

COURSE BINDER

ROY G. PERRY COLLEGE OF ENGINEERING

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT**

PRAIRIE VIEW A&M UNIVERSITY

ASSESSMENT REPORT COVER PAGE

ELEG 2101 Electric Circuits Laboratory

SPRING 2022 SEMESTER

NAME OF INSTRUCTOR: Dr. John Fuller

Revised: 08/05/2019

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 1. be able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms Law
 2. knowledge of the use of modern engineering tools such as Pspice and Multisim Workbench
 3. be able to use modern engineering tools and have competency in the use of simulation tools

Detailed Course Syllabus
(Distributed to Students at the beginning of the Semester)
ABET Outcomes measured using course should be
explicitly listed in the syllabus

ELEG 2101 Course Description

In ABET Format

Please use the following format for the course syllabi (2 pages maximum in Times New Roman 12 point font)

1.	Course number and name:	ELEG 2101 Section 1 CRN: 20106
2.	Credits and contact hours:	1 credit hour; 3 contact hours * Subject Area: Engineering Science
3.	Instructor's or course coordinator's name:	Dr. John Fuller
4.	Text book: Title:	Laboratory handout
	Author:	Laboratory Lab Manual
	Publisher, Year & Edition:	Prairie View A&M University Department of Electrical Engineering
	a. Other Supplemental material	Fundamentals of Electric Circuits, Charles Alexander, Matthew Sadiku, McGraw Hill, ISBN 978-0-07-352855-4
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	ELEG 2101 Electric Circuits Laboratory: 1 semester hour. Operation of basic laboratory-type test and measurement equipment. Experimentation in basic current-voltage relations, circuit laws and network analysis of linear DC and AC circuits. Use of oscilloscope in circuit analysis. RL, RC, RLC, resonance, Op-Amp circuits, and transient circuit experiments, Statistical analysis of elements of Electrical Circuits.
	b. Prerequisites or Co-requisites	<u>ELEG 2305</u> (may be taken concurrently)
	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</i>

		<i>learning outcomes:</i>
	1. be able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms Law	
	2. knowledge of the use of modern engineering tools such as digital multimeters, Ammeters, Digital scopes and simulation tools.	
	3. be able to use modern engineering tools and have competency in the use of simulation tools	
7	Brief list of topics to be covered	1.Component and Instrumentation Familiarization 2.Statistics 3.Construction of Circuits 4.Combinational Circuits 5.Basic Circuit Laws 6.Circuit Laws Continued 7.Analysis Techniques 8.Op Amps 9.Energy storage devices 10. Use of Oscilloscope 11.RC RL Circuits

* For all Engineering programs, indicate subject area from the following: **Math, Basic science, Engineering topic or Other**

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

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PRAIRIE VIEW
A&M UNIVERSITY

SYLLABUS

ELEG 2101 Electric Circuits Lab Spring 2022

General Course Information

Information Item	Information
Instructor:	Dr. John Fuller
Section # and CRN:	ELEG 2101 Section 1 CRN: 20106
Office Location:	Electrical Engineering Building Room 344
Office Phone:	936-261-9923
Email Address:	jhfuller@pvamu.edu
Office Hours:	MWF 10:00-11:30 am, TR 1:00 pm – 2:30 pm, or by appointment
Mode of Instruction:	Face to Face
Course Location:	Room 126 Circuits Laboratory
Class Days & Times:	1:00 - 3:50 Tuesday
Catalog Description:	<i>ELEG 2101 Electric Circuits Laboratory: 1 semester hour.</i> Operation of basic laboratory-type test and measurement equipment. Experimentation in basic current-voltage relations, circuit laws and network analysis of linear DC and AC circuits. Use of oscilloscope in circuit analysis. RL, RC, RLC, resonance, Op-Amp circuits, and transient circuit experiments, Statistical analysis of elements of Electrical Circuits.
Prerequisites:	Prerequisites: ELEG 2305 (may be taken concurrently)
Co-requisites:	
Required Text(s):	Laboratory experiments will be posted on ecourse prior to class time
Recommended Text(s):	Handout material related to experiments will be posted on ecourse prior to experiment date

General Course Information Table

Student Learning Outcomes:

1. Upon successful completion of this course, students will be able to (a) build and test Resistor, RC, RL and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments (d) verify important voltage-current relations like Kirchoff's and Ohms Law (e) Verify network analysis techniques of Mesh Analysis, Node Analysis, theorems of Source Conversion, linearity and Superposition.		
2. Upon successful completion of this course, students will have Knowledge of the use of modern engineering tools such as Digital meters, digital scopes and simulation tools.		
3. Upon successful completion of this course, students will be able to use		

modern engineering tools and have competency in the use of simulation tools		

Major Course Requirements

Method of Determining Final Course Grade

Course Grade Requirement	Value	Total
1. Eleven Lab Reports	90%	
2. Projects	10%	
Total:		100%

Course Grade Requirement Table

Grading Criteria and Conversion:

A = 90 % or better

B = 80-89 %

C = 70 – 79%

D = 60-69%

F = Less than 60%

Experiments with description:

Assignment Title or Grade Requirement	Description
1.Component and Instrumentation Familiarization	Resistor Color Code & Multimeter Measurements on DC Resistive Circuits
2.Statistics	Statistical Applications
3.Construction of Circuits	Construction of Electrical Circuits and Measuring
4.Combinational Circuits	Series and Parallel Circuits
5.Basic Circuit Laws	Kirchhoff's Laws
6.Circuit Laws Continued	Thevenin's and Norton's Theorem
7.Analysis Techniques	Nodal and Mesh Analysis & Multisim Tutorial
8.Op Amps	Operational amplifiers
9.Energy storage devices	Introduction to Capacitors and Inductors
10. Use of Oscilloscope	RC Circuit and Oscilloscope
11.RC and RL Circuits	RC and RL circuits

Detailed Description of Major Assignments Table

Course Procedures or Additional Instructor Policies

Taskstream

Taskstream is a tool that Prairie View A&M University uses for assessment purposes. One of your assignments may be required to be submitted as an "artifact," an item of coursework that serves as evidence that course objectives are met. If applicable, more information will be provided during the semester by your department, but for general information, you can visit Taskstream via the link in eCourses.

At the beginning of the first laboratory period, lab instructor will discuss safety procedures for laboratory experimentation and have students to sign off on provided safety procedures. Throughout all lab experimentation do adhere to safety procedures.

Submission of Assignments

All assignments should be submitted by the due date. Late assignments will be subject to a penalty if submitted several days late and no score for very late submission. Assignments or lab reports must be submitted by due date, which is before the starting of next laboratory

experimentation. All the assignments are to be submitted in written form and submitted through e-course. Reports are formal reports and must be submitted as such.

Formatting Documents

Microsoft Word is the standard word processing tool used at PVAMU. If you're using other word processors, be sure to use the "save as" tool and save the document in either the Microsoft Word, Rich-Text, or plain text format. File name format of your assignment must be "ELEG2011_Lab_##_firstname lastname.docx"

Laboratory Report Format

The following is a guide for your formal lab report. lab experiments are performed on a group basis and one group report is required for each experiment and submitted before the beginning of the next week lab to ecourse. Do attach your in lab work and do show all calculation in deriving an answer to given problems or questions.

Lab Report Format

Title Page as follows

Course Name: Electric Circuits Laboratory

Course #: ELEG 2101

Experiment # and name

Student Names

Date of Submission:

Date of Performance:

Department of Electrical and Computer Engineering

Prairie View A&M University

Objective

Write objective of your lab experiment.

Introduction/Theory

Provide all the theories that are related to the experiment with proper equations, figures and examples.

This should reference to the network theory class lectures or handouts from lab instructor.

Equipment

1. Digital Multimeter, model, serial number
2. DC Power Supply, model, serial number
3. ...

Procedure

Write the detail procedure step by step from start to end.

Part A

- 1.
- 2.
- 3.
- ...

Part B

- 1.
- 2.
- 3.
- ...

Circuit Diagram:

Draw or insert circuit diagram and/or figures and describe. Do include captions with figure and numbers

Answer to the Question

Do answer all questions and give basis for your answers.

Data and Results

Provide all the data that was required and obtained from the experiment.

Show circuit theoretical calculations and compare with experimental results.

Conclusion

Conclude your lab report.

You should have several paragraphs in the conclusion of your lab report as follows: In this paragraph, provide an overview of the lab experiment in a brief manner. Use a few sentences to describe the lab experiment. State if the collected data supported the main purpose of your experiment.

Discussion and contribution

Discussion on the experiment, such as what you learned and the problems that were encountered to complete the experiment.

References

- [1].
- [2].
- ...

Appendix

Attachment

Notes and experimental results are taken during the execution of the lab and attached with report. Be sure to obtain instructor's signature on lab experiment at the end of each class session.

Student Support and Success

John B. Coleman Library

The John B. Coleman Library's mission is to enhance the scholarly pursuit of knowledge, to foster intellectual curiosity, and to promote life-long learning and research through our innovative services, resources, and cultural programs, which support the Prairie View A&M University's global mission of teaching, service, and research. It maintains library collections and access both on campus, online, and through local agreements to further the educational goals of students and faculty. Website: <https://www.pvamu.edu/library/>; Phone: 936-261-1500

Academic Advising Services

Academic Advising Services offers students a variety of services that contribute to student success and lead towards graduation. We assist students with understanding university policies and procedures that affect academic progress. We support the early alert program to help students get connected to success early in the semester. We help refer students to the appropriate academic support services when they are unsure of the best resource for their needs. Faculty advisors support some students in their respective colleges. Your faculty advisor can be identified in PantherTracks. Advisors with Academic Advising Services are available to all students. We are located across campus. Find your advisor's location by academic major at www.pvamu.edu/advising. Phone: 936-261-5911

The University Tutoring Center

The University Tutoring Center (UTC) offers free tutoring and academic support to all registered PVAMU students. The mission of the UTC is to help provide a solid academic foundation that enables students to become confident, capable, independent learners. Competent and caring staff and peer tutors guide students in identifying, acquiring, and enhancing the knowledge, skills, and attitudes needed to reach their desired goals. Tutoring and academic support are offered face-to-face in the UTC, in virtual face-to-face sessions (<https://www.pvamu.edu/student-success/sass/university-tutoring-center/>), and through online sessions (<https://www.pvamu.edu/pvplace/>). Other support services available for students include Supplemental Instruction, Study Break, Academic Success Workshops, and Algebra Study Jam. Location: J. B. Coleman Library, Rm. 307; Phone: 936-261-1561; Email: pvtutoring@pvamu.edu; Website: <https://www.pvamu.edu/student-success/sass/university-tutoring-center/>

Writing Center

The Writing Center provides well-trained peer tutors to assist students with writing assignments at any stage of the writing process. Tutors help students with various writing tasks from understanding assignments, brainstorming, drafting, revising, editing, researching, and integrating sources. Students have free access to Grammarly online writing assistance. Grammarly is an automated proofreading and plagiarism detection tool. Students must register for Grammarly by using their student email address. In addition, students have access to face-to-face and virtual tutoring services either asynchronously via email or synchronously via Zoom. Location: J. B. Coleman Library, Rm. 209; Phone: 936-261-3724; Website: <https://www.pvamu.edu/student-success/writing-center/>; Grammarly Registration: <https://www.grammarly.com/enterprise/signup>

Academic Early Alert

Academic Early Alert is a proactive system of communication and collaboration between faculty, academic advisors, and PVAMU students that is designed to support student success by promptly identifying issues and allowing for intervention. Academic Early Alerts help students by providing a central location to schedule advising appointments, view advisor contact information, and request assistance. Students who recognize that they have a problem that is negatively affecting their academic performance or ability to continue school may self-refer an Academic Early Alert. To do so, students will log in to PV Place and click on Academic Early Alert on the left sidebar. Phone: 936-261-5902; Website: <https://www.pvamu.edu/student-success/early-alert/>

Student Counseling Services

The Student Counseling Services unit offers a range of services and programs to assist students in maximizing their potential for success: short-term individual, couples, and group counseling, as well as crisis intervention, outreach, consultation, and referral services. The staff is licensed by the State of Texas and assists students who are dealing with academic skills concerns, situational crises, adjustment problems, and emotional difficulties. Information shared with the staff is treated confidentially and in accordance with Texas State Law. Location: Hobart Taylor, 2nd floor; Phone: 936-261-3564; Website: <https://www.pvamu.edu/healthservices/student-counseling-services/>

Office of Testing Services

Testing Services serves to create opportunities by offering a suite of exams that aid in the students' academic and professional success. Currently, we administer entrance (HESI A2), college readiness (TSI assessment), Prior Learning (CLEP, DSST), and proctored exams. Location: Wilhelmina Delco, 3rd Floor, Rm. 305; Phone: 936-261-3627; Email: aetesting@pvamu.edu; Website: www.pvamu.edu/testing

Office of Diagnostic Testing and Disability Services

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, contact the Office of Disability Services. As a federally-mandated educational support unit, the Office of Disability Services serves as the repository for confidential disability files for faculty, staff, and students. For persons with a disability, the Office develops individualized ADA letters of request for accommodations. Other services include learning style inventories, awareness workshops, accessibility pathways, webinars, computer laboratory with adapted hard and software, adapted furniture, proctoring non-standardized test administrations, ASL interpreters, ALDs, digital recorders, Livescribe, and a comprehensive referral network across campus and the broader community. Location: Hobart Taylor, Rm. 1D128; Phone: 936-261-3583; Website: <https://www.pvamu.edu/disabilityservices/>

Center for Instructional Innovation and Technology Services (CIITS)

Distance Learning, also referred to as Distance Education, is the employment of alternative instructional delivery methods to extend programs and services to persons unable to attend college in the traditional manner. The Center for Instructional Innovation and Technology Services (CIITS) supports student learning through online, hybrid, web-assist, and 2-way video course delivery. For more details and contact information, visit:

<https://www.pvamu.edu/dlearning/distance-learning-2-2/students-2/>; Phone: 936-261-3283

Veteran Affairs

Veterans Services works with student veterans, current military and military dependents to support their transition to the college environment and continued persistence to graduation. The Office coordinates and certifies benefits for both the G.I. Bill and the Texas Hazlewood Act. Location: Evans Hall, Rm. 102; Phone: 936-261-3563; Website: <https://www.pvamu.edu/sa/departments/veteranaffairs/>

Office for Student Engagement

The Office for Student Engagement delivers comprehensive programs and services designed to meet the co-curricular needs of students. The Office implements inclusive and accessible programs and services that enhance student development through exposure to and participation in diverse and relevant social, cultural, intellectual, recreational, community service, leadership development, and campus governance. Location: Memorial Student Center, Rm. 221; Phone: 936-261-1340; Website: <https://www.pvamu.edu/studentengagement/>

Career Services

Career Services supports students through professional development, career readiness, and placement and employment assistance. The Office provides one-on-one career coaching, interview preparation, resume and letter writing, and career exploration workshops and seminars. Services are provided for students at the Northwest Houston Center and College of Nursing in the Medical Center twice a month or on a requested basis. Distance Learning students are encouraged to visit the Career Services website for

information regarding services provided. Location: Anderson Hall, 2nd floor; Phone: 936-261-3570; Website: <https://www.pvamu.edu/careerservices/>

University Rules and Procedures

Academic Misconduct

Academic dishonesty is defined as any form of cheating or dishonesty that has the effect or intent of interfering with any academic exercise or fair evaluation of a student's performance. The college faculty can provide additional information, particularly related to a specific course, laboratory, or assignment.

You are expected to practice academic honesty in every aspect of this course and all other courses. Make sure you are familiar with the *University Administrative Guidelines on Academic Integrity*, which can be found on the [Academic Integrity webpage](#). Students who engage in academic misconduct are subject to university disciplinary procedures. As listed in the *University Administrative Guidelines on Academic Integrity*, the University Online Catalog, and the Student Code of Conduct, the following are examples of prohibited conduct. This list is not designed to be all-inclusive or exhaustive. In addition to academic sanctions, any student found to have committed academic misconduct that is also a violation of criminal law may also be subject to disciplinary review and action by the Office of Student Conduct (as outlined in the Student Code of Conduct).

Forms of Academic Dishonesty:

1. **Cheating:** Deception in which a student misrepresents that he/she has mastered information on an academic exercise that he/she has not learned, giving or receiving aid unauthorized by the instructor on assignments or examinations. Examples: unauthorized use of notes for a test; using a "cheat sheet" on a quiz or exam; any alteration made on a graded test or exam which is then resubmitted to the teacher;
2. **Plagiarism:** Careless or deliberate use of the work or the ideas of another; representation of another's work, words, ideas, or data as your own without permission or appropriate acknowledgment. Examples: copying another's paper or answers, failure to identify information or essays from the internet and submitting or representing it as your own; submitting an assignment which has been partially or wholly done by another and claiming it as yours; not properly acknowledging a source which has been summarized or paraphrased in your work; failure to acknowledge the use of another's words with quotation marks;
3. **Collusion:** When more than one student or person contributes to a piece of work that is submitted as the work of an individual;
4. **Conspiracy:** Agreeing with one or more persons to commit an act of academic/scholastic dishonesty; and
5. **Multiple Submission:** Submission of work from one course to satisfy a requirement in another course without explicit permission. Example: using a paper prepared and graded for credit in one course to fulfill a requirement and receive credit in a different course.

Nonacademic Misconduct

The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires campus conditions that do not impede their exercise. Campus behavior that interferes with either (1) the instructor's ability to conduct the class, (2) the inability of other students to profit from the instructional program, or (3) campus behavior that interferes with the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. The Office of Student Conduct will adjudicate such incidents under nonacademic procedures.

Sexual Misconduct

Sexual harassment of students and employees at Prairie View A&M University is unacceptable and will not be tolerated. Any member of the university community violating the university's sexual harassment

policy will be subject to disciplinary action. In accordance with the Texas A&M University System guidelines, your instructor is obligated to report to the Office of Title IX Compliance (titleixteam@pvamu.edu) any instance of sexual misconduct involving a student, which includes sexual assault, stalking, dating violence, domestic violence, and sexual harassment, about which the instructor becomes aware during this course through writing, discussion, or personal disclosure. The faculty and staff of PVAMU actively strive to provide a learning, working, and living environment that promotes respect that is free from sexual misconduct, discrimination, and all forms of violence. If students, faculty, or staff would like assistance or have questions, they may contact the Title IX Coordinator at 936-261-2144 or titleixteam@pvamu.edu. More information can be found at www.pvamu.edu/titleix, including confidential resources available on campus.

Pregnancy, Pregnancy-related, and Parenting Accommodations

Title IX of the Education Amendments of 1972 prohibits sex discrimination, which includes discrimination based on pregnancy, marital status, or parental status. Students seeking accommodations related to pregnancy, pregnancy-related conditions, or parenting (reasonably immediate postpartum period) are encouraged to contact Student Disability Services or the Dean of Students' Office for additional information and to request accommodations.

Non-Discrimination Statement

Prairie View A&M University does not discriminate on the basis of race, color, sex, religion, national origin, age, disability, genetic information, veteran status, sexual orientation, or gender identity in its programs and activities. The University is committed to supporting students and complying with The Texas A&M University System non-discrimination policy. It seeks to establish an environment that is free of bias, discrimination, and harassment. If you experience an incident of discrimination or harassment, we encourage you to report it. If you would like to speak with someone who may be able to afford you privacy or confidentiality, there are individuals who can meet with you. The Director of Equal Opportunity & Diversity has been designated to handle inquiries regarding the non-discrimination policies and can be reached at Harrington Science Building, Suite 109 or by phone at 936-261-1744 or 1792.

Class Attendance Policy (See the University Online Catalog for Full Attendance Policy)

Prairie View A&M University requires regular class attendance. Attending all classes supports the full academic development of each learner, whether classes are taught with the instructor physically present or via distance learning technologies such as interactive video and/or the internet. Excessive absenteeism, whether excused or unexcused, may result in a student's course grade being reduced or in the assignment of a grade of "F." Absences are accumulated beginning with the first day of class during regular semesters and summer terms. Each faculty member will include the University's attendance policy in each course syllabus.

Student Academic Appeals Process

Authority and responsibility for assigning grades to students rest with the faculty. However, in those instances where students believe that miscommunication, errors, or unfairness of any kind may have adversely affected the instructor's assessment of their academic performance, the student has a right to appeal by the procedure listed in the University Online Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint.

Technical Considerations

Minimum Recommended Hardware and Software:

- Intel PC or Laptop with Windows 10 or later version; Mac with OS High Sierra*
- Smartphone or iPad/Tablet with Wi-Fi*
- High-speed Internet access
- 8 GB Memory
- Hard drive with 320 GB storage space
- 15" monitor, 800x600, color or 16 bit
- Sound card w/speakers
- Microphone and recording software
- Keyboard & mouse
- Most current version of Google Chrome, Safari, or Firefox

Note: Be sure to enable Java & pop-ups in the Web browser preferences

* Smartphones, Google Chrome books, and Android tablets may not be supported. iPads are the only tablets supported.

Participants should have a basic proficiency of the following computer skills:

- Sending and receiving email
- A working knowledge of the Internet
- Microsoft Word (or a program convertible to Word)
- Acrobat PDF Reader
- Windows or Mac OS
- Video conferencing software

Netiquette (online etiquette)

Students are expected to participate in all discussions and virtual classroom chats as directed. Students are to be respectful and courteous to others on discussion boards. Foul or abusive language will not be tolerated. Do not use ALL CAPS for communicating to others AS IT CAN BE INTERPRETED AS YELLING. Avoid slang terms such as "wassup?" and texting abbreviations such as "u" instead of "you." Limit and possibly avoid the use of emoticons. Be cautious when using humor or sarcasm as tone is sometimes lost in an email or discussion post, and the message might be taken seriously or sound offensive.

Video Conferencing Etiquette

When using Zoom, WebEx, or other video conferencing tools, confirm the visible area is tidy, clear of background clutter, inappropriate or offensive posters, and other distractions. Ensure you dress appropriately and avoid using high traffic or noisy areas. Stay muted when you are not speaking and avoid eating/drinking during the session. Before the class session begins, test audio, video, and lighting to alleviate technology issues.

Technical Support

Students should go to <https://mypassword.pvamu.edu/> if they have password issues. The page will provide instructions for resetting passwords and contact information if login issues persist. For other technical questions regarding eCourses, call the Center for Instructional Innovation and Technology Services at 936-261-3283 or email ciits@pvamu.edu.

Communication Expectations and Standards

Emails or discussion postings will receive a response from the instructor, usually in less than 48 hours. Urgent emails should be marked as such. Check regularly for responses.

Discussion Requirement

Online courses often require minimal to no face-to-face meetings. However, conversations about the readings, lectures, materials, and other aspects of the course can occur in a seminar fashion. The use of the discussion board will accomplish this. The instructor will determine the exact use of discussion boards.

It is strongly suggested that students type their discussion postings in a word processing application such as Word and save it to their PC or a removable drive before posting to the discussion board. This is important for two reasons: 1) If for some reason your discussion responses are lost in your online course, you will have another copy; 2) Grammatical errors can be greatly minimized by the use of the spell-and-grammar check functions in word processing applications. Once the post(s) have been typed and corrected in the word processing application, copy and paste to the discussion board.

COVID-19 Campus Safety Measures [NOTE: Delete this section when the COVID-19 pandemic is over]

To promote public safety and protect students, faculty, and staff during the coronavirus pandemic, PVAMU has adopted policies and practices to limit virus transmission.

- **Self-monitoring** - Students should follow CDC recommendations for self-monitoring. Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.
- **Face Coverings** - Face coverings (cloth face covering, surgical mask, etc.) are recommended in classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource, and support offices, and outdoor spaces where 6 feet of physical distancing is challenging to maintain reliably.
- **Physical Distancing** - Physical distancing should be maintained between students, instructors, and others in course and course-related activities where possible.

Personal Illness and Quarantine - Students required to quarantine are to participate in courses and course-related activities remotely and must not attend face-to-face course activities. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities. Students experiencing personal injury or illness that is too severe for the student to attend class qualify for an excused absence. To receive an excused absence, students must provide appropriate documentation to the Office for Student Conduct, studentcond

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

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

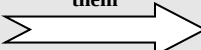
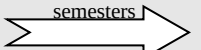
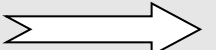
5. Were Expectations Met?

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

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
ELEG 2101 Circuits Laboratory
SPRING 2022 SEMESTER

Report Prepared by: Dr. John Fuller

Report Date: May 23, 2022

Semester	Analysis Type	Number of Students	Outcome 1.1 be able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms Law				Outcome 1.2 knowledge of the use of modern engineering tools such as digital meters, digital scopes and simulation tools				Outcome 1.3 be able to use modern engineering tools and have competency in the use of simulation tools			
			Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average /	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Spring 2022	Direct		75	70	78	77	75	70	90	88	75	70	71	62
Fall 2021	Direct		75	70	94	77	75	70	86	64	75	70	83	73
Spring 2021	Direct	23	75	70	82	83	75	70	84	78	75	70	81	78
Fall 2020	Direct	10	75	70	93	80	75	70	72	70	75	70	76	50
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		Students continue to perform on a satisfactory level for the circuit's laboratory although there is a significant drop in the overall average.				Students continue to grasp the use of laboratory instruments and are able to do circuit analysis with correspondence to lecture material.				The last two experiments of Op-Amps and RC circuits are the most demanding of all the experiments. This requires the student to go beyond the normal digital meters and use the oscilloscope for circuit analysis. The Spring 2022 semester showed a decrease in the class average for these latter experiments.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		No changes are needed for the building of circuits in the lab and analysis of those circuits using lab instruments. Problem appears to be students are not regularly attending the lab and or not submitting lab assignments.				Although it requires considerable amount of instructor time to acquaint the students with lab equipment, but after becoming familiar with the equipment the students become very competent with its use.				Analysis of transit waveforms is given at the end of the semester in the circuits lecture class. Experiments in transit circuits requires considerable time and from lab submission the students are not spending the needed time for equation derivation and circuit analysis.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 		Spring 2022 semester had a significant drop in class average in correspondence with previous three semesters.				By taking considerable time and patience with the students on using lab instruments they adjust to lab experiments and do well as experiments go from basic learning to more complex experiments.				These latter two experiments show a number of students not submitting lab assignments which reduces the overall class average.			
Were Expectations Met?			YES				YES				YES			

**Grade Sheet Showing
Student and Class Performance in Outcomes
The computed semester average in each outcome
as stated in the Assessment report are
highlighted in boldface**

[illegible]

ELEG 2101 Circuits Laboratory
FALL 2022 Dr. John Fuller Instructor

[illegible]

**OUTCOME SPECIFIC ASSIGNMENTS
USED TO ASSESS OUTCOMES**

(Provide at least two assignments used to specifically measure each outcome and justify the suitability of the assignments for the outcome being measured)

ASSIGNMENTS FOR OUTCOME 1.1

Able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms Law

-

ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET

Circuits Laboratory FALL 2021

Instructor: Dr. John Fuller

Title of Assignment

Experiment 2
Statistical application to electrical components and electrical circuit construction.

Outcome Measured Using this Assignment

Outcome 1.1
Able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
X	includes many component parts or sub-problems
	involves multiple disciplines
X	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
	science
X	mathematics

Previous experiment introduced the students to lab instruments to be used for circuit analysis. This experiment shows variation in component values and the introduction these components to building an electrical circuit and the use of instruments in actual voltage and current measurements of the constructed circuit.

Student Study Material

Mean Median Variance

Mean, median, and mode are three kinds of "averages". There are many "averages" in statistics, but these are, I think, the three most common, and are certainly the three you are most likely to encounter in your pre-statistics courses, if the topic comes up at all.

The "mean" is the "average" you're used to, where you add up all the numbers and then divide by the number of numbers. The "median" is the "middle" value in the list of numbers. To find the median, your numbers have to be listed in numerical order from smallest to largest, so you may have to rewrite your list before you can find the median. The "mode" is the value that occurs most often. If no number in the list is repeated, then there is no mode for the list.

Mean, Median, Mode, and Range

The "range" of a list of numbers is just the difference between the largest and smallest values.

-
- **Find the mean, median, mode, and range for the following list of values:**

13, 18, 13, 14, 13, 16, 14, 21, 13

The mean is the usual average, so I'll add and then divide:

$$(13 + 18 + 13 + 14 + 13 + 16 + 14 + 21 + 13) \div 9 = 15$$

Note that the mean, in this case, isn't a value from the original list. This is a common result. You should not assume that your mean will be one of your original numbers.

The median is the middle value, so first I'll have to rewrite the list in numerical order:

13, 13, 13, 13, 14, 14, 16, 18, 21

There are nine numbers in the list, so the middle one will be the $(9 + 1) \div 2 = 10 \div 2 = 5$ th number:

13, 13, 13, 13, 14, 14, 16, 18, 21

13, 13, 13, 13, 14, 14, 16, 18, 21

So the median is 14.

The mode is the number that is repeated more often than any other, so 13 is the mode.

The largest value in the list is 21, and the smallest is 13, so the range is $21 - 13 = 8$.

mean: 15
median: 14
mode: 13
range: 8

Note: The formula for the place to find the median is " $([\text{the number of data points}] + 1) \div 2$ ", but you don't have to use this formula. You can just count in from both ends of the list until you meet in the middle, if you prefer, especially if your list is short. Either way will work.

Variance

From Wikipedia, the free encyclopedia

In [probability theory](#) and [statistics](#), **variance** is the [expectation](#) of the squared deviation of a [random variable](#) from its [mean](#), and it informally measures how far a set of (random) numbers are spread out from their mean. The variance has a central role in statistics. It is used in [descriptive statistics](#), [statistical inference](#), [hypothesis testing](#), [goodness of fit](#), [Monte Carlo sampling](#), amongst many others. This makes it a central quantity in numerous fields such as [physics](#), [biology](#), [chemistry](#), [cryptography](#), [economics](#), and [finance](#). The variance is the square of the [standard deviation](#), the second [central moment](#) of a distribution, and the [covariance](#) of the

random variable with itself, and it is often represented by σ^2 , s^2 , or $\text{Var}(X)$.

Variance example using die

Fair die

A six-sided [fair die](#) can be modelled with a discrete random variable with outcomes 1 through 6, each with equal probability $\frac{1}{6}$. The expected value is $\frac{1+2+3+4+5+6}{6} = 3.5$. Therefore, the variance can be computed to be

$$\begin{aligned}\sum_{i=1}^6 \frac{1}{6} (i - 3.5)^2 &= \frac{1}{6} \sum_{i=1}^6 (i - 3.5)^2 = \frac{1}{6} ((-2.5)^2 + (-1.5)^2 + (-0.5)^2 + 0.5^2 + 1.5^2 + 2.5^2) \\ &= \frac{1}{6} \cdot 17.50 = \frac{35}{12} \approx 2.92.\end{aligned}$$

For experiment 2 the variance formula you use is

$$\text{Variance} = \frac{1}{(n-1)} \sum_{i=1}^n (X_i - \bar{X})^2 ; n=10, \text{ and } \bar{X} \text{ is the calculated mean}.$$

10 resistors with value of each being X_i

Student Sample Material

Above Average

**ELECTRICAL ENGINEERING
DEPARTMENT PRAIRIE VIEW
A&M UNIVERSITY**



- Calculations for mean, median and variance should be clearly presented and formalized.
- Circuit calculations also are not clearly presented

**ELEG – 2011 LAB
LABORATORY REPORT #2**

Multimeter Measurements on DC Resistive Circuits

Dr. John Fuller

Date of Performance:

February 8, 2022

Submitted

On

February 15th, 2022

Spring 2022

Joshua Jones

Ryan Mouton

Jaden Simmons

Points:

	Max Points	Score
Title Page	0.5	
Objective	0.5	
Introduction/Theory	2.0	
Equipment	0.5	
Procedure	3.0	
Circuit Diagrams	1.0	
Calculations, Data and Results	2.0	
Conclusions and References	0.5	
Total:	10 points	

Objective

- Measurement of voltage, current, and resistance using the digital multimeters
- provided in the lab.
- Proficiency on statistical analysis of electrical circuits based on resistance, current
- and voltage measurement.
- Verify theoretically calculated results using basic network laws.

Equipment

- Variable Power Supply
- Digital Multimeter
- Ten 0.47 k Ω resistors having the same tolerance.
- Ten 0.18 k Ω resistors having the same tolerance.

Procedure

Part A :

1. Multimeter Operation (Voltmeter - Voltage Measurement) When making voltage
2. measurements, make certain the voltmeter is connected in parallel with the
3. circuit components across which voltage is measured. A common mistake is to
4. connect the voltmeter in series with the circuit components

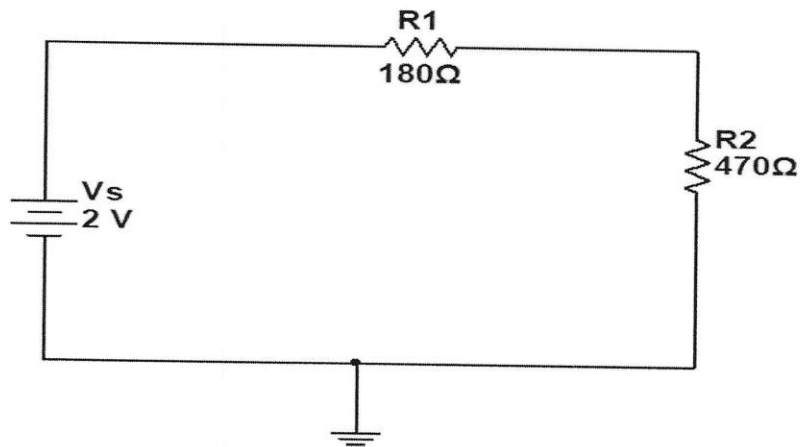
Part B: Multimeter Operation (Voltmeter - Voltage Measurement)/(Ammeter - Circuit Measurement)

- Set the Function/Range switch to the
- desired current range and press the “
- /~” selector switch to the desired
- current type (alternating current (ac)
- or direct current (dc)).
- B. For current measurements less than
- 400mA, connect the red test lead to
- the “mA” jack and the black test lead
- to the “COM” jack. For current
- measurements over 400mA or greater,
- connect the red test lead to the “10A”
- jack and the black test lead to the
- “COM” jack.
- C. Remove power from the circuit under
- test and open the normal circuit path
- where the measurement is to be taken.
- Connect the meter in series with the
- circuit.

Preparation

- ❖ Reviewed color code presentation.
- ❖ Determined color code for each of the seven nominal resistor values.
- ❖ Calculate theoretical voltages and currents for each component of the circuit described in Figure 1.

Current Diagrams:



Calculations, Data and Results:

Table 1

R=0.47 kΩ	R=0.18 kΩ	Tolerance (%)	Measurement R = 0.47 kΩ	Measurement R = 0.18 kΩ
R₁	R₁	5%	.469 kΩ	.181 kΩ
R₂	R₂	5%	.470 kΩ	.180 kΩ
R₃	R₃	5%	.470 kΩ	.182kΩ
R₄	R₄	5%	.470 kΩ	.180 kΩ
R₅	R₅	5%	.470 kΩ	.180 kΩ
R₆	R₆	5%	.470 kΩ	.180 kΩ
R₇	R₇	5%	.470 kΩ	
R₈	R₈	5%	.469kΩ	
R₉	R₉	5%	.470 kΩ	
R₁₀	R₁₀	5%	.471 kΩ	

Table 2:

Resistance Value 0.47 k Ohm		Resistance Value 0.18 k Ohm	
Mean	.470 k Ohm	Mean	.18 k Ohm
Median	.470 k Ohm	Median	.18 k Ohm
Variance	14.509	Variance	16.72

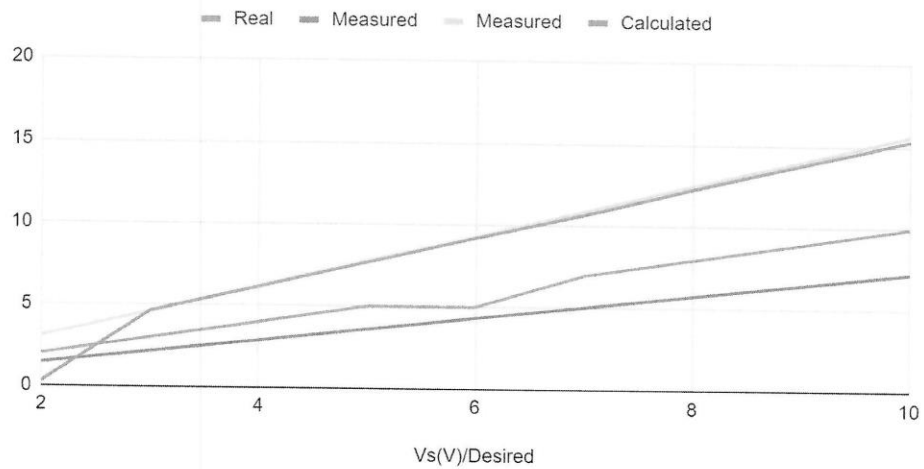
Part B: Voltage

V _s (V)		V _L (V)	I(mA)	
Desired	Real	Measured	Measured	Calculated
2	2.007	1.448	3.1	.301
3	3.009	2.171	4.6	4.62
4	3.99	2.88	6.2	6.15
5	4.99	3.60	7.8	7.69
6	4.99	4.32	9.3	9.23
7	6.98	5.03	10.9	10.7

8	7.98	5.75	12.5	12.3
9	8.98	6.47	14.0	13.8
10	9.98	7.19	15.6	15.3

Plot the Graph

$V_s(V)/\text{Real}$, $V_L(V)/\text{Measured}$, $I(\text{mA})/\text{Measured}$ and $I(\text{mA})/\text{Calculated}$



Conclusion:

After conducting each part of the lab experiment it can be concluded that we have obtained a proficiency on statistical analysis of electrical circuits based on resistance,

current and voltage measurement. We learned how to find variance by using the formula given. We saw how the measured voltage and the real voltage are very similar. We also saw how the measured resistance and resistance given correlate. We strengthen our use of Ohm's law. Furthermore, we strengthen our efficiency in building circuits and using the circuit board.

Discussion and Contributions:

Each group member provided an adequate amount of assistance to conduct the lab and calculate measurements. We collaborated with one another to be able to complete the task at hand. We also worked as a team to make sure data calculations were right and that our circuit was set up right.

Lab 2: Statistical Application to Electronic Circuits and Ohm's Law

Lab Instructor: Dr. John Fuller

Date of Performance: 2/8/22

Name	Date	Instructor Signature
<u>Ryan Markin</u>	<u>2/8/22</u>	<u>[Signature]</u>
<u>Joshua Jones</u>	<u>2/8/22</u>	<u>[Signature]</u>
<u>Jordan Simmons</u>	<u>2/8/22</u>	<u>[Signature]</u>

Lab 2: Statistical Application to Electronic Circuits and Ohm's Law

Objectives:

- Measurement of voltage, current, and resistance using the digital multimeters provided in the lab.
- Proficiency on statistical analysis of electrical circuits based on resistance, current and voltage measurement.
- Verify theoretically calculated results using basic network laws.

Components Used:

Variable Power Supply

Digital Multimeter

Ten 0.47 k Ω resistors having the same tolerance.

Ten 0.18 k Ω resistors having the same tolerance.

AVERAGE

*Calculations should
be expanded*

Electric Circuits Laboratory

Course #: ELEG 2101

Lab 2: Statistical Application to Electronic Circuits and Ohm's Law

Hummad Ahmed

Adrienne Ramos

Rommel Jones

February 15, 2022

February 08, 2022

Department of Electrical and Computer Engineering

Prairie View A&M University

Objectives:

- Measurement of voltage, current, and resistance using the digital multimeters provided in the lab.
- Proficiency on statistical analysis of electrical circuits based on resistance, current and voltage measurement.
- Verify theoretically calculated results using basic network laws.

Introduction/Theory:

The lab gave us the opportunity to better our understanding of digital multimeter usage and how it is thoroughly tested for circuit diagrams with resistance, voltage, and current. By using both the Digital Multimeter and the Elenco LCM Multimeter, the lab testers accurately record the measurements and values of the components. Moreover, it is necessary to identify how the measured values and calculated values correlate and compare the results with Variance formula to have a notion of their differences. This report is meant to force the testers into being suitable with the equipment for future assignments, making sure little to no errors in use arise later.

Equipment:

- Variable Power Supply
- Digital Multimeter
- Six $0.47\text{ k}\Omega$ resistors having the same tolerance.
- Six $0.18\text{ k}\Omega$ resistors having the same tolerance.

Procedure:

Part A:

1. The first step in the procedure in part A was to setup the multimeter. We connected the positive wire (red) to the mA slot and the negative wire (black) into the COM slot.
 2. Step two was to grab 12 resistors, 6 of which were 470 Ohm resistors and 6 180 Ohm resistors. We then had to fill out table 1 and fill in the tolerance and measurement for each individual resistor.
 3. After we finished table 1, we had to fill in table 2 and find the mean, medium, and variance for the six 470 Ohm and 180 Ohm resistors.
-

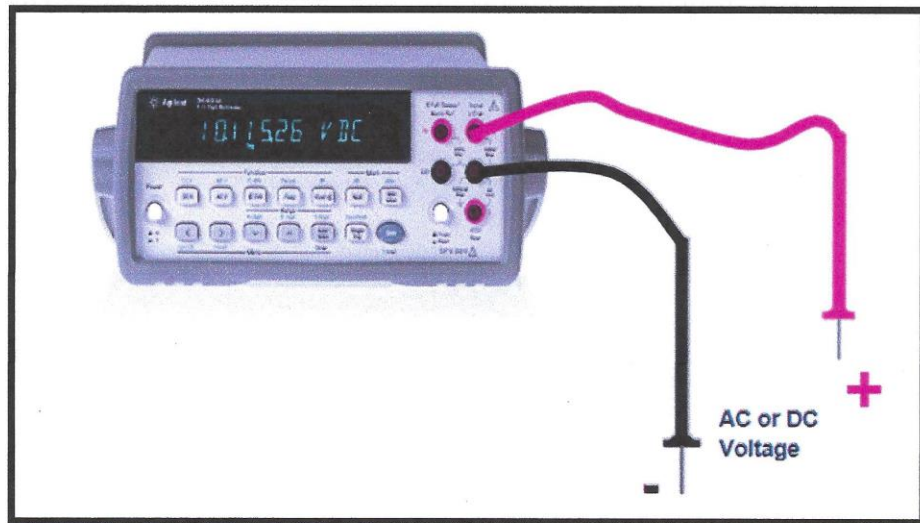
4. To get the mean we had to add the 6 measurements we got for the two resistors and then divide by 6.
5. To get the median we just found the measurement in the middle from table 1.
6. To find the variance we used the formula in figure C below.

Part B:

1. Step 1 in part b was to set up the Variable Power Supply and put the resistors in the circuit board so that we can 1, find the measured value of the voltage.
2. Step 2 we had to calculate the current by using the formula voltage/resistance according to what the desired voltage was.
3. We then had to change the desired voltage on the power supply and then see how much voltage the resistor had, and we started from 2V-10V.
4. The last step was to get the measured current that was going to the resistors with the desired voltage, which were similar to what we go in our calculations for the current.

