

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 3304- Electronics I
SPRING 2022**

I. COURSE DESCRIPTION IN ABET FORMAT

II ASSESSMENT RESULTS FOR CURRENT AND PAST THREE PERIODS

Program Outcomes Assessed in Course

Assessment Summary of Class Semester Averages for Outcomes

End of Semester Course Outcomes Assessment Reports

II. TESTS

Summary of Topics covered by Test

Original Test 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. HOMEWORK ASSIGNMENTS

Summary of Topics covered by Homework

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 3304 ELECTRONICS - I
2.	Credits and contact hours:	3 credit hours; 3 contact hours
3.	Instructor's or course coordinator's name:	Dr. Mohan Ketkar
4.	Textbook: Title:	MICROELECTRONIC CIRCUITS
	Author:	A.S. Sedra and K.C. Smith
	Publisher, Year & Edition:	Oxford University Press, 8 th Edition
	a. Other Supplemental material	1. J.O. Attia, "Circuits and Electronics: Hands-on learning with Analog Discovery" 2. Handouts 3. Electronics Circuits books in the library
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	Operational amplifiers. Diodes and nonlinear circuits. Field effect transistors. Analysis and design of linear amplifiers. Biasing, small and large signal behavior. Operation of bipolar junction transistors.
	b. Prerequisites or Co-requisites	ELEG 3303 or 3033 Minimum Grade of C and ELEG 3301 or 3013 Minimum Grade of C
	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. Understand the characteristics of operational amplifiers and should be able to design electronic circuits using operational amplifiers	
	2. Understand the operational characteristics of diodes, MOSFETs, and BJTs	
	3. Be conversant with basic electronic circuits such as rectifiers, inverting amplifiers, non-inverting amplifiers, integrators, differentiators, clipping and clamping circuits.	
	4. Recognize and analyze various MOSFET and BJT amplifier circuits	

	5. Use PSPICE or MATLAB to solve electronic circuits' problems	Outcome 6 An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
	6. Design, construct, test electronic circuit that satisfies multiple constraints	
7	Brief list of topics to be covered	Introduction to Electronics Operational Amplifiers Diodes Applications of Diodes MOSFETs Bipolar Junction Transistors

***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

End of Semester Course Assessment Report

This 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. **You cannot use any number of your choice**
- 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

- Instructor's 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**.

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 3304-P01 ELECTRONICS I (ELECTRICAL ENGINEERING MAJORS)
Spring 2022 SEMESTER

Report Prepared by: Dr. Mohan Ketkar

Report Date: May 15, 2022

Semester	Analysis Type	Number of Students	Outcome 6			
			Ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Spring 2022	Direct	8	70	70	84.2	100
Fall 2021	Direct	7	70	70	88.6	100
Spring 2021	Direct	21	70	70	80.2	85.7
Fall 2020	Direct	2	70	70	87.9	100
Spring 2020	Direct	24	70	70	82.7	91.7
Implementation Summary	Items implemented from previous report or after meeting previous instructor	Students designed circuits that meet desired specifications, create circuit for simulation, run simulation, and modify to ascertain that the specifications were met. In addition, the students wrote reports that have the following parts: (i) introduction, (ii) circuit design with calculations, (iii) experimental setup to simulate and test the designed circuit, (iv) conducting the experiment, (v) analysis and interpretation of simulation results, (vi) discussion of results, and (vii) conclusions.				
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them	Some of the students did not follow the required format for writing the project report. This resulted in students writing reports without describing in detail the experimental setup and how the experiments were conducted.				
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: (a) Require all the students to follow the format for writing the design project report. The instructor will not accept project reports that do not have the required format that address all the parts of Outcome 6. (b) Emphasize to the students the importance of (i) describing the experimental setup for testing the designed circuit, (ii) the data collected, and analyzed, and (iii) interpretation of results. (c) Sample of a good report will be provided to help the students				
Overall Trend over Periods	Ascertain if there were improvements over previous semesters	The class average decreased by 4.2 points, still higher than expected level				
Were Expectations Met?		YES				

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 3304-P01 ELECTRONICS I (COMPUTER ENGINEERING MAJORS)

Spring 2022 SEMESTER

Report Prepared by: Dr. Mohan Ketkar

Report Date: May 15, 2022

Semester	Analysis Type	Number of Students	Outcome 6			
			Ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Spring 2022	Direct	4	70	70	83.3	100
Spring 2021	Direct	10	70	70	82.7	90
Fall 2020	Direct	5	70	70	87.4	100
Spring 2020	Direct	11	70	70	79.5	81.8
Implementation Summary	Items implemented from previous report or after meeting previous instructor	Students designed circuits that meet desired specifications, create circuit for simulation, run simulation, and modify to ascertain that the specifications were met. In addition, the students wrote reports that have the following parts: (i) introduction, (ii) circuit design with calculations, (iii) experimental setup to simulate and test the designed circuit, (iv) conducting the experiment, (v) analysis and interpretation of simulation results, (vi) discussion of results, and (vii) conclusions.				
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them	Some of the students did not follow the required format for writing the project report. This resulted in students writing reports without describing in detail the experimental setup and how the experiments were conducted. Since Computer Engineering majors are not required to take the Electronics Lab, there were limitations for students to do physical experimentation.				
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: (a) Require all the students to follow the format for writing the design project report. The instructor will not accept project reports that do not have the required format that address all the parts of Outcome 6. (b) Emphasize to the students the importance of (i) describing the experimental setup for testing the designed circuit, (ii) the data collected, and analyzed, and (iii) interpretation of results. (c) Sample of a good report will be provided to help the students				
Overall Trend over Periods	Ascertain if there were improvements over previous semesters	The class average increased by 0.6 points, higher than expected level				
Were Expectations Met?		YES				

Course Grades downloaded from Canvas

	Student Name	Attendance	Test 1	Test 2	Test # 3	Course design Project	Final Exam	Current Grade
1		9.31	32	75	85	81	54	C
2		9.66	92	77	100	85	73	B
3		9.31	10	24	21	0	8	F
4		5.17	38	75	64	75	0	F
5		9.66	82	80	94	85	77	B
6		7.59	18	65	62	75	26	F
7		8.97	20	52	98	78	41	D
8		10	59	84	0	82	55	C
9		8.97	80	55	100	86	56	C
10		9.66	80	70	86	85	35	C
11		9.66	72	58	93	85	59	C
12		10	92	79	93	90	49	C
13		10	57	45	72	84	41	D
14		10	80	84	82	85	87	B
	Points Possible	10	100	100	100	100	100	

Electronics I

Spring 20222

Title of Assignment: TEST 1

TOPICS COVERED IN TEST 1

Test 1 covered the following topics:

1. Amplifiers
2. Cascaded Amplifiers
3. Circuit Models
4. Gain frequency relationship

ELEG3304 Spring 2022**Test # 1**

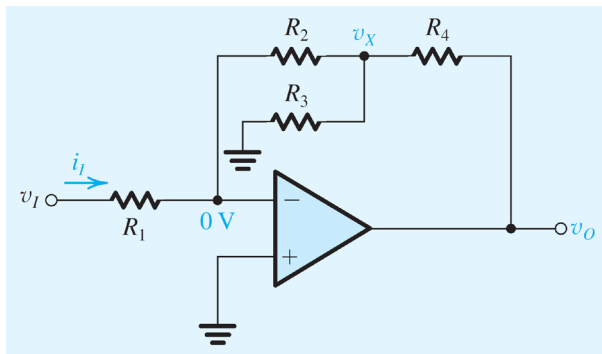
February 10

Question #	Max Points	Obtained
I	25	
II	25	
III	25	
IV	25	
Total points	100	

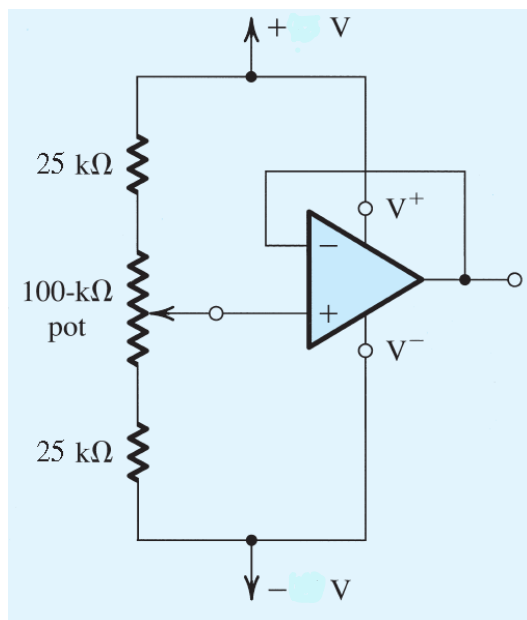
Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 1.****Handover your test to the instructor.**

- I. Various amplifier and load combinations are measured as listed below using rms values. For each, find the voltage, current, and power gains (A_v , A_i , and A_p , respectively) both as ratios and in dB:
- (a) $v_i = 25 \text{ mV}$, $i_i = 100 \text{ } \mu\text{A}$, $v_o = 5 \text{ V}$, $R_L = 50 \text{ } \Omega$
- (b) $v_i = 125 \text{ } \mu\text{V}$, $i_i = 100 \text{ nA}$, $v_o = 1.25 \text{ V}$, $R_L = 10 \text{ k}\Omega$
- II You are given two amplifiers, A and B, to connect in cascade between 20-mV, 50 k Ω source and a 50- Ω load. The amplifiers have voltage gain, input resistance, and output resistance as follows: for A, 50 V/V, 50 k Ω , 4 k Ω respectively; for B 40 V/V, 40 k Ω , 5 k Ω respectively. Evaluate two possible connections between source S and load L, namely SABL and SBAL. Write expression for the voltage gain (v_o/v_s) for each configuration. Determine the voltage gain for both configurations as ratio and in decibels. Which amplifier arrangement is better?
- III The inverting circuit with T network in the feedback is redrawn in following figure in a way that emphasizes the observation that R_2 and R_3 in effect are in parallel (because the ideal op-amp forces a virtual ground at the inverting input terminal). Use this observation to derive an expression for the gain (v_o/v_i) by first finding (v_x/v_i) and (v_o/v_x). For the latter use the voltage-divider rule applied to R_4 and ($R_2 \parallel R_3$).



- IV Figure shows a circuit that provides an output voltage v_o whose value can be varied by turning the wiper of the 100-k Ω potentiometer. Find the range (lowest and highest) over which v_o can be varied. If the potentiometer is a “25-turn” device, find the change in v_o corresponding to each turn of the pot. The $V^+ = +10.0$, and $V^- = -10.0$ volts.



ABOVE AVERAGE

ELEG3304 Spring 2022**Test # 1**

February 10

Question #	Max Points	Obtained
I	25	20
II	25	10
III	25	25
IV	25	25
Total points	100	80

Closed book, Closed notes.

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I. Various amplifier and load combinations are measured as listed below using rms values. For each, find the voltage, current, and power gains (A_v , A_i , and A_p , respectively) both as ratios and in dB:

(a) $v_i = 25 \text{ mV}$, $i_i = 100 \text{ } \mu\text{A}$, $v_o = 5 \text{ V}$, $R_L = 50 \text{ } \Omega$

(b) $v_i = 125 \text{ } \mu\text{V}$, $i_i = 100 \text{ nA}$, $v_o = 1.25 \text{ V}$, $R_L = 10 \text{ k}\Omega$

A). $A_v = \frac{v_o}{v_i} = \frac{5}{25 \times 10^{-3}} = 200$ $A_{v\text{dB}} = 20 \log(200) = 46.0205$

$A_i = \frac{i_o}{i_i} = \frac{v_o/R_L}{i_i} = \frac{5/50}{100 \times 10^{-6}} = 1000$ $A_{i\text{dB}} = 20 \log(1000) = 60$

$A_p = A_v \cdot A_i = 200 \cdot 1000 = 200 \times 10^3$ $A_{p\text{dB}} = 20 \log(200,000) = 106.0205$

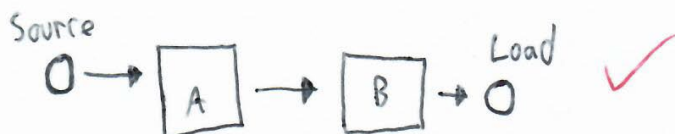
B). $A_v = \frac{v_o}{v_i} = \frac{1.25}{125 \times 10^{-6}} = 10,000$ $A_{v\text{dB}} = 20 \log(10,000) = 80$

$A_i = \frac{i_o}{i_i} = \frac{v_o/R_L}{i_i} = \frac{1.25/10,000}{100 \times 10^{-9}} = 1250$ $A_{i\text{dB}} = 20 \log(1250) = 61.938$

$A_p = A_v \cdot A_i = 10,000 \cdot 1250 = 125 \times 10^5$ $A_{p\text{dB}} = 20 \log(125,000,000) = 141.938$

20

- II You are given two amplifiers, A and B, to connect in cascade between 20-mV, 50 k Ω source and a 50- Ω load. The amplifiers have voltage gain, input resistance, and output resistance as follows: for A, 50 V/V, 50 k Ω , 4 k Ω respectively; for B 40 V/V, 40 k Ω , 5 k Ω respectively. Evaluate two possible connections between source S and load L, namely SABL and SBAL. Write expression for the voltage gain (v_o/v_s) for each configuration. Determine the voltage gain for both configurations as ratio and in decibels. Which amplifier arrangement is better?



For SABL $\frac{V_L}{V_s} = \frac{50}{50 + 50000} \cdot 50 \cdot 40$

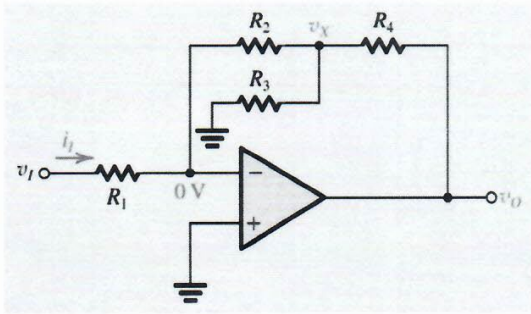
$\frac{50}{50 + 50000} \cdot 50 \cdot \frac{4000}{4000 + 4000} \cdot 40 \cdot \frac{5000}{5000 + 5000} = 0.4995$

For SBAL $\frac{V_L}{V_s} = \frac{50}{50 + 50000} \cdot 50 \cdot \frac{50000}{50000 + 5000} \cdot 40 \cdot \frac{40000}{40000 + 40000} \approx 2$

~~SABL~~ is better $\rightarrow$ why?

10

- III The inverting circuit with T network in the feedback is redrawn in following figure in a way that emphasizes the observation that R_2 and R_3 in effect are in parallel (because the ideal op-amp forces a virtual ground at the inverting input terminal). Use this observation to derive an expression for the gain (v_o/v_i) by first finding (v_x/v_i) and (v_o/v_x) . For the latter use the voltage-divider rule applied to R_4 and $(R_2 \parallel R_3)$.



$$i_I = \frac{V_I}{R_I}$$

$$V_x = -i_I \cdot R_2 =$$

$$\frac{V_i \cdot R_2}{R_1} \quad \frac{V_x}{V_I} = \frac{R_2}{R_1} \quad (1)$$

$$V_x = \frac{R_2/R_3}{(R_2/R_3) + R_4} \cdot V_o = \left[\frac{\frac{R_2 R_3}{R_2 + R_3}}{\frac{R_2 R_3}{R_2 + R_3} + R_4} \right] \cdot V_o$$

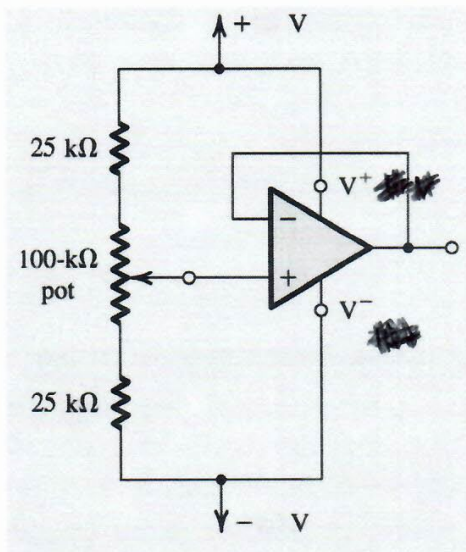
$$\frac{V_o}{V_x} = \frac{R_2 R_3 + R_2 R_4 + R_3 R_4}{R_2 R_3} \quad (2)$$

$$\frac{V_o}{V_I} = \frac{V_o}{V_x} = \frac{V_x}{V_I} = \left[-\frac{R_2}{R_1} \left(1 + \frac{R_4}{R_3} + \frac{R_4}{R_2} \right) \right]$$

25

IV

Figure shows a circuit that provides an output voltage v_o whose value can be varied by turning the wiper of the $100\text{-k}\Omega$ potentiometer. Find the range (lowest and highest) over which v_o can be varied. If the potentiometer is a "25-turn" device, find the change in v_o corresponding to each turn of the pot. The $V^+ = +10.0$, and $V^- = -10.0$ volts.



$$V_o = -10 + \frac{25}{25+100+25} (10 - (-10)) = -6$$

$$= -6.667$$

$$V_o = V_+ = -10 + \frac{25+100}{25+100+25} (10 - (-10)) =$$

$$6.667$$

$$\text{Range of output} \rightarrow (6.667 - (-6.667))$$

$$= 13.334$$

$$V/\text{Turns} = \frac{13.334}{25} = \boxed{.5334}$$

25

AVERAGE

ELEG3304 Spring 2022**Test # 1**

February 10

Question #	Max Points	Obtained
I	25	20
II	25	05
III	25	25
IV	25	20
Total points	100	70

Closed book, Closed notes.
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I.

Various amplifier and load combinations are measured as listed below using rms values. For each, find the voltage, current, and power gains (A_v , A_i , and A_p , respectively) both as ratios and in dB:

- (a) $v_i = 25 \text{ mV}$, $i_i = 100 \text{ } \mu\text{A}$, $v_o = 4 \text{ V}$, $R_L = 40 \text{ } \Omega$
 (b) $v_i = 120 \text{ } \mu\text{V}$, $i_i = 100 \text{ nA}$, $v_o = 1.2 \text{ V}$, $R_L = 10 \text{ k}\Omega$

(a) $v_i = 25 \text{ mV}$, $i_i = 100 \text{ } \mu\text{A}$, $v_o = 4 \text{ V}$, $R_L = 40 \text{ } \Omega$

$$A_v = \frac{v_o}{v_i} = \frac{4}{25 \times 10^{-3}} = 160 \quad A_v \text{ dB} = 20 \log_{10}(160) = 44.0824 \text{ dB}$$

$$A_i = \frac{v_o/R_L}{i_i} = \frac{4/40}{100 \times 10^{-6}} = 1000 \quad A_i \text{ dB} = 20 \log_{10}(1000) = 60 \text{ dB}$$

$$A_p = A_v \cdot A_i = 160 \times 1000 = 160,000 \quad A_p \text{ dB} = 10 \log_{10}(160,000) = 52.0412 \text{ dB}$$

(b) $v_i = 120 \text{ } \mu\text{V}$, $i_i = 100 \text{ nA}$, $v_o = 1.2 \text{ V}$, $R_L = 10 \text{ k}\Omega$

$$A_v = \frac{v_o}{v_i} = \frac{1.2}{120 \times 10^{-6}} = 10,000 \quad A_v \text{ dB} = 20 \log_{10}(10,000) = 80 \text{ dB}$$

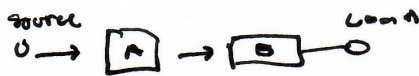
$$A_i = \frac{v_o/R_L}{i_i} = \frac{1.2/10 \times 10^3}{100 \times 10^{-9}} = 1200 \quad A_i \text{ dB} = 20 \log_{10}(1200) = 3.07918 \text{ dB}$$

$$A_p = A_v \cdot A_i = 10,000 \times 1200 = 12,000,000 \quad A_p \text{ dB} = 10 \log_{10}(12,000,000) = 7.07918 \text{ dB}$$

20

II

You are given two amplifiers, A and B, to connect in cascade between 20-mV, 50 k Ω source and a 50- Ω load. The amplifiers have voltage gain, input resistance, and output resistance as follows: for A, 40 V/V, 40 k Ω , 5 k Ω respectively; for B 50 V/V, 50 k Ω , 4 k Ω respectively. Evaluate two possible connections between source S and load L, namely SABL and SBAL. Write expression for the voltage gain (v_o/v_s) for each configuration. Determine the voltage gain for both configurations as ratio and in decibels. Which amplifier arrangement is better?



