 + 4010.39 s + 1965.09^2}$$

$$H(s) = \frac{4010.39 s}{s^2 + 3865581.09}$$

$\omega_0/Q = 3.93 \times 10^6$
 $\omega_0/Q = 4 \times 10^6$
 $\omega_0^2 = 3.86 \times 10^{12}$

Determine the input signal $v_s(t)$ of the Passive network (viii)

this part was no

Discussion of Results (ix)

-In the lab I was able to see the difference in the center frequency and bandwidth between the Active and Passive frequencies, this is show in table 1. My measured and hand calculated values were proven to create the correct waveform as shown in my numerous waveforms in figures 6-8. To obtain the Passive frequencies element values I had to apply some algebra to obtain the values I needed to create the circuit as shown in Figure 5 and the hand calculation used to make I are shown in section (iv). All of these methods and mathematical functions resulted in me successfully completing this project.

NO

Conclusion (x)

-To conclude the lab, I appreciate the practice and experience it allowed me to acquire in the multisim website. I was able to demonstrate my ability to adapt and learn on the fly to get the project done in the time frame required by my professor. All of my hand calculations and measured values were coming back to be true and I enjoyed seeing the step by step process of understanding and creating these waveforms and circuits.

Refer to the figures and tables in the text.

Member Participation

Nasir Pate- Introduction, problem statement, measurement of active & passive frequency, created the active and passive circuits, measured the bandwidth and center frequency of the active and passives frequencies, compared the active and passive frequencies.

Breland Walker- Calculated the transfer function, did the conclusion.