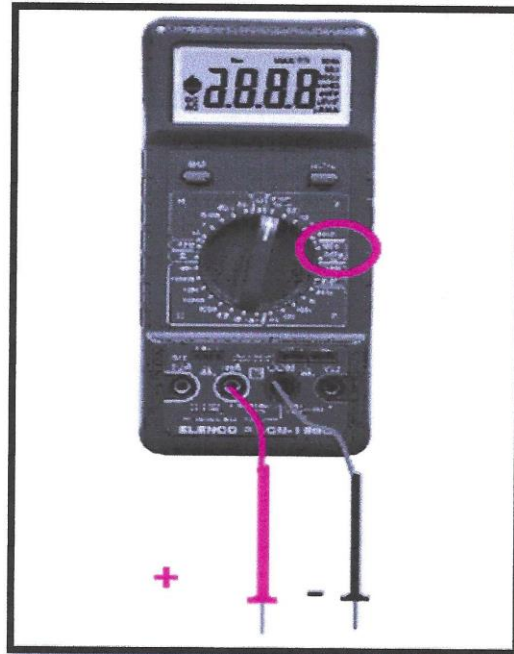
Circuit Diagram:

Figure A: Digital Multimeter



A voltmeter is an electrical instrument used to measure the potential difference between two points in an electrical or electronic circuit. It is a two terminals device, which allows a wire to be connected and lead up to another one, causing circulation. When placing the one tip of lead at one of the points to be tested and the other tip at the other point, the meter shows you the difference.

Figure B: Elenco LCM Multimeter



The Ammeter is a measuring instrument used to find the strength of current flowing around an electrical circuit when connected in series with the part of the circuit being measured. But to measure an electric current, ammeters must be connected so that the total current of interest can pass through it. Summarily, the ammeter should always be connected in series to the circuit or component being measured.

Figure C: Variance Formula

5. From the data you recorded in Table 1, calculate the mean, the median and the variance. Record your calculated variance in Table 2. (Hint: Variance

$$\text{Variance} = \frac{1}{(n-1)} \sum_{i=1}^n (X_i - \bar{X})^2 ; n=10, \text{ and } \bar{X} \text{ is the calculated mean}.$$

Answer to the Question:

The lab's purpose was to get the testers more involved with the equipment (Variable Power Supply, Digital Multimeter) to better familiarize them for future tasks. Because we were able to successfully align the cords to the right places and properly position the resistors and wires onto one another, the answers we got were almost identical to the calculated ones; as a result, the purpose was fulfilled, since the percentage error was very low and little problems came from testing

Data and Results:

Table 1: Resistance Measurement

<i>R=0.47 kΩ</i>	<i>R=0.18 kΩ</i>	<i>Tolerance (%)</i>	<i>Measurement R = 0.47 kΩ</i>	<i>Measurement R = 0.18 kΩ</i>
R ₁	R ₁	5%	0.462 Ω	0.177 k
R ₂	R ₂	5%	0.464 Ω	0.176 k
R ₃	R ₃	5%	0.465 Ω	0.178 k
R ₄	R ₄	5%	0.453 Ω	0.177 k
R ₅	R ₅	5%	0.466 Ω	0.177 k
R ₆	R ₆	5%	0.466 Ω	0.177 k

Table 2: Statistical Parameters

Resistance Value 0.47 k Ohm		Resistance Value 0.18 k Ohm	
Mean	0.4643 Ω	Mean	0.177 Ω
Median	0.464 Ω	Median	0.177 Ω
Variance	0.000038988 Ω	Variance	0.0000108 Ω

Table 3: Resistor Circuit

$V_s(V)$		$V_L(V)$	$I(mA)$	
Desired	Real	Measured	Measured	Calculated
2	2.002 V	1.402 V	3.1 mA	3.077 mA
3	3.003 V	2.165 V	4.6 mA	4.615 mA
4	4.002 V	2.887 V	6.1 mA	6.154 mA
5	4.99 V	3.608 V	7.7 mA	7.692 mA
6	5.99 V	4.32 V	9.2 mA	9.231 mA
7	6.79 V	5.03 V	10.8 mA	10.769 mA
8	7.99 V	5.76 V	12.4 mA	12.308 mA
9	8.99 V	6.48 V	13.9 mA	13.846 mA
10	9.99 V	7.20 V	15.5 mA	15.385 mA

Conclusion:

The measurements of the resistors in Part A with the relation to the color codes and original values allows us to justify the answers received, as minimal difference comes between them. The data is accurate with very little distinction shown (proven by using the Variance formula from Table 2: Statistical Parameters) and this is shown in Part B of the lab as well, with the current having similar values to the measured. In the end, the laboratory experiment was a success, as us testers measured the corresponding components and compared them with our calculated values to distinguish any errors, only to verify that our process was correct.

Discussion and Contribution:

Having the opportunity to work on another lab experiment with the same equipment and little difference allowed us to become well adept at using the multimeters, as well as the electric circuit board. More so, we were able to understand data analysis of results a lot more now as seeing the distinctions between values with variance method and the visualization of graphing outcomes brought enlightenment to correct formatting of similar projects. In this lab experiment though, the testers' responsibilities were as follows...

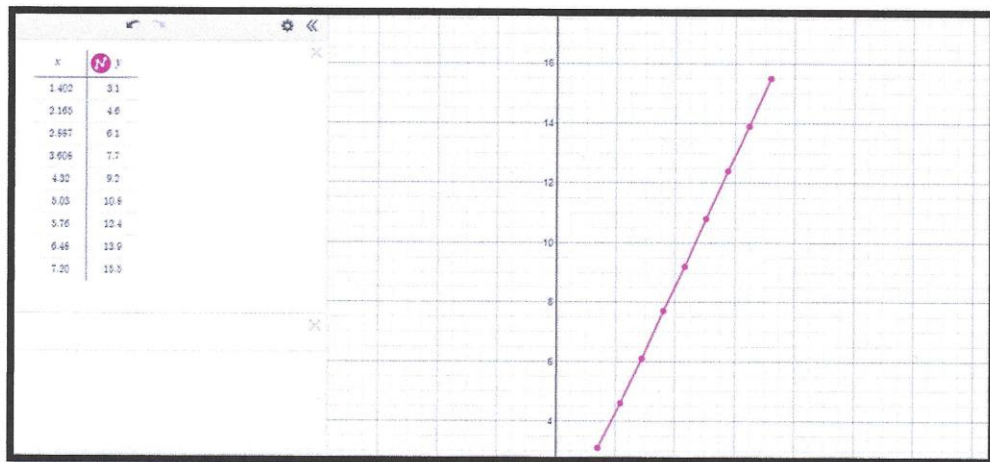
- Hummad: Took charge of measuring and authenticating the values of resistance, voltage, and current by managing the multimeters...
 - Adrienne: In control of setting up the electric circuit board and connecting the circuit compounds with the voltmeter and ammeter...
 - Rommel: Formulated the data results and calculated all the values with the offered formulas...
-

References:

“Simple Series Circuits: Series and Parallel Circuits.” *All About Circuits*, Rob Pengelly,
<https://www.allaboutcircuits.com/textbook/direct-current/chpt-5/simple-series-circuits/>.

Appendix

Voltage and Current Graph



Attachment

Series Solution

1. Since the resistors are in series, simply add the three resistances to find R_{eq} :

$$R_{eq} = 4\ \Omega + 2\ \Omega + 6\ \Omega = 12\ \Omega$$

2. To find I_{total} (the current through the battery), use $V = IR$:

$$6 = 12 I. \text{ So, } I = 6/12 = 0.5\ \text{A}$$

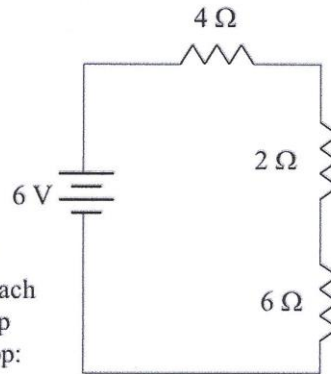
3. Since the current throughout a series circuit is constant, use $V = IR$ with each resistor individually to find the V drop across each. Listed clockwise from top:

$$V_1 = (0.5)(4) = 2\ \text{V}$$

$$V_2 = (0.5)(2) = 1\ \text{V}$$

$$V_3 = (0.5)(6) = 3\ \text{V}$$

Note the voltage drops sum to 6 V.



Calculated Values

Table 1: Resistance Measurement				
R=0.47 kΩ	R=0.18 kΩ	Tolerance (%)	Measurement R = 0.47 kΩ	Measurement R = 0.18 kΩ
R ₁	R ₁	5%	0.462 kΩ	0.177
R ₂	R ₂	5%	0.464 kΩ	0.176
R ₃	R ₃	5%	0.465 kΩ	0.178
R ₄	R ₄	5%	0.463 kΩ	0.177
R ₅	R ₅	5%	0.466 kΩ	0.177
R ₆	R ₆	5%	0.466 kΩ	0.177
R ₇	R ₇			
R ₈	R ₈			
R ₉	R ₉			
R ₁₀	R ₁₀			

Table 2: Statistical Parameters

Resistance Value 0.47 k Ohm		Resistance Value 0.18 k Ohm	
Mean	0.4643	Mean	0.177
Median	0.464	Median	0.177
Variance	0.000038988	Variance	0.0000108

avg. ← $\text{Mean: } (0.462+0.464+0.465+0.463+0.466+0.466)/6 = 0.4643$
 $(0.177+0.176+0.178+0.177+0.177+0.177)/6 = 0.177$

PART B

6. Connect the circuit in Figure 1.

Variance: $\frac{1}{(6-1)} \sum_{i=1}^6 (0.47 - 0.4643)^2 = 0.000038988$
 $\frac{1}{(6-1)} \sum_{i=1}^6 (0.18 - 0.177)^2 = 0.0000108$

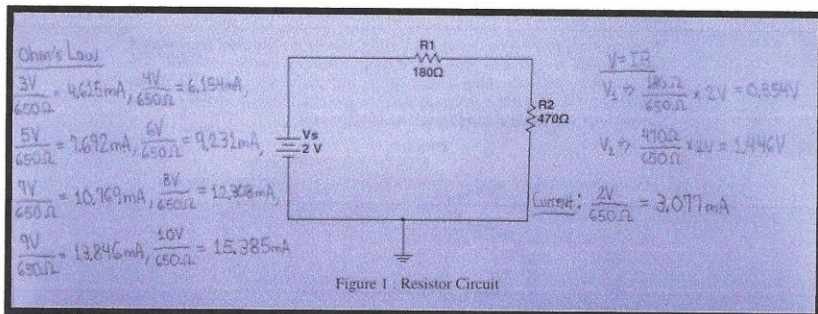


TABLE 3

$V_s(V)$		$V_L(V)$	$I(mA)$	
Desired	Real	Measured	Measured	Calculated
2	2.002V	1.402V	3.1mA	3.077mA
3	3.003V	2.165V	4.6mA	4.615mA
4	4.002V	2.887V	6.1mA	6.154mA
5	4.99V	3.608V	7.7mA	7.692mA
6	5.99V	4.32V	9.2mA	9.231mA
7	6.97V	5.03V	10.8mA	10.769mA
8	7.99V	5.76V	12.4mA	12.308mA
9	8.99V	6.48V	13.9mA	13.846mA
10	9.99V	7.20V	15.5mA	15.385mA

Signatures

Lab Instructor: Dr. John Fuller

Date of Performance: 2/8/22

Name	Date	Instructor Signature
Hummad Ahmed	2/8/22	
ADRIANE CHMOS	2/8/22	
Ronime Jones	2/8/22	

Below Average

Electric Circuits Laboratory

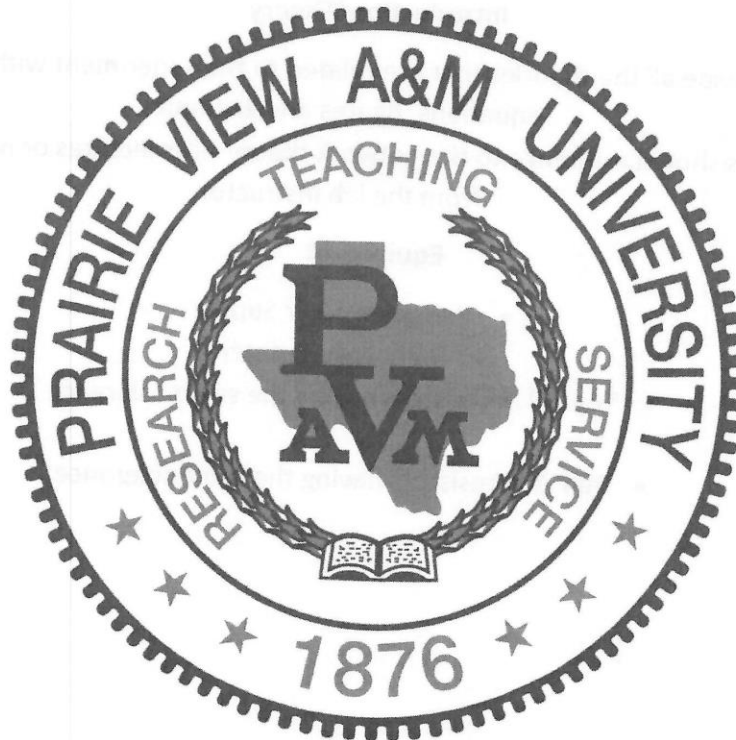
ELEG 2101

Kelechi Anaghara

Ayodele Grayson

Date of submission: 2/15/2022

Date of performance: 2/8/2022



- Calculations poorly presented
- Circuit calculations also not clearly presented
- No sign off sheet attached
- No voltage current graph

Objective

- Measurement of voltage ,current, and resistance using the digital multimeters provided in the lab.
- Proficiency on statistical analysis of electrical circuits based on resistance, current and voltage measurement
- Verify theoretically calculated results using basic network laws.

Introduction/Theory

- Provide all the theories that are related to the experiment with proper equations, figures and examples.
- This should reference to the network theory class lectures or handouts from the lab instructor.

Equipment

- Variable Power Supply
- Digital Multimeter
- Ten 0.47k resistors having the same tolerance
- Ten .18k resistors having the same tolerance

• Calculations clearly presented
• Circuit calculations also not clearly presented
• No side of sheet attached
• No voltage current graph

Procedure:

1. *Multimeter Operation (Voltmeter - Voltage Measurement)* When making voltage measurements, make certain the voltmeter is connected in parallel with the circuit components across which voltage is measured. A common mistake is to connect the voltmeter in series with the circuit components.

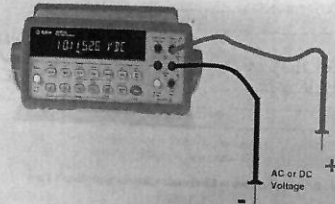


Figure A: Connection for test leads to measure voltage using an Agilent 34401A Digital Multimeter.

2. *Elenco LCM 1950 Multimeter Operation (Ammeter - Current Measurement)*



Figure B: Elenco LCM Multimeter

- A. Set the Function/Range switch to the desired current range and press the " /~ " selector switch to the desired current type (alternating current (ac) or direct current (dc)).
- B. For current measurements less than 400mA, connect the red test lead to the "mA" jack and the black test lead to the "COM" jack. For current measurements over 400mA or greater, connect the red test lead to the "10A" jack and the black test lead to the "COM" jack.
- C. Remove power from the circuit under test and open the normal circuit path where the measurement is to be taken. Connect the meter in series with the circuit.

Procedure:

Part A

When making current measurements, make certain the ammeter is connected in series with the circuit components through which current is measured. This error would effectively cause a short circuit and drastically change the circuit parameters. * CAUTION: Never connect an ammeter directly across a power supply as it will cause a short circuit and be damaged.

PART A

- Measure the resistance value of each of the two group of ten resistors given to your group using any of the two instruments in procedure 1 and 2.
- Record your measured value in the Table 1.

Table 1: Resistance Measurement

R=0.47 kΩ	R=0.18 kΩ	Tolerance (%)	Measurement R = 0.47 kΩ	Measurement R = 0.18 kΩ
R ₁	R ₁	5%	.468k	178
R ₂	R ₂	5%	.462k	180
R ₃	R ₃	5%	.464k	180
R ₄	R ₄	5%	.464k	179
R ₅	R ₅	5%	.461k	179
R ₆	R ₆	5%	.464k	178
R ₇	R ₇			
R ₈	R ₈			
R ₉	R ₉			
R ₁₀	R ₁₀			

- From the data you recorded in Table 1, calculate the mean, the median and the variance. Record your calculated variance in Table 2. (Hint: Variance

$$\text{Variance} = \frac{1}{(n-1)} \sum_{i=1}^n (X_i - \bar{X})^2 ; n=10, \text{ and } \bar{X} \text{ is the calculated mean}.$$

Table 2: Statistical Parameters

Resistance Value 0.47 k Ohm		Resistance Value 0.18 k Ohm	
Mean	.464	Mean	179
Median	.464	Median	179.5
Variance	2.592 E ⁻⁴	Variance	230231.5

Part B

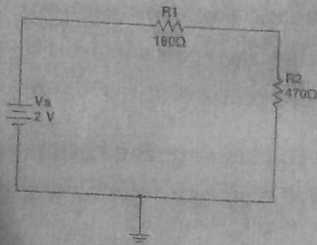


Figure 1: Resistor Circuit

7. Adjust the supply voltage as shown in Table 3, measure the corresponding current I flowing in the circuit and the voltage V_L across the $470\ \Omega$ resistor and record your readings in Table 3.

$V_s(V)$		$V_L(V)$		$I(mA)$	
Desired	Real	Measured	Measured	Calculated	
2	2.00	1.446	3.1	3.077	2
3	2.99	2.169	4.6	4.615	3
4	3.99	2.891	6.1	6.154	4
5	4.99	3.61	7.7	7.692	5
6	5.99	4.3	9.2	9.231	6
7	6.99	5.03	10.7	10.769	7
8	7.99	5.77	12.4	12.308	8
9	8.99	6.50	13.9	13.446	9
10	9.99	7.22	15.5	15.385	10

8. Plot the graph of the measured voltage V_L and the measured current I

Write a lab report and upload it into True-Outcome using the correct format shown. The report is due next class meeting. Each group member must submit a report.

Conclusion:

We measured the resistance values of .47k and .18k. We measured 6 resistors for table 1 and came up with interesting calculations. For .47k we got .468,.462,.464,464,461,.464 and .18k we got 178,180,180,179,179,178. The tolerance of 5 percent was the same throughout. Table 2 was calculating the mean, median, variance. Table 3we calculated the current using the formula and testing it out. Above this is a picture of the values we got for the experiment.

Discussion: I learned how to calculate the resistance value a hands on without using calculations. We also learned calculating the current as well.

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Circuits Laboratory
FALL 2021
Instructor: Dr. John Fuller**

Title of Assignment

**Experiment 3
Construction of electrical circuits and measuring circuit parameters**

Outcome Measured Using this Assignment

Outcome 1.1

Able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
X	includes many component parts or sub-problems
	involves multiple disciplines
X	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
	science
X	mathematics

Previous experiments introduced the students to lab instruments to be used for circuit analysis. This experiment makes use of those instruments in actual voltage and current measurements of a constructed circuit.

Student Sample Material

Above Average

Electric Circuits Laboratory

Course #: ELEG 2101

Lab 3: ~~Statistical Application to Electronic Circuits and Ohm's Law~~

Construction of Electrical Circuits

Hummad Ahmed

Ayodele Grayson

Rommel Jones

March 01, 2022

February 22, 2022

Department of Electrical and Computer Engineering

Prairie View A&M University

• measured and calculated values do not agree
with no explanation given.

Objectives:

- Measurement of voltage, current, and resistance using the multimeters provided in the lab.
- Proficiency creating electrical circuits using resistors, wires, and power supplies.
- Verify theoretically calculated results using basic network laws.

Introduction/Theory:

This lab allows the testers to construct electrical circuits and measure the circuit parameters with simple instruments. While the previous experiments bettered our experience in making simple calculations and measurements with given formulas and tools, this one was presented as an arduous task. The electric circuit board was done with a blend of series and parallel circuits, increasing the difficulty in accurately resembling the schematics of figures, measuring correct outputs of resistance and current, and calculating values through undisclosed equations.

Equipment:

- Variable Power Supply
- Digital Multimeter
- Five resistors with nominal values: 120 Ohms, 220 Ohms, 470 Ohms, 1000 Ohms, and 1800 Ohms

Procedure:

Part A

- To begin the experiment, we constructed the DC series/parallel circuit by placing different resistors onto the board (470 Ohms, 1000 Ohms, 220 Ohms, and 1800 Ohms).
- After setting up the resistors in parallel and series, the measuring of each resistor's voltage took priority, as well as the currents along them with the help of an Ammeter. Unfortunately, there was a minor error in our first trial for the voltage finding of the experiment, as one of the resistors we had was not a part of the required ones; because of this, we had to redo the process another time to accurately jot down the results.
- The next step was calculating the voltage and current of the resistors, as well as the total voltage and total current. In order to find the current surging throughout the circuit, Ohm's Law ($V = IR$) was necessary, and to obtain total current (I_{total}), we utilized (V)/(R_{total}). And as for voltage, the formula used was ($V = IR$).

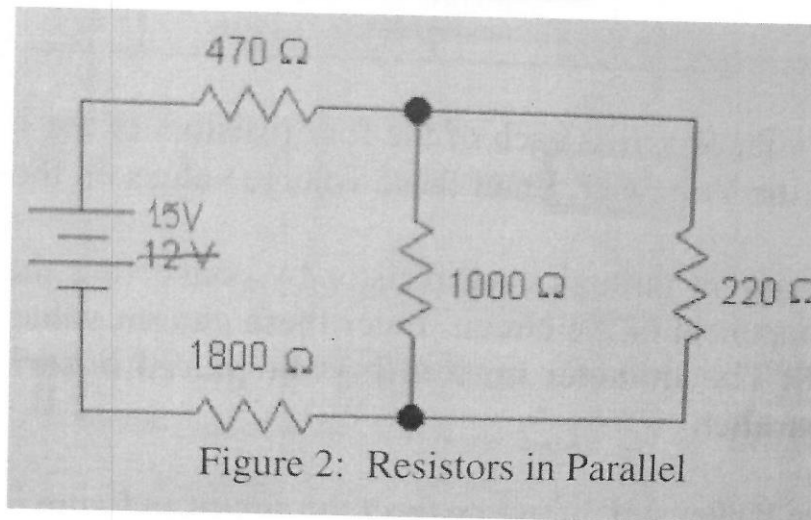
Part B:

- The construction of different series and parallel resistors in a circuit occurred by properly placing the following: a 100 Ohm and 220 Ohm resistor in parallel, as well as a 120 Ohm and 220 Ohm resistor in parallel.
- Next, we calculated the resistance across point A and B by using the Product over Sum formula ($(R1 * R2) / (R1 + R2)$).

- After calculating and verifying the answers obtained through the formula, we used the circuit components to get the measured values and compare them with our own results.
- The next key step was modifying the circuit by connecting it to 15 volts.
- Lastly, current across the X and Y branch was calculated through the Ohm's Law and verified for its authenticity by comparing it with the measured value.

Circuit Diagram:

Figure 2: Resistors in Parallel



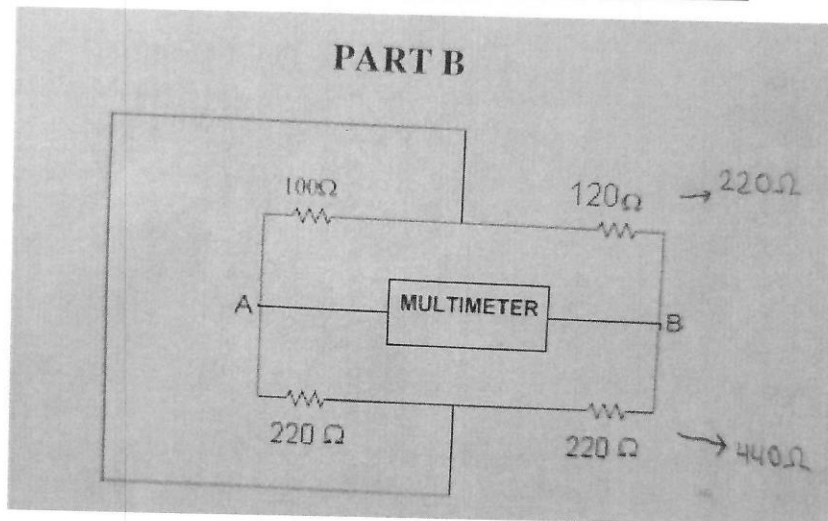
The resistors are in parallel if their terminals are connected to the same two nodes. The equivalent overall resistance is smaller than the smallest parallel resistor. When resistors are connected in parallel, more current flows from the source than would flow for any of them individually.

Table 2: Data Sheet Voltage Current Measurements

	Calculated	Measured
V_s	15V	15.60V
I_s	6.12mA	6.4mA
V_{470}	2.877V	3.92V
I_{470}	6.12mA	6.43mA
V_{1000}	1.104V	1.49V
I_{1000}	1.1mA	1.1mA
V_{1800}	11.018V	10.13V
I_{1800}	6.12mA	6.4mA
V_{220}	1.104V	1.49V
I_{220}	5.02mA	5.2mA

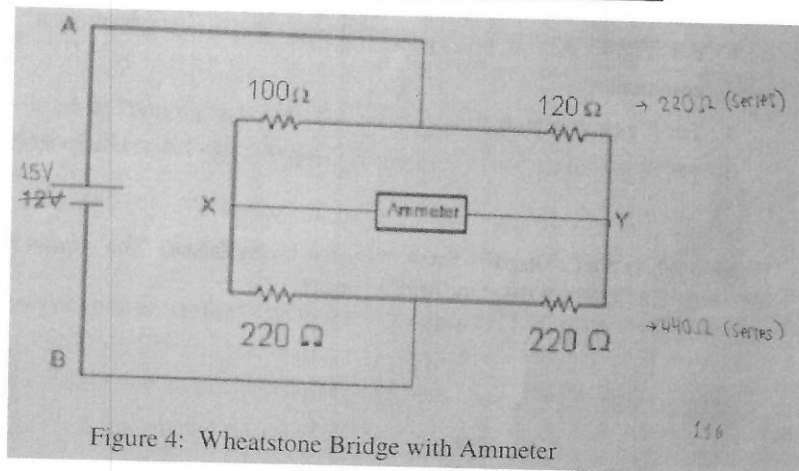
After measuring the source current with the Ammeter, the current values were entered on the Data Sheet along with the calculated values. With current being collected, the voltage values were next after measuring them across each of the four resistors of the circuit and the source voltage.

Figure 3: Wheatstone Bridge Resistance Measurement



The Wheatstone Bridge is an electrical bridge circuit used to measure resistance. It does this by balancing two legs of a bridge circuit, one leg of which includes the unknown component. The primary benefit of the circuit is its ability to provide extremely accurate measurements

Figure 4: Wheatstone Bridge with Ammeter



In order to find the current with the given Ohms around the Ammeter and the Voltage (connected to the circuit through the branch AB), we must use the Product Sum rule to collect resistance and then proceed in using the Ohm's Law. Another way to find the current of XY is by utilizing Multimeters with the Electric Circuit Board.

Answer to the Question:

(Questions 5 to 9)

5. Every single one of these voltages conformed to the Divider Rule.
6. Yes, they both were able to be found successfully through Ohm's Law and then verified through the Divider Rule, leaving any doubt for accurate results.
7. While they were not exactly the same value, they did match because of the little difference between them (Calculated Value = 146.4 Ohms, Measured Value = 145 Ohms). Some human errors arise in cases of calculating values, so having a small percent error is normal.
8. The node directly under the Wheatstone Bridge with Ammeter would be considered a "ground" node. This is because grounds symbols are attached to nodes at the bottom, symbolizing the fact that the node voltage is 0; in this case, after the section of the bridge, no voltage is available to pass through the circuit.

9. Because the resistance values are extremely large, even still after using the Product-Sum Rule, the Ohm's Law utilized to find the total current around the circuit was an extremely low number (0.007 Amps).

Conclusion:

(Questions 1 to 4)

1. Not given any pre-lab values of the circuit in Figure 1 or the image itself; however, if it is anything akin of Figure 2 and its Data Sheet of values, there would only be slight dissimilarities between them.
2. Originally there was a large error in values because a resistor of wrong color code was used but after replacing it into the circuit board, little difference amongst the values is found. The biggest gap found was between the values of 470 V (2.877V for calculated and 3.92V for measured) but it wasn't sizeable enough to raze the experiment.
3. After using the formula to determine power dissipation, it is clear that the results we found satisfy the conservation of power. In the end, the total power dissipated among the resistors equals the power supplied to the circuit initially.
4. Yes, as these equations were extremely similar to the measured values we found, indicating the process of Kirchoff's Laws were correct. All the calculated results were repeatedly checked to be an accurate answer with as little source of error as possible.

Discussion and Contribution:

This procedure allowed the users to properly understand the correlation of calculations and value measurements. Moreover, the use of the instruments in a meticulous approach and the necessity to memorize critical formula was crucial for the success of the experiment.

- Hummad: Took order of procedure for an organized experiment, taking charge of measuring and authenticating the values as well. Managed the process in measuring current across branch XY for the Figure 4 part of the experiment.
- Rommel: Found the undisclosed formula necessary in finding the calculated values of current and resistance. Then proceeded to collect this information, as well as the resistance of AB (Part B).
- Ayodele: Lead in the connections for test leads to measure voltages and current; the measured values were found and recorded from his placement of resistors and circuit components.

References:

Admin. (2018, April 24). *5 Differences Between Series and Parallel Circuits*. Electrical Engineering XYZ. Retrieved February 23, 2022, from

<https://www.electricalengineering.xyz/questions/top-5-differences-between-series-and-parallel-circuits/>

Brennan, E. (2020, February 13). *Resistors in Series and Parallel Formula Derivation*. Owlcation. Retrieved February 23, 2022, from <https://owlcation.com/stem/Resistors-in-Series-and-Parallel-Formula-Derivation>

Appendix

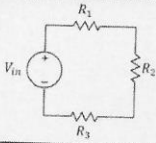
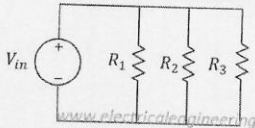
*No appendix for this week's procedure

Attachment

Multiple resistors in parallel

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots \frac{1}{R_n}$$

Along with Ohm's Law, we were required to implement the product-sum rule for parallel resistors using the formula above...

	Series	Parallel
How it looks		
Voltage	$V_{in} = V_1 + V_2 + V_3$	$V_{in} = V_1 = V_2 = V_3$
Current	$I_{series} = I_1 = I_2 = I_3$	$I_{in} = I_1 + I_2 + I_3$
Resistance	$R_{eq} = R_1 + R_2 + R_3$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
Features	If one components burns current becomes inactive	If one component burns current stops only through that branch rest part works fine

Listed above is the guide used to help direct our focus on the series and parallel circuits' formulas; they were utilized accordingly and are based off voltage, current, and resistance.

Calculated Values:

7. Turn ON the power supply and adjust it so that the output is 12V as measured on the Voltmeter

Parallel Resistors: $R_T = \frac{1}{\frac{1}{100} + \frac{1}{220}} = 180.328 \Omega$ $R_{Total} = 470 + 180.328 + 1800 = 2450.328 \Omega$

Current (same for series): $V = I \cdot R$
 $15V = I \cdot 2450.328$
 $I_s = 0.0061216 A$
 $= 6.12 mA$

$V_{470} = (470 \Omega)(0.0061216 A)$
 $= 2.877 V$

$V_{1800} = (1800 \Omega)(0.0061216 A)$
 $= 11.018 V$

$V_{for 1000 \Omega \& 220 \Omega}$
 $(V_{Total} - V_{470} - V_{1800}) / 2$
 $= 1.104 V$

$I_{1000} = \frac{1.104 V}{1000 \Omega} = 0.0011 = 1.1 mA$ $I_{470 \Omega} = \frac{V_{470 \Omega}}{R} = \frac{2.877 V}{470 \Omega} = 6.12 mA$ $I_{1800 \Omega} = \frac{V_{1800 \Omega}}{R} = \frac{11.018 V}{1800 \Omega} = 6.12 mA$

$I_{220} = \frac{1.104 V}{220 \Omega} = 0.005018 = 5.02 mA$

3

12. Measure the resistance across points A and B, using the Multimeter and enter below.

$$R_{AB} \text{ (Calculated in Prelab)} = \underline{146.4 \Omega} \text{ (show calculations).}$$

$$\begin{aligned} \text{Product-Sum Rule: } R_{eq} &= 100 // 220 + 120 // 220 \\ &= \frac{100 \times 220}{320} + \frac{120 \times 220}{340} = 146.397 \Omega \end{aligned}$$

$$R_{AB} \text{ (Measured)} = \underline{145 \Omega}$$

15. Measure the current across the branch XY, using a Multimeter and enter below.

$$\begin{aligned} I_{XY} \text{ (Calculated in Prelab)} &= \underline{4.14 \text{ mA}} \text{ (show calculations)} \\ \star I_{XY} &= \frac{V_{XY}}{R_{ab}} \rightarrow V_{XY} = V_X - V_Y \\ V_X &= V_{220 \Omega} = \frac{(15V)(220 \Omega)}{100 + 220} = 10.3125V \\ V_Y &= \frac{(15V)(220 \Omega)}{120 + 220} = 9.706V \\ V_{XY} &= V_X - V_Y = 0.6065V \\ I_{XY} &= \frac{V_{XY}}{R_{ab}} = \frac{(0.6065)}{(146.4)} = 4.14 \text{ mA} \\ I_{XY} \text{ (Measured)} &= \underline{4.5 \text{ mA}} \end{aligned}$$

Signatures:

Name	Date	Instructor Signature
<u>Hummad Ahmed</u>	<u>2/22/22</u>	<u>[Signature]</u>
<u>Rahmel Jones</u>	<u>2/22/22</u>	<u>[Signature]</u>
<u>Ayodele Grayson</u>	<u>2/22/22</u>	<u>[Signature]</u>
_____	_____	_____

Average

Electric Circuit Laboratory

ELEG 2101

**Lab #3: Construction of Electrical Circuits and measuring
circuit parameters using simple instruments**

Name	Date	Instructor Signature
Jordan Owens	2/22/2022	J. Owens
Jasmine Blond	2/22/2022	J. Owens

Jordan Owens

Jasmine Blond

Performed: 2/22/2022

Submitted: 3/1/2022

**Department of Electrical and Computer Engineering
Prairie View A&M University**

*Always explain
different in measured
and calculated*

Objective:

The overall objective for the experiment is to find the measurement of voltage, current, and resistance using the multimeters provided in the lab. We also needed to determine our proficiency for creating electrical circuits using resistors, wires, and power supplies. The final objective is to verify theoretically calculated results using basic network laws.

Introduction/Theory:

Theories that were utilized during the lab were KCL, Ohm's law, KVL. In which we implemented the equations to check and find the value of resistance current and voltage.

Equipment:

1. Variable Power Supply, Digital Multimeter
2. Seven resistors with nominal values: 120Ω , 220Ω , 470Ω , $1k\Omega$, and $1.8k\Omega$.

Procedure:

Part A: Resistance Measurements

1. *Multimeter Operation (Voltmeter- Voltage measurement)* When making voltage measurement, make certain the voltmeter is connected in parallel with the circuit components across which voltage is measured. A common mistake is to connect the voltmeter in series with the circuit components.
2. *Elenco LCM 1950 multimeter operation O(Ammeter- current Measurements)*
 - a. Set the function/range switch to the desired current range and press the ρ selector switch to the desired current type (alternating current(ac) or direct current(dc)
 - b. For current measurements less than 400 ma connect the red test lead to the "ma" jack and the black test lead to the com jack for current measurement over 400 nm or greater connect the red test lead to the 10a jack and the black test lead to the com jack
 - c. Remove power from the circuit under test and open the normal circuit path where the measurement is to be taken. Connect the ammeter in series with the circuit
3. *Power Supply Operation.:* Turn on the power supply and adjust it so that the output is 12v as asired on the voltmeter. S Measures the source current using the Ammeter and enter the current value on the Data sheet.

4. Remove the Voltmeter from the power supply and measure voltages across each of the resistors in the circuit. Enter the voltage values for each resistor on the Data Sheet.
5. Now turn OFF the power supply.
6. Connect the 220Ω resistor in parallel with the 1000Ω resistor as shown by the schematic in Figure 2.
7. Turn ON the power supply and adjust it so that the output is 12V as measured on the Voltmeter
8. Measure the source current using the Ammeter and enter the current value on the Data Sheet.
9. Measure the voltage across each of the four resistors of the circuit and the source voltage using the Voltmeter. Enter these voltage values on the Data Sheet.
10. Measure the current through each resistor by connecting the Ammeter in series with each component of the circuit. Enter these current values on the Data Sheet
11. Turn off the power supply and connect the circuit as figure 3 below

Part B

12. Measure the resistance across points A and B using the multimeter and enter below
13. Turn off the power supply and modify the circuit as in Figure 4
14. Turn on the power supply
15. Measure the current across the branch XY, using a multimeter and enter below

Circuit Diagram:

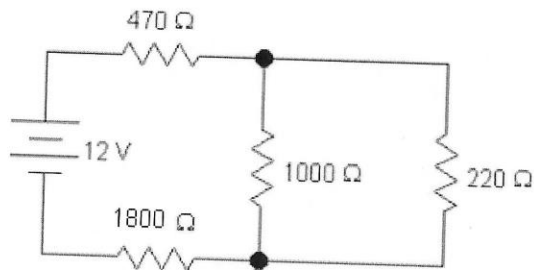


Figure 2: Resistors in Parallel

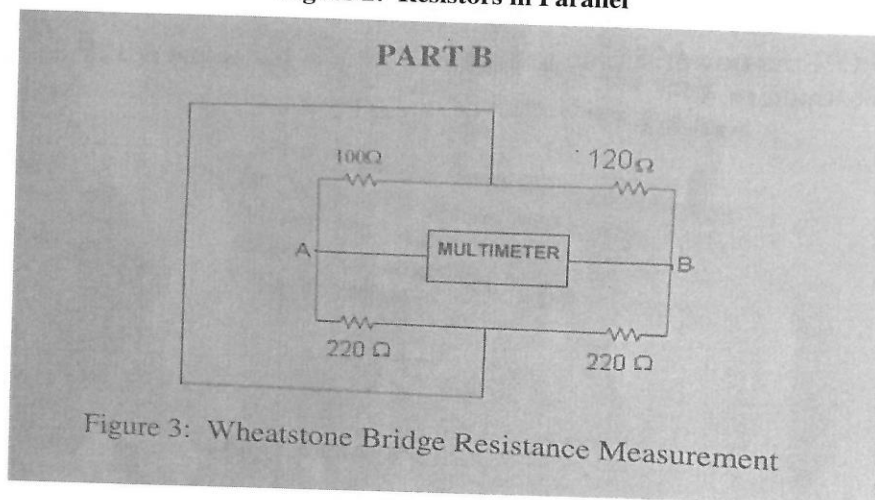


Figure 3: Wheatstone Bridge Resistance Measurement

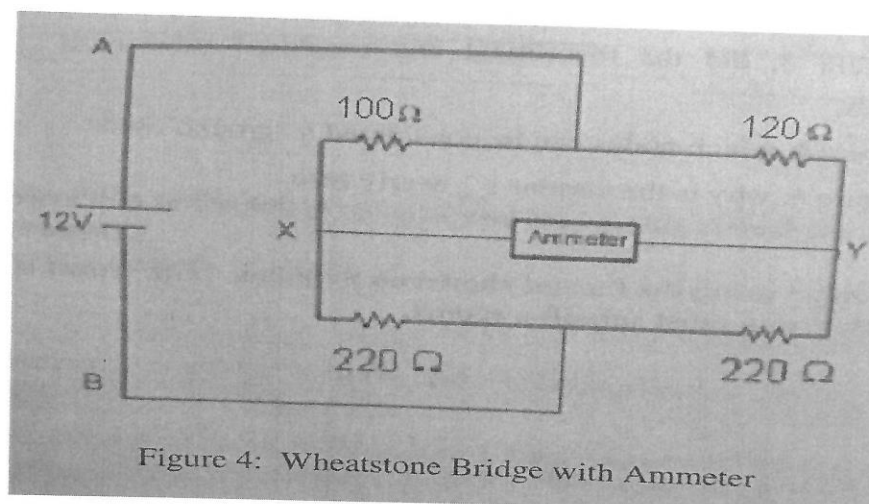


Figure 4: Wheatstone Bridge with Ammeter

Answers to the conclusion Question:

Conclusions:

1. Examine the pre-lab theoretical and measured values for voltage and current of the circuit in Figure 1. Comment on the differences.

The difference in the theoretical and measured values that the theoretical value does not take into account the practical percent error and tolerance of the resistors used.

2. Calculate theoretical voltages and currents using the measured resistance values for the circuit of Figure 2. Tabulate your results. Comment on the correlation of measured and theoretical values? Explain possible sources of error.

Multiple errors could have resulted in the difference in the voltage and current that was collected in the measured. For example, The fact that a resistor could have had less resistance than due to long term use of the item. There could have also been something wrong with the ammeter that measured the values as the previous user may cause a malfunction due to improper use.

3. Calculate the power supplied to the circuit from the power supply. Determine the power dissipation of each resistor in the circuit of Figure 2. Does your result satisfy the conservation of power law? Explain

Utilizing the formula $P = IV$ we can come up with the voltage. For when a current flows through a given element in a circuit, and losing voltage is the product of the current and voltage. Thus we have a voltage of 12V and a current of 6.4 making our dissipation 76.8.

4. Do the theoretical results agree with what is expected by Kirchoff's Laws? Explain
Yes, it should agree with what is expected by kirchoff laws. Using KVL and KCL. The theoretical results should agree with what is expected.

5. Did the voltages V470, V1000, V100, in Figure 1, conform to the Voltage Divider?

Using the formula $V_{out} = V_{in} * r_2 / (r_1 + r_2)$ did find that those voltages did conform to the Voltage Divide.

6. Did the currents I1000, and I220 in Figure 2, conform to the Current Divider?

No, the currents did not conform to the current divider because the power supplied was not equivalent to the power absorbed.

7. For Figure 3, did the theoretical and measured value of R_{ab} match. If not comment.

They did not match; however, the numbers were close in range. The calculated value was 146.38 ohms and we measured 145.6 ohms.

8. For Figure 4, which nodes can be considered a "ground" node.

The ground node could be 120 ohms.

9. For Figure 6, why is the current I_{xy} nearly zero.

N/A as were not given a figure 6. However in figure 6 we did calculate a value of .102A and I believe it to be because of the similar resistor that were in series and it being shared with voltage coming in from an and b beaceu of the 12v. If a ground was added at the bottom it also could have resulted in a dummy node.

Data and Results:

Data Sheet

Table 2: Data Sheet Voltage and Current Measurements

	Calculated Values	Measured
V_s	15V	15.62
I_s	6.12mA	6.5
V_{470}	2.87V	2.99
I_{470}	6.12mA	6.5
V_{1000}	1.103V	1.14
I_{1000}	1.103mA	1.1
V_{1800}	6.12V	11.48
I_{1800}	1.103 mA	6.5
V_{220}	1.103V	1.14
I_{220}	5.01mA	5.3

$$R_{ab}(\text{Calculated}) = 146.39\Omega$$

$$(100 \times 220) / (100 + 220) = 68.75\Omega$$

$$(120 \times 220) / (120 + 220) = 77.65\Omega$$

$$68.75 + 77.65 = 146.39\Omega$$

$$R_{ab}(\text{Measured}) = 145.6\Omega$$

$$I_{xy}(\text{Calculated}) = 0.102 \text{ A}$$

$$15V = I_{xy} \times 146.7$$

$$I_{xy} = 0.102 \text{ mA}$$

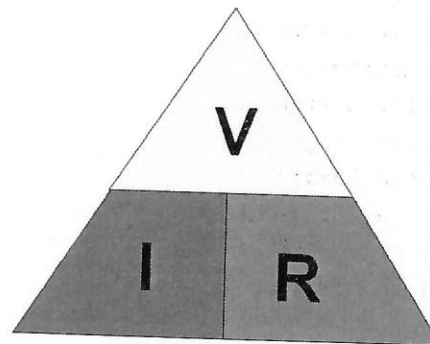
$$I_{xy} (\text{Measured}) = 4.6 \text{ mA}$$

Appendix I

5% Standard Values											
Decade multiples are available from 10 Ω through 22 M Ω											
10	11	12	13	15	16	18	20	22	24	27	30
33	36	39	43	47	51	56	62	68	75	82	91

10% Standard Values											
Decade multiples are available from 10 Ω through 1 M Ω											
10	12	15	18	22	27	33	39	47	56	68	82

Ohm's Triangle



Cover the variable you want to find and perform the resulting calculation.