S - A - B - L

A, 40 V/V, 40 k Ω , 5 k Ω



S - B - A - L

$$\frac{v_L}{v_S} = \frac{50}{50 + 50k} \times 50 \times \frac{40}{40 \times 40k} \times 5 \times \frac{50}{50 \times 50k} = 2/10201$$

$$\frac{v_L}{v_S} = \frac{50}{50 + 50k} \times 50 \times \frac{40}{40 \times 40k} \times 5 \times \frac{50}{50 \times 50k} = 2/10201$$

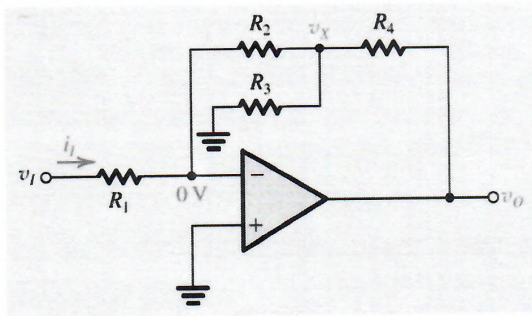
$$\frac{v_L}{v_S} = \frac{50}{50 + 50k} \times 50 \times \frac{40}{40 \times 40k} \times 5 \times \frac{50}{50 \times 50k} = 2/10201$$

$$\frac{v_L}{v_S} = \frac{50}{50 + 50k} \times 50 \times \frac{40}{40 \times 40k} \times 5 \times \frac{50}{50 \times 50k} = 2/10201$$

SABL has a higher amplifier why?

05

- III The inverting circuit with T network in the feedback is redrawn in following figure in a way that emphasizes the observation that R_2 and R_3 in effect are in parallel (because the ideal op-amp forces a virtual ground at the inverting input terminal). Use this observation to derive an expression for the gain (v_o/v_i) by first finding (v_x/v_i) and (v_o/v_x). For the latter use the voltage-divider rule applied to R_4 and ($R_2 \parallel R_3$).



$$i_I = \frac{v_i}{R_1}, \quad v_x = -i_I \cdot R_2$$

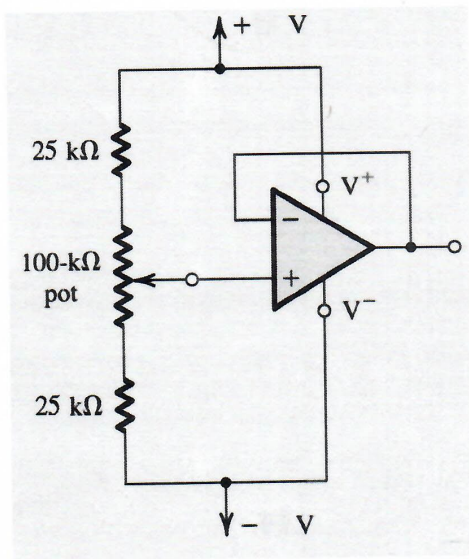
$$\frac{v_x}{v_i} = -\frac{R_2}{R_1}, \quad v_x = \frac{R_2 \parallel R_3}{(R_2 \parallel R_3) + R_4} \cdot v_o = \frac{\frac{R_2 R_3}{R_2 + R_3}}{\frac{R_2 R_3}{R_2 + R_3} + R_4}$$

$$\frac{v_o}{v_i} = -\frac{R_2}{R_1} \left(1 + \frac{R_4}{R_3} + \frac{R_4}{R_2} \right)$$

25

IV

Figure shows a circuit that provides an output voltage v_o whose value can be varied by turning the wiper of the 100-k Ω potentiometer. Find the range (lowest and highest) over which v_o can be varied. If the potentiometer is a "20-turn" device, find the change in v_o corresponding to each turn of the pot. The $V^+ = +12.0$, and $V^- = -12.0$ volts.



Set at the bottom

$$v_o = v_t = -12 + \frac{25}{25+100+25} (12 - (-12)) = -8 \text{ V}$$

Set at the top

$$v_o = v_t = -12 + \frac{25+100}{25+100+25} * (12 - (-12)) = 8 \text{ V}$$

Output $\rightarrow 8 - (-8) = 16 \text{ V}$

16 turns $\rightarrow \cancel{V/Turn}$

20

BELOW AVERAGE

ELEG3304 Spring 2022**Test # 1**

February 10

Question #	Max Points	Obtained
I	25	25
II	25	05
III	25	25
IV	25	05
Total points	100	60

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Various amplifier and load combinations are measured as listed below using rms values. For each, find the voltage, current, and power gains (A_v , A_i , and A_p , respectively) both as ratios and in dB:

(a) $v_i = 25 \text{ mV}$, $i_i = 100 \text{ } \mu\text{A}$, $v_o = 4 \text{ V}$, $R_L = 40 \text{ } \Omega$

(b) $v_i = 120 \text{ } \mu\text{V}$, $i_i = 100 \text{ nA}$, $v_o = 1.2 \text{ V}$, $R_L = 10 \text{ k}\Omega$

a.) $A_v = v_o / v_i = \frac{4 \text{ V}}{25 \text{ mV}} = 4 / 0.025 = \boxed{160}$ ✓

$A_v \text{ dB} = 20 \log(160) = \boxed{44.082 \text{ dB}}$ ✓

$A_i = v_o / i_i = \frac{4 \text{ V}}{100 \text{ } \mu\text{A}} = \frac{4}{100 \times 10^{-6}} = \boxed{1000}$ ✓

$A_i \text{ dB} = 20 \log(1000) = \boxed{60 \text{ dB}}$ ✓

$A_p = A_v \cdot A_i = \boxed{160,000}$ ✓

$A_p \text{ dB} = 10 \log(160,000) = \boxed{52.041 \text{ dB}}$ ✓

b.) $A_v = v_o / v_i = \frac{1.2 \text{ V}}{120 \times 10^{-6}} = \boxed{10,000}$ ✓

$A_v \text{ dB} = 20 \log(10,000) = \boxed{80 \text{ dB}}$ ✓

$A_i = \frac{1.2}{10,000} / 100 \times 10^{-9} = \boxed{1,200}$ ✓

$A_i \text{ dB} = 20 \log(1,200) = \boxed{61.584 \text{ dB}}$ ✓

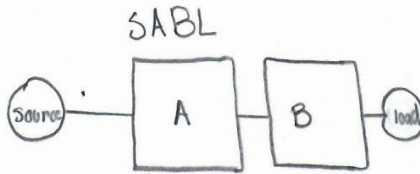
$A_p = A_v \cdot A_i = \boxed{12,000,000}$ ✓

$A_p \text{ dB} = 10 \log(12,000,000) = \boxed{70.792 \text{ dB}}$ ✓

25

You are given two amplifiers, A and B, to connect in cascade between 20-mV, 50 kΩ source and a 50-Ω load. The amplifiers have voltage gain, input resistance, and output resistance as follows: for A, 40 V/V, 40 kΩ, 5 kΩ respectively; for B 50 V/V, 50 kΩ, 4 kΩ respectively. Evaluate two possible connections between source S and load L, namely SABL and SBAL. Write expression for the voltage gain (v_o/v_s) for each configuration. Determine the voltage gain for both configurations as ratio and in decibels. Which amplifier arrangement is better?

This guy
is at
13:00



$$SABL = \frac{40}{40,000 + 5000} \times 10 \times \frac{4000}{4,000,000 + 500,000} \times 100 \times \frac{400,000}{400,000,000 + 50,000,000} = 7.015 v_o/v_s$$

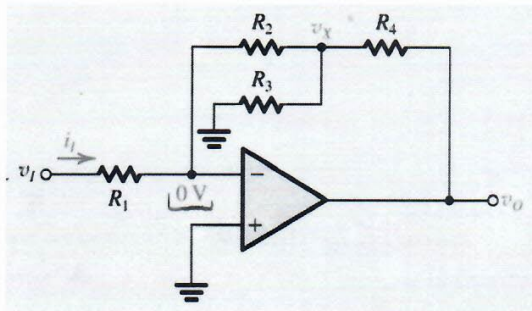
$$8.888 \times 10^{-3} \times 0.888 \times 8.888 \times 10^{-4}$$

$$SBAL = \frac{50}{50,000 + 4,000} \times 10 \times \frac{5000}{5,000,000 + 400,000} \times 100 \times \frac{500,000}{500,000,000 + 40,000,000} = 7.989 v_o/v_s$$

$$9.259 \times 10^{-3} \times 0.926 \times 9.259 \times 10^{-4}$$

05

The inverting circuit with T network in the feedback is redrawn in following figure in a way that emphasizes the observation that R_2 and R_3 in effect are in parallel (because the ideal op-amp forces a virtual ground at the inverting input terminal). Use this observation to derive an expression for the gain (v_o/v_i) by first finding (v_x/v_i) and (v_o/v_x). For the latter use the voltage-divider rule applied to R_4 and ($R_2 \parallel R_3$).



$$i_I = v_i / R_1, \quad v_x = -i_I \cdot R_2 = -\frac{v_i \cdot R_2}{R_1}$$

$$v_x / v_i = \frac{-R_2}{R_1} \quad \checkmark$$

$$v_x = \frac{R_2 \parallel R_3}{(R_2 \parallel R_3) + R_4} \cdot v_o = \frac{R_2 R_3}{R_2 + R_3} \cdot \frac{v_o}{\frac{R_2 R_3}{R_2 + R_3} + R_4}$$

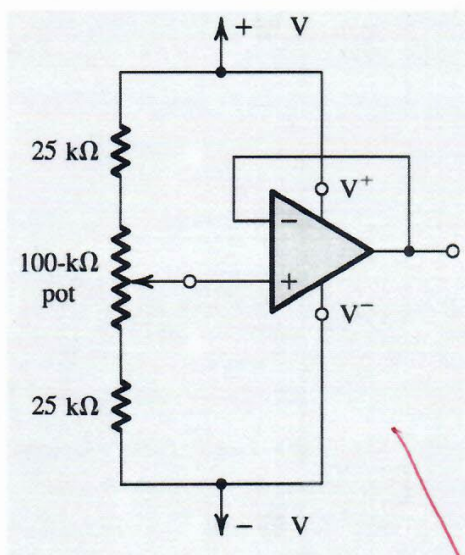
$$\frac{v_o}{v_x} = \frac{R_2 R_3 + R_2 R_4 + R_3 R_4}{R_2 R_3} \quad \checkmark$$

$$\frac{v_o}{v_i} = \frac{v_o}{v_x} \times \frac{v_x}{v_i} = \left[-\frac{R_2}{R_1} \left(1 + \frac{R_4}{R_3} + \frac{R_4}{R_2} \right) \right] \quad \checkmark$$

25

IV

Figure shows a circuit that provides an output voltage v_o whose value can be varied by turning the wiper of the $100\text{-k}\Omega$ potentiometer. Find the range (lowest and highest) over which v_o can be varied. If the potentiometer is a "20-turn" device, find the change in v_o corresponding to each turn of the pot. The $V^+ = +12.0$, and $V^- = -12.0$ volts.



$$-12 + \left(\frac{25}{25 + 100 + 25} \right) (12 - (-12)) = -284V$$

05

ELEG3304 Spring 2022**Test # 2**

March 10

Question #	Max Points	Obtained
I	24	
II	24	
III	30	
IV	22	
Total points	100	

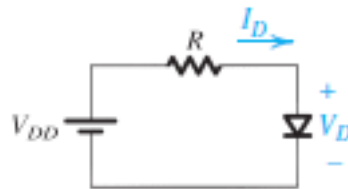
Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 2.****Handover your test to the instructor.**

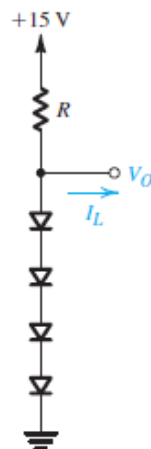
- I. Measurements made on the internally compensated amplifiers listed below provide the dc gain and the frequency at which the gain dropped by 20 dB. For each, what are the -3dB and unity-gain frequencies?
- (a) 10^5 V/V and 10^2 Hz
 - (b) 1800 V/V and 0.1 MHz
 - (c) 200 V/mV and 20 kHz

- II Design a circuit using optimum number of diodes in series with a resistor to provide a reference voltage of 3.85 V from a +10 V supply. Assume the diodes available have 0.7-V drop at 1 mA and I_{FMAX} of 1 A. Box your answers. Sketch the circuit. What is the wattage rating of the resistor? (Use V_T of 25.8 mV)

- III Use iterative-analysis procedure to determine the diode current, I_D and voltage, V_D in the circuit below for $V_{DD} = 1$ V, $R = 750 \Omega$, and a diode having $I_s = 10^{-15}$ A. Show and box all iteration results. Use four places after decimal. (Use V_T of 25.8 mV)



- IV A string of four diodes is used to provide constant voltage of 3.0 V. (a) Calculate the percentage change in the regulated voltage, V_O caused by 10% change in the power supply voltage. (b) Find the load regulation when a load of $1.2 \text{ k}\Omega$ is connected. Use $R = 1 \text{ k}\Omega$. (Use V_T of 25.8 mV)



ABOVE AVERAGE

ELEG3304 Spring 2022**Test # 2**

March 10

Question #	Max Points	Obtained
I	24	24
II	24	05
III	30	10
IV	22	15
Total points	100	54

Closed book, Closed notes.

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I. Measurements made on the internally compensated amplifiers listed below provide the dc gain and the frequency at which the gain dropped by 20 dB. For each, what are the -3dB and unity-gain frequencies?

- (a) 10^5 V/V and 10^2 Hz
 (b) 1800 V/V and 0.1 MHz
 (c) 200 V/mV and 20 kHz
 $200,000$ V/V $20,000$ Hz

a) $A_f = \frac{10^5}{10} = 10^4$
 $f_t = 10^4 \times 10^2 = 10^6$ Hz ✓
 $f_b = \frac{f_t}{A_0} = \frac{10^6}{10^5} = 10$ Hz ✓

b) $A_f = \frac{1800}{10} = 180$
 $f_t = 180 \times 100,000 = 18,000,000$ Hz ✓
 $f_b = \frac{f_t}{A_0} = \frac{18,000,000}{1800} = 10,000$ Hz ✓

c) $A_f = \frac{200,000}{10} = 20,000$
 $f_t = 20,000 \times 20,000 = 400,000,000$ Hz ✓
 $f_b = \frac{400,000,000}{200,000} = 2,000$ Hz ✓

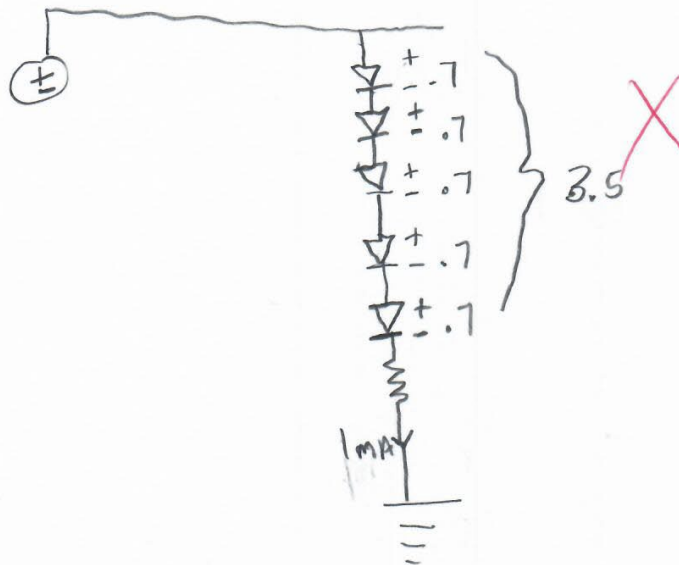
There is no negative frequency

24

- II Design a circuit using optimum number of diodes in series with a resistor to provide a reference voltage of 3.85 V from a +10 V supply. Assume the diodes available have 0.7-V drop at 1 mA and I_{FMAX} of 1 A. Box your answers. Sketch the circuit. What is the wattage rating of the resistor? (Use V_T of 25.8 mV)

$$\frac{V_{R_F}}{0.7} = \frac{3.85V}{0.7} = 5.5 \quad \boxed{n=5.5}$$

Not possible



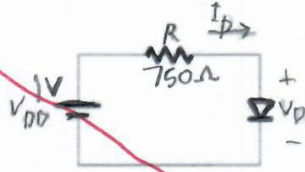
$$3.85 - 3.5 = .35V$$

$$P = I^2 R = (I_{MAX})^2 (35) = \boxed{.35mW}$$

$I^2 R$

05

- III Use iterative-analysis procedure to determine the diode current, I_D and voltage, V_D in the circuit below for $V_{DD} = 1$ V, $R = 750 \Omega$, and a diode having $I_s = 10^{-15}$ A. Show and box all iteration results. Use four places after decimal. (Use V_T of 25.8 mV)



$$I_D = \frac{V_{DD} - V_D}{R} = \frac{1.3 - .7}{750} = \boxed{.8000 \text{ mA}}$$

$$V_D = .025 \ln\left(\frac{I_D}{I_s}\right)$$

$$V_D = .025 \ln\left(\frac{.8}{10^{-15}}\right) = \boxed{.8570 \text{ V}}$$

$$I_D = \frac{V_{DD} - V_D}{R} = \frac{1.3 - .857}{750} = \boxed{.5666 \text{ mA}}$$

$$V = .025 \ln\left(\frac{.5666}{10^{-15}}\right) = \boxed{.8492 \text{ V}}$$

10

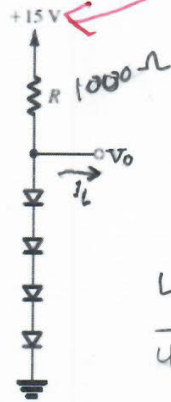
IV A string of four diodes is used to provide constant voltage of 3.0 V. (a) Calculate the percentage change in the regulated voltage, V_o caused by 10% change in the power supply voltage. (b) Find the load regulation when a load of 1.2 k Ω is connected. Use $R = 1$ k Ω . (Use V_T of 25.8 mV)

a) $I_D = \frac{15 - 3}{1} = 12 \text{ mA}$

$r_{cd} = \frac{1 \times 2.7}{12 \text{ mA}}$

$r_{cd} = 2.1667 \Omega$

$\frac{4(.225)}{4(.225) + 1000} = \frac{.9}{.9 + 1000}$



$\frac{4r_{cd}}{4r_{cd} + R} \times \Delta V$

$8.9919 \times 10^{-4} \times 1.5 = .4296\%$

~~$3.0 \times 10\% = 2.7$~~

b)

15

AVERAGE

ELEG3304 Spring 2022**Test # 2**

March 10

Question #	Max Points	Obtained
I	24	10
II	24	15
III	30	10
IV	22	15
Total points	100	50

Closed book, Closed notes.