Conclusions:

For this experiment we found the measurement of voltage, current, and resistance of a circuit with resistors in parallel. We created electrical circuits through the use of resistors, wires, and power supplies and verified the results using Kirchhoff's Voltage and Current Laws.

First we constructed the circuit. Then we used the ammeter to measure the source current and enter the current value on the Data sheet. Then we measured the voltage across each of the four resistors of the circuit and the source voltage using the Voltmeter. Next, we measured the current through each resistor by connecting the Ammeter in series with each component of the circuit. Finally we measured the resistance across points A and B and measured the current across the branch XY using the multimeter.

Discussion and Contribution:

One question that arose was where to connect the voltmeter when setting up the circuit on. It was found that the voltmeter must be connected in parallel with the circuit components across which voltage is measured. Throughout the experiment, multiple factors could have affected the outcome of the reading. We also had to be cautious of not having the ammeter always placed in series with the resistor and never parallel. This could have resulted in a malfunction in the ammeter which would alter our results. Problems that could have arisen could have been the result of the ammeter not giving a proper reading and a damaged resistor. The solution to resolve these problems would be to replace the damaged materials with new materials and redo the experiment.

Below *Average*

**Electric Circuits Laboratory
ELEG 2101**

**Lab 3: *Construction of electrical circuits &
measuring circuit parameter using simple
instruments***

- No calculations presented in report
- No answers to questions
- Measured and calculated values do not agree

Kaylin Williamson

Tarjae Hall

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Date of Submission: March 1st, 2022

Date of Performance: February 22, 2022

**Department of Electrical and Computer Engineering
Prairie View A&M University**

Lab 3:
Construction of electrical circuits and measuring circuit parameters
using simple instruments

Name: Jonae Whitaker

Lab Instructor: Dr. John Fuller

Date of Performance: FEB. 22, 2022

Name	Date	Instructor Signature
<u>Taryae Hall</u>	<u>2/22/22</u>	<u>[Signature]</u>
<u>Kaylin Williamson</u>	<u>2/22/22</u>	<u>[Signature]</u>
<u>Jonae Whitaker</u>	<u>2/22/22</u>	<u>[Signature]</u>

Lab 3: Construction of electrical circuits and measuring circuit parameters using simple instruments.

Objectives:

- Measurement of voltage, current, and resistance using the multimeters provided in the lab.
- Proficiency creating electrical circuits using resistors, wires, and power supplies.
- Verify theoretically calculated results using basic network laws.

Components Used:

- Variable Power Supply
- Digital Multimeter
- Five resistors with nominal values: 120 Ω , 220 Ω , 470 Ω , 1k Ω , and 1.8k Ω .

Objective:

- Measurement of voltage, current, and resistance using the multi-meter provided in the lab.
- Proficiency creating electrical circuits using resistors, wires, and power supplies.
- Verify theoretically calculated results using basic network laws.

Introduction/Theory:

- We will begin with building the circuit provided by the lab. Once the Circuit is built, we will be able to use the multi-meter to calculate the resistance across each resistor

Equipment:

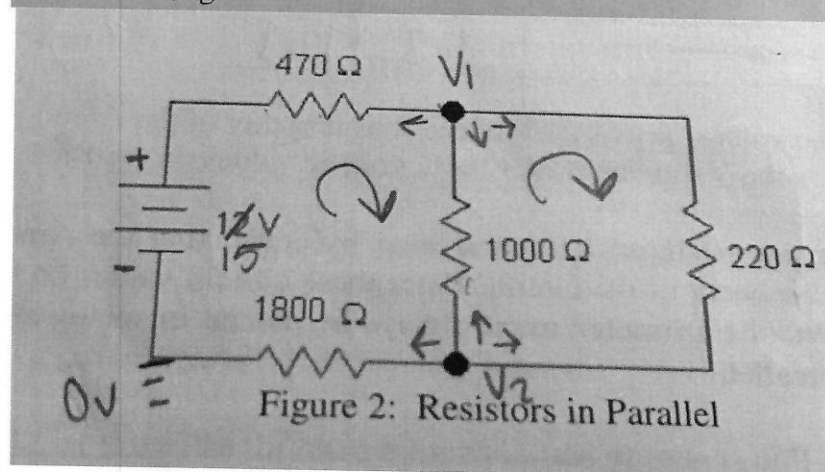
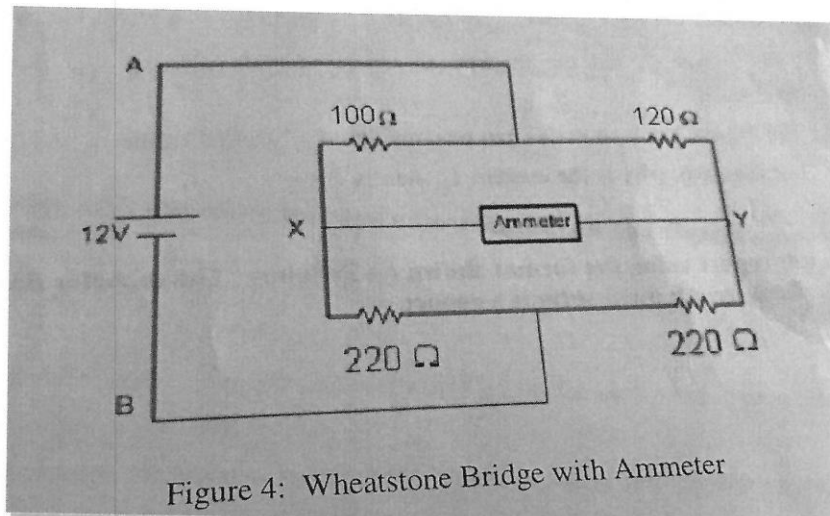
- Variable Power Supply
- Digital Multi-meter
- 120Ω resistor
- 220Ω resistor
- 470Ω resistor
- $1k\Omega$ resistor
- $1.8k\Omega$ resistor
- Volt-meter

Procedure:**Part A**

- We begin by creating the circuit we were given in our packets, on the multi-meter

- While building the circuit, we realize that it was both parallel and in series.
- Once the circuit was built we used connecting cables to connect the multi-meter to the circuit.
- After they were connected, we were able to measure the voltage across the four resistors we were given.
- Next, we found the currents throughout the circuit.
- Now that that was complete, we turned off the Multi-Meter and reconnected a different circuit.
- Once the new circuit was connected, we calculated the resistors across it.

Circuit Diagram:



Data and Results:

Table 2: Data Sheet Voltage Current measurement

	Calculated	Measured
V_s		15.5
I_s	0.0061	7.0
V₄₇₀	2.867	3.19
I₄₇₀	0.0061	7.0
V₁₀₀₀	1.35	1.26
I₁₀₀₀	6.1×10^{-6}	1.1
V₁₈₀₀	10.98	10.81
I₁₈₀₀	0.0061	7.0
V₂₂₀	1.342	1.48
I₂₂₀	5.26	5.8

R_{AB} (Calculated) = 146.4

R_{AB} (Measured) = 218

Conclusion

In conclusion, we first noticed that this circuit was a bit more detailed than the ones before. The Measurement's we produced on the multi-meter were similar the ones we calculated as a group. We used Methods like "The Mountaintop," and laws like Ohm's Law, Kirchhoff's Voltage Law, and Current Law.

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Circuits Laboratory
FALL 2021
Instructor: Dr. John Fuller**

Title of Assignment

**Experiment 4
Series and parallel circuits**

Outcome Measured Using this Assignment

Outcome 1.1

Able to (a) build R, RC and RLC circuits, (b) use the basic electrical instruments, (c) analyze the data gathered from the experiments and (d) verify important voltage-current relations like Kirchoff's and Ohms

Check the complex engineering problem characteristics related to this assignment

	Assignment problem	
	☐	involves wide-ranging or conflicting technical issues,
	☐	has no obvious solution
	☐	Addresses problems not encompassed by current standards and codes
	☐	involves diverse groups of stakeholders
	☒	includes many component parts or sub-problems
	☐	involves multiple disciplines
	☒	has significant consequences in a range of contexts
	Assignment problem involves the application of the principles of	
	☒	engineering
	☐	science
	☒	mathematics

Due to Covid restrictions Lab experiments were conducted using multisim software. The software acquainted the students with instruments that are used in real world experimentation and circuit connection as would be done in an actual laboratory environment.

Student Sample Material

Above Average

Electric Circuits Laboratory
Course #: ELEG 2101
Lab 4: Series and Parallel Circuits

Hummad Ahmed
Adrianne Ramos
Rommel Jones

February 22, 2022

February 15, 2022

Department of Electrical and Computer Engineering
Prairie View A&M University

*Equations and calculations are not
clearly presented*

Objectives:

- Review the calculation of total resistance for resistive elements connected in series and in parallel.
- Review the calculation of total power supplied and total power dissipated.
- Review the construction of a circuit from a schematic with a voltage point source.
- Introduce Kirchoff's voltage law, Kirchoff's current law, and Ohm's law in analysis of DC series/parallel circuits.
- Introduce voltage divider rule and current divider rule in the analysis of DC series/parallel circuits.

Introduction/Theory:

The lab is intended to give the experimenters a more engrossing opportunity to use the formula developed from the Network Theory lesson (Kirchoff's Laws and Ohm's Law) in order to test our enumerating progress. While using the given equipment to measure values is important, it's also critical that the testers understand how we approach certain results in a step-by-step way mathematically; this way, we're able to keep up with new techniques and complex methods in future experiments.

Equipment:

- Agilent 34401A Digital Multimeter (DMM)
- DC Power Supply
- 220-Ohm resistor
- 560-Ohm resistor
- 1000-Ohm resistor
- 1600-Ohm resistor

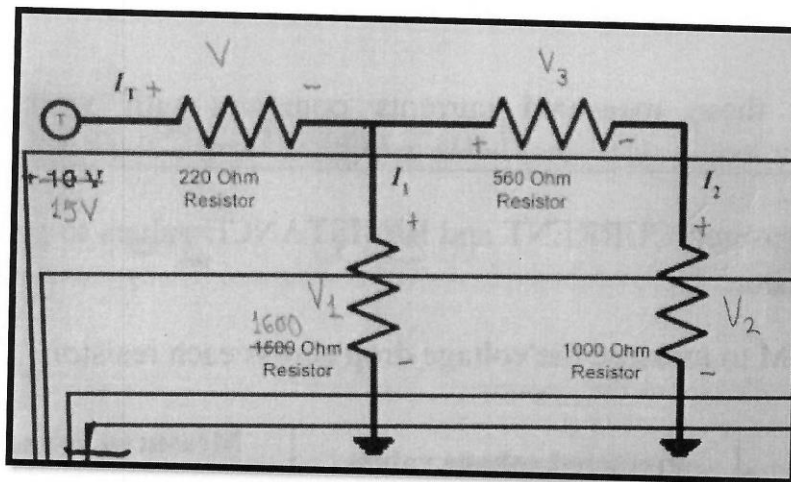
Procedure:

- **Step 1:** The first direction we had to take was making the circuit in figure 1 use the 220-Ohm, 560-Ohm, 1000-Ohm, and 1600-Ohm resistors.
- **Step 2:** We measured the value of each of the four-resistors by using the digital multimeter. Once we measured all of their values, we started to calculate the total equivalent resistance (R_t) by using the data we collected. In doing so, we added the two measured values for the series 560 and 1000, which was 550 kOhms+989 kOhms and 1600 kOhms +220 kOhms. The R_t formula was used to find the total of the resistance ($1/((1/R_1) + (1/R_2) + (1/R_3))$).

- **Step 3:** We used KCL, KVL, and Ohms law to find I_{total} , I_1 , and I_2 . I_{total} we used V/R_t . To get I_1 we used $(V \times \text{Resistor Value of } 1600) / (\text{Resistor value of } 1600 + 220 + \text{Resistor Value of } 1000 + 560)$. To get I_2 we used the same formula.
- **Step 4:** We used the DMM device to get the measured current value for I_t , I_1 , and I_2 . We then predicted the voltage drop for each of the resistors using the formula $V = I \times R$ and then we used the DMM device to get the measured voltage values for the four resistors.
- **Step 5:** We had to use the Voltage Divider Rule to verify the measured value we got for the 1000 Ohm resistor. We used the measured voltage value for the 1600 Ohm resistor (12.18) $\times$ the measured value for the 1000 Ohm resistor (989 Ohms) divided by 1539 which gave us 7.38 V.
- **Step 6:** We had to use the Power rule to find the power of each resistor. To find the power we used the formula $P = V \times I$. We then did power in = power out which we got by adding the watts together which gave us the power out and the power in we got by using the formula $V \times I_t$ (calculated current values).

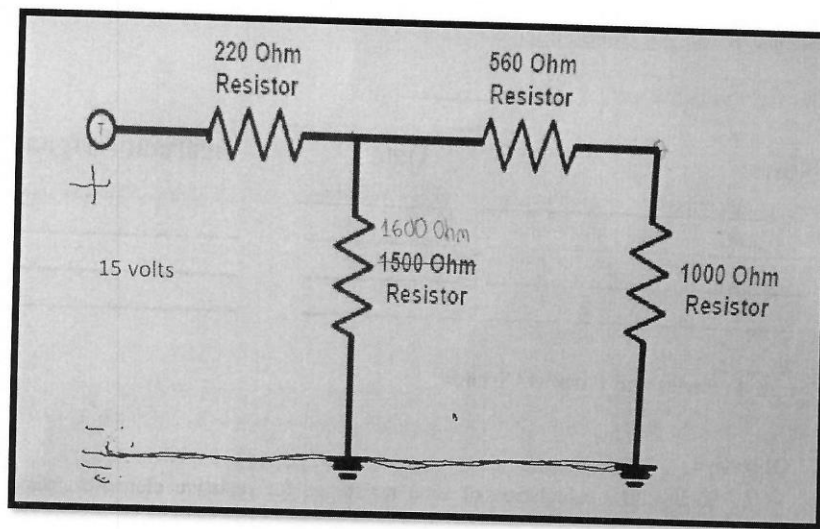
Circuit Diagram:

Figure One



A DC series/parallel circuit with the total voltage value of 15 volts, as well as the resistance values of 220 Ohms, 560 Ohms, 1600 Ohms, and 1000 Ohms. This will be constructed on the electric circuit board in order to properly measure the values with the Multimeter and compare them with the calculated results.

Figure Two



This is a DC series/parallel circuit with the same values as Figure 1, except that it also includes unknown currents that need to be measured by the testers. The figure also differs in showing direction of its conventional current flow and the voltage polarities across the resistors and DC voltage source.

Answer to the Question:

The purpose of this lab is to help the testers understand the fundamentals of calculations in these procedures, as a large part of the Series and Parallel Circuits Laboratory required us to review the elements of the circuit and master using various Network Theory equations (Kirchoff's voltage law, Kirchoff's current law, Ohm's law, etc.). Being given the chance to work out problems that needed attentive detail in steps allows the testers to improve their understanding of the formula and solve similar problems like these more easily in the future; the experiment conveniently tied in with this week's lesson of Network Theory to test our capabilities and development in the current subject.

Conclusion:

All in all, the project we were assigned was meant to test our capabilities in calculating the resistance, current, and voltage values with the formula we've been learning in Network Theory; the two courses were aligned with each other in giving students a chance to show their knowledge in the current lesson and verify growth by using it in both a hands-on approach with the circuit board and an evaluating one in reviewing calculations and equations.

Discussion and Contribution:

In this lab experiment though, the testers' responsibilities were as follows...

- Hummad: Was responsible for filling out the data tables for current with the given laws of Kirchoff and Ohm; computed the values of both measured and calculated current as well.
- Adrienne: Took charge of the Digital Multimeter and measuring all the values of the circuit; verified the DC series/parallel circuit analysis, as well as finding power (watts) through the DMM and computing of real power in circuit.
- Rommel: Calculated all of the values for the resistor, voltage, and current with the given equations; answered the questions concerning observations of the circuit and power supplied.

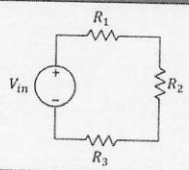
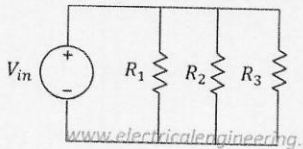
References:

Admin. (2018, April 24). *5 Differences between Series and Parallel Circuits*. Electrical Engineering XYZ. Retrieved February 16, 2022, from <https://www.electricalengineering.xyz/questions/top-5-differences-between-series-and-parallel-circuits/>

Appendix

*No appendix in Lab 4

Attachment

	Series	Parallel
How it looks		
Voltage	$V_{in} = V_1 + V_2 + V_3$	$V_{in} = V_1 = V_2 = V_3$
Current	$I_{series} = I_1 = I_2 = I_3$	$I_{in} = I_1 + I_2 + I_3$
Resistance	$R_{eq} = R_1 + R_2 + R_3$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
Features	If one components burns current becomes inactive	If one component burns current stops only through that branch rest part works fine

Calculated Values

Measured resistor values		Measured resistor values	
220-Ω	218-Ω	560-Ω	550-Ω
1500-Ω 1500	1606-Ω	1000-Ω	989-Ω

□ Using the measured values of the resistors, calculate the total equivalent resistance, R_T , as seen by the source.

$R_{series} \rightarrow R_1 = R_{218\Omega} + R_2 \quad R_2 = R_{550\Omega} + R_{989\Omega} = 550\Omega + 989\Omega = 1539\Omega$
 $R_{parallel} \rightarrow \frac{1}{R_{eq}} = \frac{1}{1606} + \frac{1}{1539} \Rightarrow R_{eq} = \frac{(1606)(1539)}{1606+1539} = 785.89\Omega$
 $R_{TOTAL} \rightarrow R_T = 218\Omega + 785.89\Omega = 1005.89\Omega$

$V = IR$
 $I_T = \frac{V}{R_{eq}}$

$R_T = 1005.89\Omega$

Step Three: DC series/parallel circuit analysis.

□ Using Kirchhoff's current law, Ohm's law, and current divider rule calculate the currents indicated in figure 2. Use your measured resistances for this calculation.

KCL
 $I_T = I_1 + I_2$
 $-15 + V + I_1 = 0$
 $-V_1 + V_3 + V_4 = 0$

Ohm's Law
 $V = 218 \cdot I_T$
 $V_1 = 1606 \cdot I_1$
 $V_2 = 989 \cdot I_2$
 $V_3 = 550 \cdot I_3$

$-15 + (218 \cdot I_T) + (1606 \cdot I_1) = 0$
 $-1606 \cdot I_1 + 550 \cdot I_3 + 989 \cdot I_2 = 0$
 $I_T = \frac{V}{R_{eq}} = \frac{15V}{1005.89\Omega} = 15.08835A$
 $I_2 = \frac{(15.088A)(1539\Omega)}{1606\Omega + 1539\Omega} = 6.90484A$
 $I_1 = \frac{(15.088A)(1606\Omega)}{1606\Omega + 1539\Omega} = 8.18332A$

Figure 2

Calculated current values	
I_T	0.0151 MA
I_1	0.0069 MA
I_2	0.0082 MA

	Measured current values
I_T	15.5 mA
I_1	7.6 mA
I_2	7.9 mA

- ☐ How does these measured currents compare with your calculated currents?
They are very similar with very little difference among them due to human error.

- ☐ Use the DMM to measure the voltage drop across each resistor.

$$V_{220\Omega} = R_1 \cdot I_T$$

$$= 220\Omega \cdot 0.0155$$

$$= 3.41V$$

$$V_{560\Omega} = R_2 \cdot I_2$$

$$= 560\Omega \cdot 0.0079$$

$$= 4.424V$$

$$V_{1000\Omega} = R_3 \cdot I_2$$

$$V_{1000\Omega} = R_4 \cdot I_2$$

	Predicted voltage values	Measured voltage values
$V_{220\Omega}$	3.41V	3.386V
$V_{560\Omega}$	4.345V	4.38V
$V_{1000\Omega}$	7.81V	7.18V
$V_{1000\Omega}$ 1000-Ω	12.206V	12.18V

Step Five: Voltage Divider Rule.

- ☐ Use the voltage divider rule to verify your measured $V_{1000\Omega}$.

$$\frac{V_T \cdot R_2}{R_1 + R_2} = \frac{12.18 \cdot 989}{1539} \rightarrow V_{1000\Omega} = 7.83V$$

	Power (watts)	$P = V^2/R$
DC Power Supply	0.225W	$15 \cdot 0.015$
220- Ω resistor	0.053W	$3.386^2/220$
1000 1000- Ω resistor	0.0924W	$12.18^2/1606$
560- Ω resistor	0.0349W	$4.38^2/550$
1000- Ω resistor	0.052W	$7.18^2/989$

$$\Sigma \text{Power}_{in} = \Sigma \text{Power}_{out}$$

$$\Sigma 0.225W = \Sigma 0.225W$$

Signatures

Lab Instructor: Dr. John Fuller

Date of Performance: 2/15/22

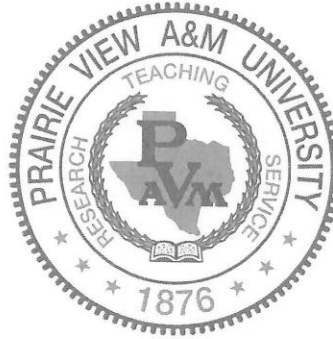
Name	Date	Instructor Signature
<u>Hummaed Ahmed</u>	<u>2/15/22</u>	<u>J. Fuller</u>
<u>Rommel Jones</u>	<u>2/15/22</u>	<u>J. Fuller</u>
<u>Adrianne Ramos</u>	<u>2/15/22</u>	<u>J. Fuller</u>
_____	_____	_____

Average

Electric Circuits Laboratory

ELEG 2101

Experiment #4: Series and Parallel Circuits



Donte Neco

India Elkhazin

Date of submission: 2/22/22

Date of performance: 2/15/22

Calculations are not clearly presented

Lab 04: Series and Parallel Circuits

Lab Instructor: Dr. John Fuller

Date of Performance: 2/15/2022

Name	Date	Instructor Signature
<u>India Elkhazin</u>	<u>2/15/2022</u>	<u>[Signature]</u>
<u>Donce New</u>	<u>2/15/2022</u>	<u>[Signature]</u>
_____	_____	_____
_____	_____	_____

Objective:

1. Review the calculation of total resistance for resistive elements in series and parallel.
2. Review the calculation of total power supplied and total power dissipated.
3. Review the construction of a circuit from a schematic with a voltage point source.
4. Introduce Kirchhoff's Current Law and Ohm's Law in analysis of DC series/parallel circuits.
5. Introduce voltage divider rule and current divider rule in the analysis of DC series/parallel circuits.

Equipment:

- Agilent 34401A Digital Multimeter (DMM)
- DC Power Supply

Department of Electrical and Computer Engineering
Prairie View A&M University

- 220Ω Resistor
- 560Ω Resistor
- 1000Ω Resistor
- 1600Ω Resistor

Procedure:

1. On a board, construct the DC series/parallel circuit in Figure 1.
2. Measure the voltage of each resistor. Using the measured values of the resistor, calculate the total equivalent resistance, R_T , as seen by the source.

Resistor Value (Ω)	Measured Value (Ω)
220	221
560	556
1600	1569
1000	989

$$R_T = 221 + (1569 \times 1545) / 3110 = 1000.45\Omega$$

3. Using Kirchhoff's Current Law, Ohm's Law and current divider rule, calculate the currents indicated in figure 2. Use your measured resistances for this calculation.

$$I_T = 15 / 1000.45 = 0.015A$$

$$KCL: I_T = I_1 + I_2$$

$$KVL = -15 + V + V_1 = 0$$

$$I_1 = (I_T)(1560) / 3160 = 0.00738A$$

$$-V_1 + V_3 + V_2 = 0$$

$$I_2 = (I_T)(1600) / 3160 = 0.00759A$$

4. Use the DMM to measure the currents I_T , I_1 and I_2 . Use your measured current and resistance values to predict the voltage drop across each resistor, then use the DMM to measure the voltage drop across each resistor.

Current	Calculated (A)	Measured (A)
I_T	0.015	0.015
I_1	0.00738	0.00771
I_2	0.00759	0.00782

$$\begin{aligned} V_{220\Omega} &= (221)(I_T) = 3.315V & V_{1000\Omega} &= (989)(I_T) = 7.466V \\ V_{560\Omega} &= (556)(I_T) = 4.197V & V_{1600\Omega} &= (1569)(I_T) = 11.689V \end{aligned}$$

Voltage	Predicted (V)	Measured (V)
$V_{220\Omega}$	3.315	3.45
$V_{560\Omega}$	4.197	4.37
$V_{1000\Omega}$	7.466	7.77
$V_{1600\Omega}$	11.689	12.15

5. Use the voltage divider rule to verify your measured $V_{1000\Omega}$.

$$V_{1000\Omega} = 7.777V$$

6. Use your measured current, voltage, and resistor values to compute the power supplied by the DC power source and the total power dissipated by the 220 Ω , 560 Ω , 1000 Ω and 1600 Ω resistors.

$$P = VI$$

$$P_{220\Omega} = (0.015)^2(221) = 0.049725W$$

$$P_{DC} = (0.015)^2(1000.45) = 0.2251W$$

$$P_{560\Omega} = (0.00782)^2(556) = 0.034W$$

$$P_{1000\Omega} = (0.00782)^2(989) = 0.060479W$$

$$P_{1600\Omega} = (0.00771)^2(1569) = 0.093267W$$

Power	Power (W)
DC Power Supply	0.225
220Ω	0.049725
560Ω	0.034
1000Ω	0.06047
1600Ω	0.093267

$$\Sigma 0.225 = \Sigma 0.237$$

Circuit Diagram:

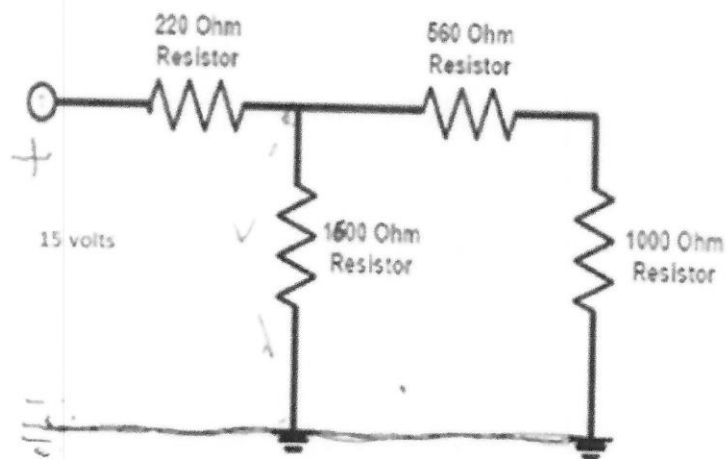
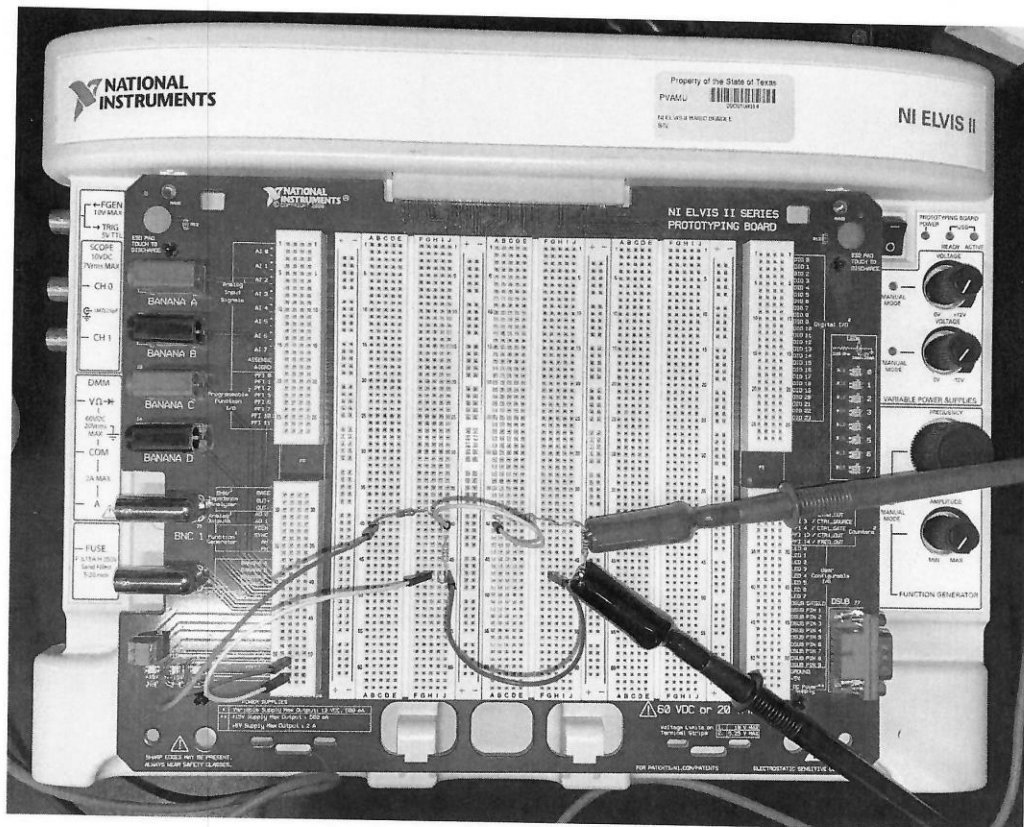


Figure 1



Answers to Questions:

From your observation of this DC series/parallel circuit will the voltage across 1000Ω resistor and 1600Ω resistor be the same or different? Different. While voltage is equivalent across a parallel circuit, there's a voltage drop across the 560Ω resistor.

How do the measured currents compare with your calculated currents? The values are similar with a slight margin for error.

Does the total power supplied equal the total power dissipated by the resistors? No

Conclusion:

The experiment verified that resistance can be determined in a multitude of ways and with that there are plenty of ways to make efficient circuits by combining series and parallel circuits. Determining that resistance can be found in more than one way and can be proven by Ohm's Law.

Below Average

ELECTRICAL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY
ELEG-2101

- How was $R_t = 978.6$ derived
- Predicted values and measured values are vastly different
- Power values?



Course Name: Electric Circuits Laboratory

Course #: ELEG 2011

Lab 4: Series and Parallel Circuits

Lab 04: Series and Parallel Circuits

Lab Instructor: Dr. John Fuller

Date of Performance: _____

Name

Date

Instructor Signature

Jarrell Reynolds

02/15/2022

[Signature]

Cymon Shy

02/15/2022

[Signature]

Jarrell Reynolds / Cymon Shy

Digital Multimeter

Ten 0.47 k Ω resistors having the same tolerance.

Ten 0.18 k Ω resistors having the same tolerance.

Part A: Resistance Measurements.

Procedure:

1. On a board construct the DC series/parallel circuit in Figure 1.
2. (For Resistors in series and parallel.) Measure the voltage of each resistor
3. Using the measured values of the resistors, calculate the total equivalent resistance, R_T , as seen by the source.
4. (DC series/parallel circuit analysis.) Using Kirchhoff's current law, Ohm's law, and current divider rule calculate the currents indicated in figure 2. Use your measured resistances for this calculation.
5. Draw on figure 2 the direction of the conventional current flow and indicate the voltage polarities across the resistors and the DC voltage source.
6. Verify DC series/parallel circuit analysis. Use the DMM to measure the currents: I_T , I_1 , and I_2
7. Use your measured CURRENT and RESISTANCE values to predict the voltage drop across each resistor.
8. Use the DMM to measure the voltage drop across each resistor.
9. Voltage Divider Rule.
10. Use the voltage divider rule to verify your measured $V_{1000\text{-}Ohm}$.
11. Compute the real power ($P = I V$, $P = I^2 R$, and $P = V^2 / R$). Use your measured current, voltage, and resistor values to compute the power supplied by the DC power source and the total power dissipated by the 220-Ohm, 560-Ohm, 1000-Ohm, and 1500-Ohm resistors.

Questions & Answers:

From your observation of this DC series/parallel circuit will the voltage across 1000-0 resistor and 1500-0 resistor be the same or different? _____

Why?

How does these measured currents compare with your calculated currents? _____

Does the total power supplied equal the total power dissipated by the resistors? ____yes____

Data and Results

☐ Measure the voltage of each resistor

	Measured resistor values		Measured resistor values
220- Ω	211	560- Ω	556
1500- Ω	1487	1000- Ω	979

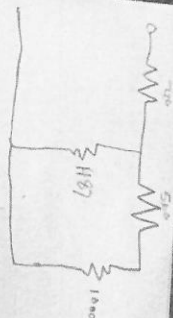
☐ Using the measured values of the resistors, calculate the total equivalent resistance, R_T , as seen by the source.

965

$$R_T = \underline{978.6}$$

	Calculated current values
I_T	0.11
I_1	0.054
I_2	0.056

	Measured current values
I_T	15.50 mA
I_1	7.74 mA
I_2	7.76 mA



$$979 + 566 = 1539$$

$$\frac{1500(1539)}{1500 + 1539} = 759.6$$

$$759.6 + 219 = 978.6$$

ASSIGNMENTS FOR OUTCOME 1.2

knowledge of the use of modern engineering tools such as digital meters, digital scopes and simulation tools

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Circuits Laboratory
FALL 2021
Instructor: Dr. John Fuller**

Title of Assignment

Lab 5 Ohms Law and Kirchoffs Law

Outcome Measured Using this Assignment

Outcome 1.2

knowledge of the use of modern engineering tools such as digital meters, digital scopes and simulation tools

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
X	includes many component parts or sub-problems
	involves multiple disciplines
X	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
	science
X	mathematics

This lab experiment solidifies the student knowledge of the basic circuit laws, the various methods of circuit analysis and laboratory equipment to measure voltages, currents and power.

Above Average

Very Good

Electric Circuits Laboratory

Course #: ELEG 2101

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

Hummad Ahmed

Rommel Jones

March 15, 2022

March 08, 2022

Department of Electrical and Computer Engineering

Prairie View A&M University

Objectives:

- Measurement of voltage, current, and resistance through the multimeters provided.
- Proficiency using the Percent Difference equation and comparing results between theoretical and experimental.
- Review the calculations of currents and voltage through Ohm's Law
- Review the calculation of total power supplied and total power dissipated.

Introduction/Theory:

This week's lab offers a review of voltage and current measurements in the first part of the experiment, as well as the supplying of power after finding values in the second part. The beginning section tests the students in their knowledge from previous labs to apply the basic formula and building of circuit, granting them familiarity with the equipment and methods. Moreover, the next section challenges them in constructing a more complex circuit and gathering the multimeter and calculated values into the same equations but in different applications.

Equipment:

- DC Power Supply
- Digital Multimeter
- Four resistors with the same nominal value of 10 ohms

Procedure:

Part A:

- Before building the circuit, the first step was to calculate the current through the 10,000 ohms resistor using Ohm's Law. By using the voltage as 5 volts and a resistor as 10,000 ohms, we were able to find the current of 0.0005 amps (our theoretical value).
- The biggest move after finding this theoretical value is finding the voltage and resistance measurements of Figure 1 after assembling the circuit. With the multimeter, we were able to get the actual resistance of the 10,000 ohms resistor (98,800 ohms), as well as the actual voltage of the circuit (4.96 volts).
- After collecting the information from above, we were able to calculate the current which acts as an experimental value. By using Ohm's Law ($V = IR$), 0.502 milliamps were calculated and confirmed as the answer.
- With the experimental value from 2c, as well as the theoretical value from 1, we can plug in the answers received into the percent difference formula, giving us 0.4%.
- The last step was to implement the measured current value found (0.49 milliamps) into the percent difference formula with the original theoretical value. Doing so allows us to obtain a distinction of 2%.

Part B:

- Using four 10,000-ohm resistors, the testers were told to build the circuit in Figure 2 on the protoboard. Before applying power to the circuit though, we adjusted the supply to 15 volts instead of 12 and ensured the wires of proper length were applied.
- After constructing the circuit board and having it guided by Professor Fuller, the usage of a multimeter was demanded in measuring the DC voltage across each circuit element. This allowed us to find values of 9.36 volts, 6.22 volts, 3.11 volts, and 3.11 volts.
- Having the voltages passing through all four resistors gives us the opportunity to calculate the values for all the indicated currents with Ohm's Law (0.936 milliamps, 0.622 milliamps, 0.311 milliamps, and 0.311 milliamps).
- Following the process of nodal analysis, we were directed to use Kirchoff's Current Law to indicate the directions of currents for nodes 1-3, as well as Kirchoff's Voltage Law to demonstrate the three loops in the circuit. These can be shown in the Attachment section on 1c and 1d.
- To end the entire experiment, we needed to determine the power absorbed or delivered by all circuit elements using the Law of Conservation of Power (proving that power is balanced for the circuit). We ended up with -14.04 milliwatts, 8.76 milliwatts, 3.87 milliwatts, 0.967 milliwatts, and 0.967 milliwatts.

Circuit Diagram:

Figure One:

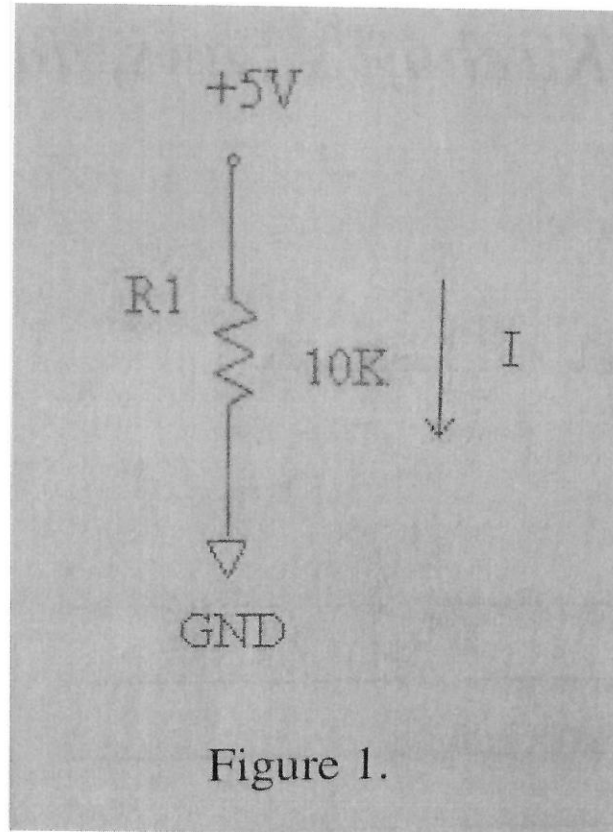
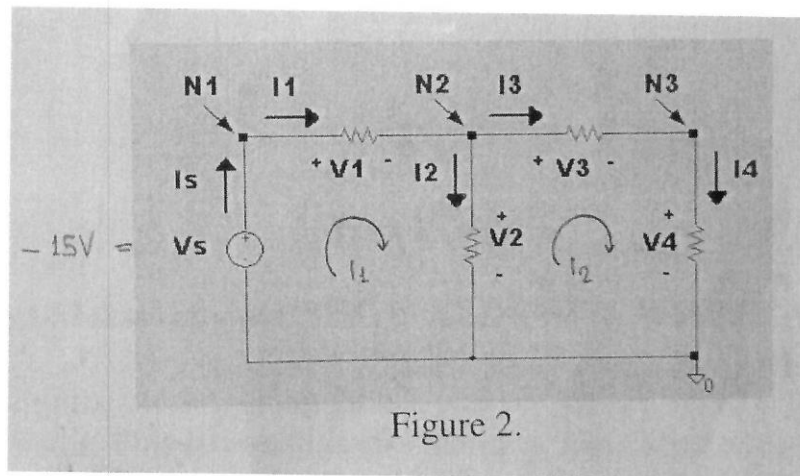


Figure 1.

The following figure is of a circuit with a resistor of 10 kilohms, a voltmeter of 5 volts, and an unknown current passing through as it approaches the ground. We will be using this to find the measured value of the current and then compare it with the experimental value through the percent difference formula.

Figure Two:



The second figure is surrounded by three nodes and has four resistors (2 in series and 2 in parallel) of 10 ohms; moreover, the voltmeter at the origin is sending out 15 volts and the ground is placed at the end.

Answer to the Question:

- **Q:** What reasons can you think of that may explain why your experimental values for I were different than your theoretical values?
- **A:** The theoretical values were based on the calculations we made, which are exactly accurate and require precise equations to get results. The experimental values, however, give meticulous answers by using the engineering tools and circuit board but human errors can arise, allowing for some inaccuracy in results.

Conclusion:

In conclusion, the objective of the lab was to master the employment of Kirchoff's Current Law, Kirchoff's Voltage Law, Ohm's Law, and the Law of Conservation of Power. A circuit was constructed using a schematic design of two given figures (prototyping boards) and then observed using different formulas and tools. Using the given sums causes the testers to better their understanding of these mathematical principles while the transformation of schematic designs to real component connections grants us expertise in wiring and composing.

Discussion and Contribution:

This experiment tested the contributors directly in their computing skills through challenging equations and experimental learning through the innovative assembly of circuits. The tasks of this lab were delegated in the following ways:

- Hummad: Constructed the electric circuits for part one and part two of the experiments, correctly setting up the resistors and power supply. This would then be used to find the measured values of the currents and voltage with the multimeter.
- Rommel: Found all the calculations through the given equations (Ohm's Law, KCL, KVL, the Law of Conservation of Power) and then utilized the results to find the percent differences in part one and part two. Jotted down the measured values found with the multimeter and compared these results with the theoretical answers.

References:

What are "Series" and "Parallel" Circuits?: Series and Parallel Circuits. All About Circuits. (n.d.). Retrieved March 10, 2022, from <https://www.allaboutcircuits.com/textbook/direct-current/chpt-5/what-are-series-and-parallel-circuits/#:~:text=In%20a%20series%20circuit%2C%20all,sets%20of%20electrically%20common%20points.>

Power Calculations: Series and Parallel Circuits. All About Circuits. (n.d.). Retrieved March 10, 2022, from <https://www.allaboutcircuits.com/textbook/direct-current/chpt-5/power-calculations/>

Appendix

$$\% = \frac{\text{Experimental} - \text{Theoretical}}{\text{Theoretical}} * 100\%$$

The equation shown above is used to calculate the percentage error between experimental measured values and theoretical actual values. The error can be expressed as an absolute error or as a relative error, which was implemented as an answer in Part 1 for D. and E.

Attachment

Calculations:

Part I

Voltage and Current Measurements. SHOW ALL UNITS WHERE APPLICABLE!