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- I. Measurements made on the internally compensated amplifiers listed below provide the dc gain and the frequency at which the gain dropped by 20 dB. For each, what are the -3dB and unity-gain frequencies?

- (a) 10^5 V/V and 10^2 Hz
 (b) 1800 V/V and 0.1 MHz
 (c) 200 V/mV and 20 kHz

(a) 10^5 v/v and 10^2 Hz

10^5 v/v

AOL (low freq)

$f_{\text{when } A \text{ drop}}$

AOL LI

10^2 Hz

1000 kHz

f_{-3dB}

f_t

10 Hz

1 MHz

(b) 1800 v/v and .1 MHz

0.1×10^6 Hz

100 v/v

1 MHz

10 Hz

(c) 200 v/mv and 20 kHz =
 200,000 v/v

2.5×10^3

20,000 v/v

2.5 kHz

500 MHz

10

- II Design a circuit using optimum number of diodes in series with a resistor to provide a reference voltage of 3.85 V from a +10 V supply. Assume the diodes available have 0.7-V drop at 1 mA and I_{FMAX} of 1 A. Box your answers. Sketch the circuit. What is the wattage rating of the resistor? (Use V_T of 25.8 mV)

$$I_D = I_S \left(\exp\left(\frac{V_D}{25.8}\right) - 1 \right)$$

$$I_D = 1 \text{ mA and } V_D = 0.7$$

$$I_S = 2.0298 \times 10^{-15}$$

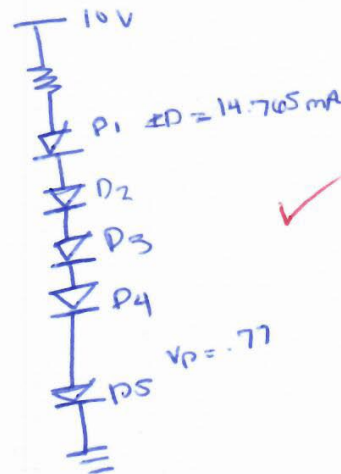
$$3.85/5 = 0.77 \text{ V}$$

$$I_D = 14.765 \text{ mA}$$

$$R = \frac{10V - 3.85}{I_D} = \frac{6.15}{14.765 \text{ mA}}$$

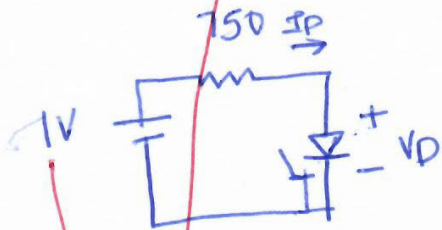
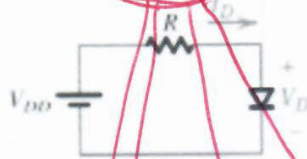
$$R = 416.525$$

$$P = VS = 90.805$$



15

- III Use iterative-analysis procedure to determine the diode current, I_D and voltage, V_D in the circuit below for $V_{DD} = 1$ V, $R = 750 \Omega$, and a diode having $I_s = 10^{-15}$ A. Show and box all iteration results. Use four places after decimal. (Use V_T of 25.8 mV)



From KVL

$$V_{DD} - I_D R - V_D = 0$$

$$I_D = \frac{V_{DD} - V_D}{R} = \frac{1 - V_D}{750}$$

$$V_2 = V_1 + V_T \ln \frac{I_2}{I_1}$$

$$V_D = 0.7 \text{ V}, I_D = \text{mA}$$

$$\text{1st } I_D = \frac{1 - 0.7}{750} = 0.4 \text{ mA or } 0.0004$$

$$V_2 = 0.7 + 0.025 \ln \left(\frac{0.0004}{1} \right)$$

$$0.7 + 0.025 (1 + 44) =$$

$$V_1 = 0.743$$

$$\text{2nd } I_D = \frac{1 - 0.743}{750} = 0.000337 = 0.337 \text{ mA}$$

$$V_2 = 0.743 + 0.025 \ln (0.337)$$

$$V_2 = 0.7432$$

$$\text{3rd } I_D = \frac{1 - 0.7432}{750} = 0.3373 \text{ mA}$$

$$0.743 + 0.025 \ln \left(\frac{0.3373}{0.337} \right)$$

$$V_3 = 0.7432 \text{ V}$$

$$\text{4th } I_D = \frac{1 - 0.7432}{750} = 0.3373 \text{ mA}$$

$$0.743 + 0.025 \ln \left(\frac{0.3373}{0.337} \right)$$

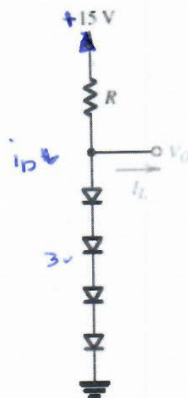
$$V_4 = 0.7432 \text{ V}$$

$$V_D = 0.7432 \text{ V}$$

$$I_D = 0.3373 \text{ mA}$$

IV

A string of four diodes is used to provide constant voltage of 3.0 V. (a) Calculate the percentage change in the regulated voltage, V_O caused by 10% change in the power supply voltage. (b) Find the load regulation when a load of $1.2 \text{ k}\Omega$ is connected. Use $R = 1 \text{ k}\Omega$. (Use V_T of 25.8 mV)



(a)

$$I_O = \frac{15 - V_O}{1}$$

$$= \frac{15 - 3}{1} = 12 \text{ mA}$$

dynamic resistance

$$r_d = \frac{n V_T}{I_d} = \frac{1 \times 25.8 \text{ mV}}{12} = 2.1667$$

$$\Delta V_O \frac{4 r_d}{4 r_d + R} \times \Delta V_S = \frac{4 \times 2.1667}{2 \times 2.1667 + 1000} \times 1.5 = 0.0128885 \text{ V}$$

$$\therefore \frac{\Delta V_O}{V_O} \times 100 = \frac{0.0128885}{3} \times 100 = 4.296\%$$

(b) $R_L = 1.2 \text{ k}\Omega$

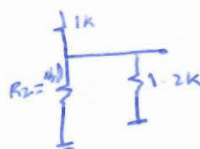
$$I_O = \frac{V_O}{1.2 \text{ k}\Omega} = \frac{3}{1.2} = 2.5 \text{ mA}$$

$$I_S = \frac{V_O - V_D}{R} = \frac{15 - 3}{1} = 12 \text{ mA}$$

$$I_D = I_S - I_O = 12 - 2.5 = 9.5$$

$$r_d = \frac{n V_T}{I_d} = \frac{1 \times 25.8 \text{ mV}}{9.5 \text{ mA}} = 2.7368 \Omega$$

15



$$= 15 \left[\frac{1}{1200} + \frac{1}{10.9471} + \frac{1}{1000} \right] = \frac{V_O'}{R} = \frac{15}{1000}$$

$$\times 0.931809 = \frac{15}{1000}$$

$$V_O' = 1.60977$$

$$\therefore \text{regulation} = \frac{V_O' - V_O}{V_O} \times 100$$

$$= \frac{1.60977 - 3}{3} \times 100 = -94.63\%$$

BELOW AVERAGE

ELEG3304 Spring 2022**Test # 2**

March 10

Question #	Max Points	Obtained
I	24	05
II	24	0
III	30	30
IV	22	0
Total points	100	35

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 2.****Handover your test to the instructor.**

I. Measurements made on the internally compensated amplifiers listed below provide the dc gain and the frequency at which the gain dropped by 20 dB. For each, what are the -3dB and unity-gain frequencies?

- (a) 10^5 V/V and 10^2 Hz
- (b) 1800 V/V and 0.1 MHz
- (c) 200 V/mV and 20 kHz

-3 dB unity gain

* $10^{20/20} = 10^1$

a) 10^5 V/V, 10^2 Hz

$10^{5/20} = 10^{0.25}$

10^4 V/V ✓

b) 1800 V/V, 0.1 MHz

180 V/V ✓

c) 200 V/mV, 20 kHz

~~2 V/mV~~

05

II

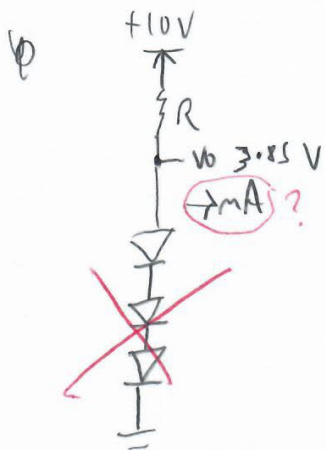
Design a circuit using optimum number of diodes in series with a resistor to provide a reference voltage of 3.85 V from a +10 V supply. Assume the diodes available have 0.7-V drop at 1 mA and I_{FMAX} of 1 A. Box your answers. Sketch the circuit. What is the wattage rating of the resistor? (Use V_T of 25.8 mV)

3.85 V from a +10 V supply

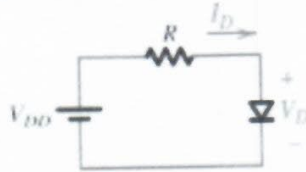
0.7 V drop at 1 mA & I_{FMAX} of 1 A

$$V_T = 25.8 \text{ mV}$$

Wattage rating?



- III Use iterative-analysis procedure to determine the diode current, I_D and voltage, V_D in the circuit below for $V_{DD} = 1\text{ V}$, $R = 750\ \Omega$, and a diode having $I_s = 10^{-15}\text{ A}$. Show and box all iteration results. Use four places after decimal. (Use V_T of 25.8 mV)



$$V_{DD} = 1\text{ V}, R = 750\ \Omega, I_s = 10^{-15}\text{ A}, V_T = 25.8\text{ mV}$$

$$\frac{1\text{ V} - 25.8\text{ mV}}{750} = \boxed{1.2989\text{ mA}}$$

$$V_T \ln \left(\frac{1.2989\text{ mA}}{1 \times 10^{-15}\text{ A}} \right) =$$

$$\boxed{0.7196\text{ V}}$$

Iteration #2

$$\frac{1 - 0.7196}{750} = \boxed{0.3738\text{ mA}}$$

$$25.8\text{ mV} \ln \left(\frac{0.3738\text{ mA}}{1 \times 10^{-15}} \right) = \boxed{0.6875\text{ V}}$$

Iteration #3

$$\frac{1 - 0.6875}{750} = \boxed{0.4167\text{ mA}}$$

$$25.8\text{ mV} \ln \left(\frac{0.4167\text{ mA}}{1 \times 10^{-15}} \right) = \boxed{0.6903\text{ V}}$$

Iteration #4

$$\frac{1 - 0.6903}{750} = \boxed{0.4129\text{ mA}}$$

$$25.8\text{ mV} \ln \left(\frac{0.4129\text{ mA}}{1 \times 10^{-15}} \right) = \boxed{0.69006\text{ V}}$$

Iteration #5 answer

$$\frac{1 - 0.69006}{750} = \boxed{0.4132\text{ mA}}$$

$$25.8\text{ mV} \ln \left(\frac{0.4132\text{ mA}}{1 \times 10^{-15}} \right) = \boxed{0.69008\text{ V}}$$

30

- IV A string of four diodes is used to provide constant voltage of 3.0 V. (a) Calculate the percentage change in the regulated voltage, V_O caused by 10% change in the power supply voltage. (b) Find the load regulation when a load of 1.2 k Ω is connected. Use $R = 1$ k Ω . (Use V_T of 25.8 mV)

4 diodes: 3 V
 a) % change in V_O ? caused by 10% change in power supply voltage, ...

10% change in power supply
 ? %

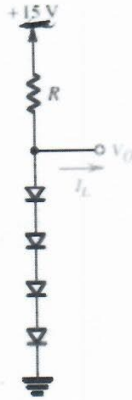
$$1.10 \times 15 = 16.5 \text{ V}$$

$$\frac{16.5 - 3}{1 \text{ k}\Omega} = .0135$$

$$\boxed{1.35\%}$$

b) load regulation, $R = 1.2 \text{ k}\Omega$

$$1.2 \text{ k}\Omega + 1 \text{ k}\Omega = 2.2 \text{ k}\Omega$$



ELEG3304 Spring 2022**Test # 3**

April 14, 2022

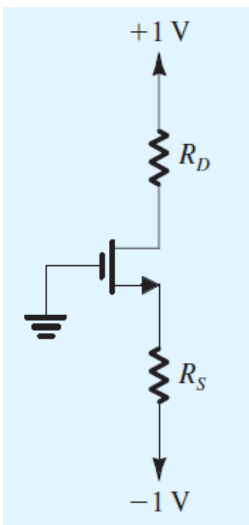
Question #	Max Points	Obtained
I	21	
II	26	
III	26	
IV	27	
Total points	100	

Closed book, Closed notes.

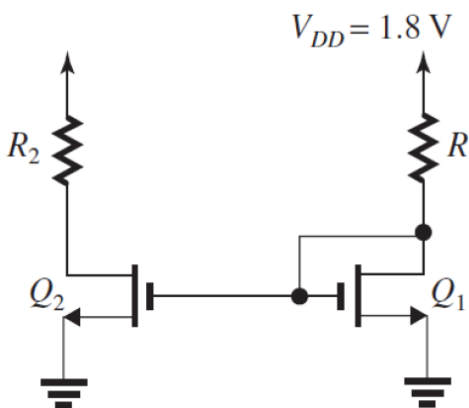
No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 3.****Handover your test to the instructor.**

Four places after decimal for all answers

- I. For a 0.18- μm process technology for which $\mu_n = 425 \text{ cm}^2/\text{V}\cdot\text{s}$ and $t_{\text{ox}} = 4.5 \text{ nm}$, find C_{ox} , k'_n , and the overdrive voltage V_{ov} required to operate a transistor having $W/L = 25$ in saturation with $I_D = 325 \mu\text{A}$. What is the minimum value of V_{DS} needed?
- II. An NMOS transistor is fabricated in a 0.4 μm process having $V'_A = 50 \text{ V}/\mu\text{m}$ of channel length. If $L = 0.8 \mu\text{m}$ and $W = 16 \mu\text{m}$, find V_A and λ . Find the value of I_D that results when the device is operated with an overdrive voltage $V_{\text{ov}} = 0.75 \text{ V}$ and $V_{\text{DS}} = 1.25 \text{ V}$. Also, find the value of r_o at this operating point. If V_{DS} is increased by 2 V, what is the corresponding change in I_D (ΔI_D). The $\mu_n C_{\text{ox}}$ is $450 \mu\text{A}/\text{V}^2$.
- III. Design the circuit to establish a drain current of 0.1 mA and a drain voltage of +0.3 V. The MOSFET has $V_{\text{tn}} = 0.5 \text{ V}$ and $W/L = 105 \mu\text{m} / 3 \mu\text{m}$. Find V_{ov} , V_{GS} , V_{S} , R_{S} , and R_{D} if the device is operating in saturation. Use $\mu_n C_{\text{ox}}$ of $0.4 \text{ mA}/\text{V}^2$.



- IV. For following circuit, both MOSFET transistors have following parameters: $V_{\text{tn}} = 0.5 \text{ V}$ and $\mu_n C_{\text{ox}} = 0.4 \text{ mA}/\text{V}^2$. $L_1 = L_2 = 0.18 \mu\text{m}$ and $W_1 = 0.72 \mu\text{m}$, $W_2 = 1.8 \mu\text{m}$. The V_{D1} is measured to be 0.7 V. If the transistor Q_2 is operating at the edge of saturation region, determine I_{D1} , R , I_{D2} , V_{D2} , and R_2 .





ELEG3304 Spring 2022**Test # 3**

April 14, 2022

Question #	Max Points	Obtained
I	21	21
II	26	16
III	26	24
IV	27	24
Total points	100	85

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 3.****Handover your test to the instructor.**

Four places after decimal for all answers

- I. For a 0.18- μm process technology for which $\mu_n = 425 \text{ cm}^2/\text{V}\cdot\text{s}$ and $t_{\text{ox}} = 4.5 \text{ nm}$, find C_{ox} , k'_n , and the overdrive voltage V_{ov} required to operate a transistor having $W/L = 25$ in saturation with $I_D = 325 \mu\text{A}$. What is the minimum value of V_{DS} needed?

$$C_{\text{ox}} = \frac{\epsilon_v \epsilon_0}{t_{\text{ox}}} = \frac{3.9 \times 8.85 \cdot 10^{-12}}{4.5 \times 10^{-9}}$$

$$\mu_n C_{\text{ox}}$$

$$C_{\text{ox}} = 7.6734 \times 10^{-3}$$

$$K_n = \cancel{325 \mu\text{A}} \quad \mu_n C_{\text{ox}} = \mu_n \cdot 7.6734 \times 10^{-3} = 425 \times 10^{-4} \cdot 7.6734 \times 10^{-3}$$

$$k'_n = 3.2612 \times 10^{-4}$$

$$V_{\text{ov}} = \sqrt{\frac{2I_D}{k'_n \frac{W}{L}}} =$$

$$\sqrt{\frac{2 \cdot 325 \times 10^{-6}}{3.2612 \times 10^{-4} \cdot 25}} = \sqrt{0.79725}$$

$$V_{\text{ov}} = .2823$$

$$V_{\text{DSmin}} = V_{\text{ov}} = .2823$$

21

- II. An NMOS transistor is fabricated in a $0.4 \mu\text{m}$ process having $V_A' = 50 \text{ V}/\mu\text{m}$ of channel length. If $L = 0.8 \mu\text{m}$ and $W = 16 \mu\text{m}$, find V_A and λ . Find the value of I_D that results when the device is operated with an overdrive voltage $V_{ov} = 0.75 \text{ V}$ and $V_{DS} = 1.25 \text{ V}$. Also, find the value of r_o at this operating point. If V_{DS} is increased by 2 V , what is the corresponding change in I_D (ΔI_D). The $\mu_n C_{ox}$ is $450 \mu\text{A}/\text{V}^2$.

$$V_A = V_A' \cdot L = 50 \cdot 0.8 = 40 \text{ V} \quad \checkmark$$

$$\lambda = \frac{1}{V_A} = \frac{1}{40} = 0.025 \quad \checkmark$$

$$I_D = \frac{1}{2} k_n' \frac{W}{L} \cdot V_{ov}^2 = \frac{1}{2} \cdot 450 \cdot 10^{-6} \cdot \frac{16}{0.8} \cdot 0.75^2 \quad (\text{WAF 2018})$$

$$I_D = 0.253 \quad \text{or} \quad 0.253$$

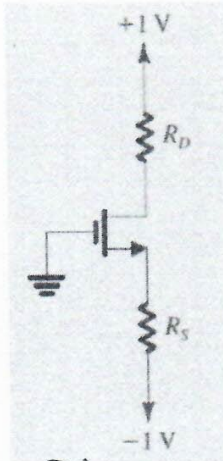
$$r_o = \frac{V_A}{I_D} = \frac{40}{0.253} = 158.0246 \quad \text{or} \quad 158.0246$$

$$\Delta I_D = \frac{\Delta V_{DS}}{r_o} = \frac{2}{158.0246} = 0.0126 \quad \text{or} \quad 0.0126$$

Math
could
be
a little off

16

- III. Design the circuit to establish a drain current of 0.1 mA and a drain voltage of +0.3 V. The MOSFET has $V_{th} = 0.5$ V and $W/L = 105 \mu\text{m} / 3 \mu\text{m}$. Find V_{ov} , V_{GS} , V_S , R_S , and R_D if the device is operating in saturation. Use $\mu_n C_{ox}$ of 0.4 mA/V^2 .



$$V_G - V_S = V_{GS}$$

$$V_G = 0 \text{ V}$$

$$V_{GS} = -V_S$$

2
0

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} [V_{GS} - V_{th}]^2$$

$$\frac{1}{2} \times 0.4 \times 10^{-3} \cdot \frac{105}{3} [V_{GS} - 0.5]^2$$

$$V_{GS} = 0.619 \text{ V}$$

$$V_S = -V_{GS} = -0.619 \text{ V}$$

$$I_S = \frac{V_S + 1}{R_S} = 0.1 \times 10^{-3} =$$

$$I_D = \frac{1}{2} \times 0.4 \times 10^{-3} \cdot \frac{105}{3} [0.619 - 0.5]^2 = \frac{0.619 + 1}{R_S}$$

$$I_D =$$

$$R_S = 3.81 \text{ k}\Omega$$

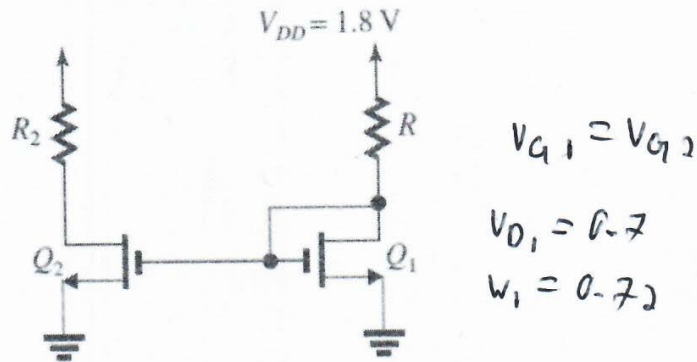
$$I_D = \frac{1 - 0.3}{R_D}$$

$$R_D = \frac{0.7}{0.1}$$

$$R_D = 7 \text{ k}\Omega$$

24

- IV. For following circuit, both MOSFET transistors have following parameters: $V_{th} = 0.5 \text{ V}$ and $\mu_n C_{ox} = 0.4 \text{ mA/V}^2$. $L_1 = L_2 = 0.18 \text{ }\mu\text{m}$ and $W_1 = 0.72 \text{ }\mu\text{m}$, $W_2 = 1.8 \text{ }\mu\text{m}$. The V_{D1} is measured to be 0.7 V . If the transistor Q_2 is operating at the edge of saturation region, determine I_{D1} , R , I_{D2} , V_{D2} , and R_2 .



$$V_{DS2} = V_{GS2} - V_{th}$$

$$I_{D1} = \frac{\mu_n C_{ox}}{2} \left(\frac{W_1}{L_1} \right) (V_{GS1} - V_{th})^2$$

$$V_{GS1} = V_{D1} = 0.7 \text{ V}$$

$$I_{D1} = \left(\frac{0.4}{2} \right) \left(\frac{0.72}{0.18} \right) (0.7 - 0.5)^2$$

$$I_{D1} = 0.032 \text{ mA}$$

$$R_1 = \frac{V_{DD} - V_{D1}}{I_{D1}} = \frac{1.8 - 0.7}{0.03} = 34.375 \text{ k}\Omega$$

$$V_{DS2} = V_{GS2} - V_{th} = 0.7 - 0.5$$

$$V_{DS2} = 0.2 \text{ V}$$

This is when $s_2 = 0$

$$R_2 = \frac{V_{DD} - V_{D2}}{0.03} = 53.33 \text{ }\Omega$$

$$R_2 = \frac{1.5999}{0.03} = 53.33 \text{ k}\Omega$$

24



ELEG3304 Spring 2022**Test # 3**

April 14, 2022

Question #	Max Points	Obtained
I	21	18
II	26	20
III	26	16
IV	27	20
Total points	100	74

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 3.****Handover your test to the instructor.**

Four places after decimal for all answers

- I. For a 0.18- μm process technology for which $\mu_n = 425 \text{ cm}^2/\text{V}\cdot\text{s}$ and $t_{\text{ox}} = 4.5 \text{ nm}$, find C_{ox} , k'_n , and the overdrive voltage V_{ov} required to operate a transistor having $W/L = 25$ in saturation with $I_D = 325 \mu\text{A}$. What is the minimum value of V_{DS} needed?

$$C_{\text{ox}} = \frac{\epsilon_{\text{ox}}}{t_{\text{ox}}} = \frac{3.9 \times (8.854 \times 10^{-12})}{(4 \times 10^{-9})} = 8.632 \text{ fF}/\mu\text{m}^2$$

$$k'_n = \mu_n C_{\text{ox}} = (425 \times 10^{-6}) (8.6 \times 10^{-3}) = 3.66 \times 10^{-6} \\ = 3.6656 \mu\text{A}/\text{V}^2$$

$$V_{\text{ov}} = \sqrt{\frac{2I_D}{k'_n (W/L)}}$$

$$I_D = \frac{1}{2} k'_n (W/L) \cdot V_{\text{ov}}^2$$

$$(325 \times 10^{-6}) = \frac{1}{2} (3.66 \times 10^{-6}) (25) (V_{\text{ov}})^2$$

$$= \sqrt{\frac{2(325 \times 10^{-6})}{(3.6656 \times 10^{-6})(25)}}$$

$$V_{\text{ov}} = 2.6632 \text{ V}$$

18

$$V_{\text{DSmin}} = V_{\text{ov}} = 2.6632 \text{ V}$$

- II. An NMOS transistor is fabricated in a $0.4\text{ }\mu\text{m}$ process having $V'_A = 50\text{ V}/\mu\text{m}$ of channel length. If $L = 0.8\text{ }\mu\text{m}$ and $W = 16\text{ }\mu\text{m}$, find V_A and λ . Find the value of I_D that results when the device is operated with an overdrive voltage $V_{ov} = 0.75\text{ V}$ and $V_{DS} = 1.25\text{ V}$. Also, find the value of r_o at this operating point. If V_{DS} is increased by 2 V , what is the corresponding change in I_D (ΔI_D). The $\mu_n C_{ox}$ is $450\text{ }\mu\text{A}/\text{V}^2$.

$$V_A = V'_A \times L = 50 \times 0.8 = 40\text{ V}$$

$$\lambda = \frac{1}{V_A} = \frac{1}{40} = 0.025$$

$$I_D = \frac{1}{2} k'_n \left(\frac{W}{L}\right) \cdot V_{ov}^2$$

$$= \frac{1}{2} (450 \times 10^{-6}) \left(\frac{16}{0.8}\right) (0.75)^2$$

$$= 0.002205\text{ A} \Rightarrow I_D = 2.205\text{ mA}$$

$$r_o = \frac{V_A}{I_D} = \frac{40}{(2.205 \times 10^{-3})} = 18,140.5896\text{ }\Omega$$

$$= 18.1406\text{ k}\Omega$$

$$\Delta I_D = \frac{\Delta V_{DS}}{r_o} = \frac{2}{18140.5896} = 1.1023 \times 10^{-4}$$

$$= 0.1103\text{ }\mu\text{A}$$

20

- III. Design the circuit to establish a drain current of 0.1 mA and a drain voltage of +0.3 V. The MOSFET has $V_{th} = 0.5$ V and $W/L = 105 \mu\text{m} / 3 \mu\text{m}$. Find V_{ov} , V_{GS} , V_S , R_S , and R_D if the device is operating in saturation. Use $\mu_n C_{ox}$ of 0.4 mA/V^2 .

$$(0.1 \times 10^{-3}) = \frac{1}{2} (0.4 \times 10^{-3}) \left(\frac{W}{L} \right) (V_{ov})^2$$

$$V_{ov} = \sqrt{\frac{2 I_D}{(0.4 \times 10^{-3}) \left(\frac{105}{3} \right)}}$$

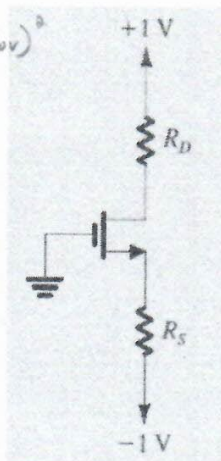
$$V_{ov} = 4.1833 \text{ V}$$

$$V_{GS} = V_{th} + \sqrt{\frac{2 I_D}{(0.4 \times 10^{-3}) \left(\frac{105}{3} \right)}}$$

$$V_{GS} = 0.6195 \text{ V}$$

$$V_S = V_{GS} = 0.6195 \text{ V}$$

$$V_S = -V_{GS}$$



$$R_D = \frac{V_{DD} - V_D}{I_D}$$

$$R_D = 7000 \Omega = 7 \text{ k}\Omega$$

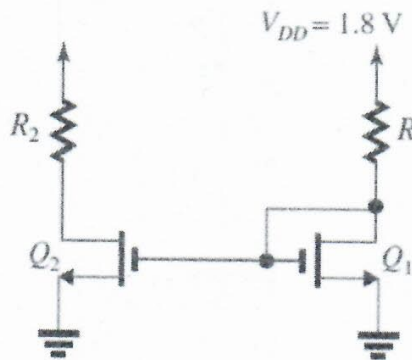
$$R_S = \frac{V_S - V_{SS}}{I_D}$$

$$\frac{0.6195 - (-1)}{(0.1 \times 10^{-3})}$$

$$R_S = 16195 \Omega = 16.195 \text{ k}\Omega$$

16

- IV. For following circuit, both MOSFET transistors have following parameters: $V_{th} = 0.5 \text{ V}$ and $\mu_n C_{ox} = 0.4 \text{ mA/V}^2$. $L_1 = L_2 = 0.18 \text{ }\mu\text{m}$ and $W_1 = 0.72 \text{ }\mu\text{m}$, $W_2 = 1.8 \text{ }\mu\text{m}$. The V_{D1} is measured to be 0.7 V . If the transistor Q_2 is operating at the edge of saturation region, determine I_{D1} , R , I_{D2} , V_{D2} , and R_2 .



$$V_{ov} = 0.7 - 0.5$$

$$V_{ov} = 0.2 \text{ V}$$

$$I_{D2} = \frac{1}{2} k'_n \left(\frac{W}{L} \right) V_{ov}^2$$

$$\frac{1}{2} (0.4 \times 10^{-3}) \left(\frac{1.8}{0.18} \right) (0.2)^2$$

$$I_{D2} = 8 \times 10^{-5} = 0.08 \times 10^{-3}$$

$$I_{D2} = 0.08 \text{ mA}$$

$$I_{D1} = \frac{1}{2} k'_n \left(\frac{0.72}{0.18} \right) (0.2)^2 = 3.2 \times 10^{-5} = 0.032 \times 10^{-3} = 0.032 \text{ mA}$$

$$R = \frac{V_{DD} - V_D}{I_D} = \frac{1.8 - 0.7}{(0.032 \times 10^{-3})} = 34375 = 34.4 \text{ k}\Omega$$

$$V_{D2} = V_{ov} = 0.2 \text{ V}$$

$$R_2 = \frac{1.8 - 0.2}{(0.08 \times 10^{-3})} = 20000 = 20 \text{ k}\Omega$$

20

ELEG3304 Spring 2022**Test # 3**

April 14, 2022

Question #	Max Points	Obtained
I	21	21
II	26	10
III	26	16
IV	27	20
Total points	100	67

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.**After finishing your test, scan all pages into a pdf file.****Upload your file on canvas under Test # 3.****Handover your test to the instructor.**

Four places after decimal for all answers

- I. For a 0.18- μm process technology for which $\mu_n = 425 \text{ cm}^2/\text{V}\cdot\text{s}$ and $t_{ox} = 4.5 \text{ nm}$, find C_{ox} , k'_n , and the overdrive voltage V_{ov} required to operate a transistor having $W/L = 25$ in saturation with $I_D = 325 \mu\text{A}$. What is the minimum value of V_{DS} needed?

0.18 μm

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = \frac{3.9 \times 8.854 \times 10^{-12}}{4.5 \times 10^{-9}} = 7.6735 \times 10^{-3} \text{ F/cm}^2$$

$$k'_n = \mu_n C_{ox} = 425 \times 10^4 \frac{\text{cm}^2}{\text{Vs}} \times 7.6735 \times 10^{-3} \frac{\text{F}}{\text{cm}^2} = 326.12 \times 10^{-4} = 326.12 \text{ mA/V}^2$$

$$I_D = \frac{1}{2} k'_n \left(\frac{W}{L}\right) (V_{DS} - V_{th})^2$$

$$I_D = \frac{1}{2} k'_n \left(\frac{W}{L}\right) (V_{ov})^2$$

$$V_{ov} = \sqrt{\frac{2 I_D}{k'_n (W/L)}}$$

$$V_{ov} = \sqrt{\frac{2 \times 325 \mu\text{A}}{326.12 \times 25}} = 0.2823 \text{ V}$$

$$V_{DS} = V_{ov} = 0.2823 \text{ V}$$

21

- II. An NMOS transistor is fabricated in a $0.4 \mu\text{m}$ process having $V_A = 50 \text{ V}/\mu\text{m}$ of channel length. If $L = 0.8 \mu\text{m}$ and $W = 16 \mu\text{m}$, find V_A and λ . Find the value of I_D that results when the device is operated with an overdrive voltage $V_{ov} = 0.75 \text{ V}$ and $V_{DS} = 1.25 \text{ V}$. Also, find the value of r_o at this operating point. If V_{DS} is increased by 2 V , what is the corresponding change in I_D (ΔI_D). The $\mu_n C_{ox}$ is $450 \mu\text{A}/\text{V}^2$.

$0.4 \mu\text{m}$

$L = 0.8 \mu\text{m}$ $W = 16 \mu\text{m}$

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} V_{ov}^2 \quad \checkmark$$

$$\lambda = \frac{1}{V_A} = \frac{1}{50} = 0.02 \quad \checkmark$$

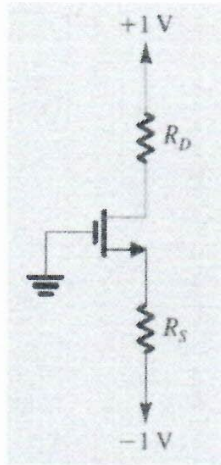
$V_{ov} = 0.75$ $V_{DS} = 1.25$

$$\frac{V_A}{I_D} = \frac{50}{0.51} = 98.04 \quad \checkmark$$

$$\Delta I_D = \frac{V_{DS}}{V_D} = \frac{1.25}{1.25} = 1.0 \quad \checkmark$$

10

- III. Design the circuit to establish a drain current of 0.1 mA and a drain voltage of +0.3 V. The MOSFET has $V_{in} = 0.5$ V and $W/L = 105 \mu\text{m} / 3 \mu\text{m}$. Find V_{ov} , V_{GS} , V_S , R_S , and R_D if the device is operating in saturation. Use $\mu_n C_{ox}$ of 0.4 mA/V^2 .



$$I_D = 0.1 \text{ mA}$$

$$V_D = +0.3 \text{ V}$$

$$I_D = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L} \right) (V_{GS} - V_{th})^2$$

$$R_D = \frac{1 - V_D}{I_D} = \frac{1 - 0.3}{0.1} \quad R_D = 700 \Omega$$

$$0.1 = \frac{1}{2} (0.4) \left(\frac{105}{3} \right) (V_{GS} - 0.5)^2$$

$$= 0.1 = \frac{21}{3} (V_S + 0.5)^2 \quad V_S = -0.379 \text{ V}$$

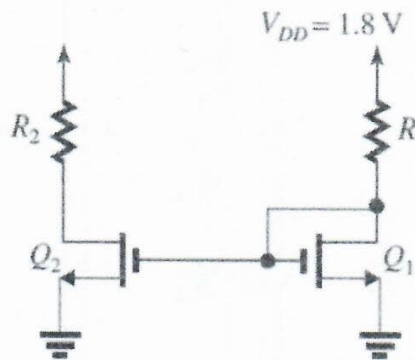
$$V_{GS} = V_D - V_S \Rightarrow V_{GS} = 0 - (-0.379)$$

$$R_S = \frac{V_S + 1}{I_D}$$

$$R_S = \frac{-0.379 + 1}{0.1} = 6.2 \text{ k}\Omega$$

16

- IV. For following circuit, both MOSFET transistors have following parameters: $V_{th} = 0.5 \text{ V}$ and $\mu_n C_{ox} = 0.4 \text{ mA/V}^2$. $L_1 = L_2 = 0.18 \mu\text{m}$ and $W_1 = 0.72 \mu\text{m}$, $W_2 = 1.8 \mu\text{m}$. The V_{D1} is measured to be 0.7 V . If the transistor Q_2 is operating at the edge of saturation region, determine I_{D1} , R , I_{D2} , V_{D2} , and R_2 .



$$V_{D2} = V_{GS2} - V_{th}$$

$$I_{D1} = \frac{\mu_n C_{ox}}{2} \left(\frac{W_1}{L_1} \right) (V_{GS1} - V_{th})^2 \quad V_{GS1} = V_{DS1} = 0.7$$

$$I_{D1} = \left(\frac{0.4}{2} \right) \cdot \left(\frac{0.72}{0.18} \right) \cdot (0.7 - 0.5)^2 \text{ mA} \quad I_{D1} = 0.032 \text{ mA}$$

$$\boxed{I_{D1} = 32 \mu\text{A}}$$

$$r_1 = \frac{V_{DD} - V_{D1}}{I_{D1}} = \frac{1.8 - 0.7}{0.032} = 34.375 \text{ k}\Omega$$

$$V_{DS} = V_{GS} - V_{th} = 0.7 - 0.5 = 0.2 \text{ V} \quad S_1 = 0$$

$$V_{D2} = \boxed{0.2 \text{ V}}$$

$$r_2 = \frac{V_{DD} - V_{D2}}{I_{D2}} = \frac{1.8 - 0.2}{0.032} = 56.25 \text{ k}\Omega$$

20

Electronics I

Spring 2022

Final Exam

ELEG3304 Spring 2022**Final Exam**May 10th, 2022

Question #	Max Points	Obtained
I	16	
II	20	
III	14	
IV	10	
V	40	
Total points	100	

Closed book, Closed notes.

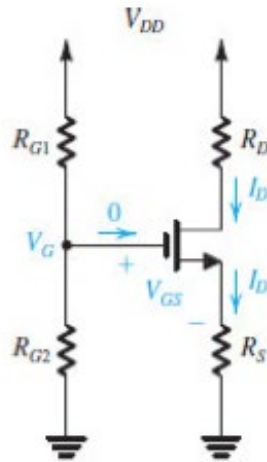
No cell phone allowed. No sharing of calculators.