1. **Before** building the circuit, using Ohm's Law, calculate the current through the 10K ohm resistor. This is your theoretical value. **Give your answer in amps (A), milliamps (mA), and microamps (uA).** Show your work to the right of Figure 1. (1A = 1,000mA = 1,000,000uA)

9.88kΩ → resistor

- Ohm's Law: $V = I \cdot R \Rightarrow I = \frac{V}{R} = \frac{5V}{(10,000\Omega)} = 0.0005 \text{ Amps} = 0.5 \text{ mA}$

Before we started constructing the circuit, we were required to apply Ohm's Law into the first section as a means of calculating the current through the 10,000-ohm resistor. By substituting the voltage with 5 volts and the resistance with 10,000 ohms, we received an answer of 0.5 mA.

Voltage and current measurements.

a. Using a multimeter, measure the actual resistance of the 10K ohm resistor **(before building the circuit)**.

9.88kΩ

b. Build the circuit in Figure 1 on the protoboard. With the multimeter set to measure DC volts, measure the voltage across the resistor.

4.96 Volts

c. One method used to measure the current through a resistor is to use Ohm's Law. Using the data you collected from 2a and 2b, calculate the current, I, through the resistor. Express your answer in milliamps. This is your experimental value.

Ohm's Law: $V = I \cdot R \Rightarrow I = \frac{V}{R} = \frac{4.96V}{9,880\Omega} = 0.0005020243A = 0.502 \text{ mA}$

d. Calculate the percent difference between the value for I you obtained in 2c, and the theoretical value for I you calculated in problem 1. Write your answer here.

$\% = \frac{0.502 - 0.5}{0.5} \times 100 = 0.4\%$

In the following sections, we implemented different methods to find the requested answers:

- Measured the resistance of the 10,000-ohm resistor with the Multimeter prior to building the circuit. By connecting the strands with it, a value of 98,800 ohms was collected.
- The next demand was to construct the circuit on the protoboard (following the design of Figure One) and then measure the voltage across the resistor with the Multimeter (giving us a value of 4.96 volts).
- After gathering the necessary information to find current (4.96 volts and 98,800 ohms), we used those values and plugged them into Ohm's Law, giving us 0.502 mA.
- With the answer from c and the original value of 0.5 mA from the first question of the experiment, we were able to find the percent difference between these values with the percent error formula. The difference ended up being only 0.4 percent.

- Another method used to measure current through a resistor is to "break" your circuit, and insert the multimeter into it to complete the connection. Measure I using the multimeter. Write your answer here.

0.49 mA

- Calculate the percent difference between the value for I you obtained in 2e and the theoretical value for I you calculated in problem 1.

$$\left| \frac{0.49 - 0.5}{0.5} \right| \times 100 = 2\%$$

Part II

- Using 10K ohm resistors, build the circuit in Figure 2 on your protoboard. Take care to lay out your circuit neatly, using wires of proper length where needed. Before connecting power to your circuit, adjust your power supply to ~~12 volts~~ 15 volts. Have an instructor look over your circuit before you apply power to your circuit.
*Need 4 10K Ohm resistors

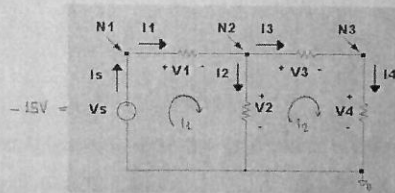


Figure 2.

- Using a multimeter measure the DC voltage across each circuit element.

$$V_1 = 9.36V \quad V_2 = 6.22V \quad V_3 = 3.11V \quad V_4 = 3.11V$$

- Using Ohm's Law, calculate the values for all the indicated currents in the circuit.

$$I_1 = \frac{9.36V}{10k\Omega} = 0.936mA \quad I_2 = \frac{6.22V}{10k\Omega} = 0.622mA \quad I_3 = \frac{3.11V}{10k\Omega} = 0.311mA$$

$$I_4 = \frac{3.11V}{10k\Omega} = 0.311mA$$

To finalize Part 1, we measured the current going through the resistor with the Multimeter (0.49 mA) and then substituted that into the percent difference equation with our original 0.5 mA answer, giving us a slightly larger answer of 2 percent. The next phase was starting the large protoboard in Part 2, and then finding the demanded calculations in the following steps:

- We needed to measure the DC voltage across each circuit element (two resistors were in series and two were in parallel), and the values we found were: $V_1 = 9.36$ volts, $V_2 = 6.22$ volts, $V_3 = 3.11$ volts, and $V_4 = 3.11$ volts.
- Now that we had the voltages of all the resistors and they had the same nominal value of 10,000 ohms, we could use Ohm's Law to calculate the values of their indicated currents, being: $I_1 = 0.936$ mA, $I_2 = 0.622$ mA, $I_3 = 0.311$ mA, and $I_4 = 0.311$ mA.

c. Using Kirchhoff's Current Law, write node equations for the currents entering and leaving Nodes 1, 2, and 3

$$\text{Node 1: } I_2 = I_1 \quad \text{Node 2: } I_1 + I_3 = I_2 \quad \text{Node 3: } I_4 = I_3$$

$$I_2 = 0.936 \text{ mA} \quad I_1 + I_3 = 0.936 \text{ mA} \quad 0.311 = 0.311 \text{ V}$$

d. Using Kirchhoff's Voltage Law, write loop equations for the three loops in the circuit.

Loop 1: $-V_1 + V_2 + V_3 = 0$

Loop 2: $-V_2 + V_3 + V_4 = 0$

e. Calculate the power delivered or absorbed by all circuit elements (P_s , P_1 , P_2 , P_3 , and P_4). Show that the Law of Conservation of Power is observed by showing that power is balanced for the circuit.

$$P_s = (-15 \text{ V})(0.936 \text{ mA}) = -14.04 \text{ mW}$$

$$P_1 = (9.36 \text{ V})(0.936 \text{ mA}) = 8.76 \text{ mW}$$

$$P_2 = (6.22 \text{ V})(0.622 \text{ mA}) = 3.87 \text{ mW}$$

$$P_3 = (3.11 \text{ V})(0.311 \text{ mA}) = 0.967 \text{ mW}$$

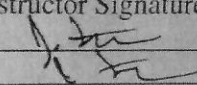
$$P_4 = (3.11 \text{ V})(0.311 \text{ mA}) = 0.967 \text{ mW}$$

Question:

In the last section of the experiment, we focused on using the Kirchhoff's Laws and the Law of Conservation of Power ($P = VI$). The KCL and KVL equations were used to figure out the steps of the nodal process and ensure the currents and voltage were accurate; as for the power delivered and absorbed, we were given the following results:

$$P_s = -14.04 \text{ mW}, P_1 = 8.76 \text{ mW}, P_2 = 3.87 \text{ mW}, P_3 = 0.967 \text{ mW}, \text{ and } P_4 = 0.967 \text{ mW}.$$

Signatures:

Lab Instructor: Dr. John Fuller		
Date of Performance: 03/01/2022		
Name	Date	Instructor Signature
Ramona Jones	03/08/2022	
Humayun Ahmed	03/08/2022	

Average

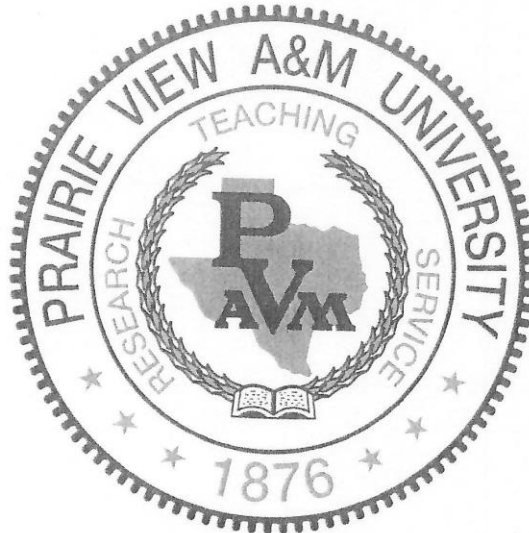
Department of Electrical and Computer Engineering

Prairie View A&M University

Electric Circuits Laboratory

ELEG 2011

Experiment #5 Ohm's Law, Kirchoff's Laws, and Conservation of
Power



Jade Grant
Lauren Allen
Tempest Lacy

Date of Submission: 03/08/22
Date of Performance: 03/22/2022

No sign off attached

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

Lab Instructor: Dr. John Fuller

Date of Performance: _____

Name	Date	Instructor Signature
Lauren Allen	03/08/2022	*Last Page*
Jade Grant	03/08/2022	
Tempest Lacy	03/08/2022	

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

Part I

Voltage and Current Measurements. SHOW ALL UNITS WHERE APPLICABLE!

1. **Before** building the circuit, using Ohm's Law, calculate the current through the 10K ohm resistor. This is your theoretical value. **Give your answer in amps (A), milliamps (mA), and microamps (uA).** Show your work to the right of Figure 1. (1A = 1,000mA = 1,000,000uA)

$$\begin{aligned} V &= 1\text{K} \\ I &= \frac{V}{R} \\ I &= \frac{5\text{V}}{10\text{k}\Omega} \\ I &= 0.5\text{mA} \end{aligned}$$

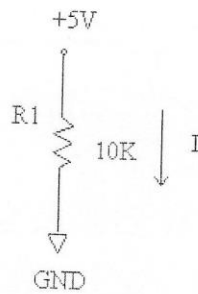


Figure 1.

2. Voltage and current measurements.

- a. Using a multimeter, measure the actual resistance of the 10K ohm resistor **(before building the circuit)**.

9.82kΩ

- b. Build the circuit in Figure 1 on the protoboard. With the multimeter set to measure DC volts, measure the voltage across the resistor.

5.00V

- c. One method used to measure the current through a resistor is to use Ohm's Law. Using the data you collected from 2a and 2b, calculate the current, I, through the resistor. Express your answer in milliamps. This is your experimental value.

$$I = \frac{5V}{9.82k\Omega} \quad I = 0.51mA$$

- d. Calculate the percent difference between the value for I you obtained in 2c, and the theoretical value for I you calculated in problem 1. Write your answer here.

$$\frac{0.5\text{mA} - 0.5\text{mA}}{0.5\text{mA}} \times 100 = 1.96\%$$

$$\% = \frac{\text{Experimental} - \text{Theoretical}}{\text{Theoretical}} \times 100\%$$

- e. Another method used to measure current through a resistor is to "break" your circuit, and insert the multimeter into it to complete the connection. Measure I using the multimeter. Write your answer here.

0.5mA

- f. Calculate the percent difference between the value for I you obtained in 2e and the theoretical value for I you calculated in problem 1.

$$\frac{0.5\text{mA} - 0.5\text{mA}}{0.5\text{mA}} \times 100 = 0\%$$

Part II

3. Using 10K ohm resistors, build the circuit in Figure 2 on your protoboard. Take care to lay out your circuit neatly, using wires of proper length where needed. Before connecting power to your circuit, adjust your power supply to 12 volts. Have an instructor look over your circuit before you apply power to your circuit.

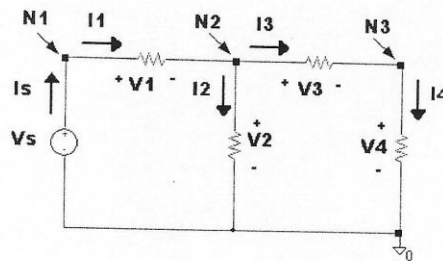


Figure 2.

- a. Using a multimeter measures the DC voltage across each circuit element.

$$\begin{array}{lll} V_1 = 9.36V & V_3 = 3.11V & V_5 = 15.63V \\ V_2 = 6.24V & V_4 = 3.12V & \end{array}$$

- b. Using Ohm's Law, calculate the values for all the indicated currents in the circuit.

$$\begin{array}{lll} \text{circuit. } I_3 = \frac{15.63V}{10k\Omega} = 1.563mA & I_1 = \frac{9.36V}{10k\Omega} = 0.936mA & I_2 = \frac{6.24V}{10k\Omega} = 0.624mA \\ I_4 = \frac{3.11V}{10k\Omega} = 0.311mA & I_5 = \frac{3.12V}{10k\Omega} = 0.312mA & \end{array}$$

- c. Using Kirchhoff's Current Law, write node equations for the currents entering and leaving Nodes 1, 2, and 3.

$$\begin{array}{ll} N_1: I_3 = I_1 & N_2: I_3 = I_4 \\ N_1: I_1 = I_2 + I_3 & \end{array}$$

- d. Using Kirchhoff's Voltage Law, write loop equations for the three loops in the circuit.

$$\begin{array}{ll} \text{the circuit. } -V_5 + V_1 + V_2 = 0 & -15.63 + 9.36 + 6.24 = -0.03 \\ -V_2 + V_3 + V_4 = 0 & -6.24 + 3.11 + 3.12 = -0.01 \end{array}$$

- e. Calculate the power delivered or absorbed by all circuit elements (P_s , P_1 , P_2 , P_3 , and P_4). Show that the Law of Conservation of Power is observed by showing that power is balanced for the circuit.

$$\begin{array}{l} \text{by showing that power is balanced for the circuit.} \\ P_s = 15.63V \times 1.563 = 24.43W \quad P_4 = 3.12V \times 0.312 = 0.973W \\ P_1 = 9.36V \times 0.936 = 8.76W \\ P_2 = 6.24V \times 0.624 = 3.89W \\ P_3 = 3.11V \times 0.311 = 0.967W \end{array}$$

Conclusions Question:

1. What reasons can you think of that may explain why your experimental values for I were different from your theoretical values?

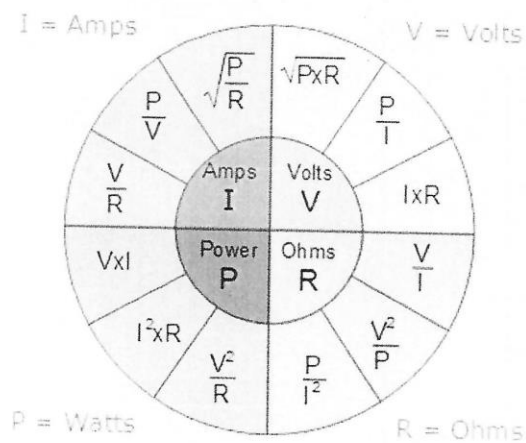
The theoretical value is completely based on calculation, but the experimental value is done with the help of a circuit which is connected by us. When we measure the current value it has to pass through the composed present in the circuit. Loose connection decides error in the measurements. These are the main reasons for the difference between theoretical and experimental value.

Discussion and Contribution:

While performing the lab, we did run into a few problems. The most impactful error we encountered was measuring by using the correct equations. Our group measured the given values by placing them in an equation. We quickly understood the problem and redirected to the correct method for each value in the equation. We also ran into minor issues that could have been avoided such as using the wrong values. Although they were misconstrued, we should have still double checked our errors as we went along.

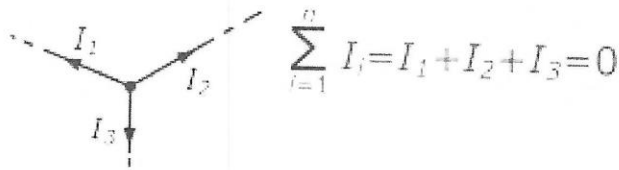
Each group member contributed the exact amount of work into the lab. We all made sure that each of us took turns using the breadboard as well as typing the lab report.

Appendix:



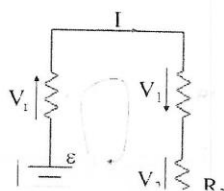
First Kirchhoff Law

The sum of all currents leaving a node in any electrical network is always equal to zero.



Kirchhoff's Voltage Law (KVL)

The algebraic sum of voltages around a closed loop must be zero



1. Draw current direction (arbitrary) and label the voltage direction (determined by the defined current direction). Voltage on a voltage source is always from positive to negative end.
2. Define either clockwise or counterclockwise direction as voltage

Below Average

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

Lab Instructor: Dr. John Fuller

Date of Performance: 3/8/22

Name	Date	Instructor Signature
<u>Jasmine Bland</u>	<u>3/8/22</u>	<u>[Signature]</u>
<u>Jordan Owens</u>	<u>3/8/22</u>	<u>[Signature]</u>

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

Lab 5: Ohm's Law, Kirchoff's Laws, and Conservation of Power

- No graph of current voltage
- poorly presented calculations

Part I

Voltage and Current Measurements. SHOW ALL UNITS WHERE APPLICABLE!

1. Before building the circuit, using Ohm's Law, calculate the current through the 10K ohm resistor. This is your theoretical value. Give your answer in amps (A), milliamps (mA), and microamps (uA). Show your work to the right of Figure 1. (1A = 1,000mA = 1,000,000uA)

$$\begin{aligned} V &= IR \\ I &= \frac{V}{R} \\ R &= \frac{V}{I} \end{aligned} \quad \begin{aligned} (10)(.5) &= 10 \\ \frac{10}{20} &= I = .5 \text{ mA} \\ \frac{10}{.5} &= R = 20 \text{ k}\Omega \end{aligned}$$

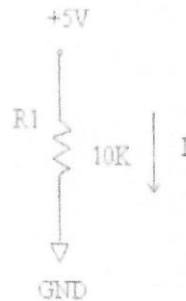


Figure 1.

2. Voltage and current measurements.

- a. Using a multimeter, measure the actual resistance of the 10K ohm resistor (before building the circuit).

$$R = 9.85 \Omega$$

- b. Build the circuit in Figure 1 on the protoboard. With the multimeter set to measure DC volts, measure the voltage across the resistor.

$$V = 4.97 \text{ V}$$

- c. One method used to measure the current through a resistor is to use Ohm's Law. Using the data you collected from 2a and 2b, calculate the current, I , through the resistor. Express your answer in milliamps. This is your experimental value.

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

$$I = 0.504 \text{ A}$$

- d. Calculate the percent difference between the value for I you obtained in 2c, and the theoretical value for I you calculated in problem 1. Write your answer here.

$$\frac{0.504 - 0.5}{0.5} \cdot 100 = 0.8\% \text{ Percent error}$$

$$\% = \frac{\text{Experimental} - \text{Theoretical}}{\text{Theoretical}} * 100\%$$

- e. Another method used to measure current through a resistor is to "break" your circuit, and insert the multimeter into it to complete the connection. Measure I using the multimeter. Write your answer here.

4.97 mA

- f. Calculate the percent difference between the value for I you obtained in 2e and the theoretical value for I you calculated in problem 1.

$$\frac{4.97}{5.00} \cdot 100 = 0.6\%$$

Part II

3. Using 10K ohm resistors, build the circuit in Figure 2 on your protoboard. Take care to lay out your circuit neatly, using wires of proper length where needed. Before connecting power to your circuit, adjust your power supply to 15 volts. Have an instructor look over your circuit before you apply power to your circuit.

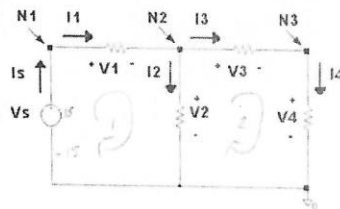


Figure 2.

- a. Using a multimeter measure the DC voltage across each circuit element.

$$V_1 = 4.38 \text{ kV} \quad V_3 = 3.13 \text{ kV}$$

$$V_2 = 6.25 \text{ kV} \quad V_4 = 3.12 \text{ kV}$$

- b. Using Ohm's Law, calculate the values for all the indicated currents in the circuit.

$$I = \frac{V}{R} \quad I_1 = \frac{V}{R} = \frac{4.38}{10 \text{ k}\Omega} = 0.438 \quad I_3 = \frac{V}{R} = \frac{3.13}{10} = 0.313$$

$$I_2 = \frac{V}{R} = \frac{6.25}{10 \text{ k}\Omega} = 0.625 \quad I_4 = \frac{V}{R} = \frac{3.12}{10} = 0.312$$

- c. Using Kirchhoff's Current Law, write node equations for the currents entering and leaving Nodes 1, 2, and 3.

$$i_3 = i_1 \quad 9.38 = 9.38$$

$$i_1 = i_2 + i_3 \quad 9.38 = 6.25 + 3.13 \Rightarrow 9.38 = 9.38$$

$$i_3 = i_4 \quad 3.13 = 3.12$$

- d. Using Kirchhoff's Voltage Law, write loop equations for the three loops in the circuit.

$$\begin{aligned} > -15.66V + 9.38 + 6.25 = 0 \\ & 0.03 = 0 \end{aligned}$$

$$\begin{aligned} & -6.25 + 3.13 + 3.12 = 0 \\ & 0 = 0 \end{aligned}$$

- e. Calculate the power delivered or absorbed by all circuit elements (P_s , P_1 , P_2 , P_3 , and P_4). Show that the Law of Conservation of Power is observed by showing that power is balanced for the circuit.

$$P_{\text{delivered}} = V_s \cdot I_3 = 15.66 \cdot \frac{0.938}{10} = 14.69 \text{ mW}$$

Question:

1. What reasons can you think of that may explain why your experimental values for I were different than your theoretical values?

Within the experiment, the calculated value can be assumed a guaranteed value while the experimental values have a percent error. However, due to percentage error because of worn out resistors, the calculated values don't add up to the measured values of the resistors.

Outcome 1.3

Students are able to use modern engineering tools
and have competency in the use of simulation tools

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Circuits Laboratory
FALL 2021
Instructor: Dr. John Fuller**

Title of Assignment

**Experiment 9
Op Amp Circuits**

Outcome Measured Using this Assignment

Outcome 1.3

Students are able to use modern engineering tools and have competency in the use of simulation tools

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
X	includes many component parts or sub-problems
	involves multiple disciplines
X	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
	science
X	mathematics

This Laboratory experiments gives the student experimentation and advanced circuit analysis on electronic circuits such as the op-amp circuit. Demonstrate the use of software tools to simulate complex engineering problems such as Op Amp circuits and RC, RL, RLC circuits

Student Sample Material

Above Average

Electric Circuits Laboratory

Course #: ELEG 2101

Lab 9: Op Amp Circuits

Hummad Ahmed

Rommel Jones

Adrienne Ramos

May 03, 2022

April 26, 2022

Department of Electrical and Computer Engineering

Prairie View A&M University

Purpose:

The purpose of this lab is to demonstrate how the operational amplifier is used in practical electrical engineering circuit applications and build on our experience in using them through experimentation.

Objectives:

- Use Multisim to complete the Integrator and Differentiator parts of the lab.
- The fulfillment of the overhead sections is to be added to the Op-Amp Inverter circuit.
- Understand how to use software to simulate an electrical circuit through multisim
- Calculate the voltages and currents dissipated in the resistors and capacitors.

Introduction/Theory:

This lab introduces the operational amplifier or "op amp". The circuit is already constructed on a single IC (integrated circuit) and in this lab, we will use the IC in several of its most popular configurations.

Equipment:

- Solderless Breadboard
- Cables and Wires
- Decade Capacitor Box
- Several Watt Resistors
- IC Operational Amplifier
- 15V Batteries of positive and negative values

Procedure:Inverting Amplifier

- The pinout diagram for the LM741 op amp IC is shown in figure 1. Use this to construct the inverting op amp circuit shown in figure 2.
- At first, use $R_1 = 1\text{k}\Omega$ and $R_2 = 33\text{k}\Omega$. Derive the gain formula $A_v = -R_2/R_1$ and experimentally verify the gain for a 100Hz sine wave.
- Also calculate and measure the gain with $R_2 = 10\text{k}\Omega$ and $R_2 = 100\text{k}\Omega$.

Noninverting Amplifier

- Construct the noninverting amplifier shown in figure 3 with $R_1 = 1\text{k}\Omega$ and $R_2 = 33\text{k}\Omega$. It is important to derive and experimentally verify the gain relation for the report.

Current-to-Voltage Converter

- An op amp can be used to produce a voltage proportional to a given current. Construct the circuit in figure 4.

- Verify that $V_{out} = -I_{in}R_2$ for this circuit. (That is, do the following for several voltage settings on the variable power supply: Measure the supply voltage and from this calculate I_{in} . Use the formula to calculate a theoretical V_{out} and compare this to a measured V_{out} .)
- Now, replace the current source with a photodiode as shown in figure 5.

Integrator

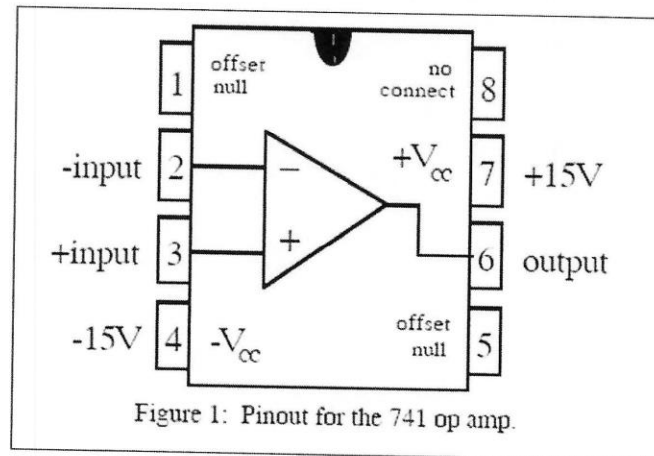
- Construct the integrator shown in figure 6. Sketch the input and output waveforms for 1kHz sine wave, triangle wave, and square wave inputs.
- Try to guess what each waveform will look like ahead of time. As the report is being drafted, include the designs, and show that the output waveform is indeed the integral of the input waveform.

Differentiator

- Construct the differentiator circuit in figure 7. Sketch the input and output waveforms for a 1kHz sine wave, triangle wave, and square wave input as for the integrator.
- For the report, included are the sketches of the circuits and a showing that the output waveform is indeed the derivative of the input waveform.

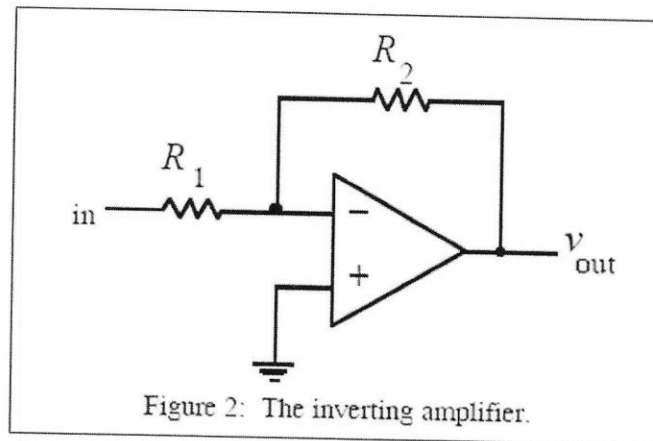
Circuit Diagram:

LM741 Operational Amplifier



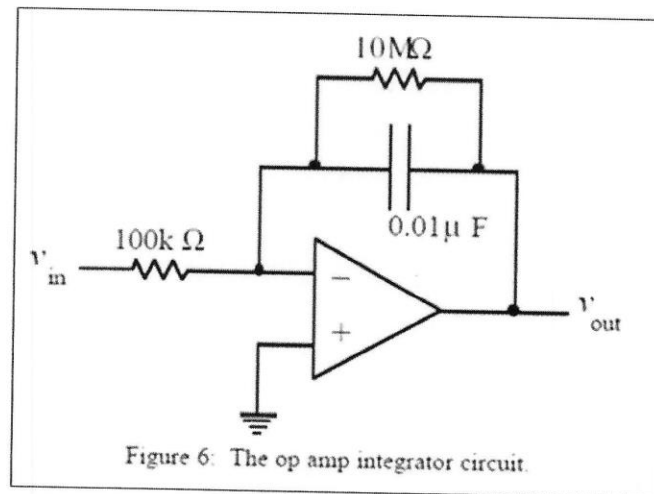
The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards. The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, freedom from oscillations, etc. In the case of the figure above, it is comprised of 8 pins and has a voltage source of 15 volts throughout the system.

Inverting Amplifier



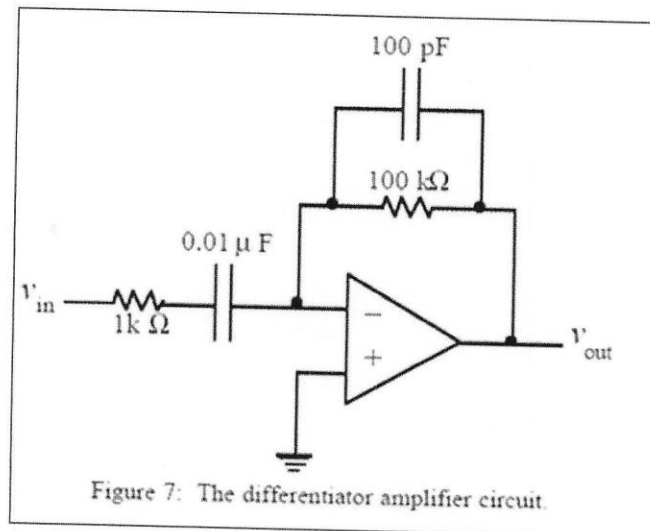
For this circuit, we use two external resistors to create feedback circuit and make a closed loop circuit across the amplifier. At first, we used $R_1 = 1\text{k}\Omega$ and $R_2 = 33\text{k}\Omega$ for the network but later, implemented $R_2 = 10\text{k}\Omega$ and $R_2 = 100\text{k}\Omega$ into the gain formula as well.

Integrator Circuit



The name "operational amplifier" came from this amplifier's ability to perform mathematical operations. Two good examples of this are the integrator and differentiator which perform the operations of integration and differentiation, respectively. Following its purpose, us testers were instructed to show that the output waveform is indeed the integral of the input waveform. And in this case, the resistors have varying values of $100\text{k}\Omega$ and $10\text{M}\Omega$, while the capacitor is $0.01\mu\text{F}$.

Differentiator Amplifier



Lastly, the differentiator (a type of electronic amplifier) is constructed in an analogous way to the integrator circuit, having the same kind of equipment but marked differently throughout the channels. For Figure 7, the lab wanted the testers to find out if the output waveform is indeed the derivative of the input waveform. Specifically, we have capacitors of 100pF and 0.01 uF, with resistors of 1kΩ and 100kΩ throughout the circuit.

Answer to the Question:

Q: Why is this (Figure Two) called an inverting amp?

A: It is considered this because it is an operational amplifier circuit with an output voltage that changes in the opposite direction as the input voltage. Essentially, it is out of phase by 180 degrees and the voltage course is not directed into the amplifier directly.

Q: What is it (the resistor not in the ideal integrator circuit) there for? What would integrating this constant do after a short time?

A: The practical integrator overcomes the limitations of an ideal integrator that uses a resistor in parallel with a capacitor. As for the integration process, because the capacitor is a frequency dependent element, the amount of charge that is established across the plates is equal to the time domain integral of the current. That is, it takes a certain amount of time for the capacitor to fully charge, as it can only charge exponentially.

Q: Why do you think it (the capacitor not in the ideal amplifier) is here? Could high voltages damage a chip or put a significant noise into the circuit?

A: For the capacitor being unideal, it is because an ideal op amp differentiator has too many disadvantages. For example. The gain of the differentiator increases as frequency increases, so the system would start to become unstable and break into the oscillations. Another fundamental reason is the input impedance would decrease as the frequency increases, causing the circuit to become extremely sensitive to noise. As a result, high voltages and frequencies are not to be used in integrated circuits.

Conclusion:

The operational amplifier, or “op-amp,” is a special electronic device that contains a multistage voltage amplifier. It was designed to be a building block device that could be conveniently used in a wide range of electrical engineering circuit applications where voltage amplifiers are required. The input/output characteristics of an op-amp are that of a differential amplifier but in the lab, the students’ operating exploration also revolved around an integrator and current-to-voltage converter.

Discussion and Contribution:

This week’s assignment was split off into the concrete technician process and the software enactment due to limited time. Because an extension was necessary to complete the circuit in time, the following students divided their work in the following ways...

- Rommel: Handled the calculations/experimental values needed in the specified circuits and took a foremost role in the draft groundwork.
- Hummad: Worked on the software assembly for the lab parts needing multism, designing intricate circuits according to the figures.
- Adrienne: Managed the assembly of the inverting amplifier and coordinated with other working students to verify the ensuing procedure.

References:

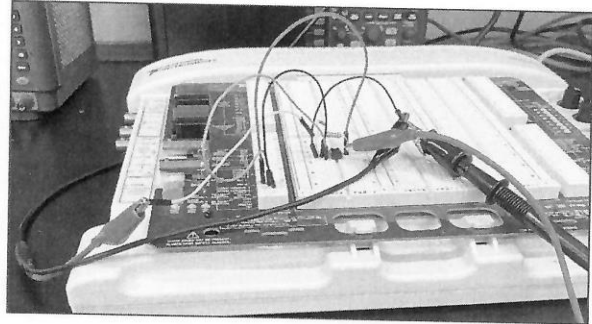
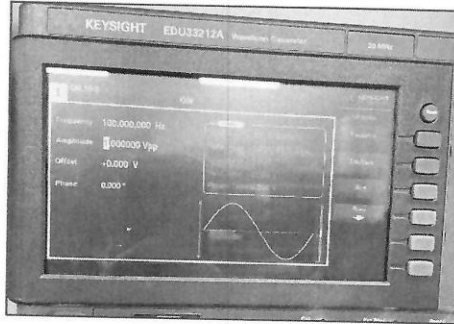
- RC integrator theory of a series RC circuit.* Basic Electronics Tutorials. (2022, March 30). Retrieved April 29, 2022, from <https://www.electronics-tutorials.ws/rc/rc-integrator.html>
- Saini, A. (2021, June 10). *Ideal differentiator by using op-amp: Circuit, analysis and applications.* EEEbooks4U. Retrieved April 29, 2022, from <https://eebooks4u.com/2021/06/10/ideal-differentiator-by-using-op-amp/>
- What are the limitations of ideal integrator?* Philosophy. (n.d.). Retrieved April 29, 2022, from <https://philosophy-question.com/library/lecture/read/71173-what-are-the-limitations-of-ideal-integrator>

Appendix

*No appendix listed in this week’s laboratory experiment

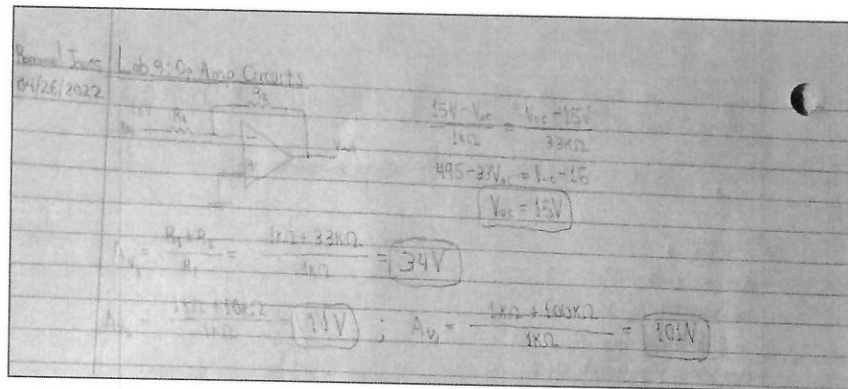
Attachment:

Circuit Designs

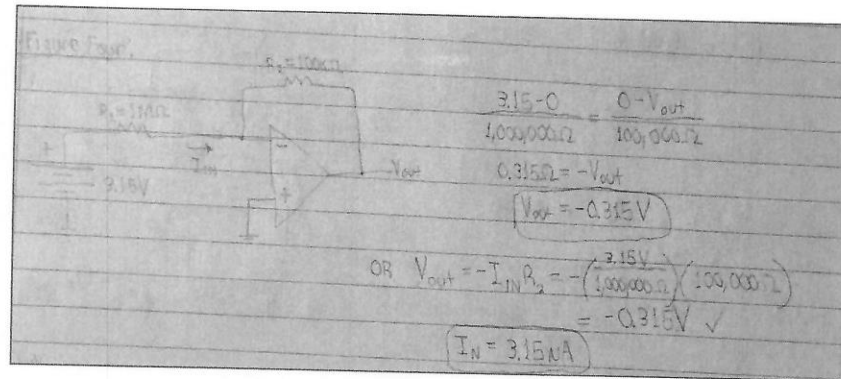


To complete the Integrator and Differentiator parts of the lab, multisim was necessary due to the ample tools it provided. These two parts were added to the completed Op-Amp Inverter circuit section that was finalized. As for the Non-Inverting Op-Amp, we were not required to submit the constructed design because there was an issue with the genesis.

Calculations



For the inverting amplifier, the testers were asked to use resistors 1 and 2 in the gain formula; this would give us the ratio of output voltage to input voltage of an amplifier. After finding the inceptive outcome, we needed to implement changes in the values of the second resistors twice for additional measured gains. In the end, we received answers of 34V, 11V, and 101V.



Furthermore, the fourth figure (current-to-voltage converter) asks us to verify that $V_{out} = -I_{in}R_2$ for this circuit. By following this formula with resistor 2 acting as $100,000\Omega$, the voltage turned out to be $-0.315V$. To ensure this was accurate, nodal analysis was generated with the starting voltage source being $3.15V$. In the end, our original answer was discerned to be correct, and no issues surfaced in our measurements either.

Signatures

Name	Date	Instructor Signature
Ammaad	4/26/22	gj
Romina	4/26/22	gj
Adrienne	4/26/22	gj

Average

Electric Circuits Laboratory ELEG 2011 Op Amp
Circuits

Akili Todman, Mohammed Khan, Hussein Hassan

DOS:5/10/22

DOP:5/3/22

Objective

- Learn about different varieties of Operational Amplifiers
- Understand how different parts can change how Operational Amplifiers work
 - Learn how to master the oscilloscope

Introduction

The point of this lab was to introduce the operational amplifier. We followed the circuits constructed for us from the lab. There are 7 different Op Amps we used in this lab. Inverting which is one of the main ones used in our Network Theory class it goes by the formula $(-R_f/R_1)V_{in} = V_{out}$. The next one is Noninverting which is the other main one used in our Network Theory class which goes by the formula $(1+R_f/R_1)V_{in}=V_{out}$. We use the Current to Voltage Converter as well which uses the formula $-I_{in}R_2= V_{out}$. The Integrator which uses AC power sources as well as the Differentiator.

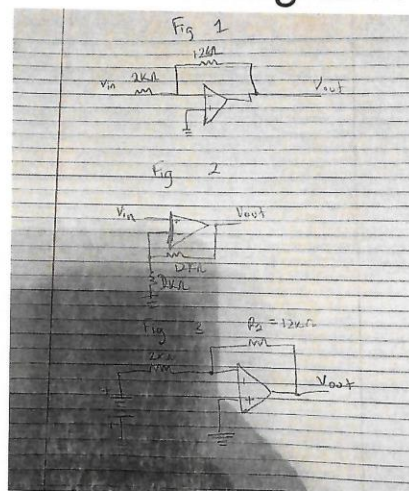
Equipment

- Multimeter
- Resistors
- Multisim
- Op Amps
- Capacitors
- Voltage Source

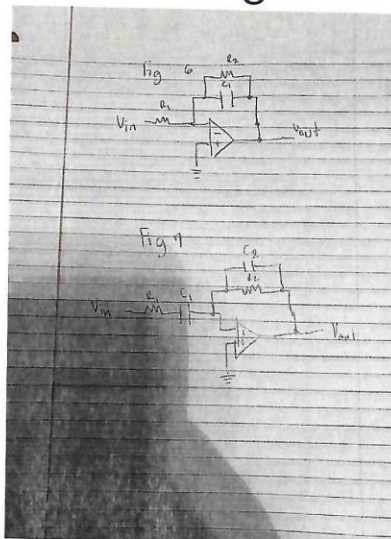
Procedure

1. Build Operational Amplifier
2. Test Vout for Op Amp
3. Test Current for Op Amp (if needed)
4. Use Oscilloscope for Op Amp (if needed)
5. Do theoretical data
6. Compare theoretical data with experiment data

Circuit Diagram P1



Circuit Diagram P2



Answer to the Question

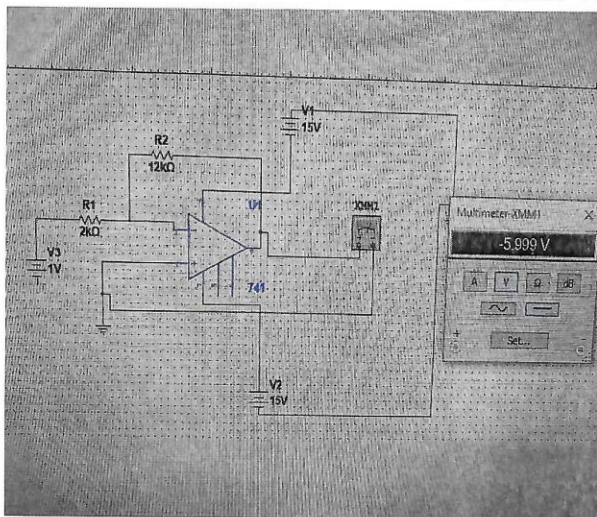
What would happen if you integrate a constant in a short period of time?

There would be a faster rate of voltage change hence why the oscilloscope waves are going faster from the output

Why is the 100 pF not an ideal capacitor?

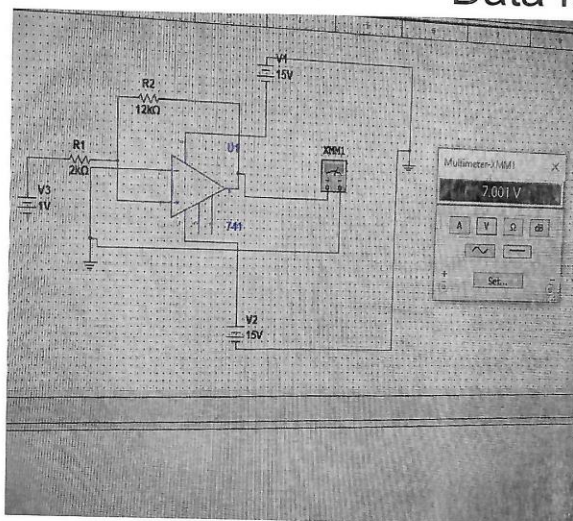
Because it is the derivative of the amplifier.