Four places after decimal for all answers

- I. Consider an n-channel MOSFET with $t_{ox} = 5.1 \text{ nm}$, $\mu_n = 450 \text{ cm}^2/\text{V}\cdot\text{s}$, $V_t = 0.7 \text{ V}$, and $W/L = 15$. What is the value of k'_n ? Identify the region of operation and find the drain current in the following four cases. Use $\epsilon_r = 3.9$ for Silicon and $\epsilon_o = 8.8542 \times 10^{-12} \text{ F/m}$. (Total 16 points)

- $v_{GS} = 2.0 \text{ V}$ and $v_{DS} = 1.0 \text{ V}$
- $v_{GS} = 2.0 \text{ V}$ and $v_{DS} = 2.0 \text{ V}$
- $v_{GS} = 2.5 \text{ V}$ and $v_{DS} = 1.5 \text{ V}$
- $v_{GS} = 2.7 \text{ V}$ and $v_{DS} = 2.0 \text{ V}$

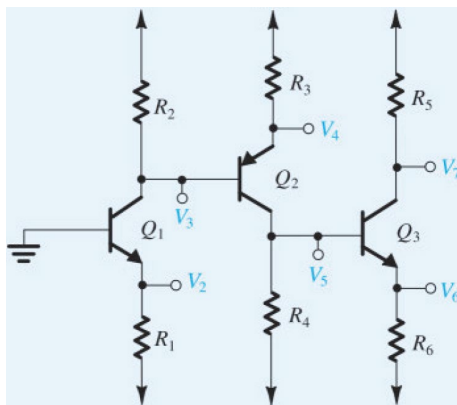
- II. (a) Determine the drain current, the drain voltage, and V_{OV} . Use $R_{G1} = 9 \text{ M}\Omega$, $R_{G2} = 6 \text{ M}\Omega$, $R_D = R_S = 4.3 \text{ k}\Omega$. The device parameters are $V_t = 1.0 \text{ V}$, Use $k'_n(W/L)$ value of 1.5 mA/V^2 . Neglect channel length modulation. Use $V_{DD} = +10.0 \text{ V}$. (b) Calculate power absorbed by the MOSFET. (Total 20 points)



- III. A transistor for which $I_S = 10^{-16} \text{ A}$ is conducting a collector current of 1.2 mA . Use β of 140 and V_T of 25.8 mV . (a) Find v_{BE} . (b) Find I_{SE} and I_{SB} for this transistor. (Total 14 points)

- IV. Consider an npn transistor whose base – emitter drop is 0.75 V at a collector current of 4.0 mA . What current will it conduct at $v_{BE} = 0.70 \text{ V}$? What is its base – emitter voltage for $i_C = 7.5 \mu\text{A}$? (Total 10 points)

- V. Using β of 140 and V_T of 25.8 mV , find (a) voltages V_3, V_4, V_5, V_6 , and V_7 and currents I_{E1}, I_{E2} , and I_{E3} . Given $R_1 = 10 \text{ k}\Omega$, $R_2 = 10 \text{ k}\Omega$, $R_3 = 4.3 \text{ k}\Omega$, $R_4 = 3.3 \text{ k}\Omega$, $R_5 = 1.8 \text{ k}\Omega$, $R_6 = 1.2 \text{ k}\Omega$. Use $V_{CC} = +5 \text{ V}$ and $V_{EE} = -5 \text{ V}$. Put your final eight values in a table. (Total 40 points)



ABOVE AVERAGE

ELEG3304 Spring 2022**Final Exam**May 10th, 2022

Question #	Max Points	Obtained
I	16	16
II	20	12
III	14	14
IV	10	10
V	40	35
Total points	100	87

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.

Four places after decimal for all answers

- I. Consider an n-channel MOSFET with $t_{ox} = 5.1 \text{ nm}$, $\mu_n = 450 \text{ cm}^2/\text{V}\cdot\text{s}$, $V_t = 0.7 \text{ V}$, and $W/L = 15$. What is the value of k'_n ? Identify the region of operation and find the drain current in the following four cases. Use $\epsilon_r = 3.9$ for Silicon and $\epsilon_0 = 8.8542 \times 10^{-12} \text{ F/m}$. (Total 16 points)

a. $v_{GS} = 2.0 \text{ V}$ and $v_{DS} = 1.0 \text{ V}$

b. $v_{GS} = 2.0 \text{ V}$ and $v_{DS} = 2.0 \text{ V}$

c. $v_{GS} = 2.5 \text{ V}$ and $v_{DS} = 1.5 \text{ V}$

d. $v_{GS} = 2.7 \text{ V}$ and $v_{DS} = 2.0 \text{ V}$

$$t_{ox} = 5.1 \text{ nm}$$

$$\mu_n = 450 \text{ cm}^2/\text{V}\cdot\text{s}, V_t = 0.7 \text{ V}, W/L = 15$$

$$k'_n = \mu_n \epsilon_{ox}$$

$$\frac{450 \times \epsilon_{ox}}{t_{ox}} = \frac{450 \epsilon_r \epsilon_0}{t_{ox}}$$

$$\frac{450 \times 3.9 \times 8.8542 \times 10^{-12}}{5.1 \times 10^{-7} \text{ m}}$$

$$k'_n = 304.6886 \times 10^{-6}$$

a) $v_{GS} = 2.0 \text{ V}$ $v_{DS} = 1.0 \text{ V}$

$$v_{GS} > V_t$$

$$v_{DS} < v_{GS} - V_t$$

$$1 < 2 - 0.7$$

$$I_D = k'_n \frac{W}{L} \left\{ (v_{GS} - V_t)(v_{DS} - \frac{v_{DS}^2}{2}) \right\}$$

$$= 304.6886 \times 10^{-6} \times 15 \left\{ (1.3) \cdot (1 - \frac{1}{2})^2 \right\} = 304.6886 \times 10^{-6} \times 15 \times (1.3 - 0.5)$$

$$I_D = 3.6563 \text{ mA}$$

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b) $v_{GS} > V_t$ $v_{GS} = 2$ $v_{DS} = 2$

$$v_{DS} > v_{GS} - V_t$$

$$2 > 2 - 0.7$$

$$I_D = \frac{1}{2} k'_n \frac{W}{L} (v_{GS} - V_t)^2 = \frac{1}{2} 304.6886 \times 10^{-6} \times 15 \times (1.3)^2$$

$$I_D = 3.9619 \text{ mA}$$

c) $v_{GS} = 2.5 \text{ V}$ $v_{DS} = 1.5 \text{ V}$

$$1.5 < 2.5 - 0.7 \quad 304.6886 \times 10^{-6} \times 15 \left[(1.8)(1.5) - \frac{(1.5)^2}{2} \right]$$

$$1.5 < 1.8$$

$$\frac{2}{2}$$

$$I_D = 7.1983 \text{ mA}$$

d)

$$\frac{1}{2} \times 304.6886 \times 10^{-6} \times 15 \times (2)^2$$

$$I_D = 9.1406 \text{ mA}$$

- II. (a) Determine the drain current, the drain voltage, and V_{OV} . Use $R_{G1} = 9 \text{ M}\Omega$, $R_{G2} = 6 \text{ M}\Omega$, $R_D = R_S = 4.3 \text{ k}\Omega$. The device parameters are $V_t = 1.0 \text{ V}$, Use $k_n(W/L)$ value of 1.5 mA/V^2 . Neglect channel length modulation. Use $V_{DD} = +10.0 \text{ V}$. (b) Calculate power absorbed by the MOSFET. (Total 20 points)

$$V_{DD} \times \frac{R_{G2}}{R_{G1} + R_{G2}}$$

$$\frac{9 \times 6}{9 + 6} = 3.6 \text{ V}$$

$$a) I_D = \frac{V_G - V_{GS}}{R_S}$$

$$\frac{3.6 - V_{GS}}{4.3 \text{ k}\Omega} = \frac{1}{2} \times 1.5 \text{ mA/V}^2 (V_{GS} - 1)^2$$

$$3.6 - V_{GS} = 3.225 (V_{GS} - 1)^2$$

$$\Rightarrow 3.225 V_{GS}^2 - 5.452 V_{GS} + 0.375 = 0$$

$$V_{GS} = 1.756 \text{ V}$$

$$I_D = \frac{3.6 - 1.756}{4.3} = 0.429 \text{ mA}$$

$$V_D = V_{DD} - I_D R_D = 10 - (0.429 \times 4.3)$$

$$V_D = 7.155 \text{ V}$$

$$V_{OV} = V_{GS} - V_t = 1.756 - 1 = 0.756 \text{ V}$$

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$$b) I_D = V_{DS} \quad V_{DS} = V_{DD} - I_D (R_D + R_S)$$

$$9 - (9.6 \text{ k}\Omega \times 0.429) = V_{DS} = 3.319 \text{ V}$$

$$P_{abs} = 2.276 \text{ mW} = 0.429 \times 5.319$$

- III. A transistor for which $I_S = 10^{-16}$ A is conducting a collector current of 1.2 mA. Use β of 140 and V_T of 25.8 mV. (a) Find v_{BE} . (b) Find I_{SE} and I_{SB} for this transistor. (Total 14 points)

$$I_C = I_S e^{\frac{V_{BE}}{V_T}}$$

$$I_C = I_S e^{\frac{V_{BE}}{V_T}}$$

$$10^{-16} = I_C / e^{\frac{V_{BE}}{V_T}}$$

$$\Rightarrow e^{\frac{V_{BE}}{V_T}} = \frac{I_C}{I_S} = \frac{1.2 \times 10^{-3}}{10^{-16}}$$

$$\frac{V_{BE}}{25.8 \times 10^{-3}} = \ln \left(\frac{1.2 \times 10^{-3}}{10^{-16}} \right)$$

$$V_{BE} = (25.8 \times 10^{-3}) \times 30.12 =$$

$$V_{BE} = 0.777 \text{ V}$$

$$I_{SE} = I_S / \beta$$

$$I_{SB} = I_S / \beta$$

$$\beta = 140$$

$$\frac{\beta}{\beta + 1} = \frac{140}{141} = 0.9929$$

$$I_{SE} = I_S / \beta = \frac{10^{-16}}{0.9929} = 1.0071 \times 10^{-16} \text{ A}$$

$$I_{SB} = I_S / \beta = \frac{10^{-16}}{141} = 7.1429 \times 10^{-19} \text{ A}$$

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- IV. Consider an *npn* transistor whose base-emitter drop is 0.75 V at a collector current of 4.0 mA. What current will it conduct at $v_{BE} = 0.70$ V? What is its base-emitter voltage for $i_C = 7.5 \mu\text{A}$? (Total 10 points)

$$I_D = I_C \Rightarrow \frac{4 \times 10^{-3} \text{ A}}{e^{0.75/25 \times 10^{-3}}}$$

$$= \frac{4 \times 10^{-3}}{0.003 \times 10^3} \Rightarrow \frac{4 \times 10^{-3}}{e^{30}} = \frac{4 \times 10^{-3}}{1.0 \times 10^3} = 3.77 \times 10^{-3} \times 10^{-23}$$

$$I_C = 3.77 \times 10^{-6} \text{ A}$$

$$I_{C1} = I_C e^{\frac{V_{BE}}{V_T}} = 3.77 \times 10^{-6} \times e^{\frac{0.70}{25 \times 10^{-3}}} [e^{2e}]$$

$$= 3.77 \times 10^{-6} \times 1.414 \times 10^{12} = 5.3288 \times 10^{-4} = 0.54 \text{ mA} \quad \boxed{I_{C1} = 0.54 \text{ mA}}$$

$$I_{C2} = 7.5 \mu\text{A}, V_{BE}$$

$$I_{C2} = I_C e^{\frac{V_{BE}}{V_T}}$$

$$\frac{I_{C2}}{I_C} = e^{\frac{V_{BE2}}{V_T}}$$

$$\frac{7.5 \times 10^{-6}}{3.77 \times 10^{-6}} = e^{\frac{V_{BE2}}{V_T}}$$

$$1.98 \times 10^{10} = e^{\frac{V_{BE2}}{V_T}}$$

$$\ln [1.98 \times 10^{10}] = \frac{V_{BE2}}{V_T}$$

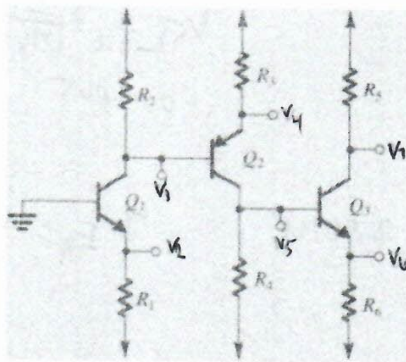
$$23.70 = \frac{V_{BE2}}{V_T}$$

$$V_{BE2} = 23.70 \times 25 \times 10^{-3} = 0.592 \text{ V}$$

$$V_{BE2} = 0.592 \text{ V}$$

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V. Using β of 140 and V_T of 25.8 mV, find (a) voltages V_3, V_4, V_5, V_6 , and V_7 , and currents I_{E1}, I_{E2} , and I_{E3} . Given $R_1 = 10 \text{ k}\Omega, R_2 = 10 \text{ k}\Omega, R_3 = 4.3 \text{ k}\Omega, R_4 = 3.3 \text{ k}\Omega, R_5 = 1.8 \text{ k}\Omega, R_6 = 1.2 \text{ k}\Omega$. Use $V_{CC} = +5 \text{ V}$ and $V_{EE} = -5 \text{ V}$. Put your final eight values in a table. (Total 40 points)



$$V_2 = -0.7 \text{ V}$$

$$I_{E1} = \frac{V_2 + 5}{R_1} = \frac{-0.7 + 5}{10 \text{ k}\Omega}$$

$$I_{E1} = 0.43043 \text{ mA} \text{ or } 0.43 \text{ mA}$$

$$I_{C1} = \frac{\beta}{1+\beta} I_{E1} = \frac{140}{141} \times 0.43 \text{ mA} = 0.42695 \text{ mA}$$

$$\frac{5 - V_3}{10 \text{ k}\Omega} = I_{C1} + I_{R2}$$

$$V_4 = V_3 + 0.7$$

$$(I_{E2}) = \frac{V_{CC} - (V_3 + 0.7)}{R_3} = \frac{5 - (V_3 + 0.7)}{4.3}$$

$$I_{E2} = \frac{4.3 - V_3}{4.3} \text{ mA}$$

$$I_{R2} = \frac{1}{1+\beta} I_{E2} = \frac{4.3 - V_3}{4.3 \times 141} \text{ mA}$$

$$\frac{5 - V_3}{10} = 0.42695 + \frac{4.3 - V_3}{4.3 \times 141}$$

$$0.00695 = V_3 \left[\frac{1}{10} - \frac{1}{4.3 \times 141} \right]$$

$$V_3 = 0.68 \text{ V}$$

$$V_4 = 0.7 + V_3 = 1.38 \text{ V}$$

$$I_{E2} = \frac{4.3 - V_3}{4.3} \text{ mA} = \frac{4.3 - 0.68}{4.3}$$

$$I_{E2} = 0.841 \text{ mA}$$

$$I_{C2} = \frac{\beta}{1+\beta} I_{E2} = \frac{140}{141} \times 0.841 \text{ mA} = 0.834 \text{ mA}$$

$$I_3 = \frac{V_5 + 4.3}{1.2} \text{ mA}$$

$$I_{R3} = \frac{1}{1+\beta}$$

$$I_{E3} = \frac{V_5 + 4.3}{1.2 \times 141}$$

Look on the back for more work on #5

$$0.841 \text{ mA} = \frac{V_5 + 5}{3.3} \text{ mA} + \frac{V_5 + 4.3}{1.2 \times 141}$$

$$V_5 \left[\frac{1}{3.3} + \frac{1}{1.2 \times 141} \right] + I_{B3} = \frac{V_5 + 5}{3.3} + \frac{V_5 + 4.3}{1.2 \times 141}$$

$$V_5 \left[\frac{1}{3.3} + \frac{1}{1.2 \times 141} \right] = -0.1065$$

$$\frac{V_5 + 4.3}{1.2 \times 141}$$

$$V_5 = -2.286 \text{ V}$$

$$V_6 = V_5 - 0.7 \Rightarrow V_6 = -2.987 \text{ V}$$

$$I_{E3} = \frac{V_5 + 4.3 \text{ mA}}{1.2} = \frac{-2.987 + 4.3}{1.2}$$

$$I_{E3} = 1.0938 \text{ mA}$$

$$I_{C3} = \frac{\beta}{1+\beta} I_{E3} = \frac{140}{141} \times 1.0938 \text{ mA} = I_{C3} = 1.086 \text{ mA}$$

$$(1.086 \times 1.8 \text{ k}\Omega) = V_7 = 3.045 \text{ V}$$

$I_{E1} = 0.43 \text{ mA}$	$V_2 = -0.7 \text{ V}$
$I_{E2} = 0.44 \text{ mA}$	$V_3 = 0.68 \text{ V}$
$I_{E3} = 1.0938 \text{ mA}$	$V_4 = 1.36 \text{ V}$
	$V_5 = -2.286 \text{ V}$
	$V_6 = -2.987 \text{ V}$
	$V_7 = 3.045 \text{ V}$

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AVERAGE

ELEG3304 Spring 2022**Final Exam**May 10th, 2022

Question #	Max Points	Obtained
I	16	16
II	20	12
III	14	14
IV	10	10
V	40	25
Total points	100	77

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.

Four places after decimal for all answers

1. Consider an n-channel MOSFET with $t_{ox} = 5.1 \text{ nm}$, $\mu_n = 450 \text{ cm}^2/\text{V}\cdot\text{s}$, $V_t = 0.7 \text{ V}$, and $W/L = 15$. What is the value of k'_n ? Identify the region of operation and find the drain current in the following four cases. Use $\epsilon_r = 3.9$ for Silicon and $\epsilon_0 = 8.8542 \times 10^{-12} \text{ F/m}$. (Total 16 points)

- a. $V_{GS} = 2.0 \text{ V}$ and $V_{DS} = 1.0 \text{ V}$
 b. $V_{GS} = 2.0 \text{ V}$ and $V_{DS} = 2.0 \text{ V}$
 c. $V_{GS} = 2.5 \text{ V}$ and $V_{DS} = 1.5 \text{ V}$
 d. $V_{GS} = 2.7 \text{ V}$ and $V_{DS} = 2.0 \text{ V}$

a) $V_{GS} = 2.0 \text{ V}$ and $V_{DS} = 1.0 \text{ V}$

$$V_{GS} > V_t$$

Nmos on

$$V_{DS} < V_{GS} - V_t$$

$$1 < 2 - .7$$

Nmos is triode region

$$I_D = k_n \frac{W}{L} (V_{GS} - V_t) V_{DS} - \frac{V_{DS}^2}{2}$$

$$304.686 \times 10^{-6} \times 15 \times (1.3) \times 1 - \frac{1^2}{2}$$

$$= 304.686 \times 10^{-6} \times 15 \times 1.3 - .5$$

$$I_D = 3.6563 \text{ mA}$$

b) $V_{GS} = 2.0$ and V_{DS}

$$V_{GS} > V_t$$

$$V_{DS} > V_{GS} - V_t$$

$$2 > 2 - .7$$

Nmos is in saturation region

$$I_D = \frac{1}{2} k_n \frac{W}{L} (V_{GS} - V_t)^2$$

$$= \frac{1}{2} \times 304.686 \times 10^{-6} \times 15 \times (1.3)^2$$

$$I_D = 3.862 \text{ mA}$$

given $t_{ox} = 5.1 \text{ nm}$ $\mu_n = 450 \text{ cm}^2/\text{V}\cdot\text{s}$ $V_t = .7 \text{ V}$

$W/L = 15$ use $\epsilon_r = 3.9$ for Silicon

$\epsilon_0 = 8.8542 \times 10^{-12}$

$$k_n' = \frac{\mu_n \epsilon_0}{t_{ox}}$$

$$= \frac{450 \times 8.8542 \times 10^{-12}}{5.1 \times 10^{-9}}$$

$$= \frac{3.98539 \times 10^{-6}}{5.1 \times 10^{-9}}$$

$$k_n' = 781.46 \times 10^{-6}$$

c) $V_{GS} = 2.5 \text{ V}$ and $V_{DS} = 1.5$

$$V_{GS} > V_t$$

$$V_{DS} < V_{GS} - V_t$$

$$1.5 < 2.5 - .7$$

$$1.5 < 1.8$$

Nmos in triode

$$I_D = k_n \frac{W}{L} (V_{GS} - V_t) V_{DS} - \frac{V_{DS}^2}{2}$$

$$= 304.686 \times 10^{-6} \times 15 \times (1.8)(1.5) - \frac{(1.5)^2}{2}$$

$$I_D = 2.198 \text{ mA}$$

d) $V_{GS} = 2.7$ and V_{DS}

$$V_{DS} = V_{GS} - V_t$$

$$2 = 2.7 - .7$$

Nmos in saturation region

$$I_D = \frac{1}{2} k_n \frac{W}{L} (V_{GS} - V_t)^2$$

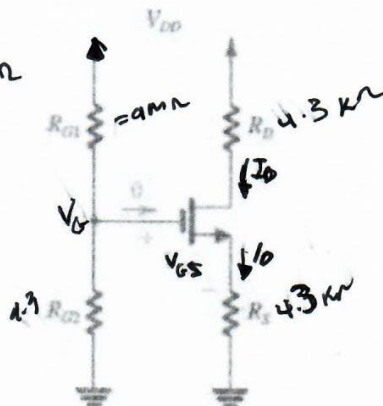
$$= \frac{1}{2} \times 304.686 \times 10^{-6} \times 15 \times (2)^2$$

$$I_D = 4.1406 \text{ mA}$$

16

- II. (a) Determine the drain current, the drain voltage, and V_{OV} . Use $R_{G1} = 9 \text{ M}\Omega$, $R_{G2} = 6 \text{ M}\Omega$, $R_D = R_S = 4.3 \text{ k}\Omega$. The device parameters are $V_t = 1.0 \text{ V}$. Use $k_n (W/L)$ value of 1.5 mA/V^2 . Neglect channel length modulation. Use $V_{DD} = +10.0 \text{ V}$. (b) Calculate power absorbed by the MOSFET. (Total 20 points)

given $R_{G1} = 9 \text{ M}\Omega$
 $R_{G2} = 6 \text{ M}\Omega$, $R_D = R_S = 4.3 \text{ k}\Omega$
 $V_t = 1.0 \text{ V}$, $k_n (W/L) = 1.5 \text{ mA/V}^2$
 $V_{DD} = 10.0$



$$V_{G1} = \frac{V_{DD} \times R_{G2}}{R_{G1} + R_{G2}}$$

$$= \frac{10 \times 6}{9 + 6} = 3.0 \text{ V}$$

$$V_G - V_{GS} = I_D R_S = 0$$

$$I_D = V_G - V_{GS}$$

In saturation region R_S equation ✓

$$I_D = \frac{1}{2} k_n \frac{W}{L} (V_{GS} - V_t)^2$$

$$\frac{3.0 - V_{GS}}{4.3 \text{ k}} = \frac{1}{2} \times 1.5 (V_{GS} - 1)^2$$

$$3.225 V_{GS}^2 - 5.952 V_{GS} - 0.375 = 0$$

$$V_{GS} = 1.75 \text{ V}$$

Quadratic $\rightarrow$ two solutions

$$I_D = \frac{3.0 - 1.75}{4.3 \text{ k}} = 0.28 \text{ mA}$$

$$V_D = V_{DD} - I_D R_D = 10 - (0.28 \times 4.3 \text{ k})$$

$$V_D = 1.15 \text{ V}$$

$$V_{OV} = V_{GS} - V_t = 1.75 - 1 = 0.75 \text{ V}$$

$$V_{OV} = 0.75 \text{ V}$$

12

- III. A transistor for which $I_S = 10^{-16}$ A is conducting a collector current of 1.2 mA. Use β of 140 and V_T of 25.8 mV. (a) Find V_{BE} . (b) Find I_{SE} and I_{SB} for this transistor. (Total 14 points)

given $I_S = 10^{-16}$ $I_C = 1.2$ mA
 $\beta = 140$, $V_T = 25.8$ mV

$V_{BE} = ?$
 $I_{SE} = ?$
 $I_{SB} = ?$

$$I_C = I_S e^{\frac{V_{BE}}{nV_T}}$$

$n = 1$

$$I_C = I_S e^{\frac{V_{BE}}{V_T}}$$

$$10^{-16} = I_C / e^{\frac{V_{BE}}{V_T}}$$

$$e^{\frac{V_{BE}}{V_T}} = \frac{I_C}{I_S} = \frac{1.2 \times 10^{-3}}{10^{-16}}$$

$$\frac{V_{BE}}{25.8 \times 10^{-3}} = \ln \left(\frac{1.2 \times 10^{-3}}{10^{-16}} \right)$$

$V_{BE} = \cancel{45.951} (25.8 \times 10^{-3})$
 $\times 30.12 = .777$ ✓

$V_{BE} = .78$ V

$$I_{SE} = I_C / \alpha$$

$$I_{SE} = I_S / \beta$$

$$\alpha = \frac{\beta}{\beta + 1} = \frac{140}{140 + 1} = .993$$

$$I_{SE} = \frac{I_S}{\alpha} = \frac{10^{-16}}{.993}$$

$$= 9.007 \times 10^{-16}$$

$$I_{SB} = I_S / \beta = \frac{10^{-16}}{140}$$

$$= 7.143 \times 10^{-19}$$

14

- IV. Consider an *npn* transistor whose base-emitter drop is 0.75 V at a collector current of 4.0 mA. What current will it conduct at $v_{BE} = 0.70$ V? What is its base-emitter voltage for $i_C = 7.5 \mu\text{A}$? (Total 10 points)

emitter drop = .75 $v_{BE} = .75$
 collector current 4.0 mA $i_C = 7.5 \mu\text{A}$

$V_t = 25 \text{ mV}$
 $I_s = \text{constant}$

$$I_C = \frac{I_C}{e^{v_{BE}/V_t}} \rightarrow 4 \times 10^{-3} \text{ A} = \frac{4 \times 10^{-3}}{e^{.75/0.025}} \rightarrow \frac{4 \times 10^{-3}}{e^{30}}$$

$$= \frac{4 \times 10^{-3}}{1.06 \times 10^{13}} \rightarrow 3.77 \times 10^{-3} \times 10^{-13}$$

$$I_s = 3.77 \times 10^{-16} \text{ amp}$$

I) $v_{BE} = .70$ V an I_C

$$3.77 \times 10^{-16} \times e^{.70/0.025} = 10$$

$I_C = .54 \text{ mA}$

II) $7.5 \mu\text{A}$ v_{BE} ?

$$I_C = I_s e^{v_{BE}/V_t}$$

$$= \frac{I_C}{I_s} = e^{v_{BE}/V_t} = \frac{7.5 \times 10^{-6}}{3.77 \times 10^{-16}}$$

$$1.95 \times 10^{10} = e^{v_{BE}/V_t}$$

$$\ln [1.95 \times 10^{10}] = \frac{v_{BE}}{V_t}$$

$$23.70 = \frac{v_{BE}}{V_t}$$

$$v_{BE} = 23.70 \times 25 \times 10^{-3}$$

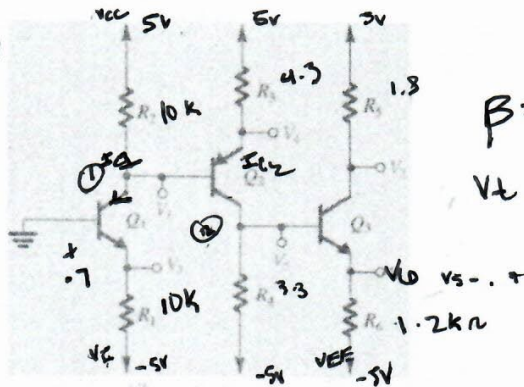
$v_{BE} = 592 \text{ V}$

V. Using β of 140 and V_T of 25.8 mV, find (a) voltages V_3, V_4, V_5, V_6 , and V_7 and currents I_{E1}, I_{E2} , and I_{E3} . Given $R_1 = 10 \text{ k}\Omega, R_2 = 10 \text{ k}\Omega, R_3 = 4.3 \text{ k}\Omega, R_4 = 3.3 \text{ k}\Omega, R_5 = 1.8 \text{ k}\Omega, R_6 = 1.2 \text{ k}\Omega$. Use $V_{CC} = +5 \text{ V}$ and $V_{EE} = -5 \text{ V}$. Put your final eight values in a table. (Total 40 points)

$$I_{E3} = \frac{P}{V_T} = I_{E2} \frac{140}{141} \times 1.094 \rightarrow 1.081 \text{ mA}$$

$$V_7 = 3 - (1.081 \text{ mA} \times 1.8)$$

$$3.645$$



$$\beta = 140$$

$$V_T = 25.8$$

given $R_1 = 10 \text{ k}\Omega$

$$R_2 = 10 \text{ k}\Omega, R_3 = 4.3 \text{ k}\Omega$$

$$R_4 = 3.3 \text{ k}\Omega, R_5 = 1.8, R_6 = 1.2$$

$$V_{CC} = +5 \text{ V and } V_{EE} = -5$$

$$V_2 = -0.7$$

$$I_{E1} = \frac{V_2 + 5}{R_1} = \frac{-0.7 + 5}{10 \text{ k}}$$

$$I_{E1} = 0.43 \text{ mA}$$

$$I_{C1} = \frac{\beta}{1+\beta} I_{E1} = \frac{140}{141} \times 0.43 \text{ mA}$$

$$I_{C1} = 0.426 \text{ mA}$$

Q1

$$\textcircled{1} \frac{5 - V_3}{10 \text{ k}\Omega} = I_{C1} + I_{B2}$$

$$V_4 = V_3 + 0.7$$

$$I_{E2} = \frac{V_{CC} - (V_3 + 0.7)}{R_3} = \frac{5 - (V_3 + 0.7)}{4.3}$$

$$I_{B2} = \frac{1}{1+\beta} I_{E2} = \frac{4.3 - V_3}{4.3 \times 141}$$

$$\frac{5 - V_3}{10} = 0.426 + \frac{4.3 - V_3}{4.3 \times 141}$$

$$0.0069 = V_3 \left[\frac{1}{10} - \frac{1}{4.3 \times 141} \right] \Rightarrow V_3 = 0.68 \text{ V}$$

$$V_4 = V_3 + 0.7 = 1.38 \text{ V}$$

$$I_{E2} = \frac{4.3 - V_3}{4.3} \text{ mA} = \frac{4.3 - 0.68}{4.3}$$

$$I_{E2} = 0.84 \text{ mA} \quad I_{C2} = \frac{\beta}{1+\beta} I_{E2} = \frac{140}{141} \times 0.84$$

$$I_{C3} = \frac{V_5 + 4.3 \text{ k}\Omega}{1.2 \text{ k}\Omega} = 0.83 \text{ mA}$$

$$\text{KVL} \textcircled{2} \frac{V_5 + 5}{3.3} + 0.83 = \frac{V_5 + 5}{3.3} + \frac{5 + 4.3}{1.2 \times 141}$$

$$V_5 \left[\frac{1}{3.3} \times \frac{1}{1.2 \times 141} \right] = -0.065$$

$$V_5 = 2.286 \text{ V}$$

$$V_6 = 2.986 \text{ V} \quad V_5 - 0.7$$

$$I_{E3} = \frac{V_5 + 4.3}{1.2} = \frac{2.986 + 4.3}{1.2}$$

$$I_{E3} = 1.094 \text{ mA}$$

Table

V_3	0.68 V
V_4	1.38 V
V_5	-2.286 V
V_6	-2.986 V
V_7	3.645 V
I_{E1}	0.43 mA
I_{E2}	0.84 mA
I_{E3}	1.094 mA

25

BELOW AVERAGE

ELEG3304 Spring 2022**Final Exam**May 10th, 2022

Question #	Max Points	Obtained
I	16	15
II	20	0
III	14	14
IV	10	0
V	40	30
Total points	100	59

Closed book, Closed notes.

No cell phone allowed. No sharing of calculators.

Three
places after decimal for all answers

- I. Consider an n-channel MOSFET with $t_{ox} = 5.1 \text{ nm}$, $\mu_n = 450 \text{ cm}^2/\text{V}\cdot\text{s}$, $V_t = 0.7 \text{ V}$, and $W/L = 15$. What is the value of k'_n ? Identify the region of operation and find the drain current in the following four cases. Use $\epsilon_r = 3.9$ for Silicon and $\epsilon_0 = 8.8542 \times 10^{-12} \text{ F/m}$. (Total 16 points)

- a. $v_{GS} = 2.0 \text{ V}$ and $v_{DS} = 1.0 \text{ V}$
b. $v_{GS} = 2.0 \text{ V}$ and $v_{DS} = 2.0 \text{ V}$
c. $v_{GS} = 2.5 \text{ V}$ and $v_{DS} = 1.5 \text{ V}$
d. $v_{GS} = 2.7 \text{ V}$ and $v_{DS} = 2.0 \text{ V}$

n-channel MOSFET
Find Drain Current

a.) $V_{GS} = 2.0 \text{ V}, V_{DS} = 1.0 \text{ V}$

$V_{GS} > V_{DS}$
 $V_{DS} < V_{GS} - V_t$

triode region

$$I_D = K_n' \frac{W}{L} \left((V_{GS} - V_t) V_{DS} - \frac{V_{DS}^2}{2} \right)$$

$$= 304.689 \times 10^{-6} \times 15 \left((1.3) 1 - \frac{1^2}{2} \right)$$

$I_D = 3.656 \text{ mA}$

b.) $V_{GS} = 2.0 \text{ V}, V_{DS} = 2.0 \text{ V}$

$V_{GS} = V_{DS}$
 $V_{DS} > V_{GS} - V_t$

saturation region

$$I_D = \frac{1}{2} \cdot 304.689 \times 10^{-6} \times 15 \times (1.3)^2$$

$I_D = 3.862 \text{ mA}$

c.) $V_{GS} = 2.5 \text{ V}, V_{DS} = 1.5 \text{ V}$

$V_{GS} > V_{DS}$
 $V_{DS} < V_{GS} - V_t$

triode region

$K_n = \mu_n C_{ox}$

$$I_D = 304.689 \times 10^{-6} \times 15 \times \left((1.8) 1.5 - \frac{1.5^2}{2} \right) = 450 \times \frac{C_{ox}}{t_{ox}}$$

$I_D = 3.085 \text{ mA}$

$= 450 \times \frac{\epsilon_r \epsilon_0}{t_{ox}}$

$= 450 \times \frac{3.9 \cdot 8.8542 \times 10^{-12}}{5.1 \times 10^{-9}}$

$K_n = 304.689 \times 10^{-6}$

d.) $V_{GS} = 2.7 \text{ V}, V_{DS} = 2.0 \text{ V}$

$V_{GS} > V_{DS}$
 $V_{DS} = V_{GS} - V_t$

saturation region

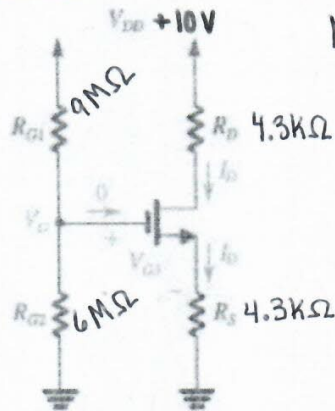
$$I_D = \frac{1}{2} \cdot 304.689 \times 10^{-6} \times 15 \times 2^2$$

$I_D = 9.141 \text{ mA}$

2×10^{-4}

10.125

- II. (a) Determine the drain current, the drain voltage, and V_{ov} . Use $R_{G1} = 9\text{ M}\Omega$, $R_{G2} = 6\text{ M}\Omega$, $R_D = R_S = 4.3\text{ k}\Omega$. The device parameters are $V_t = 1.0\text{ V}$, Use $k_n(W/L)$ value of 1.5 mA/V^2 . Neglect channel length modulation. Use $V_{DD} = +10.0\text{ V}$. (b) Calculate power absorbed by the MOSFET. (Total 20 points)



Find Drain Current, Voltage, V_{ov}
Find Power Absorbed

a.) Drain Current + Voltage, V_{ov}

b.) Power Absorbed



- III. A transistor for which $I_S = 10^{-16}$ A is conducting a collector current of 1.2 mA. Use β of 140 and V_T of 25.8 mV. (a) Find v_{BE} . (b) Find I_{SE} and I_{SB} for this transistor. (Total 14 points)

Transistor w/ collector current
1.2 mA

a.) Find V_{BE}

$$I_C = I_S e^{\frac{V_{BE}}{n V_T}}$$

$$10^{-16} = I_C / e^{\frac{V_{BE}}{V_T}}$$

$$e^{\frac{V_{BE}}{V_T}} = \frac{I_C}{I_S} = \frac{1.2 \times 10^{-3}}{10^{-16}}$$

$$\frac{V_{BE}}{25.8 \times 10^{-3}} = \ln \left(\frac{1.2 \times 10^{-3}}{10^{-16}} \right)$$

$$V_{BE} = (25.8 \times 10^{-3}) \times 30.12$$
$$= 0.777$$

$$\underline{V_{BE} = 0.777 \text{ V}}$$

b.) Find I_{SE} and I_{SB}

$$\frac{\beta}{\beta + 1} = \frac{140}{141} = 0.993$$

$$\underline{I_{SE}} = I_S / \frac{\beta}{\beta + 1} = \frac{10^{-16}}{0.993} = 1.007 \times 10^{-16} \text{ A}$$

$$\underline{I_{SB}} = I_S / \beta = \frac{10^{-16}}{140} = 7.143 \times 10^{-19} \text{ A}$$

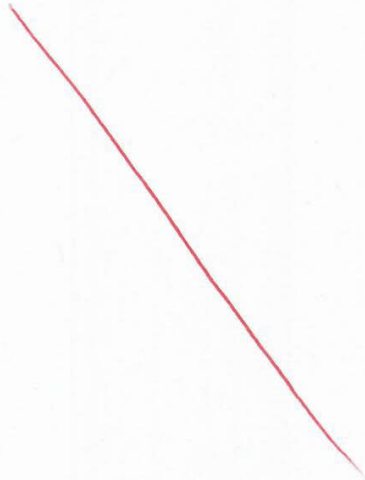
14

- IV. Consider an *npn* transistor whose base-emitter drop is 0.75 V at a collector current of 4.0 mA . What current will it conduct at $v_{BE} = 0.70\text{ V}$? What is its base-emitter voltage for $i_C = 7.5\text{ }\mu\text{A}$? (Total 10 points)