Data for Figure 2



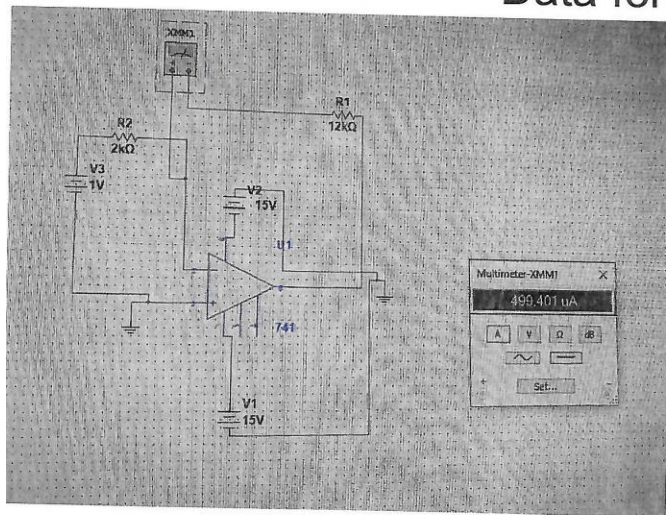
$$\left(\frac{-12}{2} \right) (1) = -6 = \frac{-R_F}{R_{in}} V_{in}$$

Data for Figure 3



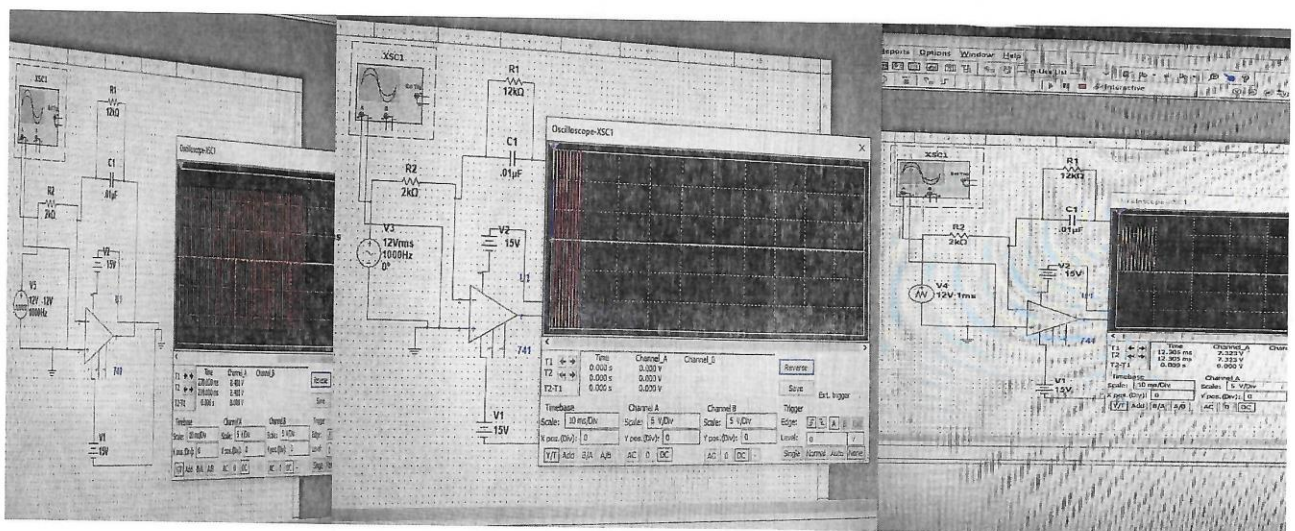
$$\left(1 + \frac{12}{20}\right)(1) = 7V$$

Data for Figure 4

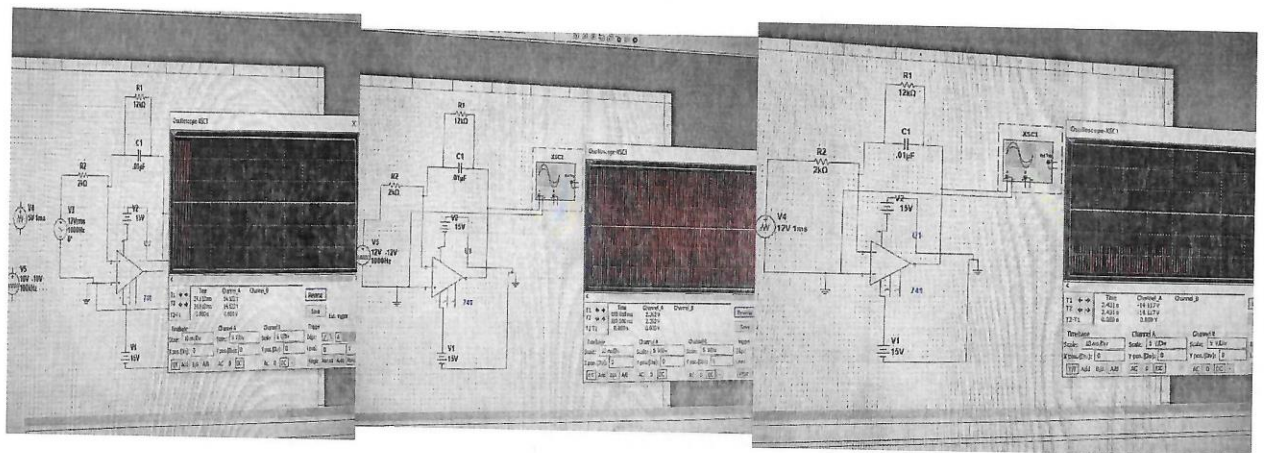


$$-6 = I_{in}(12,000)$$
$$\frac{-6}{12,000} = -0.0005 \text{ A}$$

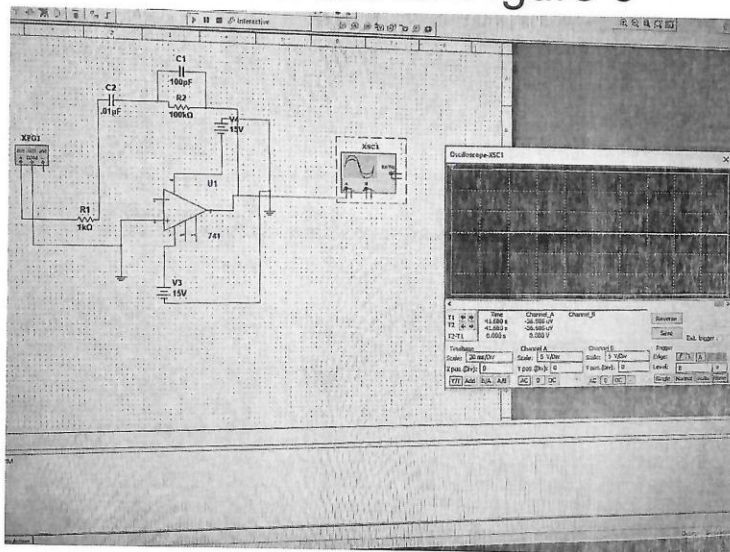
Data for Figure 5 inputs



Data for Figure 5 outputs



Data for Figure 6



Conclusion

Operational Amplifiers work in different ways depending on which one you are using. The common use of them is to amplify the voltage coming into the Op Amp. Through this lab we learn how to build op amp circuits. We also learn the different outputs created from those op amp circuits as well.

Contribution

We all worked on the different figures from the lab. Akili did the theoretical work, Hussein did the first part of the lab report while Mohammed did the ending part of the lab report. Akili did the circuit diagrams and gave them to us so we could put them in the report.

Outcome 1.3

Students are able to use modern engineering tools and have competency in the use of simulation tools

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Circuits Laboratory
FALL 2021
Instructor: Dr. John Fuller**

Title of Assignment

Experiment 10
RC Circuits

Outcome Measured Using this Assignment

Outcome 1.3

Students are able to use modern engineering tools and have competency in the use of simulation tools

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
X	includes many component parts or sub-problems
	involves multiple disciplines
X	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
	science
X	mathematics

Laboratory experiments up to this point has been related to DC sources with analysis using voltmeters and ammeters. Now they are introduced to time varying circuits. This laboratory experiment is directly related to course lectures on RC circuits and provide the students with a visual realization of in class calculations using actual signal generators and oscilloscopes

Student Sample Material

Above Average

**Electric Circuits Laboratory
ELEG 2101**

Lab 10: *RC Circuits*

Kaylin Williamson

Tarjae Hall

Jonae Whitaker

Time constants calculated incorrectly

Date of Submission: May, 2022

Date of Performance: May 3rd, 2022

**Department of Electrical and Computer Engineering
Prairie View A&M University**

Objective:

- In this lab we will be able to explore the behavior of an RC circuit by using the Multisim software

Introduction/Theory:

(i) Equations for Charging and Discharging of a Capacitor

For an RC circuit, the expression for charging the capacitor is given as:

$$V_C(t) = V_S \left(1 - e^{-\frac{t}{RC}} \right) + V_C(0) \quad (1)$$

and that for discharging of the capacitor is:

$$V_C(t) = V_C(0) e^{-\frac{t}{RC}} \quad (2)$$

where,

$V_C(0)$ = *initial voltage across the capacitor*

(ii) Square Wave Generator:

One can quickly charge and discharge a capacitor by using a function generator to generate the square wave. The output of function generator is shown in Figure 1. One can control the amplitude of the generator and the period T . The period and the repetition frequency are related by the expression $f = 1/T$.

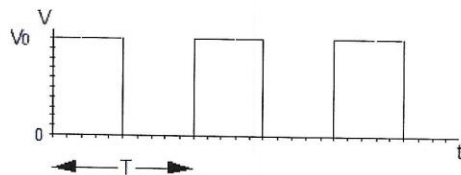


Figure 1: Output of Square-wave Generator

(ii) The Time Constant

For RC circuit, the time constant is given as $\tau = RC$. The time constant determines the rate of charging or discharging of a capacitor. After τ seconds, the voltage will have decreased to e^{-1} (about .368) of its initial value. After 2τ seconds, it will have decreased to e^{-2} (0.135) its initial value, and after 3τ seconds, the voltage will have decreased to 0.0067 of the initial value.

Pre-Lab Calculations

For a square wave generator, given the repetition frequencies shown in Table 1, determine the corresponding period.

Table 1 Frequency vs. Period of a Square-wave Generator shown in Figure 1

Number	1	2	3	4	5
Frequency (Hz)	100	500	1000	5000	10000
Period (s)					

For the RC circuit, shown in Figure 4, calculate the time constant for the various values of R and C, shown in Table 2.

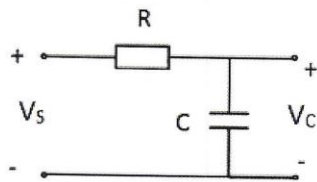


Figure 4: RC Circuit

Table 2: Time Constants of various RC Values of a Circuit

#	1	2
R	1000 Ω	1000 Ω
C	0.022 μF	1.0 μF
τ (s)		
5τ (s)		

Equipment:

- Multisim
- Waveform Generator
- 0.022 μF , and 1.0 μF Capacitors
- 1 K Ω resistor

Procedure/Circuit Diagram:

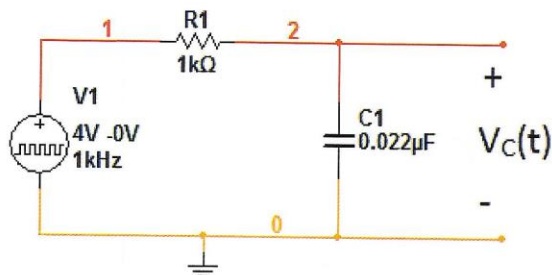


Figure 5: RC Circuit for Experiment

Step #1:

Build the Circuit:

Use breadboard to build the circuit shown in Figure 5. Connect AWG1 (yellow wire) to node 1 of the circuit. Also, connect Scope Channel 1 positive (orange wire) to node 1. In addition, connect the Ground (black wire) to node 0 of the circuit. Moreover, connect the Scope Channel 1 negative (orange-white wire) to node 0. Furthermore, connect Scope Channel 2 positive (blue wire) to node 2, and the Scope Channel 2 negative (blue-white wire) to node 0.

Step #2:

Generation of Square Wave:

Click on the WaveGen in the main WaveForms screen. Go to Basic → Square → Frequency (set to 1 KHz) → Amplitude (set to 2 V) → Offset (set to 2V) → Symmetry (set to 50%) → Click on “Run AWG1.”

Activation of Scope:

Click on the Scope in the main WaveForms screen. Go to Run → Autoset → Measure → Add → Channel 1 Vertical → Frequency → Add Selected Measurement → Close Add Instrument.

Make sure the transient waveform of $V_C(t)$ is clearly displayed while the capacitor is charging and discharging. *Hint: Click on the **AutoSet** button to automatically rescale the scope axes.*

Figure 6 shows the Digilent Analog Discovery WaveGen setup.

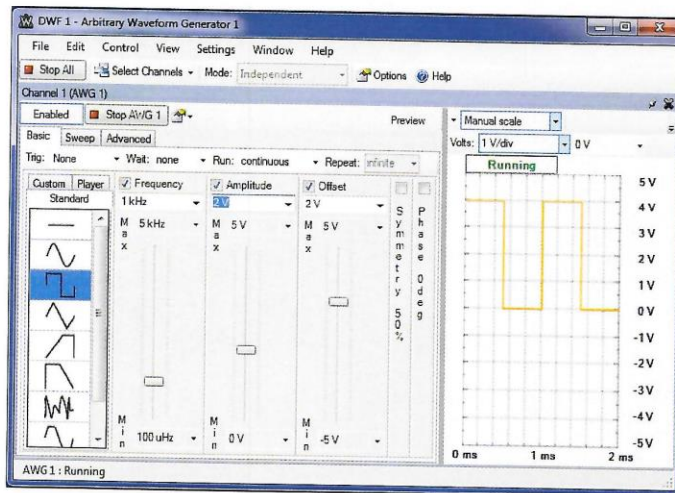


Figure 6: WaveGen Setup

Step 3:

Observe the input and output waveforms. The input and output waveforms are shown in Figure 7. Draw the input and output waveforms of the RC circuit (you can export the scope waveforms into a spreadsheet and plot the input and output waveforms). Measure the time constants of the charging and discharging of the capacitor.

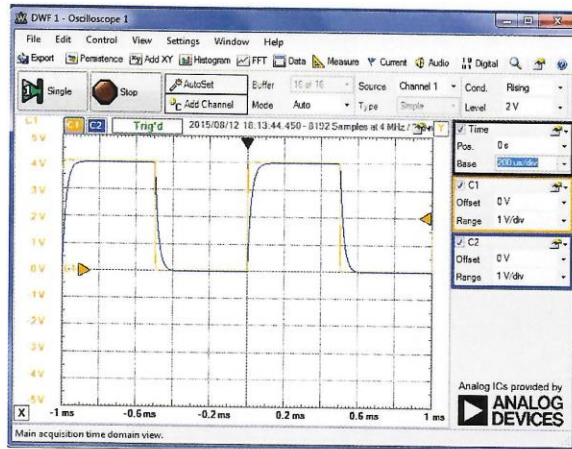


Figure 7: The Input and Output Waveforms

Step 4:

If the frequency of the square wave generator is increased to 10 KHz, while keeping the $R = 1\text{ K}\Omega$ and $C = 0.022\text{ }\mu\text{F}$, draw the input and output waveforms.

Step 5:

Replace the $0.022\text{ }\mu\text{F}$ capacitor by $1.0\text{ }\mu\text{F}$ capacitor, and keep the $R = 1\text{ K}\Omega$ and the frequency of the square wave at 1 KHz. Draw the input and output waveforms of the RC circuit.

Data and Results:

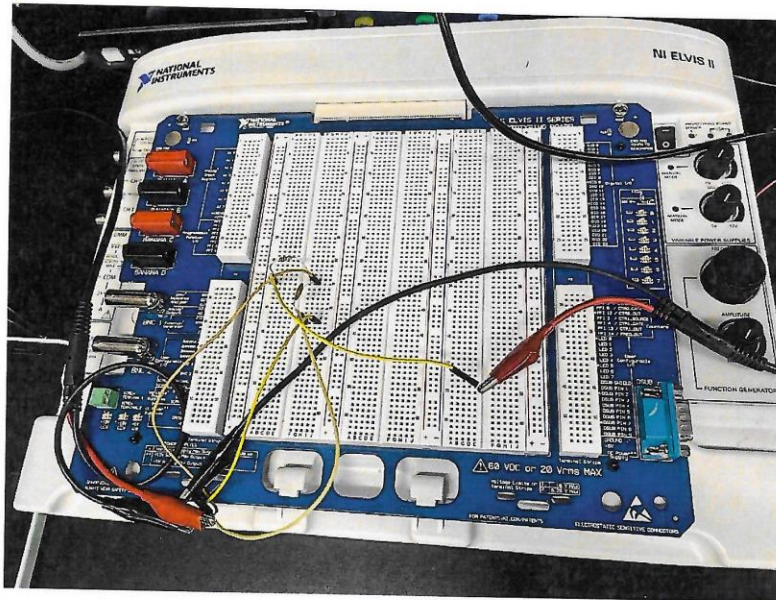
Table 1 Frequency vs. Period of a Square-wave Generator shown in Figure 1

Number	1	2	3	4	5
Frequency (Hz)	100	500	1000	5000	10000
Period (s)	0.1	0.002	0.001	2×10^{-4}	1×10^{-4}

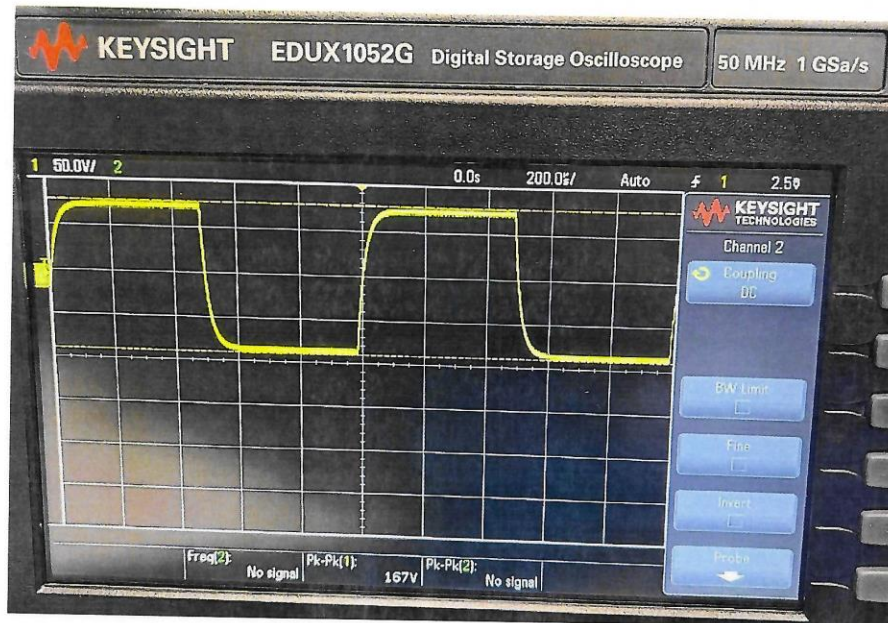
Table 2: Time Constants of various RC Values of a Circuit

#	1	2
R	$1000\text{ }\Omega$	$1000\text{ }\Omega$
C	$0.022\text{ }\mu\text{F}$	$1.0\text{ }\mu\text{F}$
τ (s)	22	1000
5τ (s)	110	5000

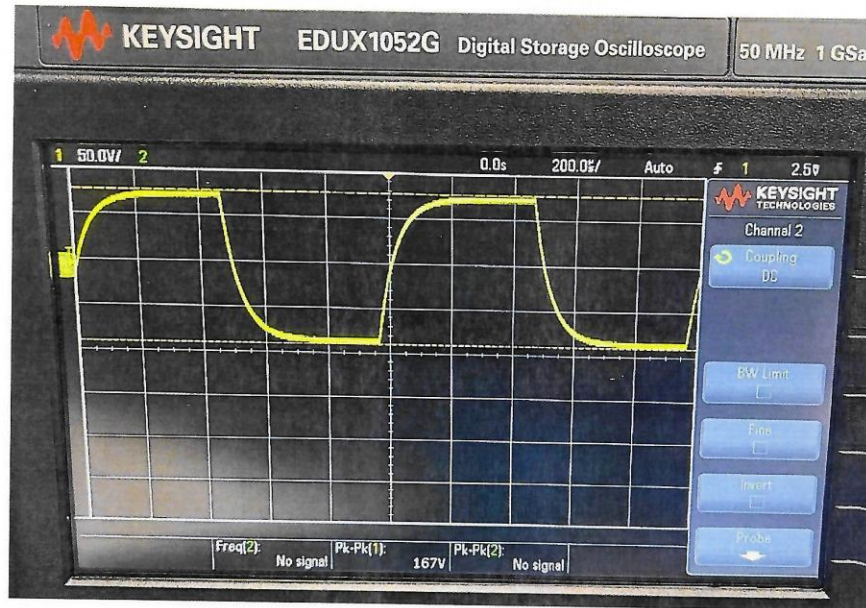
Set up



Wave One



Wave Two



Discussion and Contribution

(ii) Why is the output waveform obtained in Step #4 different from that of Step #3?

The capacitor in step 3 was smaller than the capacitor in step 4. The larger the capacitor the more curve of the RC wave

Conclusion

In conclusion, we were able to get a better understanding of the behavior of an RC circuit by using the Multisim software. We were able to understand that the difference between the capacitors will result in the difference of the waveforms. When we changed the size of the capacitor and used a larger one, we could see the difference within the curves of the waves that were being generated.

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 2301

LAB #10: RC CIRCUITS

Lab Instructor: Dr. John Fuller

Name	Date	Instructor Signature
<u>Indie Whitaker</u>	<u>5/3/22</u>	<u>[Signature]</u>
<u>Tarjae H</u>	<u>5/3/22</u>	<u>[Signature]</u>
<u>Kaylin W</u>		<u>[Signature]</u>

(A) Introduction:

In this laboratory, you will explore the behavior of an RC circuit by using the Multisim software.

(i) Equations for Charging and Discharging of a Capacitor

For an RC circuit, the expression for charging the capacitor is given as:

$$V_c(t) = V_s \left(1 - e^{-\frac{t}{RC}} \right) + V_c(0) \quad (1)$$

and that for discharging of the capacitor is:

$$V_c(t) = V_c(0) e^{-\frac{t}{RC}} \quad (2)$$

where,

$V_c(0)$ = initial voltage across the capacitor

(ii) Square Wave Generator:

One can quickly charge and discharge a capacitor by using a function generator to generate the square wave. The output of function generator is shown in Figure 1. One can control the amplitude of the generator and the period T. The period and the repetition frequency are related by the expression $f = 1/T$.

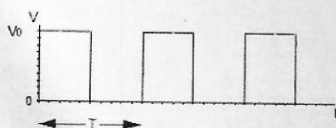


Figure 1: Output of Square-wave Generator

Average

Electric Circuits Laboratory
ELEG 2011
RC Circuits

Mo Khan, Akili Todman, and Hussein Hassan

DOS:5/13/22
DOP:4/26/22

Objective

- Get introduced to the behavior of an RC circuit
- Learn the equation for dis/charging a capacitor
- Using a function generator to create a square wave
- Calculating time constant using R, resistors and C, capacitance values

Introduction

This lab is meant to introduce us to RC circuits. The lab instructs us to construct a basic RC circuit for us to analyze. We initially before the experiment learn about time constant in an RC circuit given as, $(\tau)T=RC$. Also the period given frequency as, $t=1/F$. We calculated these values for Figure 4: RC Circuit to familiarize. We will also use waveform generators to manipulate the RC circuit to analyze difference in output waveforms.

Equipment

- 0.022 μF and 1.0 μF Capacitors
- 1 $\text{K}\Omega$ resistor
- NI Elvis (Bread Board)
- Waveform Generator

Procedure

1. Build RC Circuit in Figure 5 on breadboard
2. On Square Wave Generator set $F=1\text{KHz}$, Amplitude= 2V, Offset=2V, Symmetry=50%
3. Set scope to Autoset
4. Observe and record input and output waveforms
5. Increase frequency of wave generator to 10KHz, record and draw in/output waveforms
6. Replace 0.022 μF capacitor with 1.0 μF capacitor, record and draw in/output waveforms

Pre-Lab Calculations

Pre-Lab Calculations

Period (s) = $T = \frac{1}{F}$ Table 1

$F = 100 \text{ Hz}, T = \frac{1}{100} = 0.01 \text{ s}$

$F = 500 \text{ Hz}, T = \frac{1}{500} = 0.002 \text{ s}$

$F = 1000 \text{ Hz}, T = \frac{1}{1000} = 0.001 \text{ s}$

Table 2

#	1	2
$R (\Omega)$	1000 Ω	1000 Ω
$C (\mu F)$	0.022 μF	1.0 μF
$T (s)$	0.00022 s	0.001 s
$5T (s)$	0.0011 s	0.005 s
$\tau = RC$	$1000 \cdot 0.022 \cdot 10^{-6} = 0.000022 \text{ s}$	$1000 \cdot 1.0 \cdot 10^{-6} = 0.001 \text{ s}$
$\tau = 5T$	$5 \cdot 0.00022 = 0.0011 \text{ s}$	$5 \cdot 0.001 = 0.005 \text{ s}$

(a) The Time Constant

For RC circuit, the time constant is given as $\tau = RC$. This time constant determines the rate of charging or discharging of a capacitor. After $t = \tau$ seconds, the voltage will have decreased to 0.632 (about 36.8%) of its initial value. After 2τ seconds, it will have decreased to 0.135 (or 13.5%) of its initial value, and after 3τ seconds, the voltage will have decreased to 0.050 of its initial value.

(b) Pre-Lab Calculations

For a square wave generator, given the frequencies shown in Table 1, determine the corresponding period.

Table 1: Frequency vs. Period of a Square-wave Generator shown in Figure 1

Frequency (Hz)	1	2	3	4	5
Period (s)	0.01	0.005	0.0033	0.0025	0.002

For the RC circuit, shown in Figure 4, calculate the time constant for the various values of R and C, shown in Table 2.

Figure 4: RC Circuit

Table 2: Time Constants of various RC Values of a Circuit

R	1	2
R	1000 Ω	1000 Ω
C	0.022 μF	1.0 μF
$\tau = RC$	$1000 \cdot 0.022 \cdot 10^{-6} = 0.000022 \text{ s}$	$1000 \cdot 1.0 \cdot 10^{-6} = 0.001 \text{ s}$

(c) Equipment and Materials Needed:

- 0.022 μF and 1.0 μF Capacitors
- 1 K Ω resistor
- Signal Source

(d) Experiment

$\tau (s)$

Constructed Circuit and Circuit Diagram

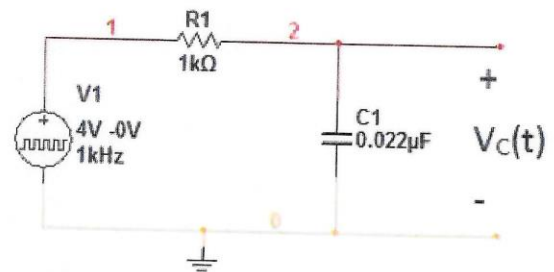
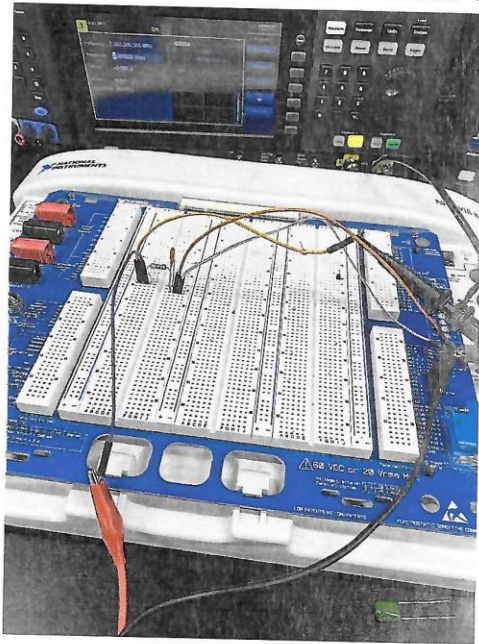
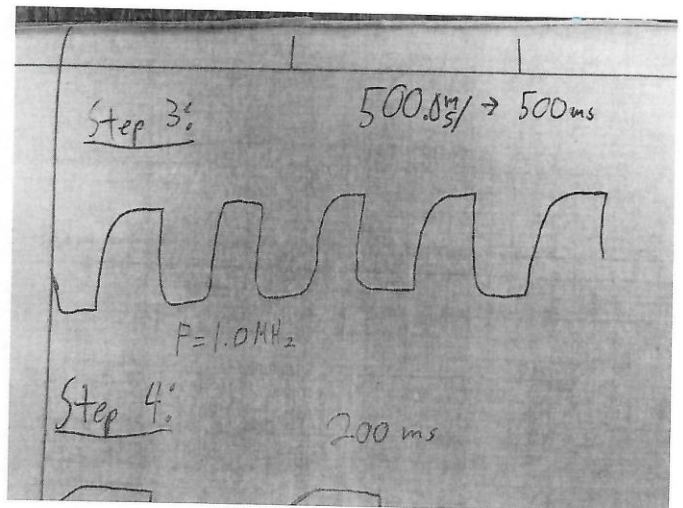


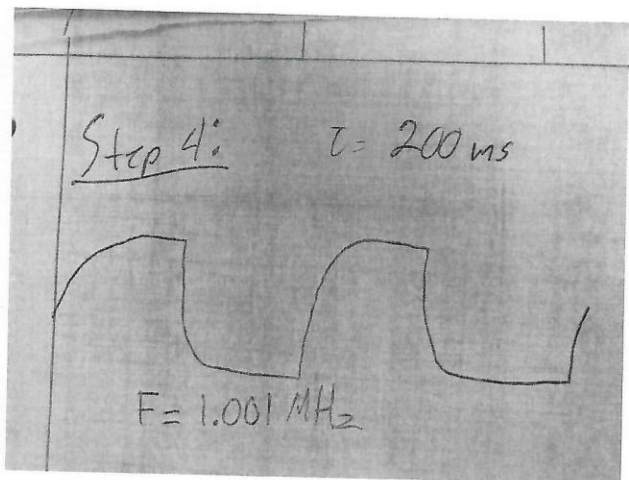
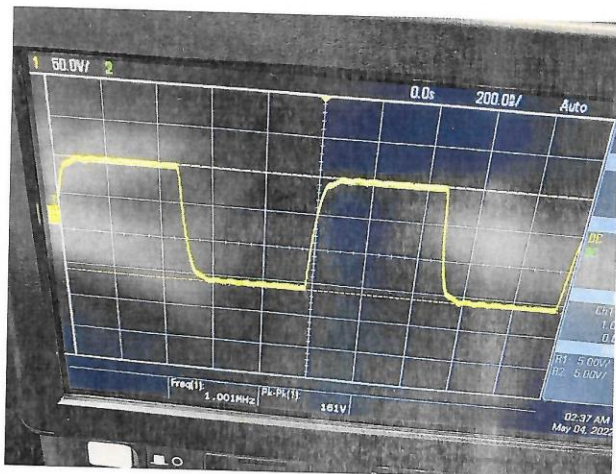
Figure 5: RC Circuit for Experiment

Step 3

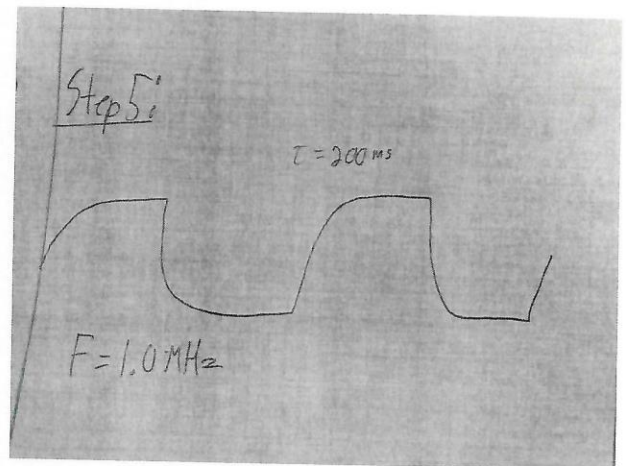
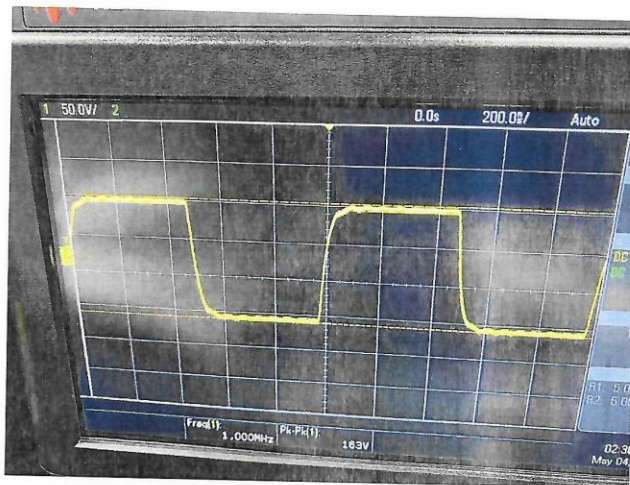
Measured time constant was 500 ms



Step 4



Step 5



Post-Lab Questions

- I. The time constant measured was not equal to the value calculated in Table 2
 - II. The wave output in Step 4 is different from Step 3 because the frequency was increased
 - III. The wave output in Step 5 is different from Step 3 because the capacitance was increased
 - IV. The frequency should be about the same as the square wave since the time constant value is the same
-

Conclusion

In conclusion, we were introduced to RC circuits and learned how to use a wave generator to quickly charge and discharge a capacitor. We also learned how to calculate time constant $(\tau)T=RC$ and period $t=1/f$. Through this lab we learned how changing capacitor and frequency values can alter output waveforms of the RC circuit. Raising the capacitance and raising the frequency both had the same outcome of lowering the time constant.

Contribution

During the lab Mohammad built the circuit from Figure 5 and Hussein and Akili managed the waveform generator/oscilloscope this lab had relatively no hiccups since we were pretty familiar with the oscilloscope. The pre-lab work and the drawn figures were made by Mohammad. The beginning half of the lab report was made by Hussein and Akili did the ending part of the lab report.

Other Lab Experiments

Very Good

Electric Circuits Laboratory

Course #: ELEG 2101

Lab 6: Thevenin's and Norton's Theorem and the Principle of Superposition

Hummad Ahmed

Rommel Jones

Adrianne Ramos

April 12, 2022

March 29, 2022

Department of Electrical and Computer Engineering

Prairie View A&M University

Purpose:

Experimentally determine the Thevenin and Norton equivalent circuits by measuring the open circuit voltage and short circuit currents of the test circuits. Use the principle of superposition along with Thevenin's and Norton's theorems to reduce complex circuits to simple voltage and current source models. Compute the theoretical equivalents and compare them to the experimental equivalents.

Objectives:

- Develop circuit construction skills.
- Develop DC circuit voltage and current measurement skills.
- Make lab measurements that verify the Thevenin and Norton theorems.
- Experimentally apply the principle of superposition in the laboratory.

Introduction/Theory:

The superposition theorem for electrical circuits is stated as follows: the voltage or current response for a linear system in any branch of a bilateral linear circuit having more than one independent source equals the algebraic sum of the responses. This sum, however, is caused by each independent source acting alone, where all the other independent sources are replaced by their internal impedances. To verify the contribution of each source, all the others first must be set to zero (restricting their voltage flow in the system). This procedure is followed for each source in turn, then the resultant responses are computed to determine the true operation of the circuit.

Equipment:

- DC Power Supply
- Digital Multimeter (DMM)
- Five resistors with four known values (4.3 k Ω , 5.6 k Ω , 8.2 k Ω , & 6.2 k Ω) and one more value to find (V_{ab})
- Three voltage values of 5 volts, -15 volts, and 15 volts
- Breadboard

Procedure:Figure 6's Process)

- In anticipation of contriving the avowedly intricate circuit, we gathered five resistors with differing values (4.3 k Ω , 5.6 k Ω , 8.2 k Ω , 15 k Ω , and 6.2 k Ω). Having the confirmed by color coding and securing placement of correct fare completes this first step.
- By securing the resistors for the circuit, we were permitted to measure the voltage of V_{ab} with the Digital Multimeter.
- After procuring the measurement of V_{ab} , the voltage for the 5V_{dc} source was procured through the equipment, along with the -15 V_{dc} source and the +15 V_{dc} source. The

answers we received would be recorded in the Table and used to help verify our calculations in the later steps.

- With all three of the voltages found from the arranged sources, our next objective was to find the sum of all the voltages as a means of verifying their equivalence to the measured value of V_{ab} .
- As for the initiating procedure of step sixteen, us testers were obligated to discover the theoretical values of V_{ab} , $5 V_{dc}$ source, $-15 V_{dc}$ source, and $+15 V_{dc}$ source. Gathering the necessary equations was crucial in coming up with accurate answers.
- Foremost, one of the testers attempted to find the four values by using Mesh Analysis (technique used to find the currents circulating around a loop or mesh within any closed path of a circuit). Although the sections they halted at were accurate, the process persisted, and they were unable to get equivalent results as the measured values.
- Unable to make a proper assessment with the mesh formula, the next option to apply was Nodal Analysis (a method that provides a general procedure for analyzing circuits using node voltages as the variables). After running into a few errors with the mathematical part (partly due to computation misuse), we were able to find similar values to the measured ones from the earlier steps.
- The course of action in properly using Nodal Analysis is in the following order:
 1. Choose reference (ground node).
 2. Label voltages at other nodes.
 3. Write Kirchoff's Current Law at $n-1$ nodes.
 4. Define currents in terms of $I = (V_{higher} - V_{lower})/R$.
 5. Substitute current I equations into Kirchoff's Current Law node equations.
 6. Get rid of fractions by multiplying both sides by least common denominator.
 7. Solve system of equations using Cramer's rule or another technique.
- With the steps being completed, the next plan in motion was to find $5V_{dc}$ source, so we set $-15V$ and $+15V$ to zero to finalize the requirements. For $-15V_{dc}$, we set $5V$ and $+15V$ to zero as well, and as for the $+15V$ source, a similar process was applied in stationing the value to zero.
- Lastly, we had to find the sum of our theoretical values and implement a comparison with the realized values of V_{ab} . The table and all the theoretical/measured values would be filled up with little human error observed.

Figure 3's Process.)

- Construct the circuit shown in Figure 1 and measure the voltage, V_{ab} , across the $10 k\Omega$ resistor. Record the value of V_{ab} for future use in Table 1 but it is also important to use a DC power supply for the battery.

- Remove the 10 k Ω resistor from the circuit in Figure 1 and measure the Thevenin's open circuit voltage, V_{oc} , for the remaining circuit. Figure 2 shows the circuit used to make the open circuit voltage measurements.
- Connect an ammeter between the points a and b as shown in Figure 3 and measure the short circuit current, I_{sc} . Record the value in Table 1 for future use, and also note the positive direction of current flow.
- From the measurements made in parts 2 and 3, calculate the Thevenin's equivalent resistance for the circuit. This is numerically equal to Norton's equivalent resistance. Use the following formula to find these values: R_{TH} = the Thevenin's equivalent resistance & R_N = Norton's equivalent resistance.
- After recording the values on Table one, we're responsible for calculating the theoretical values of R_{TH} , R_N , V_{oc} , and I_{sc} for the circuit. With the correct results found, citing them down in the measured values section is crucial.
- Using the Thevenin's equivalent circuit, compute the value of V_{ab} with the 10 k Ω resistor attached to points a-b.
- Using Norton's equivalent circuit, compute the value of V_{ab} with the 10 k Ω resistor attached to points a-b.

Figure 4's Process.)

- Construct the circuit show in Figure 4 and measure the voltage across points a and b. Record this value in Table 2 for later use but understanding how to use dc power supplies for the batteries is necessary.
- Use the principle of superposition to find the value of V_{ab} in Figure 4. To practically use superposition in the lab, sequentially disconnect each dc power supply from the circuit and replace them with short circuits in turn.
- Find the value of V_{ab} due solely to the 5 Vdc source and record the value in Table 2. Find the value of V_{ab} due solely to the -15 Vdc source and record the value in Table 2. Add these two measurements to find the total response and record it in Table 2.
- Remove the 8.2 k Ω resistor and measure the Thevenin's open circuit voltage.
- Add a 10-ohm resistor and an ammeter between points a-b to measure, I_{sc} . Figure 5 shows this circuit. Record this reading in Table 2.

Circuit Diagram:

Circuit One – Figure One

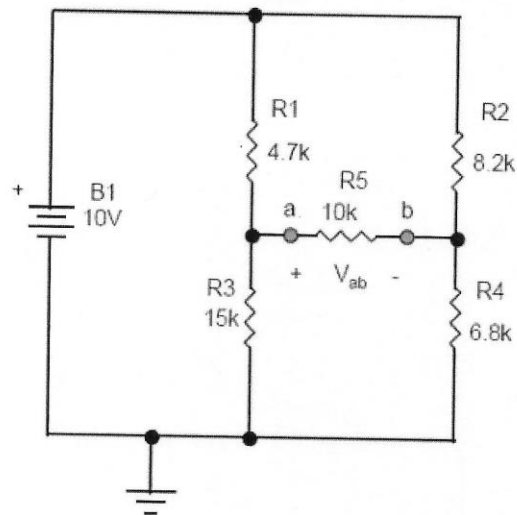


Figure 1. Test Circuit for Part 1 of the Experiment.

The circuit design as shown is listed with a voltmeter of 10 volts and has a total of five resistor values (4.7 k Ω , 8.2 k Ω , 15 k Ω , 6.8 k Ω , and 10 k Ω). However, because there was an absence of some certain color-coded resistors, we were told to replace 4.7 k Ω and 6.8 k Ω with values of 4.3 k Ω and 6.2 k Ω . Furthermore, our main objectives with the completed assembly were to find the value of V_{ab} , measure the short circuit current I_{sc} , and calculate the Thevenin's equivalent resistance for the loop.

Circuit Two – Figure Four

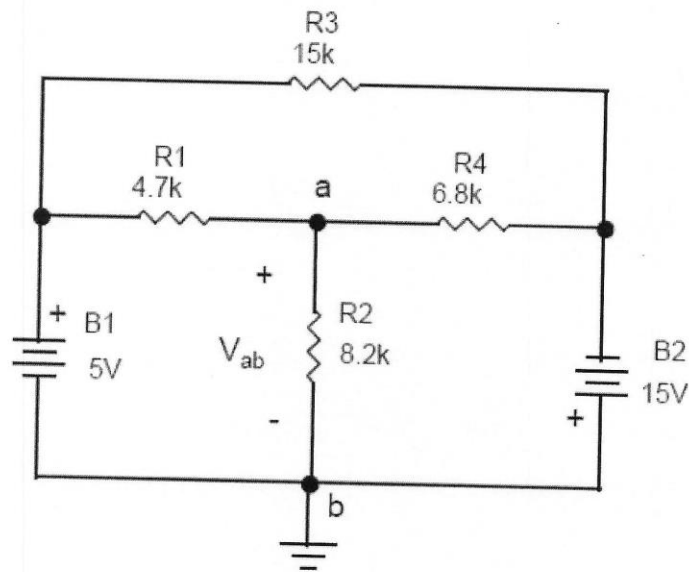


Figure 4. Circuit 2 Showing the Voltage V_{ab} .

For Circuit 2 shown above, it is intended to display the unknown value of V_{ab} as a means for the user to seek out its numeral. Differing from the earliest targeted one, it has two voltmeters of 5V and 15V, along with four varying resistors (4.7 k Ω , 8.2 k Ω , 15 k Ω , and 6.8 k Ω). There is a similarity in the change of two resistors though, making them 6.2 k Ω and 4.3 k Ω instead of their original merits. Aside from finding the voltage between points a and b, we were instructed to reconstruct the circuit in order to get V_{ab} , as well as V_{oc} , I_{sc} , & the resistances for Norton's Theorem/Thevenin's Theorem.

Circuit Three – Figure Six

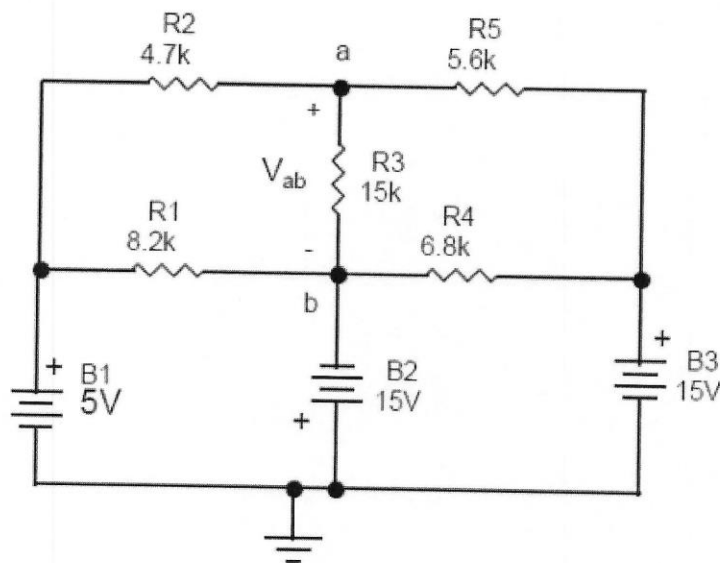


Figure 6. Circuit 3 Schematic.

The striking figure above displays a circuit that the testers must construct on their breadboard in section 15/16. Initially, three voltage values of 5 volts, -15 volts, and 15 volts are allocated to perch abreasted in parallel (the way they are positioned makes them node voltages). As for the resistors of the circuit (4.3 k Ω , 5.6 k Ω , 8.2 k Ω , 6.2 k Ω , & V_{ab}), they're set in an arbitrary manner near different nodes that'll measure the experimenter's knowledge so far. Because the circuit is constructed to compel the usage of mesh or nodal analysis (depends on the user's preference) and the necessity to verify the Superposition theorem using earlier results (this process is used eventually, when Superposition and Thevenin's theorem are established), this week's procedure is arguably the most arduous up to this point.

Answer to the Question:

Question (Indirect): How were Thevenin's Theorem and Norton's Theorem applied in this experiment, and in what ways were their usefulness explored?

Answer: Consider the initial resistor two as the load resistor. To find the voltage and current across this load resistor, you can follow superposition theorem. But in this circumstance, say your load resistance is subjected to change, then each time your resistor value changes, you need to apply superposition theorem and recalculate the current and voltages. Thevenin's Theorem or Norton's Theorem makes this process facile by temporarily removing the load resistance from the original circuit and reducing what's left to an equivalent circuit. The load resistance can then

be re-connected to this “equivalent circuit” and calculations carried out as if the whole network were nothing but a simple series circuit:

Conclusion:

Thevenin’s Theorem states that it is possible to simplify any linear circuit to an equivalent circuit with just a single voltage source and series resistance connected to a load. Especially for this experiment with the handling of passive components, such as resistors or capacitors, the qualification of “linear” is identical to that found in the Superposition Theorem, where all the underlying equations must be analogue. Moreover, Norton’s Theorem is similar with its position in simplifying these kinds of circuits but it’s different in its execution; it simplifies any linear circuit to an equivalent circuit with just a single current source and parallel resistance connected to a load.

Discussion and Contribution:

Because Lab 6 was extensive in its instructions and building of various circuits, as well as its complicated usage of certain formulas, the work was split into three ways as a means of ensuring well-timed results and maximized efforts. After discussing who would complete what (based off functions in previous experiments), the assignments tasked went as follows:

- Hummad: Experimentally determined the Thevenin and Norton equivalent circuits by computing the open circuit voltage and short circuit currents of the circuits. These would then be recorded in the theoretical sections of the tables, and he ensured that the other quantities were found through the multimeter.
- Rommel: Calculated the theoretical equivalents of the Thevenin and Norton’s theorems values and compared them to the experimental equivalents. Also handled the calculations for the required tables with Nodal Analysis and listed equations, recording all the established in charts.
- Adrienne: After gathering the necessary components listed in the packet, he proceeded to assemble the circuits by following the procedure and ensuring each one was accurate, as depicted in the figures.

References:

- Electrical4U. (2021, May 3). *What is Nodal Analysis in Electric Circuits?* Electrical4U. Retrieved March 30, 2022, from [https://www.electrical4u.com/nodal-analysis-in-electric-circuits/#:~:text=Nodal%20analysis%20is%20a%20method,Kirchhoff's%20Current%20Law%20\(KCL\).](https://www.electrical4u.com/nodal-analysis-in-electric-circuits/#:~:text=Nodal%20analysis%20is%20a%20method,Kirchhoff's%20Current%20Law%20(KCL).)
- Mesh Current Method and Analysis: DC Network Analysis.* All About Circuits. (n.d.). Retrieved March 30, 2022, from <https://www.allaboutcircuits.com/textbook/direct-current/chpt-10/mesh-current-method/>

Appendix

*No appendix is listed on this week's lab experiment

Attachment:

Table 1- Figure 1 Circuit

Quantity	Value	
	Measured	Theoretical
V_{ab} (V)	3.18 V	3.082 V
V_{oc} (V)	5.39 V	5.2V
I_{sc} (mA)	0.78 mA	0.717 mA
R_{TH} (k Ω)	6.75 k Ω	7.25 k Ω
R_N (k Ω)	6.75 k Ω	7.25 k Ω

Table 2- Figure 4 Circuit

Quantity	Value	
	Measured	Theoretical
V_{ab} (V)	-2.48 V	-2.44 V
V_{ab} (V) 5Vdc Source	2.32 V	2.25 V
V_{ab} (V) -15Vdc Source	-4.71 V	-4.69 V
V_{ab} (V) Sum	-2.48 V	-2.44 V
V_{oc} (V)	-6.18 V	-6.94 V
I_{sc} (mA)	-1.29 mA	-3.36 mA
R_{TH} (k Ω)	2.49 k Ω	2.07 k Ω
R_N (k Ω)	2.49 k Ω	2.07 k Ω

Table 3- Figure 6 Circuit

Quantity	Value	
	Measured	Theoretical
V_{ab} (V)	21.21 V	20.85 V
V_{ab} (V) 5Vdc Source	2.41 V	2.434 V
V_{ab} (V) -15Vdc Source	12.96 V	8.288 V
V_{ab} (V) +15Vdc Source	5.83 V	5.61 V
V_{ab} (V) Sum	21.18 V	16.332 V

Table Quantities' Calculations

Finding V_{oc} (Figure 1)
 Node 1: $i_1 + i_2 = 0$
 $\left(\frac{V_a - 15}{4.7} + \frac{V_a - 0}{15} = 0\right) \Rightarrow \left(\frac{V_a}{4.7} - \frac{15}{4.7} + \frac{V_a}{15} = 0\right) \quad \text{LCD: 69.75}$
 $150V_a - 2250 + 43V_a = 0$
 $193V_a = 2250$
 $V_a = 11.652V$

Node 2:
 $i_2 + i_3 = 0$
 $\left(\frac{V_b - 15}{6.2} + \frac{V_b - 0}{6.2} = 0\right) \Rightarrow \left(\frac{V_b}{6.2} - \frac{15}{6.2} + \frac{V_b}{6.2} = 0\right) \quad \text{LCD: 6.2}$
 $6.2V_b - 9.3 + 6.2V_b = 0$
 $12.4V_b = 9.3$
 $V_b = 6.4583V$

$V_{oc} = 11.652 - 6.4583 = 5.2V$

Finding I_{sc}
 Loop 1: $-15 + 4.7(i_1 - i_2) + 15(1 - i_2) = 0$
 $-15 + 4.7i_1 - 4.7i_2 + 15 - 15i_2 = 0$
 $4.7i_1 - 19.7i_2 = 0$
 $i_1 = 4.191i_2$

Loop 2: $8.2i_2 + 4.3i_2 - 4.3i_1 = 0$
 $12.5i_2 = 4.3i_1$
 $i_2 = 0.344i_1$

Loop 3: $6.2i_3 + 15i_2 - 15i_1 = 0$
 $i_3 = 0.70155i_1$

Solving for i_1 :
 $-15 + 4.7i_1 - 4.3(0.344i_1) = 0$
 $-15 + 4.7i_1 - 1.4812i_1 = 0$
 $3.2188i_1 = 15$
 $i_1 = 4.660A$

$i_2 = 0.344i_1 = 1.595A$
 $i_3 = 0.70155i_1 = 3.269A$

$I_{sc} = i_2 - i_3 = 1.595 - 3.269 = -1.674A$
 $I_{sc} = 1.674A$

$R_{TH} = R_N = \frac{V_{oc}}{I_{sc}} = \frac{5.2V}{3.117A} = 1.656\Omega$

Our starting point for Figure 1 involved finding the open circuit voltage of the system but we lacked the means to solve it, as we didn't have the values of V_a and V_b . To move forward, nodal analysis was wielded, as it would help find the individual nodal voltages in a quick fashion. After following the intricate procedure to solve this electrical network, we ended up getting 11.658 volts as V_a and 6.4583 volts as V_b ; using the open circuit rule of the b-point being subtracted from the a-point, 5.2 volts was verified to be the theoretical value of V_{ab} . When finding the current of the series circuit, we followed a similar procedure through Mesh Analysis, finding the three mesh currents of the network in order to use system of equations. This allowed us to gather their values (most importantly I_2 and I_3), exhibiting I_{sc} to be 0.717 amps. All that remained was using the $R_{TH} = R_N = (V_{oc} / I_{sc})$ rule to get our final theoretical results on the table (7.25 k Ω).

Problem 1: Table 2 - Figure 4 Circuit

Node a: $V_a = 5$, $V_b = -5$, $V_c = 15$
 $V_d = 0$, $V_e = 0$, $V_f = 0$

1. CD: $\left(\frac{V_d - V_e}{4.3} + \frac{V_d - V_f}{2.2} + \frac{V_d - V_g}{6.2} \right) \times 212.612$
 $-2.31 + 0.000V_d + 0.000V_d + 0.000V_d + 0.000V_d = 0$
 $(12.612) V_d = -2.31$
 $V_d = -2.44V$

5VTS: $\left(\frac{V_e - V_f}{4.3} + \frac{V_e - V_g}{2.2} + \frac{V_e - V_h}{6.2} \right) \times 212.612$
 $0.000V_e - 2.31 + 0.000V_e + 0.000V_e + 0.000V_e = 0$
 $(12.612) V_e = 2.31$
 $V_e = 2.2V$

-15VTS: $\left(\frac{V_f - V_g}{4.3} + \frac{V_f - V_h}{2.2} + \frac{V_f - V_i}{6.2} \right) \times 212.612$
 $0.000V_f + 0.000V_f + 0.000V_f + 0.000V_f + 0.000V_f = 0$
 $(12.612) V_f = -4.69$
 $V_f = -4.69V$

SUM: $V_{ab} = 2.2 + (-4.69) = -2.44V$

V_{oc}: $V_{oc} = 4.69 - 2.25 = 2.44V$

Finding I_{sc} (Nodal Analysis)

Loop 1: $-5 + 4.3(I_1 - I_2) + 2.2(I_1 - I_3) = 0$
 $-5 + 12.5I_1 - 8.2I_2 - 4.3I_3 = 0$

Loop 2: $-15 + 2.2(I_2 - I_1) + 6.2(I_2 - I_3) = 0$
 $-15 + 14.4I_2 - 8.2I_1 - 6.2I_3 = 0$

Loop 3: $15I_3 + 6.2(I_3 - I_2) + 4.3(I_3 - I_1) = 0$
 $25.5I_3 - 4.3I_1 - 6.2I_2 = 0$

SYSTEM OF EQUATIONS

$I_1 = 3.063A$
 $I_2 = 3.36A$
 $I_3 = 1.33A$

$I_{sc} = I_2 = 3.36A$

As for the next circuit, we are given a compound electrical network with two voltage values of V_{ab} to find. Although in this case, the nodal analysis procedure is much simpler than the first circuit's (the least common denominator process uses the "setting zero" proceeding to rid connections of other voltages). By implementing this new strategy, us testers found that the original $V_{ab} = -2.44$ volts, (5V) $V_{ab} = 2.2$ volts, and (-15V) $V_{ab} = -4.69$ volts. We have the means to find the sum value as a result (-2.44 volts), as well as the other missing ones. For current specifically, we did the exact method used on Figure 1, getting the values for the three currents and then substituting the necessary into the equation for I_{sc} (-3.36A).

Lab 8: Multisim Electronic workbench

Electric Circuits Laboratory

Course #: ELEG 2101

Lab 8: Multisim Electronics Workbench

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April 19, 2022

April 12, 2022

Department of Electrical and Computer Engineering

Prairie View A&M University

Purpose:

This innovative laboratory procedure helps students learn and understand circuit analysis concepts by using Electronic Workbench software to simulate actual laboratory experiments on a computer. The testers work with circuits drawn on the computer screen and with simulated instruments similar to the lab tools.

Objectives:

- Develop web-based circuit construction skills.
- Understand how to use software to simulate an electrical circuit
- Electronically apply the procedure of oscilloscopes in Multisim.
- Calculate the voltages and currents dissipated in the resistors and capacitors.

Introduction/Theory:

In this experiment, the students will learn how to build and take measurements in simulated electrical circuits. The circuit will be simulated on Multisim Electronics Workbench, which is an industry standard SPICE simulation and circuit design software for analog, digital, and power electronics in education and research. With this, the experimenters will build circuits with hardware components and verify the accuracy of the measurements compared with the simulation results.

Equipment:

- Multimeter (Amps, Volts, or Ohms)
- Function Generator (Sine, Square, and Triangular Waveforms)
- Wattmeter
- Oscilloscope (2-Channel)
- Bode Plotter
- Logic Analyzer

Procedure:**Example 1 (A simple resistor network)**

- To begin, click on the Source Components icon on the Parts Bin tool bar. This produces a selection of parts including various sources. Select a battery source from the menu by clicking on it. Click on more on the blank screen to place the battery.
 - After placing the battery on the screen, double click on it to get a menu to set the battery values. With this in place, the next item to choose will be the voltage dependent current source. The process of selecting certain tools is extremely similar to step one.
 - After getting the source with a ground symbol from the Source Components, there will be four resistors to be added to the circuit (1.0 k Ω , 2.0 k Ω , 2.0 k Ω , and 1.0 k Ω)
 - With the components in place, we were ready to connect the wires by moving the cursor to a component wire end and going to a second component, clicking on its wire end.
-

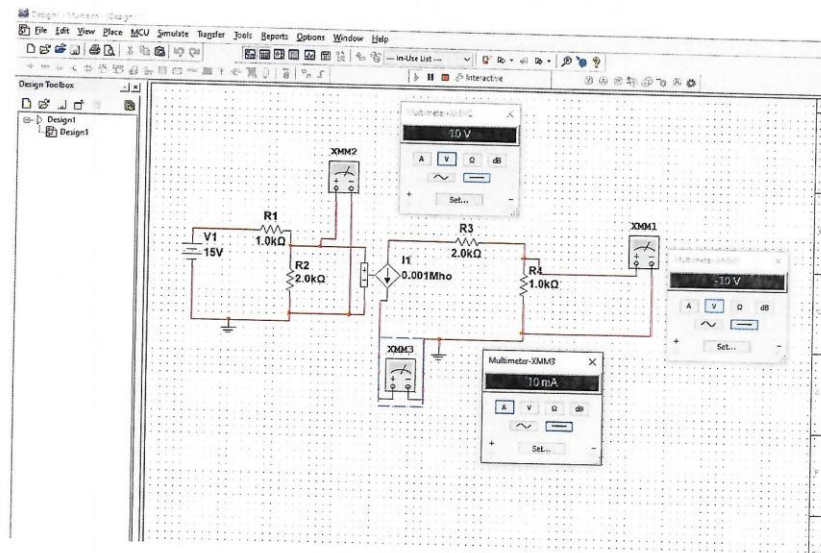
- After connecting all the necessary points and choosing good paths for the wires passing, the circuit in this example becomes ready for simulation. However, the last thing to do is find a way to see the output with multimeters.
- Going to the instrument's toolbar on the right side of the screen, we were able to obtain the multimeters and place them along the simulated circuit board. This gave us a proper way to view the results of the simulation.
- Interchanging between ammeter, ohmmeter, and voltmeter, we were able to successfully find the values of the probed values.

Example 2 (An RC network using the oscilloscope and Bode Plotter)

- In this example, we essentially use the oscilloscope and the Bode Plotter in an RC circuit that has an AC source.
- The first step is to place a $10\text{ k}\Omega$ resistor, a $1.0\text{ }\mu\text{F}$ capacitor, a $100\text{ }\Omega$ resistor, an AC voltage source, and an analog ground on the drawn circuit. By using the cursor, we're able to draw in the connecting wires.
- For this circuit, we will take the input to be the 10-volt AC source and the output to be the voltage across the series combination of R2 and C1. Our next priority is opening the oscilloscope control window and setting the values on the screen.
- After running the simulation (pushing the F5 function key or the rocker switch), it was important for us to observe and save the data collected. With this, we can read into the file through Excel and Matlab. As for the Bode plotter, its purpose was to allow us testers to look at the frequency response of the circuit.

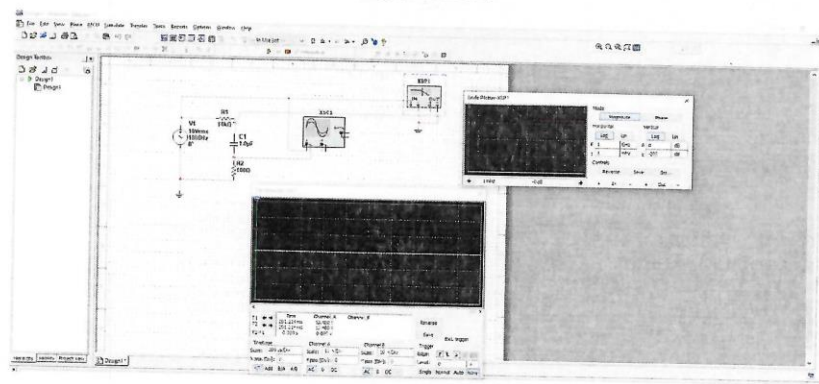
Circuit Diagram:

Figure E1-5



This is the complete circuit of Example One, with all the components and wires in place. This was fundamentally a simple network to create, in which we just needed to simulate a circuit having a dependent voltage controlled current source, four resistors, a battery, and a meter to measure the output. As soon as the assembly procedure was finished, the connecting of multimeter to resistor 3 was applied and the voltage across R3 itself was taken as the output volt. With every preparation in place, the result of the simulation was shown by using a multimeter and we were able to confirm these results through calculations.

Figure E2-1



After working on Example Two, we were able to obtain the complete circuit showing the oscilloscope and Bode Plotter. Centrally, this is a basic RC circuit with all components in place, but it is important to note that we had to change the default value of the AC voltage source to 10 volts; this was done by clicking on the source and setting the value on the pop-up menu. The circuit with the oscilloscope would be connected after finishing the previous steps, and as soon

as this was done, setting values for different entities was needful. For example, channel A was set to 10 V/Div and channel B to 200 mv/Div, or the positioning of the channels themselves. Aside from the creation and editing of the circuit and its values, there was the data reading process that had to be adjusted.

Answer to the Question:

There was no direct question in this week's lab. The protocol we followed allowed us to transition to the next steps without trouble. Other than an indirect debriefing on what the objectives are for this week's assignment, we weren't mandated to answer a specific question. However, it can be said that the students are participating in this Multisim Electronics Workbench in order to build up on their experience in utilizing the function generator and oscilloscope.

Conclusion:

The Electronics Workbench uses multisim to simulate DC and AC electric circuit experiments on a computer screen using simulated instruments to make circuit measurements, recreating a real laboratory environment. The features it offers encourage student participation in the learning process by requiring them to compare measured data with the theoretical results. This leads to a much more effective learning process and a longer retention of the theoretical concepts.

Discussion and Contribution:

First and foremost, our results did make sense in the end, as our calculated values and theoretical ones aligned, as well as with our neighbors' work. No anomalies originated in the data, and besides little possible human error, there is little doubt to formulate with the intricateness displayed in our lab. As for each member's contributions this week...

- Hummad: Created the circuits shown in Figure One and Figure Two through the Multisim application, inserting different tools and measures to recreate them flawlessly.
- Rommel: Found the experimental values for the voltages and current of the first example through the Ohm's Law and unit conversions.
- Adrienne: Tested the designs of the multisim circuits and ensured the wave forms were accurate in the oscilloscopes.

References:

Electronics Workbench Multisim 8 Simulation and Capture User Guide. (n.d.). Retrieved April 15, 2022, from https://inst.eecs.berkeley.edu/~ee100/su07/handouts/MultiSim8_SimulationAndCapture_UsersGuide.pdf

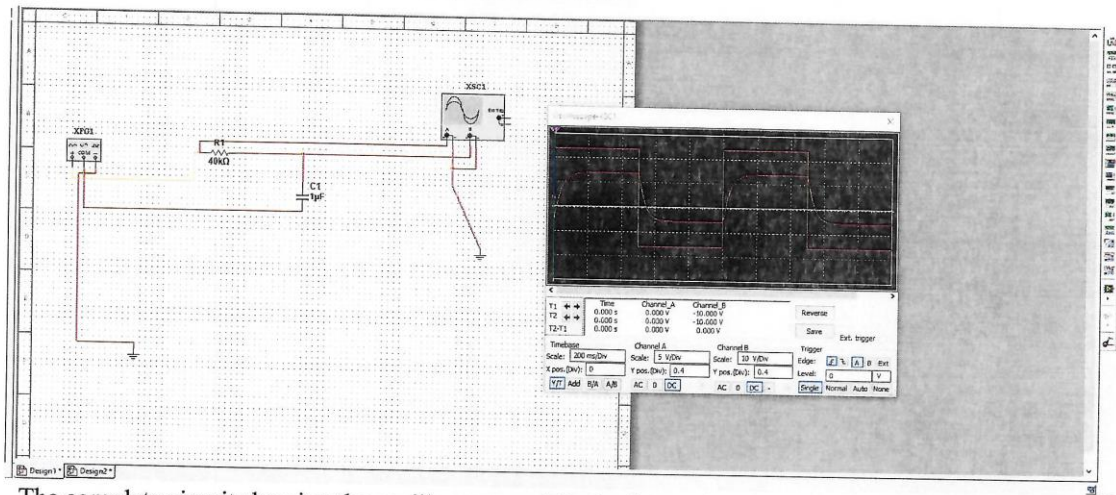
What is Multisim? NI. (n.d.). Retrieved April 14, 2022, from <https://www.ni.com/en-us/shop/electronic-test-instrumentation/application-software-for-electronic-test-and-instrumentation-category/what-is-multisim.html>

Appendix

*No appendix displayed in this week's laboratory experiment.

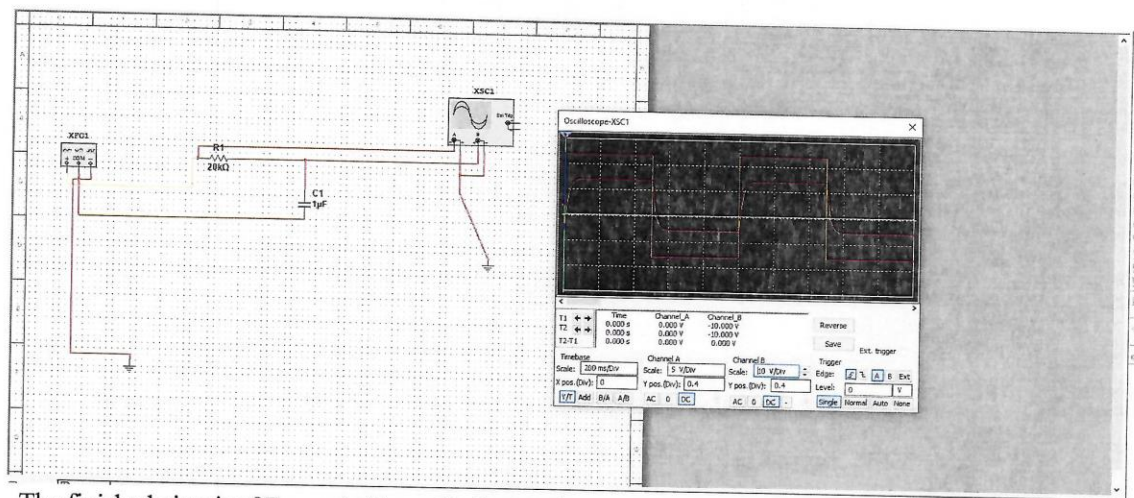
Attachment:

Capacitor Network



The complete circuit showing the oscilloscope and Bode plotter. As shown in the figure above, we were able to successfully create the given circuit and work out its correct values into the oscilloscope tool.

Square Waves

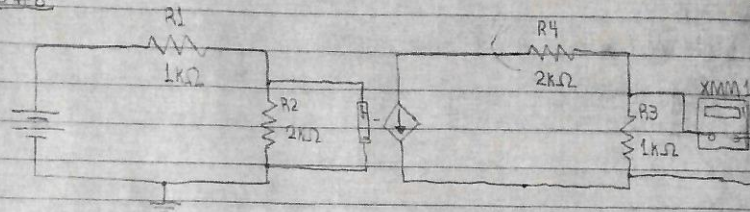


The finished circuit of Example Two, displaying the square waves in the oscilloscope (periodic waves that vary abruptly in amplitude between two fixed values, spending equal times at each).

Example One Calculations

Lab #8

Rommel Torres
04/12/2022



- Voltage for first section: $V = IR \Rightarrow I = \frac{V}{R} = \frac{15V}{1k\Omega + 2k\Omega} = 5mA$

$$V = IR = (5mA)(2k\Omega) = 10V$$

- Current for the second section:

$$0.001 Mho \Rightarrow \frac{1}{1000} Mho = 1000\Omega$$

$$V = IR \Rightarrow I = \frac{V}{R} = \frac{(10V)}{(1000\Omega)} = 0.01A \rightarrow 10mA$$

- Voltage for the third section:

$$V = IR = (-10mA)(1.0k\Omega) \Rightarrow (-0.01A)(1000\Omega) = -10V$$

↑
going through negative end

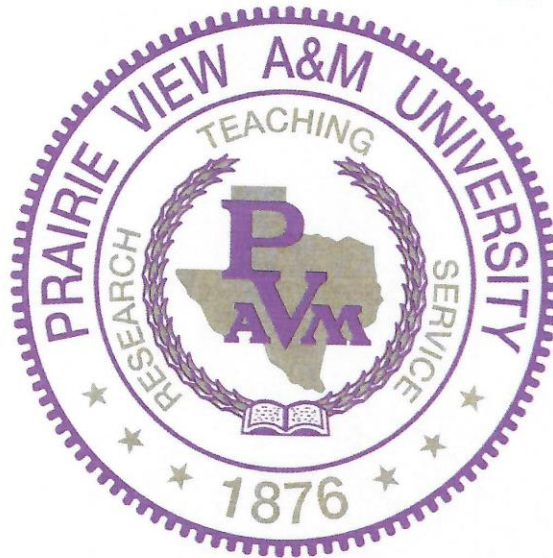
As stated earlier in the discussion section, the process of Ohm's Law and unit conversions were taken to find the values of the voltages and current flowing in Example One. For the first section, we accounted for the current initially and used a total resistance of 3 kΩ to get 5 mA; this helped us understand that the voltage source's value was 10 volts. As for the second section, the unit conversion from Mho to Ohms was initiated first, giving a chance to establish an accurate answer through Ohm's Law (10 mA). As for the last part of the circuit, we ensured that the current in the Ohm's Law was negative due to its opposite flow and then converted all needed subjects to their original units (-10 mA to -0.01 A and 1.0 kΩ to 1000 Ω). After implementing these newly found measurements into the formula, we got an answer of -10 V.

Signatures

Name	Date	Instructor Signature
Hammad Ahmed	4/12/22	AA [Signature]
Danniel Jones	4/12/22	DJ [Signature]
Adrienne Ramos	4/12/22	AR [Signature]

Exp 7: Nodal and Mesh Analysis

No Signoff attached



Electric Circuits Laboratory

ELEG2011

Experiment 7: Nodal and Mesh Analysis

Names: Ayodele Grayson And Kelechi Anaghara

Date of submission: 03/29/22

Date of performance: 03/22/22

Department of Electrical and Computer Engineering
Prairie View A&M University

Objective

Name: _____

Lab Instructor: Dr. John Fuller

Date of Performance: _____

Lab 7: Nodal and Mesh Analysis

Name

Date

Instructor Signature

Ayodele Grayson

3/22/2022

Kelechi Anagha

March 22

[Signature]

Lab 7: Nodal and Mesh Analysis

OBJECTIVES:

1. To construct a planar circuit having two voltage sources and five resistors.
2. To study node voltages and mesh currents.
3. To compare calculated and measured results using both nodal and mesh analysis.

BACKGROUND & THEORY:

SUMMARY OF NODE VOLTAGE (N-V) METHOD

1. Number of equations needed is one less than the number of essential nodes, except as noted in item 7 below.
2. Select one of the essential nodes as a reference node (the node with the most branches usually is a good choice).
3. Then assign node voltages at the other essential nodes. By definition, node voltages are a "rise" above ref. node.
4. Next, generate N-V equations by summing currents at each non-reference node (using KCL). Currents are to be considered leaving the node; unless a current source exists in the branch (then you use the direction of the arrow for determining the sign).
5. If a voltage source exists in the branch, subtract or add its voltage (depending on polarity) to the node voltage before dividing by the resistance in the branch.

Equipment:

- DC Power Supply
- Digital Multimeter (DMM)
- Resistors one each: $1\text{k}\Omega$, $1.5\text{k}\Omega$, $1.8\text{k}\Omega$, $3.3\text{k}\Omega$, and $4.7\text{k}\Omega$.
- Breadboard

Procedure:

1. Construct the circuit shown in Figure 1 using available power supply, resistors, breadboard, and connecting wires provided. $R_1 = 1.5\text{k}\Omega$, $R_2 = 1\text{k}\Omega$, $R_3 = 3.3\text{k}\Omega$, $R_4 = 4.7\text{k}\Omega$, $R_5 = 1.8\text{k}\Omega$.

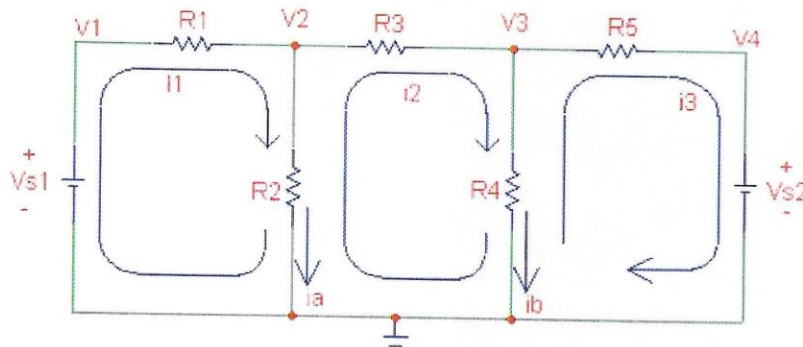


Figure 1

2. Set $V_{s1} = 6\text{V}$ and $V_{s2} = 12\text{V}$.
3. Note that the reference node, nodal voltages (V_1 , V_2 , V_3 , & V_4) and mesh currents (i_1 , i_2 , & i_3) have already been designated.
4. Measure all node voltages (not Branch voltages) and the mesh currents (not the Branch currents I_A , & I_B).
5. Don't forget to measure all the resistor values.

Circuit:

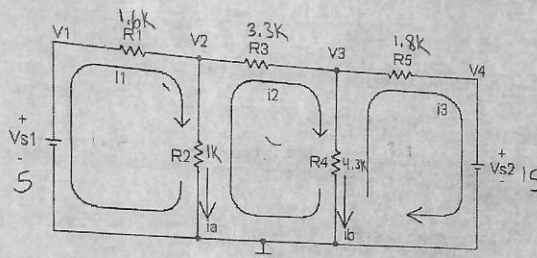
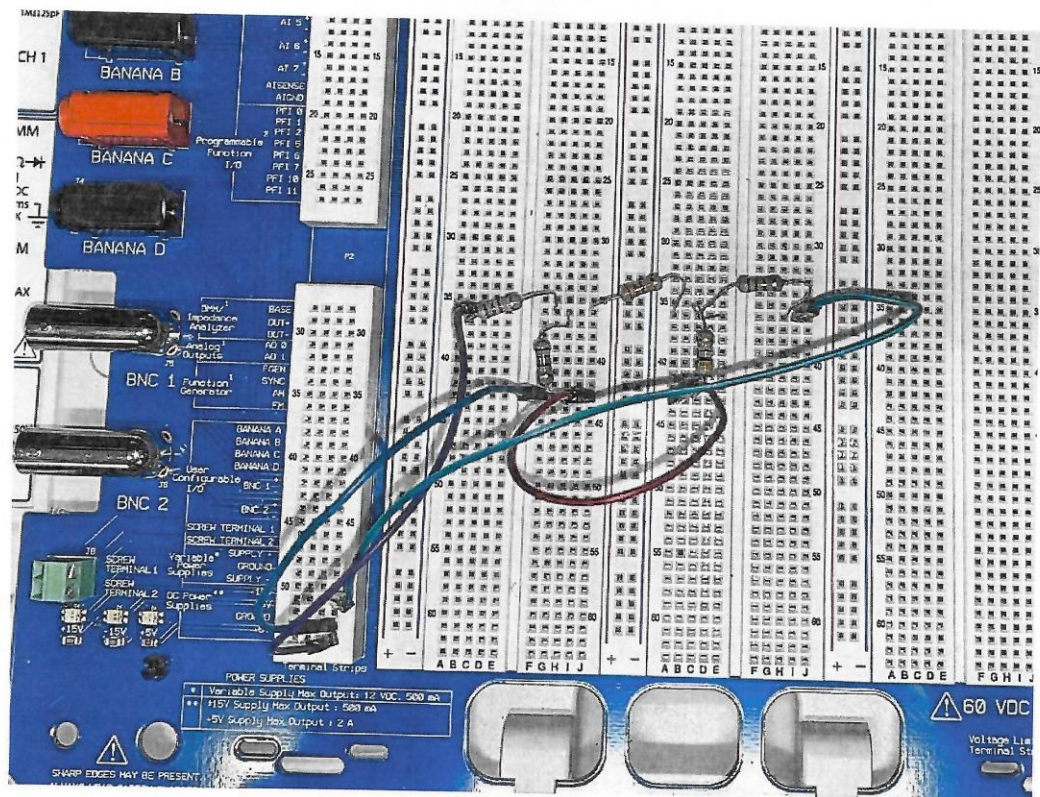


Figure 1

2. Set $V_{S1} = 6\text{ V}$ and $V_{S2} = 12\text{ V}$.
3. Note that the reference node, nodal voltages (V_1 , V_2 , V_3 , & V_4) and mesh currents (I_1 , I_2 , & I_3) have already been designated.
4. Measure all node voltages (not Branch voltages) and the mesh currents (not the Branch currents i_a & i_b).
5. Don't forget to measure all the resistor Values.

COMPARISONS AND QUESTIONS:

1. From your measured mesh currents, calculate the value of the branch currents i_a and i_b shown in Figure 1. Using top to bottom in the vertical branches and left to right in the horizontal branches, what are the currents in each of the other five branches?
2. By observation, what are the values of V_1 and V_4 ? With the given values of V_{S1} and V_{S2} . Using plus reference at the top of the vertical branches and at the left for horizontal branches, what are the seven branch voltages in terms of the node voltages?
3. Node Equations:
 - a. Set up the node equations for the circuit, and solve for V_2 and V_3 , using **nominal** values of resistances and **nominal** values of the voltage sources. **Show all your calculations.**
 - b. Compare all measured node voltages with the calculated values.
 - c. Repeat a & b using the measured values of resistances and measured values of the source voltages. You may use a computer or calculator to solve the equations.



Handwritten circuit analysis on lined paper. The circuit diagram shows a voltage source of 5V connected to a network of resistors (1.6, 3.3, 1.8, 4.3, 1.2) and a dependent current source (1.2V₂). The analysis includes nodal equations for V₂ and V₃, and a mesh analysis for currents I₁, I₂, and I₃.

Nodal Analysis:

$$\frac{V_2 - 5}{1.6} + \frac{V_2 - V_3}{3.3} + \frac{V_2}{1} = 0$$

$$\frac{V_2}{1.6} - \frac{5}{1.6} + \frac{V_2 - V_3}{3.3} + \frac{V_2}{1} = 0$$

$$\frac{1}{1.6}V_2 - 3.125 + \frac{1}{3.3}V_2 - \frac{1}{3.3}V_3 + V_2 = 0$$

$$1.93V_2 - 3.30V_3 = 3.125$$

$$\frac{V_3 - 5}{1.8} + \frac{V_3 - V_2}{3.3} + \frac{V_3}{4.3} = 0$$

$$\frac{1}{1.8}V_3 - 8.3 + \frac{1}{3.3}V_3 - \frac{1}{3.3}V_2 + \frac{1}{4.3}V_3 = 0$$

$$-0.30V_2 + 1.09V_3 = 8.3$$

Matrix Solution:

$$\begin{bmatrix} 1.93 & -3.30 \\ -0.30 & 1.09 \end{bmatrix} \begin{bmatrix} V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 3.125 \\ 8.3 \end{bmatrix}$$

Mesh Analysis:

$$-5 + 1.6I_1 + 1I_1 - 1I_2 = 0$$

$$2.6I_1 - 1I_2 = 5$$

$$1I_2 - 1I_1 + 3.3I_2 + 4.3I_2 - 4.3I_3 = 0$$

$$-1I_1 + 8.6I_2 - 4.3I_3 = 0$$

$$1.6I_1 + 3.3I_3 + 4.3I_3 = 0$$

$$1.6I_1 + 7.6I_3 = 0$$

$$I_1 = -4.75I_3$$

$$2.6(-4.75I_3) - 1(-4.75I_3) = 5$$

$$-12.25I_3 + 4.75I_3 = 5$$

$$-7.5I_3 = 5$$

$$I_3 = -0.667A$$

Currents:

$$I_1 = 1.2A$$

$$I_2 = 1.6A$$

$$I_3 = 3.6A$$

Data:

Current

Measured

Calculated

I1	1.4mA	1.2mA
I2	1.7mA	1.6mA
I3	3.7mA	3.6
Ia	3.1mA	2.8
Ib	2.02mA	2mA

Node	Measured	Calculated
V1	4.96V	5V
V2	2.8V	2.9V
V3	8.2V	8.4V
V4	15.58V	15V

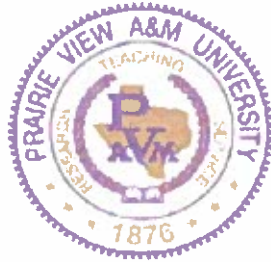
R2 power= 7.84

R4 power=15.63

Conclusion: We learned how to calculate the circuit current and voltage using Nodal and Mesh analysis. Using the formula to calculate each current within the circuit same for each voltage. While getting the information we also calculated the power using $V \cdot I$.

AVERAGE

**Department of Electrical and Computer Engineering
Prairie View A&M University
Electric Circuits Laboratory
ELEG-2011**



9.3
poorly written

Fall 2021

LABORATORY REPORT:

Experiment 9 Op-Amp Circuits

Conducted on
November 15, 2021

Submitted by:
Dylan Freeman
Julian Claiborne
Demiro Baeza

On
December 3, 2021

Objective

- To construct a circuit using the op-amps
- To study integrator and differentiator circuits
- To learn how to measure voltage outputs in an operational amplifier

Introduction/Theory

This experiment includes measuring voltage outputs of operational amplifiers as well as the voltage gain. The theories used in the experiment include voltage gain formulas ($A_v = -R_2/R_1$, $A_v = R_1 + R_2/R_1$).

Equipment List

- DC Power Supply
- Waveform Generator
- Oscilloscope Adjuster
- 741 OP-Amp
- 100k-ohm resistor
- 1k-ohm resistor
- 33k-ohm resistor
- 10M-ohm resistor

Procedure

Inverting:

1. Construct the circuit shown in Figure 2.
2. Use $R_1 = 1\text{k-ohm}$ and $R_2 = 33\text{k-ohm}$ resistance and derive the gain.
3. Verify the gain experimentally, using 100Hz.
4. Replace the resistors with 10k-ohm and 100k-ohm respectfully, and repeat steps 2 and 3.

Non-Inverting:

1. Construct the circuit shown in Figure 3
2. Use $R_1 = 1\text{k-ohm}$ and $R_2 = 33\text{k-ohm}$ resistance and derive the gain.
3. Verify the gain experimentally, using 100Hz.

Integrator:

1. Construct the circuit shown in Figure 4A
2. Sketch the input and output waveforms for 1kHz sine wave, and square wave inputs.