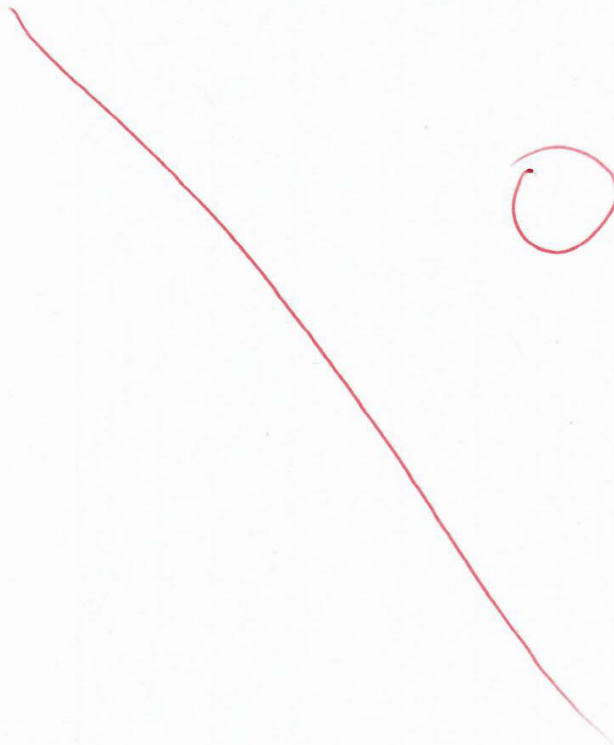
NPN base-emitter transistor

Find current and voltage

Current Conducted at V_{BE}



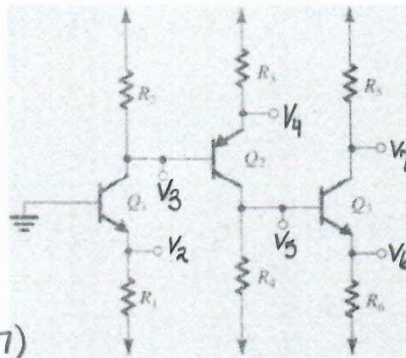
Base-emitter Voltage for i_C



5 voltages

3 currents

V. Using β of 140 and V_T of 25.8 mV, find (a) voltages V_3, V_4, V_5, V_6 , and V_7 and currents I_{E1}, I_{E2} , and I_{E3} . Given $R_1 = 10 \text{ k}\Omega, R_2 = 10 \text{ k}\Omega, R_3 = 4.3 \text{ k}\Omega, R_4 = 3.3 \text{ k}\Omega, R_5 = 1.8 \text{ k}\Omega, R_6 = 1.2 \text{ k}\Omega$. Use $V_{CC} = +5 \text{ V}$ and $V_{EE} = -5 \text{ V}$. Put your final eight values in a table. (Total 40 points)



Using β and V_T , find voltages and currents

$$V_2 = -0.7 \text{ V}$$

$$I_{E1} = \frac{V_2 + 5}{R_1} = \frac{-0.7 + 5}{10 \text{ k}\Omega}$$

$$I_{E1} = 0.430 \text{ mA}$$

$$I_{E2} = \frac{4.3 - V_3}{4.3} \text{ mA} = \frac{4.3 - 0.68}{4.3}$$

$$I_{E2} = 0.842 \text{ mA}$$

$$I_{C2} = \frac{140}{141} \times 0.842 = 0.836 \text{ mA}$$

$$-2.993 \text{ V}$$

30

$$V_6 = V_5 - 0.7 = -2.986 \text{ V}$$

$$V_5 = -2.286 \text{ V}$$

$$I_{E3} = \frac{V_5 + 4.3}{1.2} = 1.678 \text{ mA}$$

$$I_{C3} = \frac{140}{141} \times 1.678 \text{ mA} = 1.666 \text{ mA}$$

$$V_7 = 5 - I_{C3} R_5 = 5 - (1.666 \text{ mA} \times 1.8 \text{ k}\Omega)$$

$$V_7 = 2.999 \text{ V}$$

Table:

Voltage	Currents
$V_3: 0.68 \text{ V}$	$I_{E1}: 0.430 \text{ mA}$
$V_4: 1.38 \text{ V}$	$I_{E2}: 0.842 \text{ mA}$
$V_5: -2.286 \text{ V}$	$I_{E3}: 1.678 \text{ mA}$
$V_6: -2.986 \text{ V}$	
$V_7: 2.999 \text{ V}$	

ELECTRICAL & COMPUTER ENGINEERING
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
ELEG3304 ELECTRONICS I

Instructor: Dr. Mohan Ketkar

ELEG3304 Spring 2022

Course Design Project

In this assignment you will be (a) design a DC power supply to meet the specifications and (b) design experimental set up to test a DC power supply to measure performance parameters

After completing the designs each student will write a report with following items in it.

- a. **Introduction:** Introduce the reader to the project goals.
- b. **Define the objectives:** Describe the two parts of the assignment. Discuss how you will be approaching the solutions. State clearly any assumptions you make, if any.
- c. **Develop Experiment to Test circuits:** Identify parameters to be measured; identify the equipment or component for measuring the parameters of interest, and provide the steps for setting up and conducting the experiment. Upload the screenshots of each circuit including the probes.
- d. **Conduct Experiment (Extra Credit Optional):** Conduct experiment (testing), collect the data needed.
- e. **Design and calculations**
- f. **Discussion** Show that your design meets the specifications. Make direct comparisons between expected results and experimental measurements. Comment on major differences, if any.
- g. **Conclusions:** Draw appropriate conclusions and recommendations using engineering judgement.

You have to upload your report to two places (i) eCourse and (ii) Taskstream ELEG3304 Assignment (Outcome 6) by April 29, 2022 by 11:59 pm.

- (a) DC Power supply specifications

Input voltage: 120 V AC, 60 Hz

Output voltage: 9V

Max output current: 350 mA

Output ripple: Less than 50 mV_{pp} at max current

Describe methods to provide short circuit protection.

List all part numbers.

Determine the cost of your design.

- (b) Design experimental set up to test your power supply. Describe a procedure to test and measure (a) ripple, (b) line regulation (10% change) and (c) load regulation (10%)

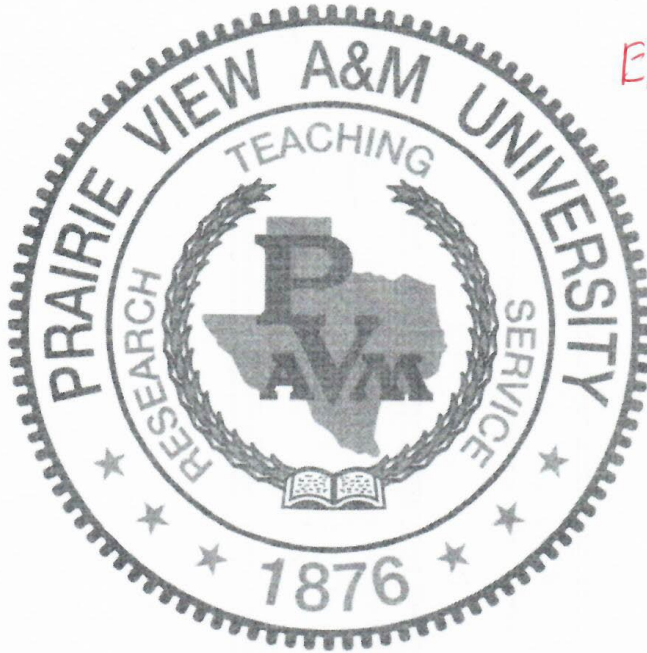
Above AVERAGE

GRADING SCHEME FOR ASSIGNMENT

ELE9

Item	Points achieved	Maximum Points
1. Objectives and constraints - Plan of the project - Involve safety and economic features	27	30
2. Literature review and preliminary design Simulation results	4	5
3. Circuit design - Calculations and simulations - Include safety and economic considerations	14	15
4. Design of Experimental set up Test equipment needed	18	20
5. Analysis and interpretation of results - Present data in tabular form or graphical form. - Use of appropriate statistical method to analyze the results.	14	15
6. Discussion of results and Conclusions Draw appropriate conclusions	9	10
7. General write-up of report Grammar and adequacy of graphs and figures Proper labeling of graphs and figures Proper references	4	5
8. Composite Grade	90	100
9. Grade for Student Outcome 6 (Items #3, 4, 5, and 6)	55	60
10. Grade for Student Outcome 6 (Normalized to 100%)	91.7	100

Course Design Project – DC Power Supply



Excellent work

ELEG 3304– Electronics I ✓

Adrian Small ✓

Dr. Mohan Ketkar

Spring 2022 ✓

Date of Submission: 04/29/22

Date of Performance: 03/24/22

PVAMU College of Engineering

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Discussion of Results.....	8
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Introduction

The DC power supply is an electronic device that can supply electric power to an electric load. Moreover, the device's purpose is to convert electric current from a power source to an accurate voltage, current, and frequency to power the load. For this design project, we are tasked with analyzing the power supply parameters and constructing the device with the given specifications.

Objective and Constraints

To meet the DC power supply specifications, we will use an input signal of 120 AC voltage with a frequency of 60 Hz, producing a DC output of 9V, maintaining a maximum current of 350 mA, and keeping the voltage ripple less than 50 mV. The method to prevent any short circuit from occurring is by using a voltage regulator, one of the design components. In particular, the linear voltage regular can provide both protection against short circuits and overload of the current by smoothing out the voltage and keeping the level at a constant voltage. One of the safety factors includes using the RC filter, in which the capacitors from the filter aids in reducing the ripple voltage. A high ripple voltage can cause significant loss of power and overheating of electrical components, damaging the circuit and inefficiency of accurate measurements. The voltage regular serves as a safety component that keeps the voltage level at constant DC output. According to Mouser Electronics, the total cost for the design of the equipment needed is \$12.61. From an individual price for the full-wave bridge rectifier (\$4.87), transformer (\$5.08), voltage regulator (\$1.96), two capacitors (\$0.50), and two resistors (\$0.20).

Develop Experiments to Test Circuits/Circuit Design

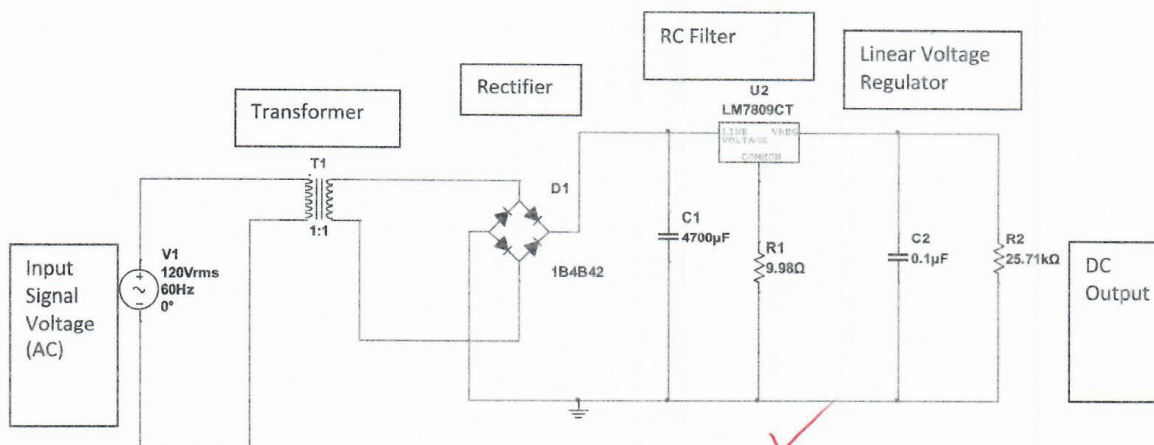
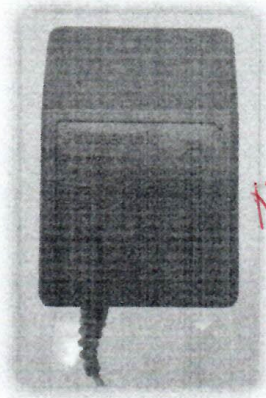


Figure 1: DC Power Regulated Supply Configuration

In Multisim, we have created the DC circuit power supply and plan to measure the device in the lab. We will need to use the Multimeter, Breadboard, and Oscilloscope to estimate the parameters in the lab. The parameters that we will measure in *Figure 1* include the DC output voltage, voltage ripple, and max current. We can then calculate the load regulation (10%), line regulation (10%), and voltage ripple in both simulation and lab measurement from these parameters. The procedure for lab measurement requires the DC power supply to be measured by the Multimeter, assemble the resistors load on the Breadboard, using the Oscilloscope to collect the value of the voltage ripple.



Not
clearly
visible

Figure 2: AC/DC Adapter Power Supply with Operating Metrics

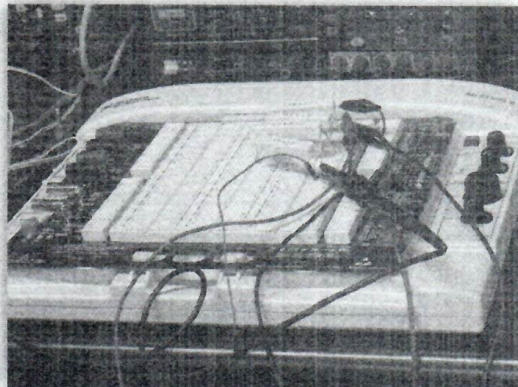


Figure 3: The Four Resistors in Series Value of 24.8Ω on Breadboard

Conduct Experiment

After setting up the equipment in the lab, we can now analyze to test the DC power supply and test the power supply in Multisim. In the laboratory, we have used four resistors in series to achieve the resistor value of 24.8Ω (referenced in *Fig 3*), close to the resistance load value in Multisim. The resistors were placed onto the Breadboard to find VL's voltage load. When using the Multimeter, we obtained the DC output voltage, V_O . The measure value results in a voltage of 8.98 V. The Multimeter with the reading can be shown below in *Figure 4*. The no-load voltage, V_{NL} , results in a voltage of 14.95 V. This voltage will be helpful later in the **Design and Calculation** section when calculating the load regulation.

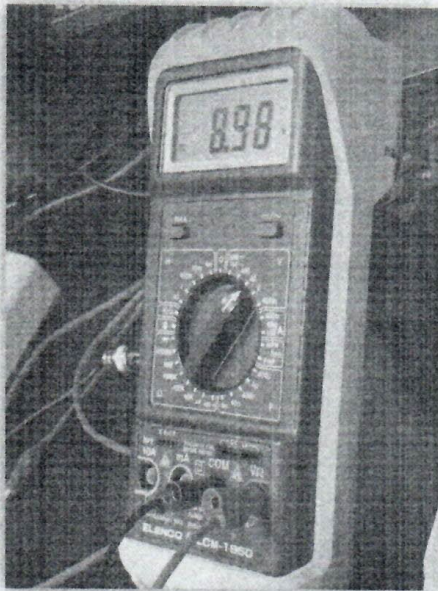


Figure 4: DC Output Voltage of the AC/DC Power Supply using the Multimeter

Furthermore, we have computed the max current by using the V_O/R_L to value the current at 362.5 mA. In retrospect, it went beyond the design specification. The last parameter to be measured is the voltage ripple, $V_{peak-peak}$. Using the Oscilloscope, we gathered the ripple to produce a voltage of 68 mV.

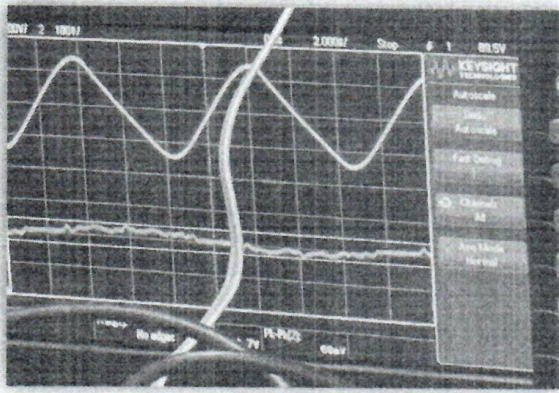


Figure 4: Voltage Ripple of the AC/DC Power Supply using the Oscilloscope

In Multisim, we have assembled the circuit (*Fig. 1*) to test the basis of the given specifications of the power supply. When testing the V_O , the DC output voltage has valued precisely at 9V. In this circuit, the max current, I_{max} , results in a current of 350 mA, and the ripple voltage is tested at 669 μV or 0.669 mV. The simulation for the test reads can be shown below in *Figure 5*.

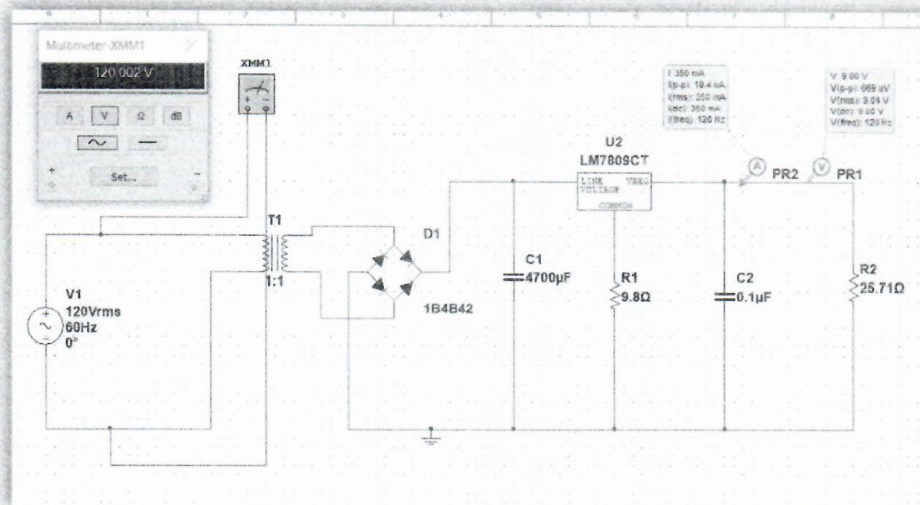


Figure 5: DC Regulated Power Supply with testing parameters of I_{max} , V_O , and V_{p-p} in Multisim

Design and Calculations

The metrics for the calculations are the load and line regulations. Ideally, the goal is to achieve a 0% for both regulations. The load regulation accounts for the measurement of the regulator to maintain a DC output voltage, besides the change in the current load. The line regulation accounts for the ΔV_{OUT} and ΔV_{IN} or the change in voltage out and voltage input. The formula for $Line\ Regulation = \left(\frac{\Delta V_{OUT}}{\Delta V_{IN}} \right) * 100\%$ and $Load\ Regulation = \frac{V_{NL} - V_{FL}}{V_{FL}} * 100\%$. Acquiring a 10% change for both regulations. For the physical device, the $V_{NL} = 14.95\text{ V}$ and $V_{FL} = 8.98\text{ V}$ so that we can compute load regulation (10%). Thus, the load regulation is 66.48%. However, we cannot determine the line regulation due to

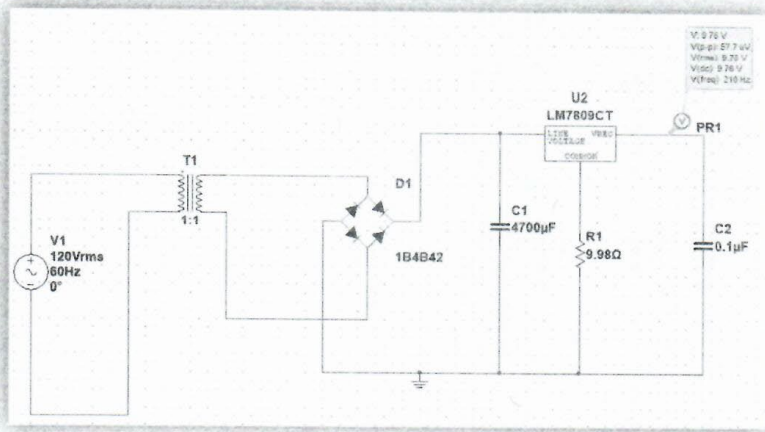


Figure 6: DC Regulated Power Supply with testing parameters of V_{NL} at 9.76 V in Multisim

Line Regulation			
	Voltage	Current	Ripple
Normal (120V AC)	9V	350 mA	0.669 mA
-10%	9V	350 mA	0.364 mA
+10%	9V	350 mA	0.499 mA

Table 1: Load Regulation (10%) of ΔV_{OUT} and ΔV_{IN}

The experimental analysis of the line regulation in Multisim results in 0%, taking $120\text{ V} * .01 = 12\text{ V}$ (10% change). At 108 V , the output voltage stays at 9V; thus, the $\left(\frac{9V - 9V}{108V} \right) * 100 = 0\%$.