3. Show that the output waveforms is indeed the integral of the input waveforms
- Differentiator:
1. Construct the circuit shown in Figure 4B
 2. Sketch the input and output waveforms for 1kHz sine wave, and square wave inputs.
 3. Show that the output waveforms are indeed the derivative of the input waveforms

Circuit Diagram:

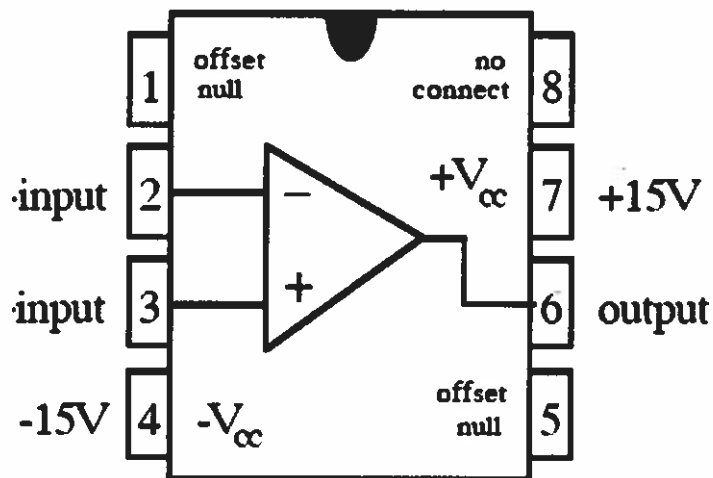


Figure 1. Schematic of 741 Op-Amp

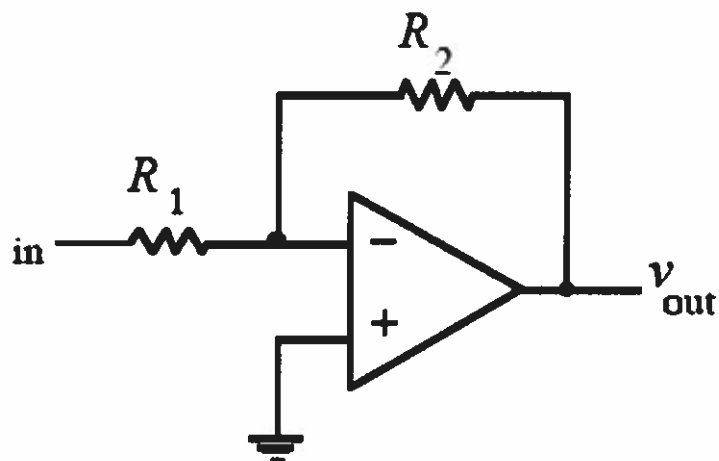


Figure 2. Schematic of Inverting Op-Amp

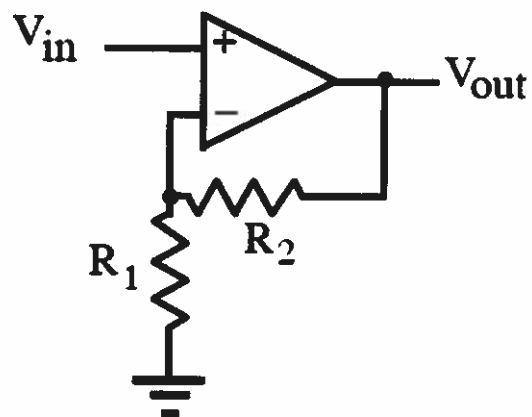


Figure 3. Schematic of Non-Inverting Op-Amp

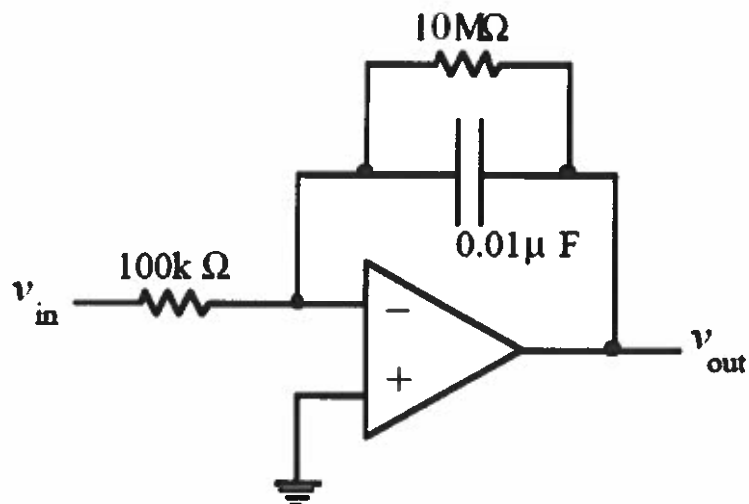


Figure 4A. Schematic of Integrator Op-Amp

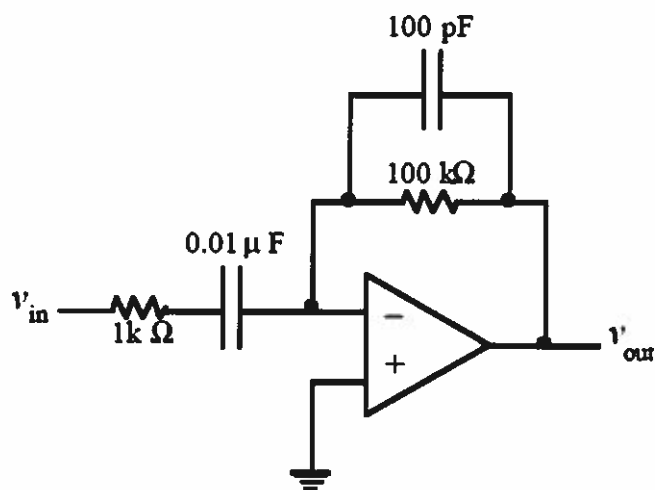


Figure 4B. Schematic of Differentiator Op-Amp

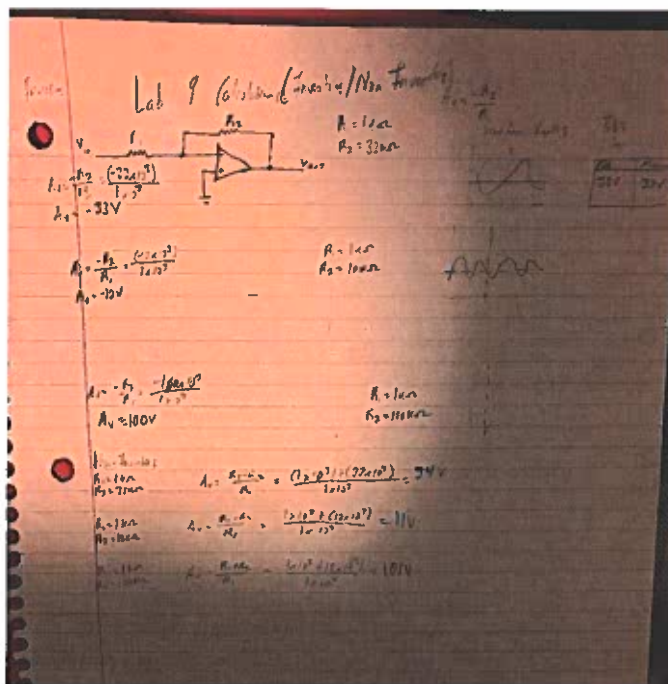


Figure 5. Calculations for Inverting and Non-Inverting Parts of the Lab

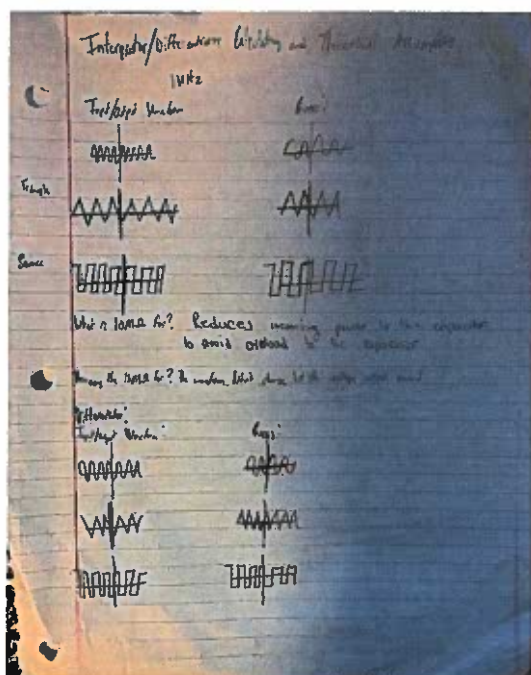


Figure 6. Estimated Graphs for the Lab

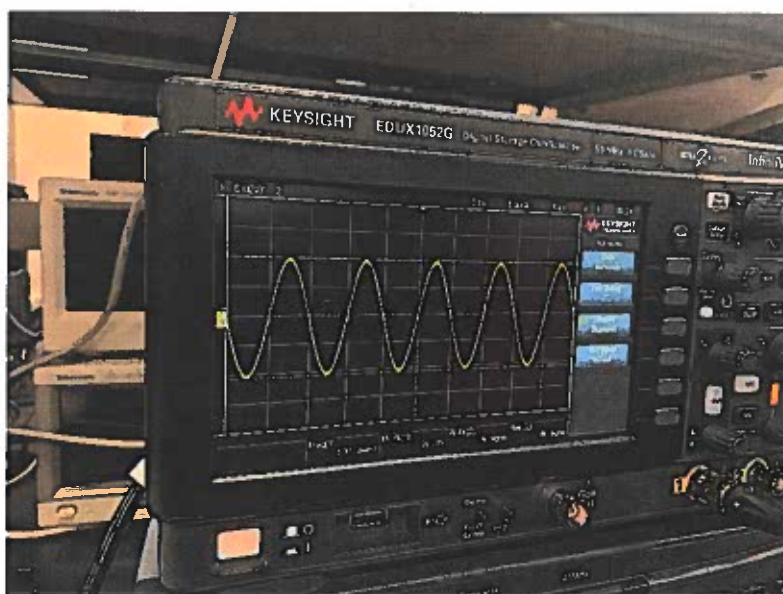


Figure 7. Inverting Amp Graph(1kohm resistor)

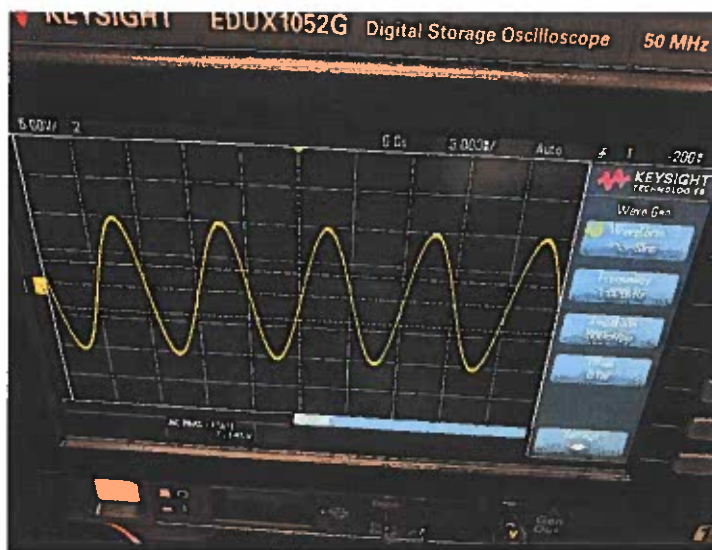


Figure 8. Inverting Amp Graph(10kohm resistor)



Figure 9. Inverting Amp Graph(100kohm resistor)

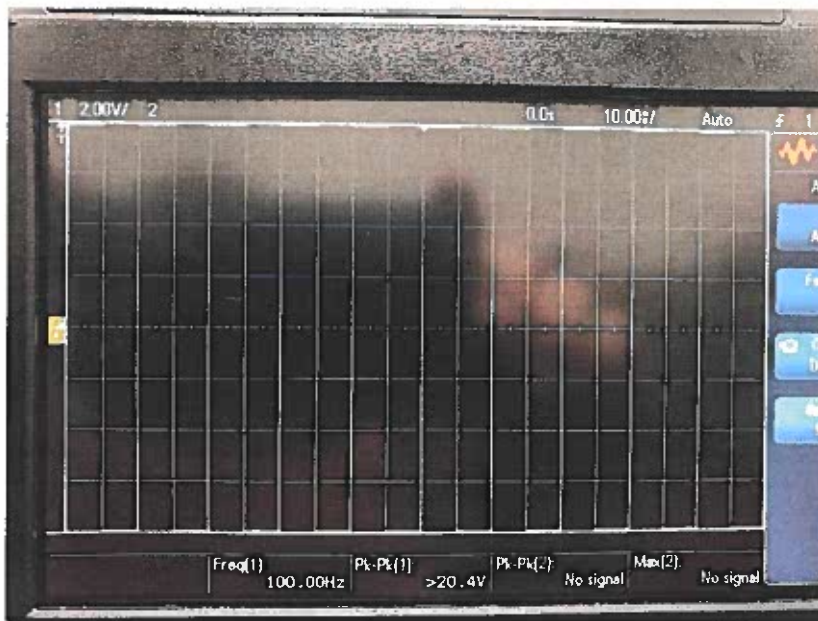


Figure 10. Non-Inverting Amp Graph

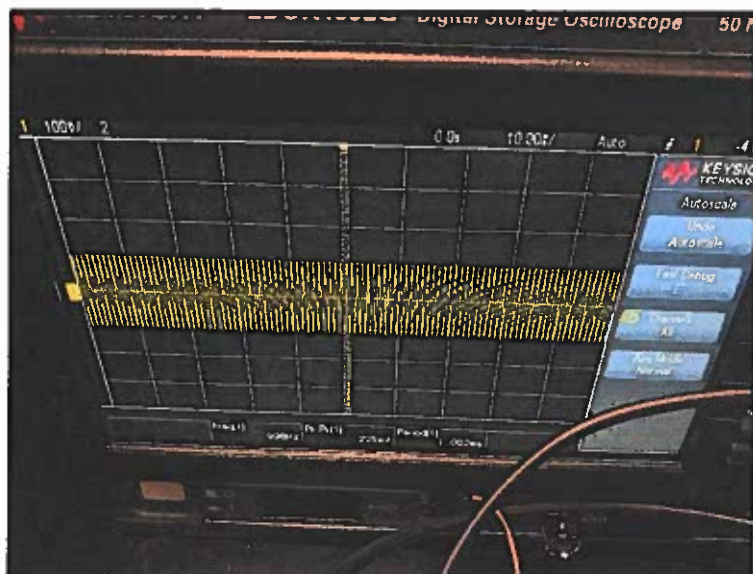


Figure 11. Integrator Amp Graph(Sin Wave)

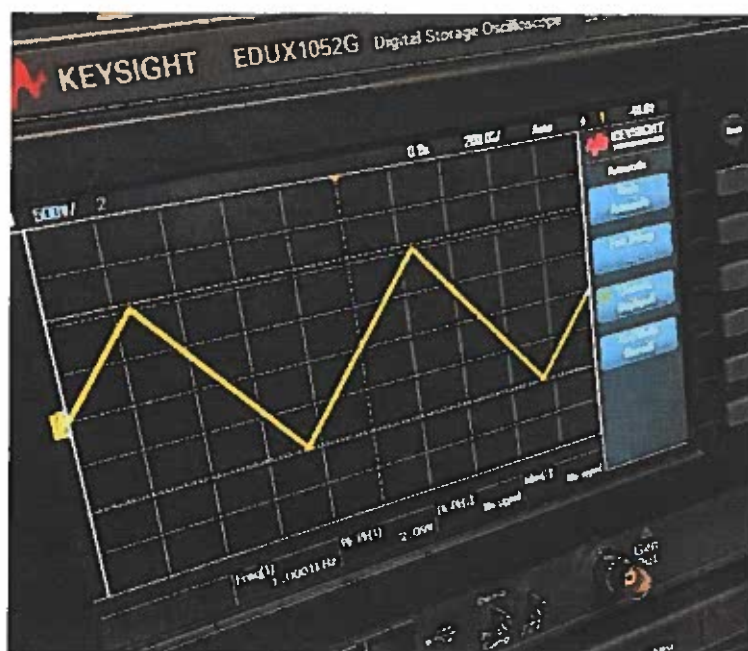


Figure 12. Integrator Amp Graph(Triangle Wave)

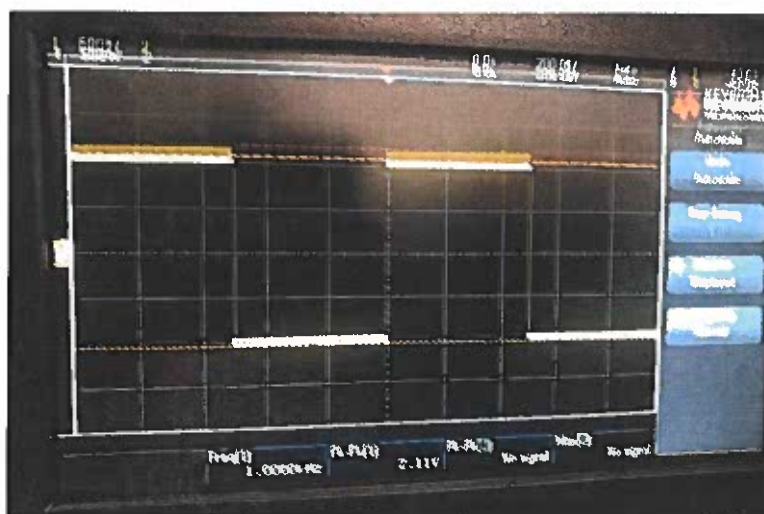


Figure 13. Integrator Amp Graph(Square Wave)

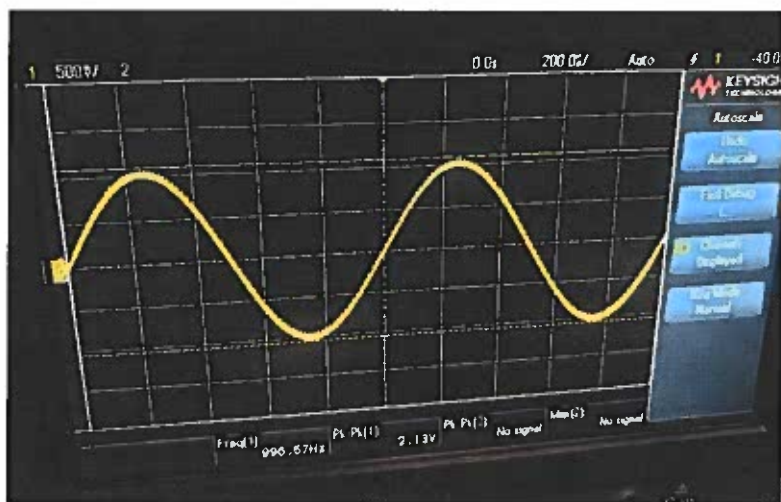


Figure 14. Differentiator Amp Graph(Sin Wave)

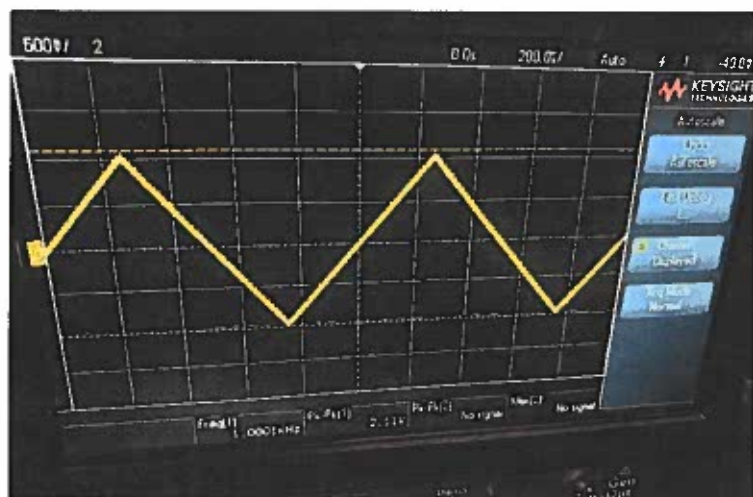


Figure 15. Differentiator Amp Graph(Triangle Wave)

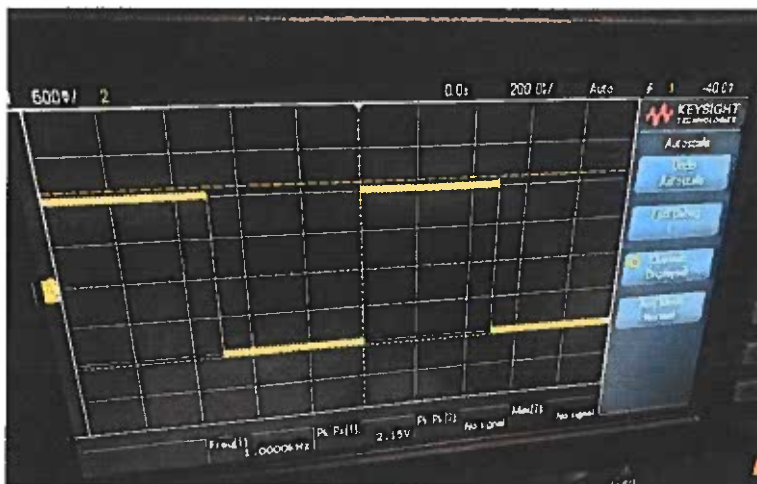


Figure 16. Differentiator Amp Graph(Square Wave)

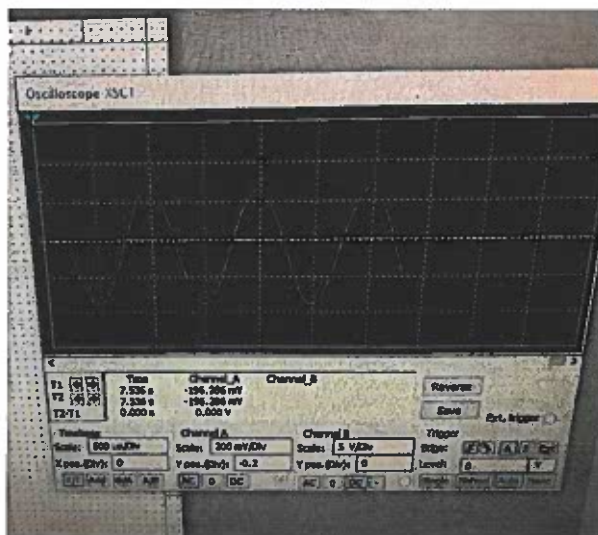


Figure 17. Differentiator Amp Graph(Sine, Waveform Software)

Examination of Results

Figures 1-4 show the schematics used for this lab. The other figures highlight and describe the graphs and calculations for the different types of op-amps used in this experiment. They help illuminate the definition of an inverting op-amp, non-inverting op-amp, integrator op-amp, and finally, a differentiator op-amp. For the integrator and differentiator op-amps, there are three types of waves involved, sin, square, and triangular. There is also an estimated sketch for those different types of graphs, which are included in the results. Our theoretical sketches aligned with our measured graphs.

Questions

Why is this specific op-amp called an inverting amp?

This specific op-amp is called an inverting amp because of the negative feedback is given back to the input from the output.

What is the 10Mohm resistor there for?

The 10Mohm resistor reduces incoming power to the capacitor to avoid an overload of the capacitor

What did removing the 10Mohm resistor do to the circuit?

The circuit did not change after removal.

Did your theoretical values align with your measurements(Verify using measured values)? Our theoretical values corresponded to measurements. We feel as though the discrepancies in our measured values were due to the equipment that was given to us being old, or faulty.

Conclusion

Throughout the lab, we found out how to record the voltage out for different op-amp circuits. The circuit theoretical and the measured values for the voltage output, current of circuits used in the lab aligned very well. Our calculated voltage gain also corresponded to our findings in the lab. Although there were small discrepancies between the measured and calculated values, the measured values were still within the given tolerance for the resistors. In all of our calculations and measurements, the theoretical values were in the tolerance range of the resistors. We used the non-inverting and inverting op-amp equations to solve their respective voltage gains. For the integrator and differentiator op-amps, we proved why they are named the way they are through our waveforms. We were able to discuss of a DC component was present in the input waveform, which concludes to the input would be integrated but the output would increase dramatically.

All in all the experiment was a success. We as a group were able to assemble and arrange an op-amp circuit efficiently, and then attach two resistors to the previous circuit. We were also able to calculate theoretical values for each part of the experiment, and those values helped determine a basis for which our measured values should correspond to. We also proved two different types of op-amps(integrator and differentiator). The discrepancies between our theoretical values and our measured values may have been due to the equipment given to us. To be specific the resistors. However, the resistor issue was not a hindrance to the overall outcome of the experiment.

Discussion

This lab helped us understand different types of basic op-amps. We were able to apply what we learned during the lecture to the lab. We believe that with knowing the op-amp equations we can decipher most basic op-amp problems.

References

There are no references for this experiment

Appendix

There is no appendix for this experiment

Name: Dylan Freeman, Julian Claborn, Demiro Baeza

Lab Instructor: Dr. John Fuller

Date of Performance: 11/8/21

J. Full
11/15/2021

Lab 9: Op Amp Circuits

Lab 9: Op Amp Circuits

INTRODUCTION

This lab introduces the operational amplifier or "op amp". The circuit is already constructed for you on a single IC (integrated circuit) and in this lab we will use the IC in several of its most popular configurations.

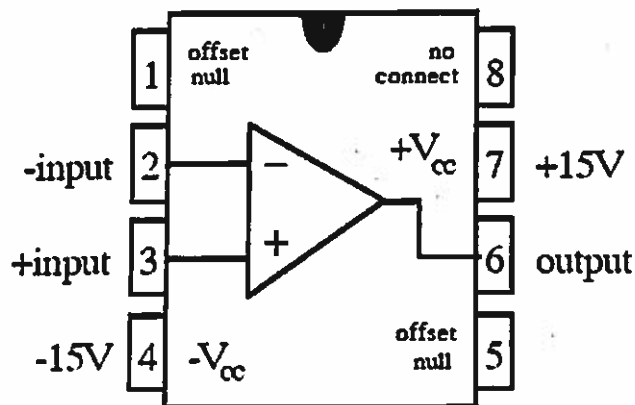


Figure 1: Pinout for the 741 op amp.

INVERTING AMPLIFIER

The pinout diagram for the LM741 op amp IC is shown in figure 1. Use this to construct the inverting op amp circuit shown in figure 2.

Demiro. Baeza @ ~~gmail.com~~
gmail.com

$$R_1 = 1k\Omega$$

$$R_2 = 33k\Omega$$

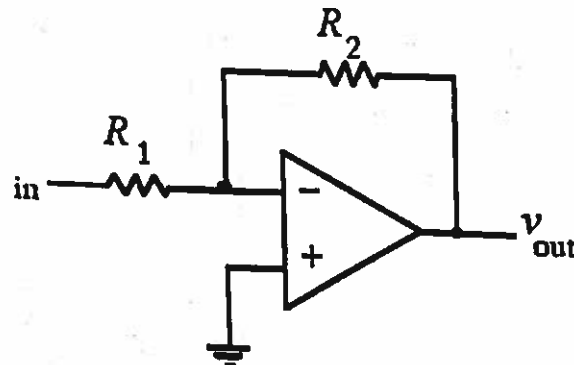


Figure 2: The inverting amplifier.

At first, use $R_1 = 1k\Omega$ and $R_2 = 33k\Omega$. Derive the gain formula $A_v = -R_2 / R_1$ and experimentally verify the gain for a 100Hz sine wave. Also calculate and measure the gain with $R_2 = 10k\Omega$ and $R_2 = 100k\Omega$. For your lab report, give your derivation and compare the 2 calculated and measured gains. Why is this called an inverting amp?

NONINVERTING AMPLIFIER

Construct the noninverting amplifier shown in figure 3 with $R_1 = 1k\Omega$ and $R_2 = 33k\Omega$. For your report, derive and experimentally verify the gain relation

$$A_v = \frac{R_1 + R_2}{R_1}$$

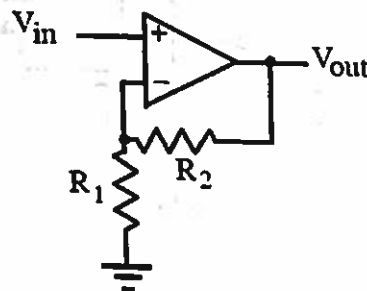


Figure 3: The noninverting amplifier.

CURRENT-TO-VOLTAGE CONVERTER

An op amp can be used to produce a voltage proportional to a given current. Construct the circuit in figure 4.

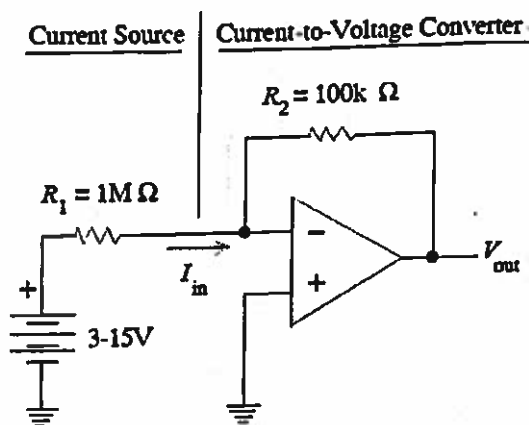


Figure 4: Current source with current-to-voltage converter.

Verify that $V_{out} = -I_{in}R_2$ for this circuit. (That is, do the following for several voltages settings on the variable power supply: Measure the supply voltage and from this calculate I_{in} . Use the formula to calculate a theoretical V_{out} and compare this to a measured V_{out} . Include these measured values and calculations in your report along with a brief discussion of the agreement between theory and measurement.)

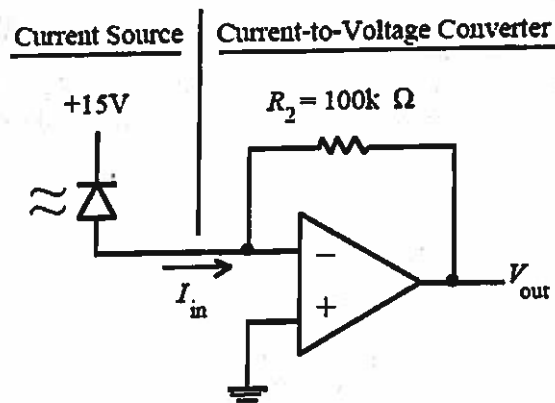


Figure 5: Photodiode with current-to-voltage converter.

Now replace the current source with a photodiode as shown in figure 5. Look at V_{out} with the oscilloscope. For your lab report, measure the intensity of light (steady and oscillating) in the room.

INTEGRATOR

The name "operational amplifier" came from this amplifier's ability to perform mathematical operations. Two good examples of this are the integrator and differentiator which perform the operations of integration and differentiation, respectively.

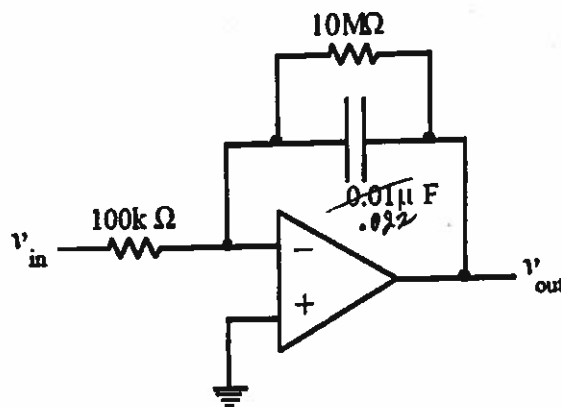


Figure 6: The op amp integrator circuit.

Construct the integrator shown in figure 6. Sketch the input and output waveforms for 1kHz sine wave, triangle wave, and square wave inputs. Try to guess what each waveform will look like ahead of time. For your report, include your sketches and show that the output waveform is indeed the integral of the input waveform. Note that the $10\text{M}\Omega$ resistor (a very large value) is not in the ideal integrator circuit. What is it there for? (Think about what would happen if a small DC component was present in the input waveform. What would integrating this constant do after a short time?). Try removing it and describe what happens. Briefly discuss this in your report.

DIFFERENTIATOR

Construct the differentiator circuit in figure 7. Sketch the input and output waveforms for a 1kHz sine wave, triangle wave, and square wave input as for the integrator. For your report, include your sketches and show that the output waveform is indeed the derivative of the input waveform.

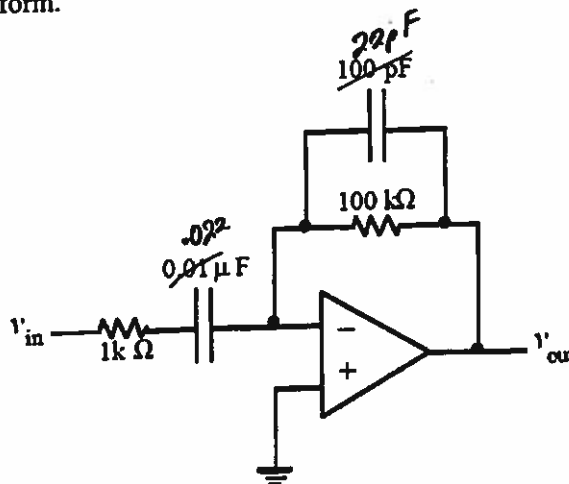


Figure 7: The differentiator amplifier circuit.

Note here that the 100 pF capacitor (a very small value) is not in the ideal amplifier. Why

do you think it is here? (Think about the derivative of a square wave, for example. Could high voltages damage a chip or put a significant noise into the circuit?) Briefly discuss this in your report.

BELOW AVERAGE



Electric Circuits Laboratory

Course # ELEG 2101

Lab 9: Op amps

Group Members:

Faisal ahmed

Nicholas gregoire

Spenser Anderson

Keigan Kenney

8.6

No Op Amp circuit
shown or calculation

Date Of Performance: 11-15-2021

Objective

Introduction/Theory

This lab introduces the operational amplifier or “op amp”. The circuit is already constructed a single IC(integrated circuit) and in this lab we will use the IC in several of its most popular configurations.

Equipment

- LM741 op amp
- 1k Ω , 15k Ω , 10k Ω , 100k Ω , 10M Ω resistors
- .01 μ F, 100pF capacitor
- Multisim

Procedure

Inverting amplifier

The pinout diagram for the LM741 op amp IC is shown in figure 1. Use this to construct the inverting op amp circuit shown in figure 2. At first use $R_1 = 1$ and $R_2 = 100$. Derive the gain formula $A_v = -R_2 / R_1$ and experimentally verify the gain for a 100 Hz sine wave. Also calculate and measure the gain with $R_2 = 10$ and $R_2 = 100$. For your lab report, give your derivation and compare the 2 calculated and measured gains. Why is this called an inverting amp?

Non-Inverting Amplifier

Construct the noninverting amplifier shown in figure 3 with $R_1 = 1$ and $R_2 = 33$. For your report, derive and experimentally verify the gain relation.

Current-to-Voltage Converter

An op amp can be used to produce a voltage proportional to a given current. Construct the circuit in figure 4. Verify that $V_{out} = -I_{in}R_2$ for this circuit. (That is, do the following several voltages settings on the variable power supply: Measure the supply voltage and from this calculate I_{in} . Use the formula to calculate a theoretical V_{out} and compare this to a measured V_{out} . Include these measured values and calculations in your report along with a brief discussion of the agreement between theory and measurements). Now replace the current source with a photodiode as shown in figure 5. Look at V_{out} with the oscilloscope. For your lab report, measure the intensity of light (steady and oscillating) in the room.

Integrator

The name “operational amplifier” came from this amplifiers ability to perform mathematical operations. Two good examples of this are the integrator and differentiator which perform the operations of integration and differentiation, respectively. Construct the integrator shown in figure 6. Sketch the input and output waveforms for 1kHz sine wave, triangle wave, and square wave inputs. Try to guess what each wave form will look like ahead of time. For your report, include your sketches and show that the output waveform is indeed the integral of the input waveform. Note that the 10M ohm resistor(a very large value) is not the ideal integrator circuit. What is it there for? (Think about what would happen if a small DC component was present in the input waveform. What would integrating this constant do after a short time?). Try removing it and describe what happens. Briefly discuss this in the report.

Differentiator

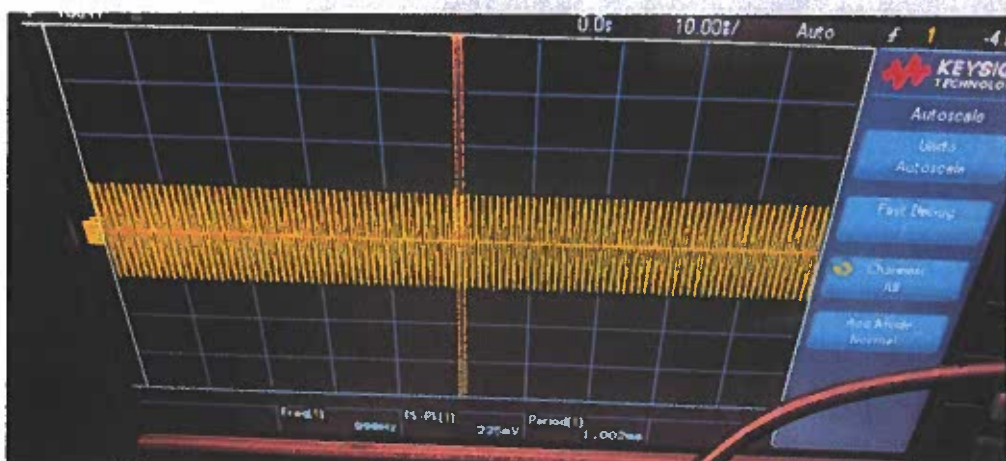
Construct the differentiator circuit in figure 7. Sketch the input and output waveforms for a 1kHz sine wave, triangle wave, and square wave input as for the integrator. For your report, include

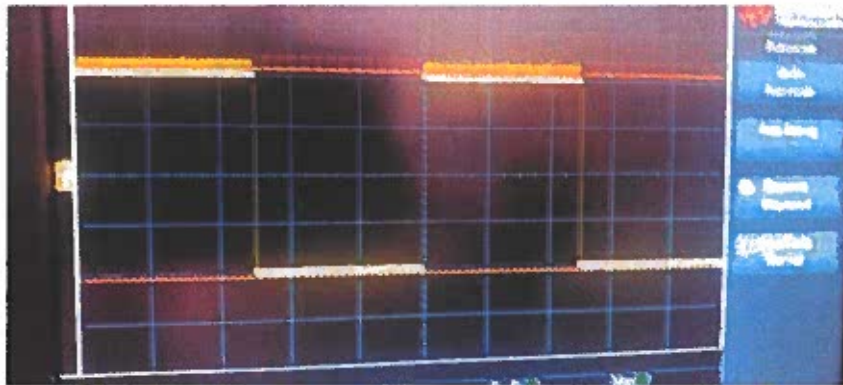
your sketches and show that the output waveform is indeed the derivative of the input waveform. Note here that the 100pF capacitor (a very small value) is not in the ideal amplifier. Why do you think it is here? (Think about the derivative of a square wave, for example. Could high voltages damage a chip or put significant noise into the circuit?) Briefly discuss this in your report.

Circuit Diagram

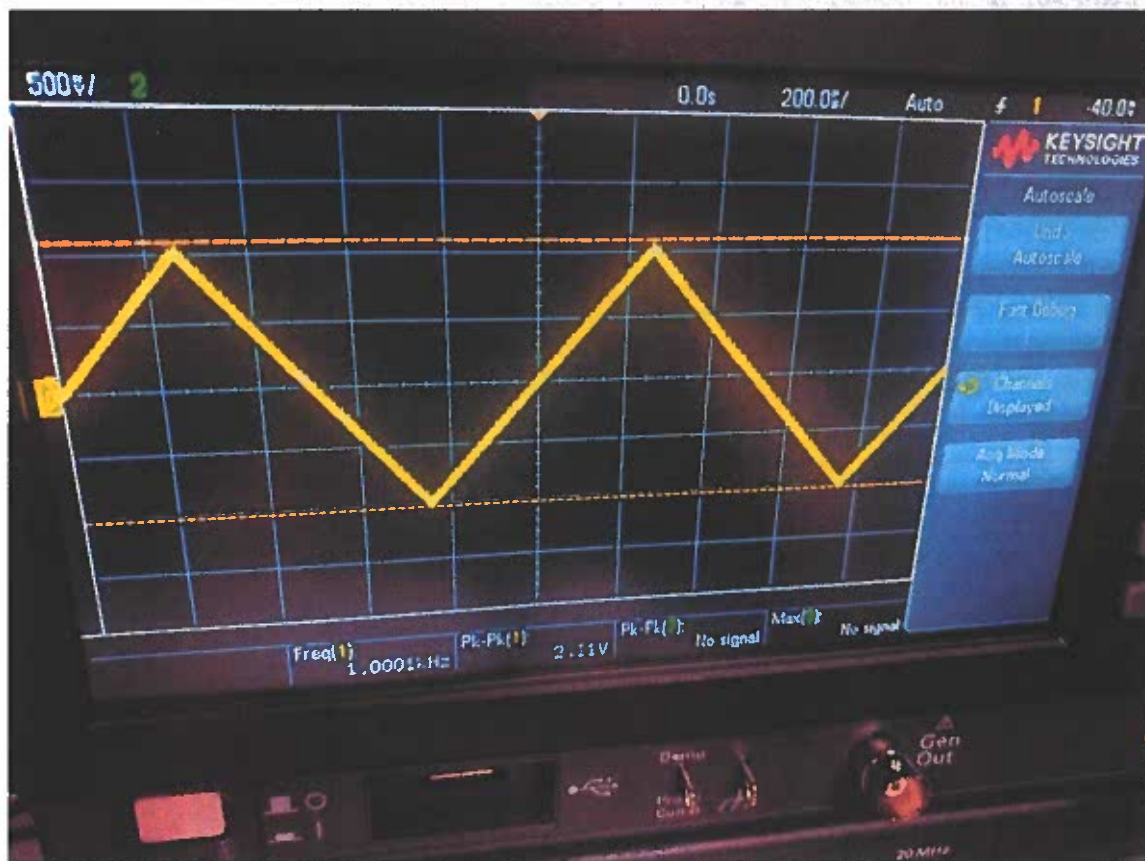


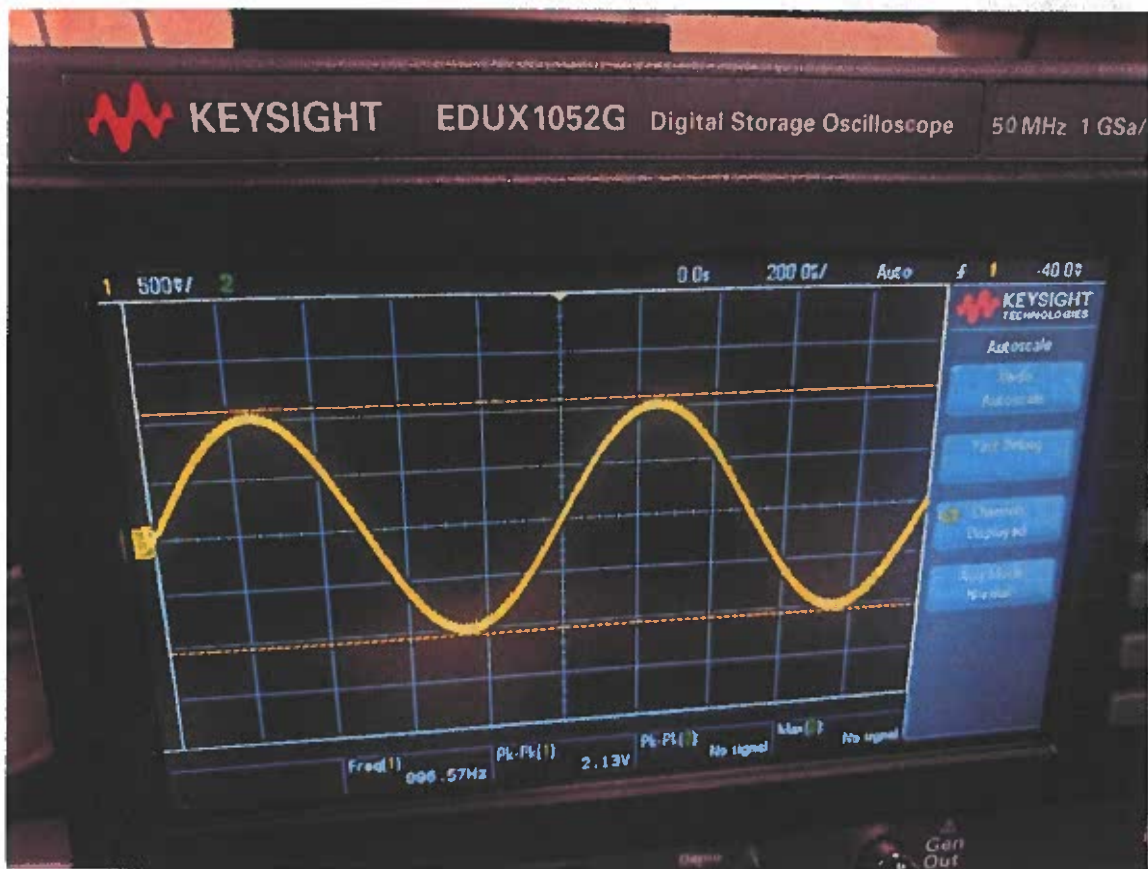
Figure 1: integral waves

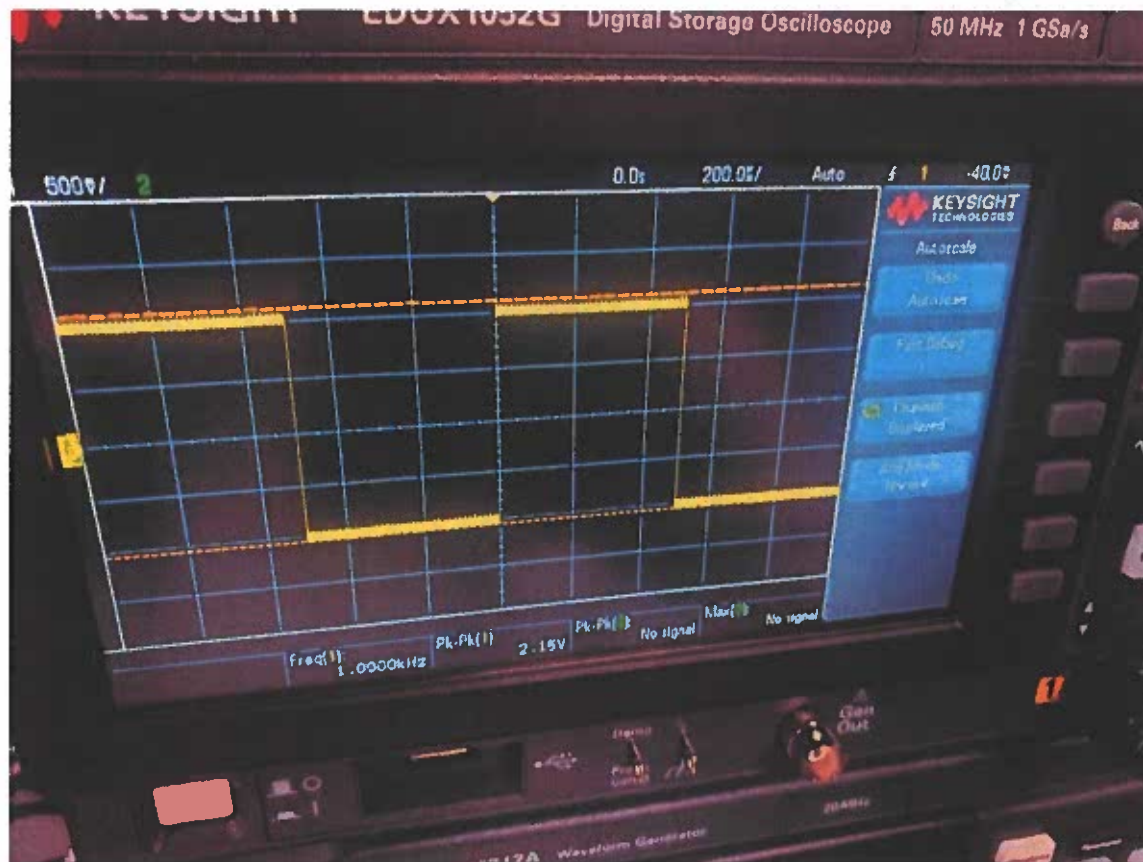




Figures 2: Differentiators







Answer to the Questions

Why is figure 1 and inverted op amp? This op amp inverts the signal that comes in from the negative side.