The $\Delta V_{IN} * 10\% = 12$, adding now 12 V results to 132 V , and at 132 V , the output voltage reached 9.00 V . Thus $\left(\frac{9V - 9V}{132V} \right) * 100 = 0\%$

Load Regulation		
	V_{NL}	V_{FL}
Normal (120 AC)	9.76 V	9V
-10%	8.78 V	8.1 V
+10%	10.74 V	9.9V

Table 2: Load Regulation (10%) of V_{NL} and V_{FL}

For the load regulation for the simulation, compute to $\frac{8.78\text{ V} - 8.1\text{ V}}{8.1\text{ V}} * 100 = 8.4\%$ and $\frac{10.74\text{ V} - 9.9\text{ V}}{9.9\text{ V}} * 100 = 8.48\%$

Discussion of Results

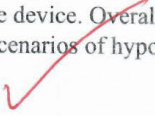
Testing the physical device and simulation circuit, we have found the overall indicators of each parameter and can infer the outcome of each measurement. From the experimental analysis, we have compiled the parameters to be precisely the design specifications that produce favorable results. For example, the voltage output (9V) also helps achieve the I_{max} at 350 mA. Also, the circuit had durable protection against any short circuit or overload of current and voltage. Thus, making the circuit's functionality most prominent in this analysis. However, when testing and measuring the physical DC power supply. The voltage output (8.98V) did not meet the design specifications as well as the I_{max} (362.5 mA) and ripple (68 mV). We can speculate that the physical device's internal circuit is deteriorating from these parameters and also can be an old device. The table below shows the parameters for both the theoretical and actual analysis.

Parameters	Theoretical	Actual
V_{ripple}	0.669 mV	68 mV
V_{out}	9.00V (DC)	8.98 V
I_{max}	350 mA	362.5 mA
R_L	25.71 Ω	24.8 Ω

Table 3: DC Power Supply Parameters of Theoretical and Actual Results

Conclusion

It is evident that the simulation circuit meets the criteria and durably performed well against the physical device. The results confirm that the device is weakening and maturing, so in a few months to a couple of years, the power supply is to be obsolete because of the aging of the internal electronic components. From an engineering perspective, the physical DC supply will always be subjective to aging; that is why there are many updated versions there. However, the life cycles of the electronics components emphasize the need to develop more lasting electronics to reduce the process of aging and maintain a longer life cycle of the device. Overall, the analysis underscores the purpose of testing the concept and analyzing both scenarios of hypothetical and actual indications.



Very good

AVERAGE

GRADING SCHEME FOR ASSIGNMENT

CPEG

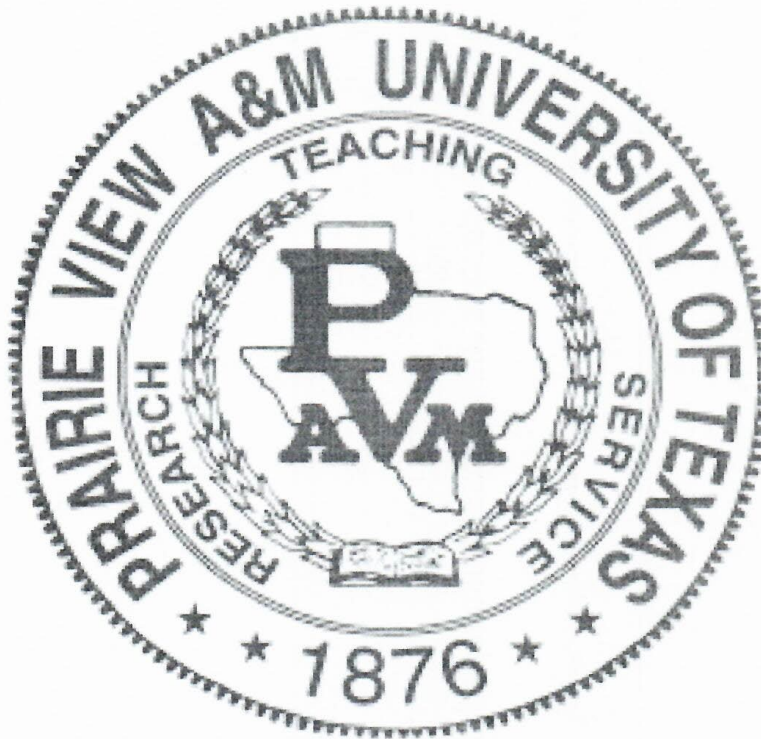
Item	Points achieved	Maximum Points
1. Objectives and constraints - Plan of the project - Involve safety and economic features	26	30
2. Literature review and preliminary design Simulation results	4	5
3. Circuit design - Calculations and simulations - Include safety and economic considerations	13	15
4. Design of Experimental set up Test equipment needed	17	20
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6. Discussion of results and Conclusions Draw appropriate conclusions	8	10
7. General write-up of report Grammar and adequacy of graphs and figures Proper labeling of graphs and figures Proper references	4	5
8. Composite Grade	85	100
9. Grade for Student Outcome 6 (Items #3, 4, 5, and 6)	51	60
10. Grade for Student Outcome 6 (Normalized to 100%)	85	100

Course Design Project ✓

ELEG 3304 ✓

Electronics I ✓

Good



Designed BY: Trevion Jordan ✓

Introduction:

In this project, you will (a) develop a DC power supply that meets the requirements, and (b) implement an experimental setup to test a DC power supply and analyze performance metrics. The specifications of this experiment includes:

(a) DC Power supply specifications

Input voltage: 120 V AC, 60 Hz

Output voltage: 9V

Max output current: 350 mA

Output ripple: Less than 50 mV_{pp} at max current

Describe methods to provide short circuit protection.

Determine the cost of your design

(b) Design experimental set up to test your power supply. Describe a procedure to test and measure (a) ripple, (b) line regulation (10% change) and (c) load regulation (10%)

Other ramification also in this project are :

- a. **Introduction:** Introduce the reader to the project goals.
- b. **Define the objectives:** Describe the two parts of the assignment. Discuss how you will be approaching the solutions. State clearly any assumptions you make, if any.
- c. **Develop Experiment to Test circuits:** Identify parameters to be measured; identify the equipment or component for measuring the parameters of interest, and provide the steps for setting up and conducting the experiment. Upload the screenshots of each circuit including the probes.
- d. **Conduct Experiment (Optional):** Conduct experiment (testing), collect the data needed. e. **Design and calculations**
- f. **Discussion: Show** that your design meets the specifications. Make direct comparisons between expected results and experimental measurements. Comment on major differences, if any.
- g. **Conclusions:** Draw appropriate conclusions and recommendations using engineering judgment.

Objectives/Procedure:

Circuit to another of multiple circuits Transformers can also be used for isolation, Where the voltage in equals the voltage out with separate coils not electrically bonded to one another

Parameters given for this experiment:

i/p voltage : 110 to 120V

o/p: 9v to 12.2 V

$f = 60 \text{ HZ}$

Turns ratio = $V_{DN} = 0.7 \text{ V}$

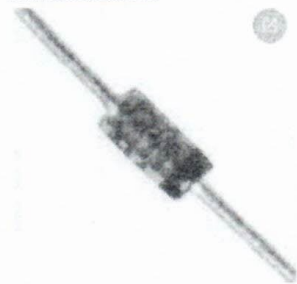
$V_{Z0} = 12\text{V}; r_2 = 2\Omega$

Current range = 10mA - 350mA

Turns ratio: The amount of voltage induced in each turn of the secondary winding will be the same as the voltage across each turn of the primary winding

$K_t = N_1 \div N_2$

Zener diode



Vishay BZX55C3V3-TR

Zener Diodes

\$0.20

Mouser Electronics

Figure 1a

A Zener diode is a special type of diode designed to reliably allow current to flow "backwards" when a certain set reverse voltage, known as the Zener voltage, is reached.

Zener diodes are manufactured with a great variety of Zener voltages and some are even variable. Some Zener diodes have a sharp, highly doped p-n junction with a low Zener voltage, in which case the reverse conduction occurs due to electron quantum tunneling in the short space between p and n regions – this is known as the Zener effect, after Clarence Zener.

Ripple Voltage:

Ripple voltage in electronics is the residual periodic variation of the DC voltage within a power supply which has been derived from an alternating current (AC) source. This ripple is due to incomplete suppression of the alternating waveform after rectification.

Calculations:

$$n = \frac{N_1}{N_2}$$

from fig for R_1

$$R_1 \text{ min} = \frac{V_{\text{min}} - V_2}{I_{\text{max}}}$$

$$V_{\text{min}} = \frac{110 \times 3.2}{2} = 19.44 \text{ V}$$

$$V_{\text{min}} = 19.44 \text{ V}$$

$$I_{\text{max}} = I_{2\text{max}} + I_{\text{min}} \\ = 100 \text{ mA} + 25 \text{ mA} =$$

$$125 \text{ mA}$$

$$R_1 = \frac{19.4 - 12.2 - 1.4}{125 \times 10^{-3}}$$

$$R_1 = 46.76 \Omega$$

$$R_1 = \frac{5.84}{125 \times 10^{-3}}$$

$$= 46.76 \Omega$$

$$R_1 = 46.76 \Omega$$

$$\text{ripple voltage } (V_{\text{max}} - 2V_{0N}) \left[\frac{1}{2R_1C_1} \right]$$

from i/p voltage

$$V_{\text{max}} = \frac{120 \times \sqrt{2}}{2} = 21.2 \text{ V}$$

$$V_{0\text{max}} = 21.2 \text{ V}$$

$$S = \frac{1}{f} = \frac{1}{60}$$

$$f = 60 \text{ Hz}$$

$$0.2 = 21.21 - 1.4 \left[\frac{1/60}{2 \times 46.76 \times C_1} \right]$$

$$\frac{0.2}{19.81} = \frac{1}{9611.2 C_1}$$

$$1122.24 C_1 = 19.81$$

$$C_1 = 0.0176521 \text{ F} \approx 17.652 \text{ mF}$$

Circuit Design:

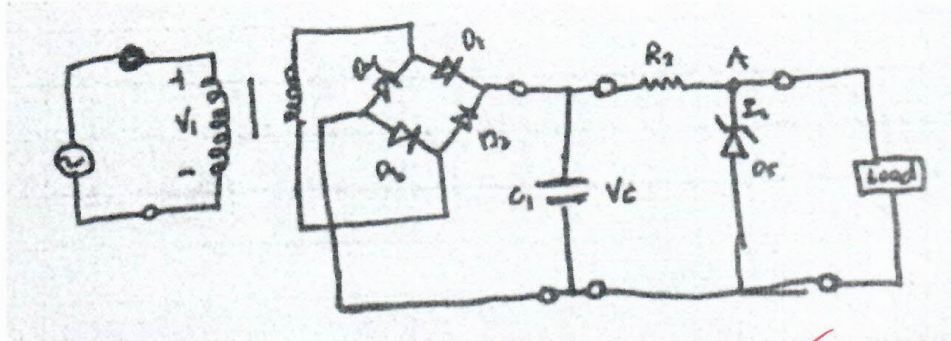


Figure 2A: Experimental Circuit Design

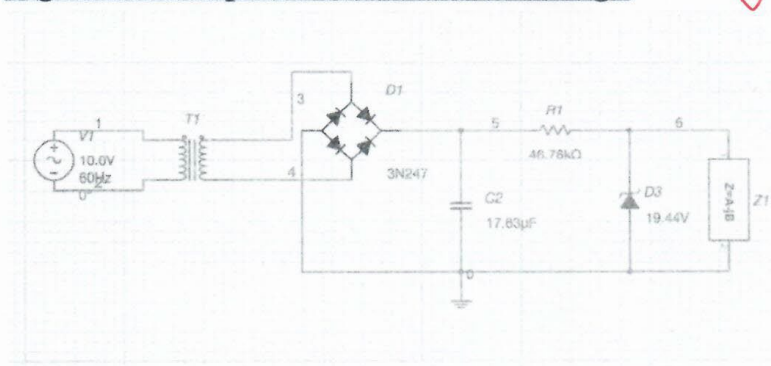


Figure 2B: Multisim Circuit Design

Simulation?

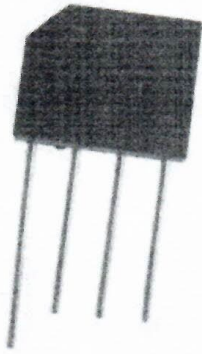


Figure 3B: Bridge Rectifiers 3N427



Discussion/ Conclusion:

First and foremost, we would like to discuss the cost of the schematic and do extensive research of all the parts of the project the parts for are fairly cheap. For example, the zener diode(**Figure 1A**) is only twenty cents and in this economy; I'm surprised that anything is less than a dollar, especially for electrical equipment. Anyhow, with parts being so cheap, such as the Bridge Rectifiers(**Figure 3B**), less than about twenty cents a part, I estimate that circuit would cost around 5 dollar minimum.

In conclusion, I would really like to go farther in this project and actually take it hands-on by designing the project in the lab. Gain more knowledge by getting more experience in person rather than just a experimental prototype. However there are many things I learned during this project such as new types of diodes and their function. This will definitely help when moving to industry and testing and designing new hardware in the future.

Sources For experiment :

https://en.wikipedia.org/wiki/Zener_diode ✓

[https://www.digikey.com/en/products/detail/onsemi/1N5236B/9](https://www.digikey.com/en/products/detail/onsemi/1N5236B/977584)

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Below AVERAGE

Idonor

CSEG

GRADING SCHEME FOR ASSIGNMENT

Item	Points achieved	Maximum Points
1. Objectives and constraints - Plan of the project - Involve safety and economic features	23	30
2. Literature review and preliminary design Simulation results	3	5
3. Circuit design - Calculations and simulations - Include safety and economic considerations	12	15
4. Design of Experimental set up Test equipment needed	16	20
5. Analysis and interpretation of results - Present data in tabular form or graphical form. - Use of appropriate statistical method to analyze the results.	11	15
6. Discussion of results and Conclusions Draw appropriate conclusions	7	10
7. General write-up of report Grammar and adequacy of graphs and figures Proper labeling of graphs and figures Proper references	3	5
8. Composite Grade	75	100
9. Grade for Student Outcome 6 (Items #3, 4, 5, and 6)	46	60
10. Grade for Student Outcome 6 (Normalized to 100%)	76.7	100

Eromosele Idonor ✓

ELEG 3304 ✓

Dr. Ketkar ✓

April 29, 2022 ✓

DC Power Supply ✓

In this project I will design and test the specifications of a DC power supply. I will explain the design, the materials that would be used to make the power supply, the testing methods and machines required to do the tests, my finds compared to the ideal, and my conclusions on the results of my testing and my overall thoughts of the project.

This demonstration is split into the parts, first I will show a complete design of a DC power supply that has an input voltage of 120 V AC at 60 HZ, and I will also cover the overall costs and build. Then I will explore how the power supply could be tested to showcase the ripple, line regulation and load regulation.

In this experiment we need to measure the ripple of a dc power supply, the line regulation and the load regulation. The materials for the power supply are three diodes, two of them being 1N4007 and the last one being 1N4729A. Along with two capacitors both being one being $.78\mu f$ and the other being $780\mu f$. Lastly but not least are the two resistors needs, both being 470 Kilo Ohm resistors. With all these components assuming both power modules are provided the total cost of these materials would be under ten dollars. To test the power supply, we would need a N6782A source measure unit to hook up to the power supply and test the load and line regulation. Then we would need an oscilloscope to test the ripple in the power supply. To start we would start by assembling the power supply circuit by circuit connecting the 120 volt ac

power with the first resistor until it is fully built. Then we would test the ripple, then the line regulation and lastly the load regulation.

The ideal regulation for load and line should be 0% in a perfect scenario. The load regulation is the measurement of the regulator to maintain a DC output voltage beside the change in the current load. The line regulation is for the ΔV_{out} and ΔV_i which is the change in voltage

input and output. The load regulation formula is $\frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$ while the line regulation

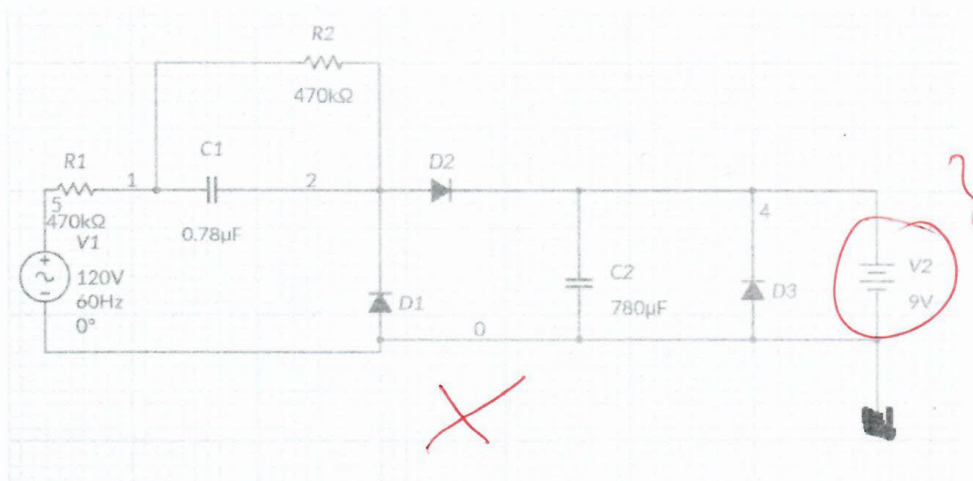
formula is $\frac{\Delta V_{OUT}}{\Delta V_i} \times 100\%$. *did you do this?* The experimental analysis of the line regulation in multisim results in

0% by taking $120V \times .01 = 12V$, which is a 10% change. At 108 V, the output voltage stays at

9V so the load regulations would be $\left(\frac{9V - 9V}{12V} \right) \times 100 = 0\%$. The reactance of the capacitors

could be found as $x = \frac{1}{2\pi fc}$ so $0.34 = \frac{1}{2 \times \pi \times 60 \times C}$ so $C = \frac{1}{2 \times 3.14 \times 60 \times 0.34}$, so reactance is

equal to $0.78 \mu f$.



My design includes the needed 120 V at 60 Hz AC input voltage along with the output voltage of 9V. The results I received from working on the experiment in multisim were close but not exactly what I had been expecting. There were small discrepancies that were in the margin of error and could have been chalked up to my own error. The voltage output of my experiment did not end up at 108 V after testing line regulations so my load regulation test was .513% instead of the desired 0%. My voltage had been 109.5 and I was not sure how I has mis-entered a value to reach that level.

In conclusion, my power supply was accurate enough to get the desired effect out of testing but there is always room for improvement in the layout and or the material that I used to build and test the power supply. There were some areas of the design that I stumbled at such as getting it to have a good short circuit resistance and having a good reactance was the best answer I arrived at. I also assumed the cost for the capacitors because I could not find the exact version I has used but I estimated based on what I had seen to arrive at my materials pricing.

OK
You could have asked for help & done better