What is the 10 M Ω there for? It is there to control the output voltage.

Integrating this constant makes the voltage larger over time.²

Conclusion

In this lab we used Op Amps configured for integration and differentiation and tested it with sine waves, triangle waves, and square waves as inputs. After this lab we understood how these Op Amps in certain configurations performed and altered the incoming signals.

Discussion and Contribution

This lab was pretty straight forward. While we performed this lab we did not come across any challenges.

Faisal Ahmed
Nicholas Gregoire
Name: Spencer Anderson
Lab Instructor: Dr. John Fuller
Date of Performance: _____

Nigel Hurrey

J. Full
11/15/2021

Lab 9: Op Amp Circuits

Lab 9: Op Amp Circuits

INTRODUCTION

This lab introduces the operational amplifier or "op amp". The circuit is already constructed for you on a single IC (integrated circuit) and in this lab we will use the IC in several of its most popular configurations.

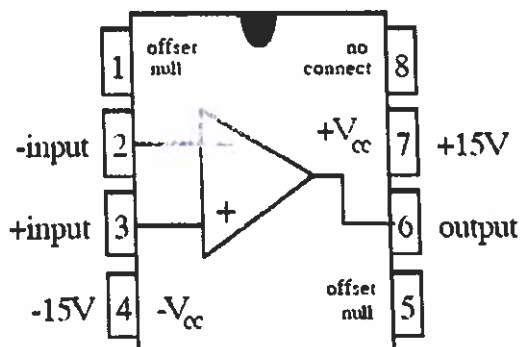


Figure 1: Pinout for the 741 op amp.

INVERTING AMPLIFIER

The pinout diagram for the LM741 op amp IC is shown in figure 1. Use this to construct the inverting op amp circuit shown in figure 2.



**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
Circuits Laboratory
FALL 2021
Instructor: Dr. John Fuller**

Title of Assignment

**Experiment 10
RC Circuits**

Outcome Measured Using this Assignment

Outcome 1.3

Students are able to use modern engineering tools and have competency in the use of simulation tools

Check the complex engineering problem characteristics related to this assignment

Assignment problem	
	involves wide-ranging or conflicting technical issues,
	has no obvious solution
	Addresses problems not encompassed by current standards and codes
	involves diverse groups of stakeholders
X	includes many component parts or sub-problems
	involves multiple disciplines
X	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
	science
X	mathematics

Laboratory experiments up to this point has been related to DC sources with analysis using voltmeters and ammeters. Now they are introduced to time varying circuits. This laboratory experiment is directly related to course lectures on RC circuits and provide the students with a visual realization of in class calculations using actual signal generators and oscilloscopes

Sample Student Work

ABOVE AVERAGE



10

Lab Report #10

RC Circuits

Electric Circuits Laboratory

ELEG 2101

Roshaan Turner, Summer Brandon, Abdulmalik Arogundade

Date of Submission: 12/03/21

Date of Performance: 11/22/21

Department of Electrical and Computer Engineering

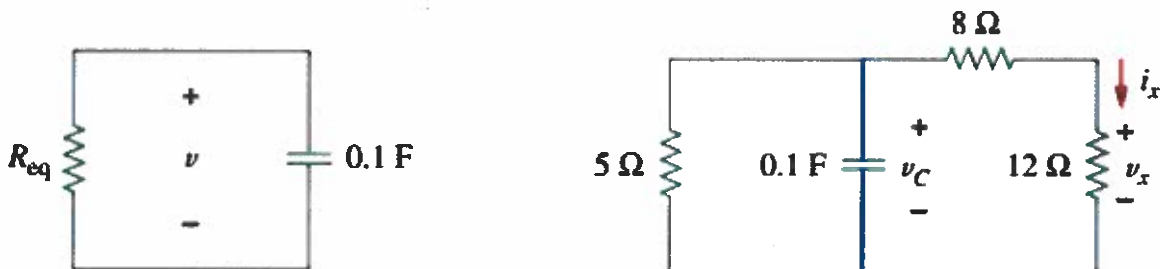
Prairie View A&M University

- **Objectives:**

- I. Explore the behavior of an RC Circuit by using the Multism software
- II. Examine the charging and discharging process of capacitors in RC Circuit

- **Theory:**

All RC and DC circuits contain a source of electromotive force (battery), resistors, and capacitors. However, in contrast to DC circuits without capacitors, the currents of RC circuits take some time to reach their constant values. This lab will focus more on RC Circuits, which are electrical circuits that consist of resistors, inductors, and capacitors that are all connected in series or in parallel. The following figures illustrate the variables within the RC Circuit.



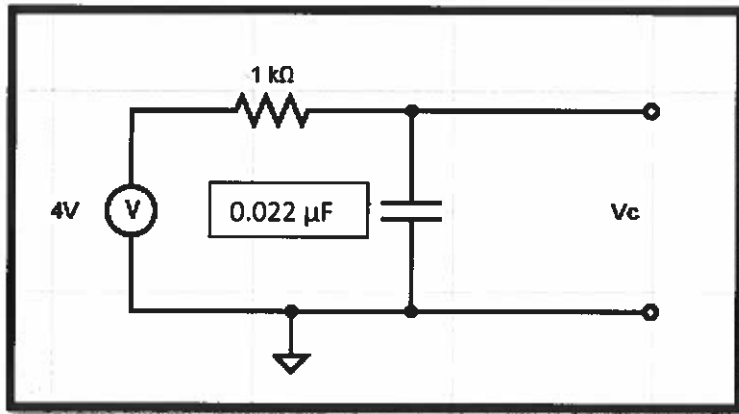
- **Equipment:**

- Multism software

- **Procedure:**

- Use breadboard to build the circuit shown in Figure 5. Connect AWG1 (yellow wire) to node 1 of the circuit. Also, connect Scope Channel 1 positive (orange wire) to node 1. In addition, connect the Ground (black wire) to node 0 of the circuit. Moreover, connect the Scope Channel 1 negative (orange-white wire) to node 0. Furthermore, connect Scope Channel 2 positive (blue wire) to node 2, and the Scope Channel 2 negative (blue-white wire) to node 0.
- Click on the WaveGen in the main WaveForms screen. Go to Basic → Square → Frequency (set to 1 KHz) → Amplitude (set to 2 V) → Offset (set to 2V) → Symmetry (set to 50%) → Click on “Run AWG1.”
- Click on the Scope in the main WaveForms screen. Go to Run → Autoset → Measure → Add → Channel 1 Horizontal → Frequency → Add Selected Measurement → Close Add Instrument.
- Observe the input and output waveforms. The input and output waveforms are shown in Figure #7. Draw the input and output waveforms of the RC circuit (you can export the scope waveforms into a spreadsheet and plot the input and output waveforms). Measure the time constants of the charging and discharging of the capacitor.
- If the frequency of the square wave generator is increased to 10 KHz, while keeping the $R = 1\text{ K}\Omega$ and $C = 0.022\text{ }\mu\text{F}$, draw the input and output waveforms.
- Replace the $0.022\text{ }\mu\text{F}$ capacitor by $1.0\text{ }\mu\text{F}$ capacitor and keep the $R = 1\text{ K}\Omega$ and the frequency of the square wave at 1 KHz. Draw the input and output waveforms of the RC circuit.

- **Circuit Diagrams:**



- **Figure #1: RC Circuit for Experiment**

- **Questions:**

- **Is the time-constant measured in Step #3 equal to that calculated and shown in Table #2?**

Yes

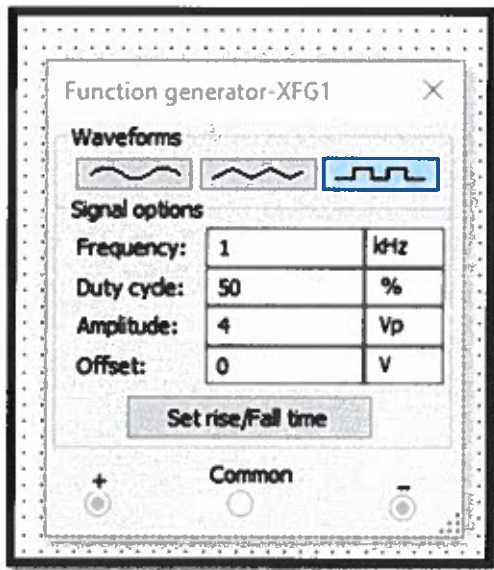
- **Why is the output waveform obtained in Step #4 different from that of Step #3?**

Step #4 asked that you measure the frequency of the Square-wave with the $0.022\mu\text{F}$ capacitor.

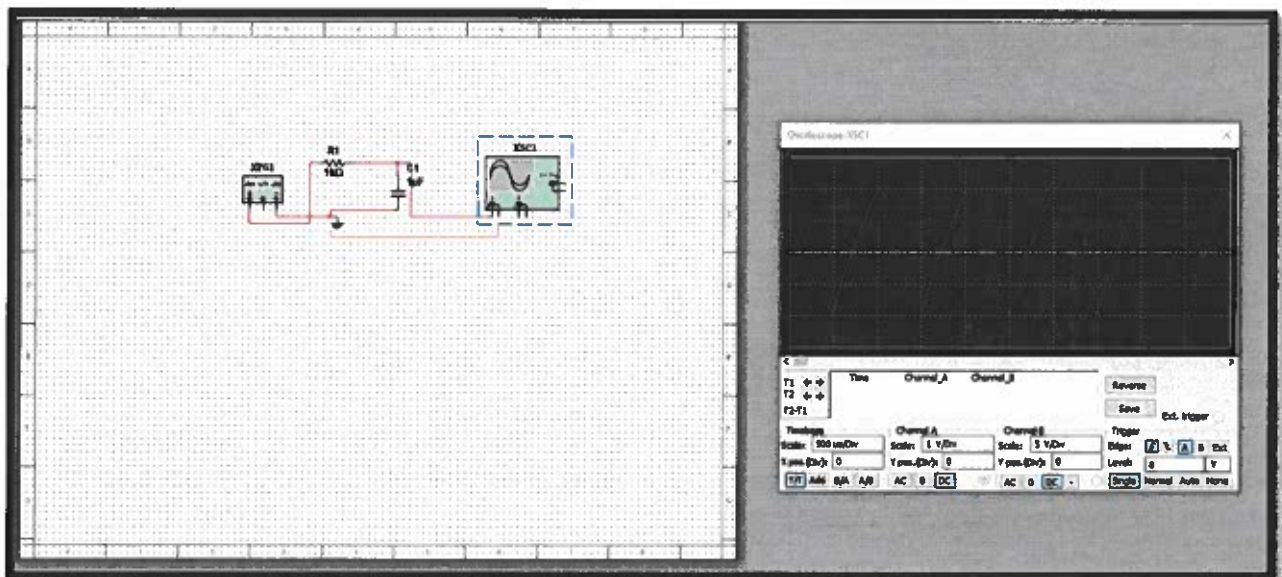
- **Why is the output waveform obtained in Step #5 different from that of Step #3?**

Step #5 asked that you measure the frequency of the Square-wave with the $1.0\mu\text{F}$ capacitor.

- **Data:**

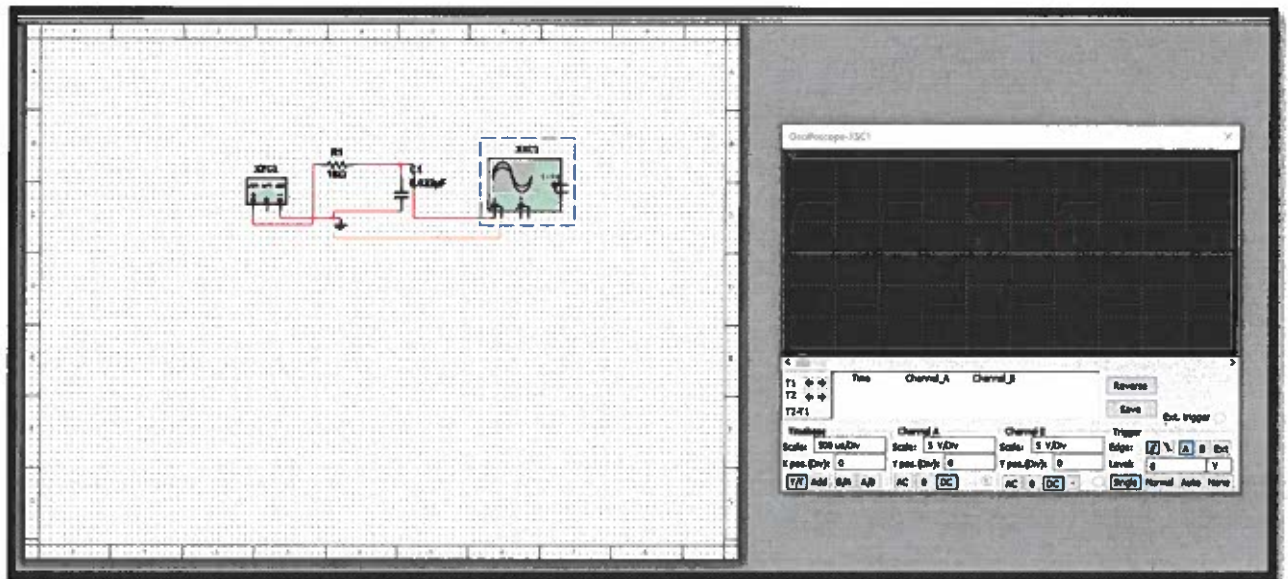


- Figure #2: Data input on Multism software

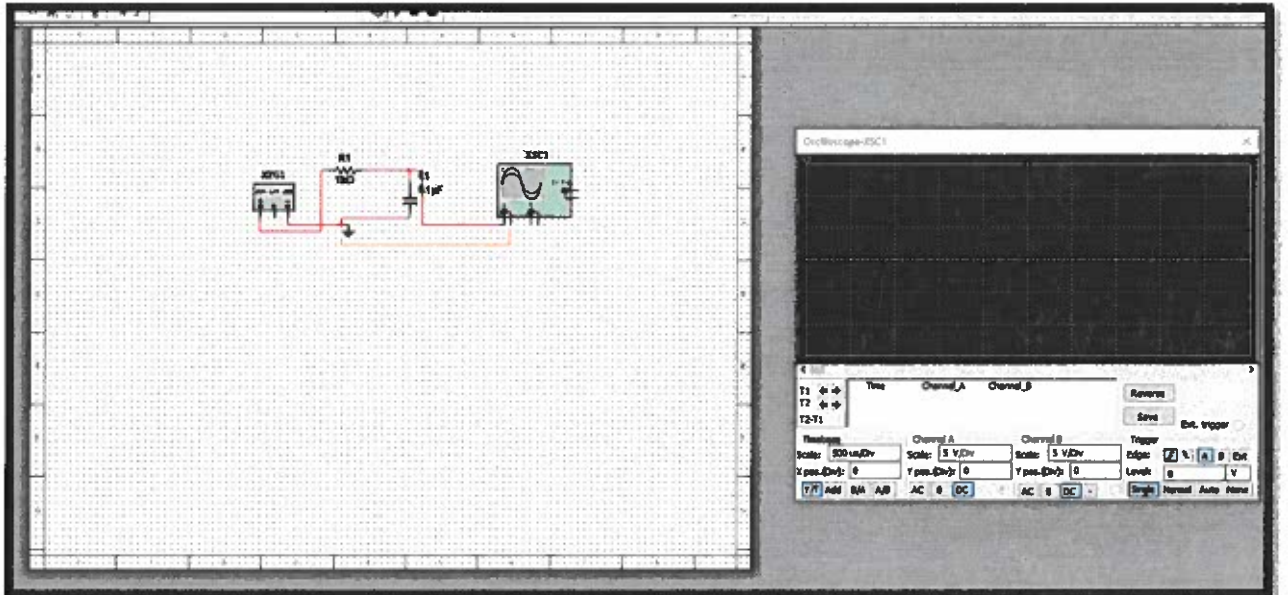


- Figure #3: Triangle-wave output on Multism software using the 1.0μF capacitor.

- **Data Continued:**



- Figure #4: Square-wave output on Multism software using the 0.022μF capacitor.



- Figure #5: Sine-wave output on Multism software using the 0.022μF capacitor.

- **Data Continued:**

- $V_c(t) = V_s \left(1 - e^{\frac{-t}{RC}}\right) + V_c(0)$

- $V_c(t) = V_c(0)e^{\frac{-t}{RC}}$

- $V_c(0) = \text{initial voltage across the capacitor}$

- $f = \frac{1}{T}$

- $\tau = RC$

Table #1: Frequency v. Period of a Square-wave Generator

Number	1	2	3	4	5
Frequency (Hz)	100	500	1000	5000	10000
Period (s)	0.01	0.002	0.001	0.0002	0.0001

Table #2: Time Constants of various RC Values of a Circuit

#	1	2
R	1000 Ω	1000 Ω
C	0.022 μF	1.0 μF
τ (s)	22	1000
5 τ (s)	110	5000

• Calculations:

Frequency	100	500	1000	5000	10,000
Period	0.01	0.002	0.001	0.0002	0.0001

$$f = \frac{1}{T}$$

$$100 = \frac{1}{T} = 0.01$$

$$500 = \frac{1}{T} = 0.002$$

$$1000 = \frac{1}{T} = 0.001$$

$$5000 = \frac{1}{T} = 0.0002$$

$$10,000 = \frac{1}{T} = 0.0001$$

$$\tau = RC$$

R	1000 Ω	1000 Ω
C	0.022 μF	1.0 μF
τ	22	1000
5τ	110	5000

$$\tau = (1000)(0.022)$$

$$= 22$$

$$\tau = (1000)(1.0)$$

$$= 1000$$

$$5\tau = 5(1000)(0.022)$$

$$= 110$$

$$5\tau = 5(1000)(1.0)$$

$$= 5000$$

- **Discussion:**

In this experiment, physical RC circuits consisting of a source of electromotive force, resistors, connecting wires and capacitors that would usually be used to determine the time required to completely charge or discharge specific capacitors were completely absent.

The experiment did not ask much of us, as the Multism software was the only tool of focus during the lab. We were to first mirror the circuit illustrated in Figure #1 onto the software using 1.0 μ F capacitor and measure and capture the waveforms provided from the circuit. The same process would be repeated for the 0.022 μ F capacitor, as we would once again capture and measure the values and waveforms provided from the circuit. Afterwards, we were to take these values and use them to find the time constant τ that is directly proportional to the product of the capacitance and resistance present within the circuit.

- **Conclusion:**

We were able to get the Sine-waves working correctly and utilized the waveforms for our benefit, as we found that the time constants of capacitors from three RC circuits were successfully determined experimentally and compared to their theoretical values which were determined mathematically.

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 2101

Name Roshan Turner

Summer D Multisim

J. J. J. 11/22/2021

Date 11-22-21

LAB #10: RC CIRCUITS

(A) Introduction:

In this laboratory, you will explore the behavior of an RC circuit by using the Multisim software.

(i) Equations for Charging and Discharging of a Capacitor

For an RC circuit, the expression for charging the capacitor is given as:

$$V_C(t) = V_S \left(1 - e^{-\frac{t}{RC}} \right) + V_C(0) \quad (1)$$

and that for discharging of the capacitor is:

$$V_C(t) = V_C(0) e^{-\frac{t}{RC}} \quad (2)$$

where,

$V_C(0)$ = initial voltage across the capacitor

(ii) Square Wave Generator:

One can quickly charge and discharge a capacitor by using a function generator to generate the square wave. The output of function generator is shown in Figure 1. One can control the amplitude of the generator and the period T. The period and the repetition frequency are related by the expression $f = 1/T$.

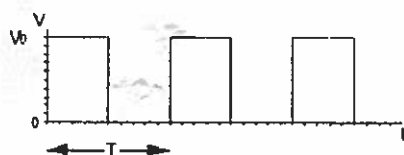


Figure 1: Output of Square-wave Generator

(ii) The Time Constant

For RC circuit, the time constant is given as $\tau = RC$. The time constant determines the rate of charging or discharging of a capacitor. After τ seconds, the voltage will have decreased to e^{-1} (about .368) of its initial value. After 2τ seconds, it will have decreased to e^{-2} (0.135) its initial value, and after 3τ seconds, the voltage will have decreased to 0.0067 of the initial value.

AVERAGE

**Department of Electrical and Computer Engineering
Prairie View A&M University
Electric Circuits Laboratory
ELEG-2011**



Fall 2021

9.5
Calculation should
be part of formal
report

LABORATORY REPORT:

Experiment 10 RC Circuits

Conducted on
November 22, 2021

Submitted by:
Dylan Freeman
Julian Claiborne
Demiro Baeza

On
December 3, 2021

Objective

- To construct a circuit on a waveform software
- To study RC circuits
- To learn how to measure the charging and discharging of a capacitor

Introduction/Theory

This experiment includes measuring the charging and discharging of a capacitor. The theories used in the experiment include $V_c(t) = V_s(1 - e^{-t/RC}) + V_c(0)$ for charging a capacitor and $V_c(t) = V_c(0)e^{-t/RC}$.

Equipment List

- .022uF Capacitor
- 1uF Capacitor
- Waveform Software Generator
- 1K-ohm resistor

Procedure

Pre-Lab:

WaveGen Setup

Click on the WaveGen in the main WaveForms screen. Go to Basic → Square → Frequency (set to 1 KHz) → Amplitude (set to 2 V) → Offset (set to 2V) → Symmetry (set to 50%) → Click on "Run AWG1."

Scope Activation

Click on the Scope in the main WaveForms screen. Go to Run → Autoset → Measure → Add → Channel 1 Horizontal → Frequency → Add Selected Measurement → Close Add Instrument.

Lab Steps:

1. Observe the input and output waveforms
2. Draw the input and output waveforms of the RC circuit
3. Measure the time constants of the charging and discharging of the capacitor
4. If the frequency of the square wave generator is increased to 10kHz, while keeping the $R=1k\text{ ohm}$ and $C=.022\mu\text{F}$, draw the input and output waveforms
5. Replace the .022uF with the 1uF capacitor, and repeat step 4.

Circuit Diagram:

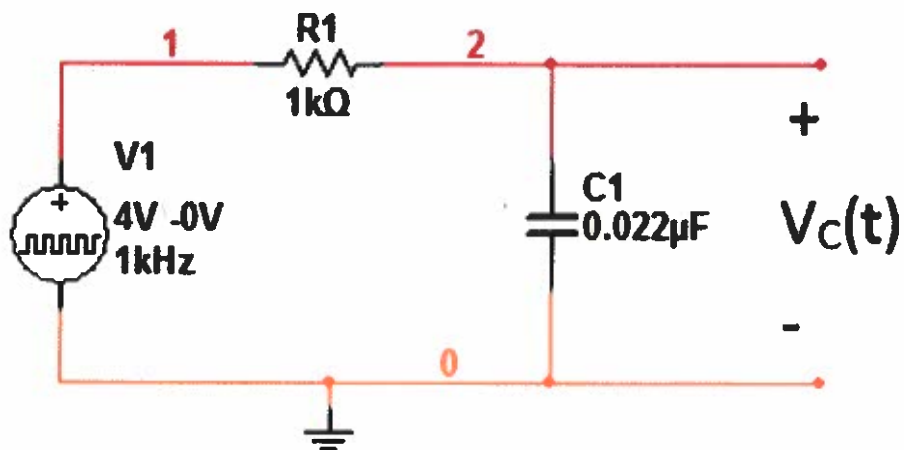


Figure 1. Schematic of RC Circuit for Experiment

Table 1. Frequency vs. Period of a Square-Wave Generator

Number	Frequency(Hz)	Period(s)
1	100	0.01
2	500	0.02
3	1000	0.001
4	5000	2×10^{-4}
5	10000	1×10^{-4}

Table 2. Time Constants of Various RC Values of a Circuit

Number	R(ohms)	C(F)	Time Constant	5Time Constants(s)
1	1000	0.022uF	$2.2 \times 10^{-5}s$	1.1×10^{-4}
2	1000	1uF	0.001	0.005

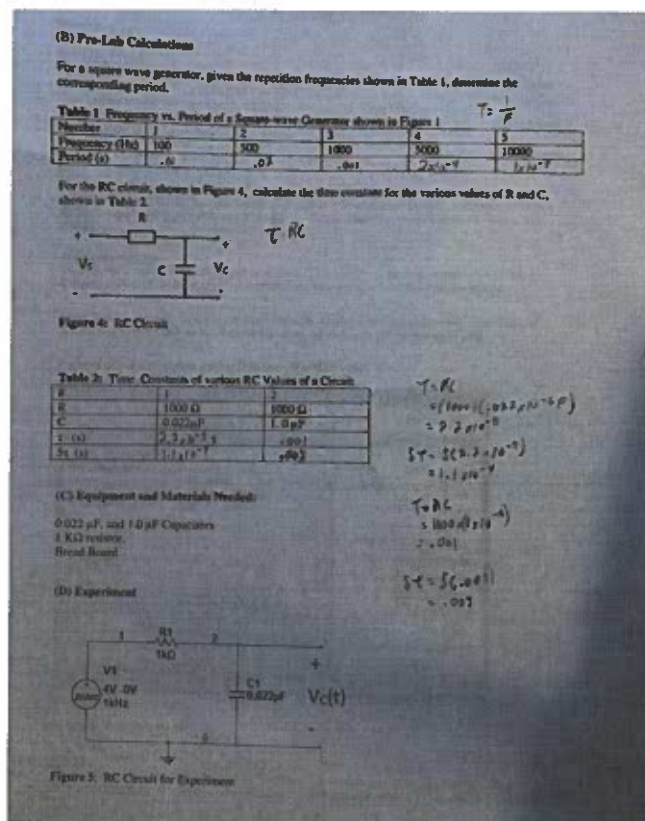


Figure 2. Calculations for Tables 1 and 2

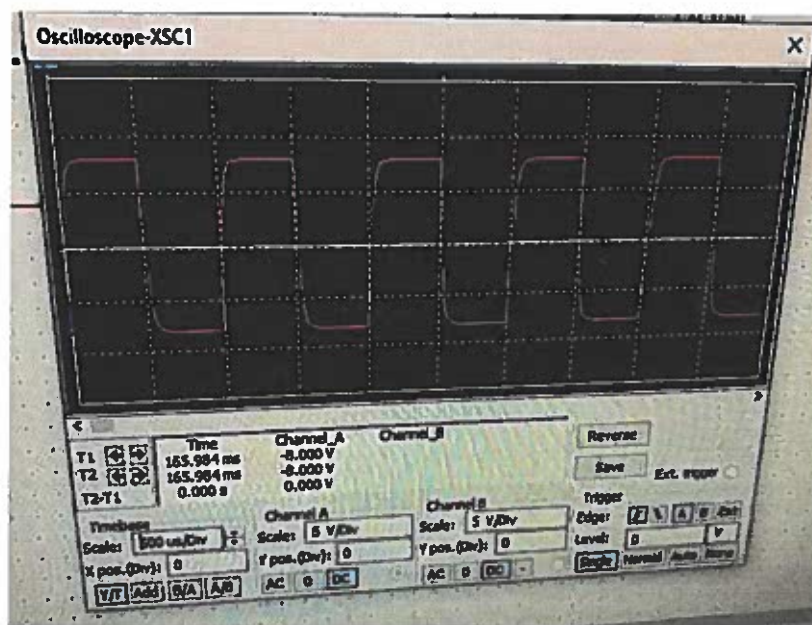


Figure 3. Output for 1 μF at 10kHz

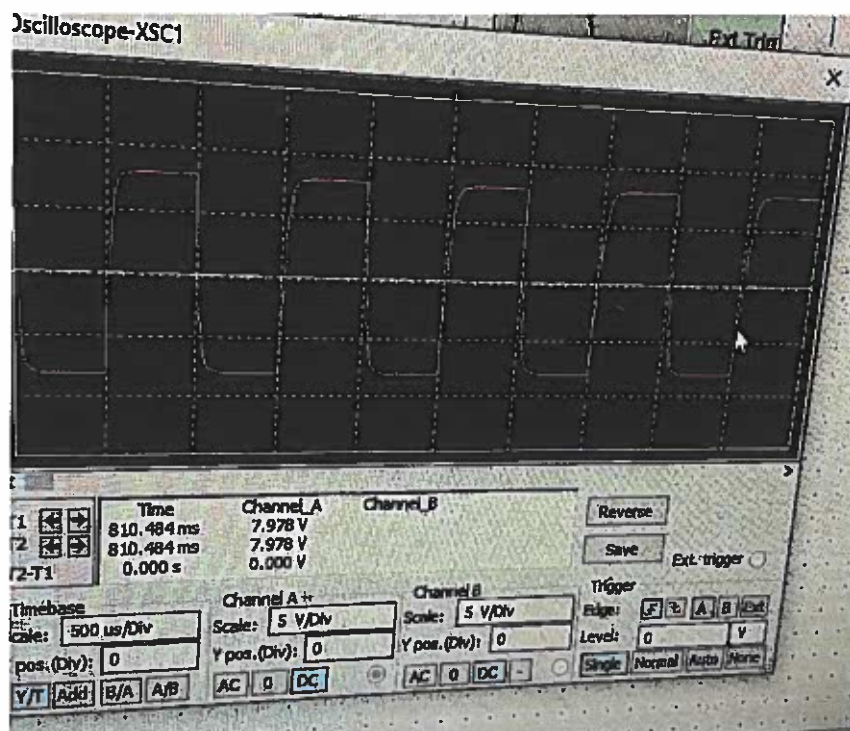


Figure 4. Output for .022uF at 10kHz

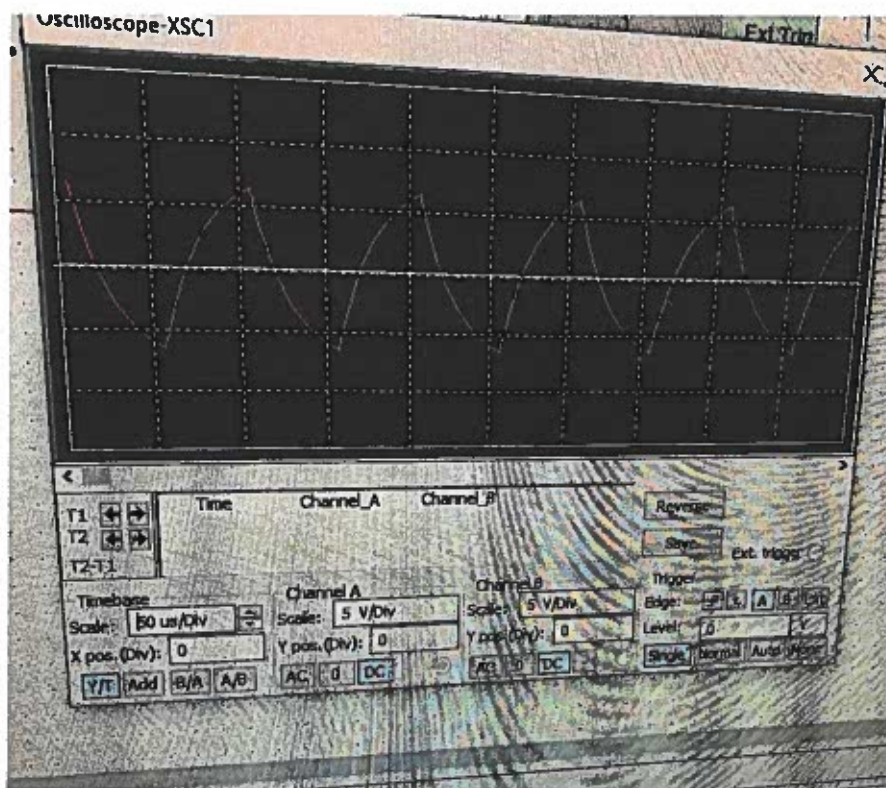
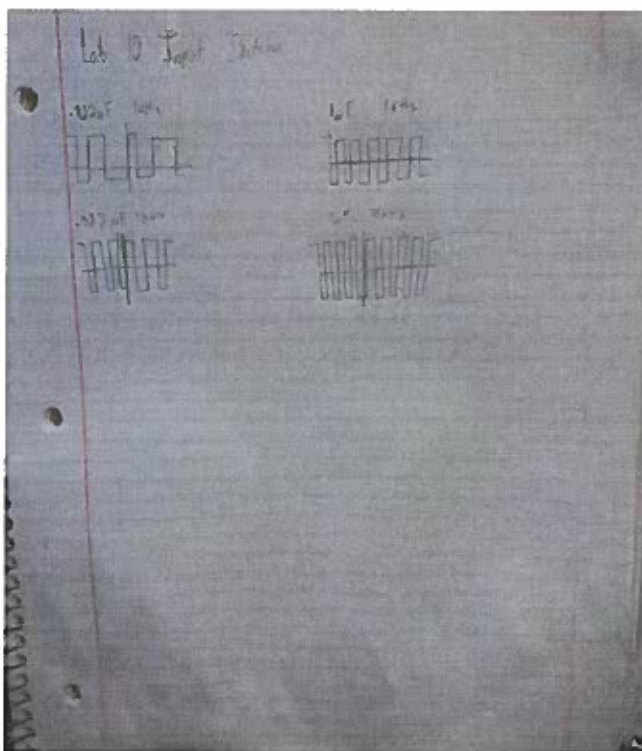
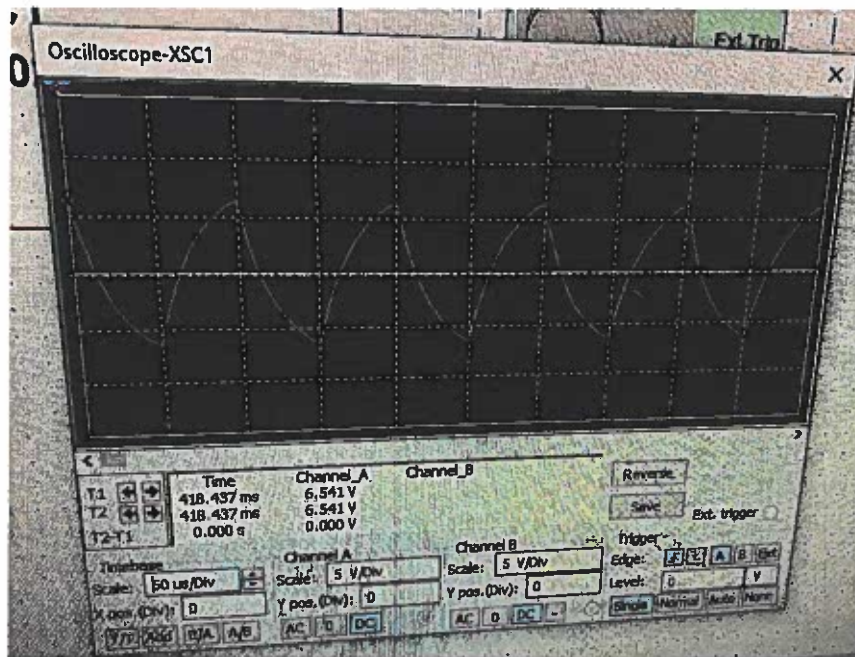


Figure 5. Output for 1uF at 1kHz



Examination of Results

Figure 1 shows the schematics used for this lab. The other figures highlight and describe the waveform output for each independent capacitor and frequency. They help illuminate the definition of a time constant and the charging and discharging of a capacitor. There is also an estimated sketch for those different types of graphs, which are included in the results. Our theoretical sketches aligned with our measured graphs.

Questions

Is the time constant measured in step 3 equal to that calculator and shown in table 2?

Yes, they are equal when comparing the time constant in step 3 to the calculated time constant in table 2.

Why is the output waveform obtained in step 4 different from that of step 3?

The output waveform is different between the two steps because the frequency increased.

Why is the output waveform obtained in step 5 different from that of step 3?

The output waveform is different between the two steps because the capacitor is changed from .022uF to 1uF.

For the square wave input signal with $R=1\text{kohm}$ and $C=1.0\text{uF}$, estimate the period of the square wave that will make the output waveform almost a square wave?

_____ The period is equal to $T=1/f$. For the 1kohm and $C=1\text{uF}$, the period at 1kHz is .001, and for 10kHz is .0001.

Conclusion

Throughout the lab, we found out how to record the time constant for the different RC circuits. The circuit theoretical and the measured values for the voltage output, current of circuits used in the lab aligned very well. Our calculated values and estimated sketches coexisted together. Although there were small discrepancies between the measured and calculated values, the measured values were still within the given tolerance for the resistors. In all of our calculations and measurements, the theoretical values were in the tolerance range of the resistors. We used the WaveForm generator system to formulate the output graphs. We were able to discuss time constants and capacitors, and decipher the charging and discharging of the capacitor.

All in all the experiment was a success. We as a group were able to assemble and arrange RC circuits. We were also able to calculate theoretical values for each part of the experiment, and those values helped determine a basis for which our measured values should correspond to. The discrepancies between our theoretical values and our

measured values may have been due to the equipment given to us. To be specific the resistors. However, the resistor issue was not a hindrance to the overall outcome of the experiment.

Discussion

This lab helped us understand different types of basic RC circuits. We were able to apply what we learned during the lecture to the lab. We believe that with knowing the charging and discharging equations we can decipher most basic time constant problems.

References

There are no references for this experiment

Appendix

There is no appendix for this experiment

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ELEG 2101

Name Dylan Freeman, Julian Claiborne,
Date 11/22/21 Demiro Boz...

J. Juth
11/22/2021

LAB #10: RC CIRCUITS

(A) Introduction:

In this laboratory, you will explore the behavior of an RC circuit by using the Multisim software.

(i) Equations for Charging and Discharging of a Capacitor

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and that for discharging of the capacitor is:

$$V_C(t) = V_C(0) e^{-\frac{t}{RC}} \quad (2)$$

where,

$V_C(0)$ = *initial voltage across the capacitor*

(ii) Square Wave Generator:

One can quickly charge and discharge a capacitor by using a function generator to generate the square wave. The output of function generator is shown in Figure 1. One can control the amplitude of the generator and the period T. The period and the repetition frequency are related by the expression $f = 1/T$.

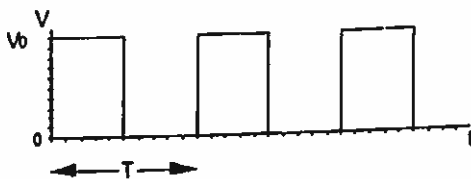


Figure 1: Output of Square-wave Generator

(ii) The Time Constant

For RC circuit, the time constant is given as $\tau = RC$. The time constant determines the rate of charging or discharging of a capacitor. After τ seconds, the voltage will have decreased to e^{-1} (about .368) of its initial value. After 2τ seconds, it will have decreased to e^{-2} (0.135) its initial value, and after 3τ seconds, the voltage will have decreased to 0.050 of the initial value.

(B) Pre-Lab Calculations

For a square wave generator, given the repetition frequencies shown in Table 1, determine the corresponding period.

$$T = \frac{1}{F}$$

Table 1 Frequency vs. Period of a Square-wave Generator shown in Figure 1

Number	1	2	3	4	5
Frequency (Hz)	100	500	1000	5000	10000
Period (s)	.01	.02	.001	2×10^{-4}	1×10^{-4}

For the RC circuit, shown in Figure 4, calculate the time constant for the various values of R and C, shown in Table 2.

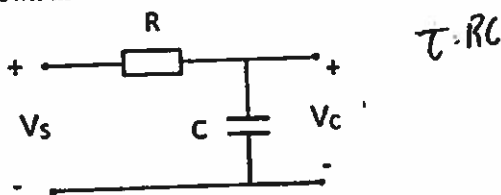


Figure 4: RC Circuit

Table 2: Time Constants of various RC Values of a Circuit

#	1	2
R	1000 Ω	1000 Ω
C	0.022 μF	1.0 μF
τ (s)	2.2×10^{-5} s	.001
5 τ (s)	1.1×10^{-4}	.005

$$\begin{aligned} \tau &= RC \\ &= (1000)(.022 \times 10^{-6} \text{ F}) \\ &= 2.2 \times 10^{-5} \\ 5\tau &= 5(2.2 \times 10^{-5}) \\ &= 1.1 \times 10^{-4} \end{aligned}$$

(C) Equipment and Materials Needed:

0.022 μF , and 1.0 μF Capacitors
1 K Ω resistor,
Bread Board

$$\begin{aligned} \tau &= RC \\ &= 1000(1 \times 10^{-6}) \\ &= .001 \end{aligned}$$

$$\begin{aligned} 5\tau &= 5(.001) \\ &= .005 \end{aligned}$$

(D) Experiment

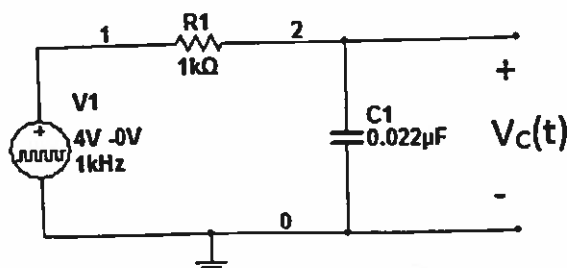


Figure 5: RC Circuit for Experiment

Step #1:

Build the Circuit:

Use breadboard to build the circuit shown in Figure 5. Connect AWG1 (yellow wire) to node 1 of the circuit. Also, connect Scope Channel 1 positive (orange wire) to node 1. In addition, connect the Ground (black wire) to node 0 of the circuit. Moreover, connect the Scope Channel 1 negative (orange-white wire) to node 0. Furthermore, connect Scope Channel 2 positive (blue wire) to node 2, and the Scope Channel 2 negative (blue-white wire) to node 0.

Step #2:

Generation of Square Wave:

Click on the WaveGen in the main WaveForms screen. Go to Basic → Square → Frequency (set to 1 KHz) → Amplitude (set to 2 V) → Offset (set to 2V) → Symmetry (set to 50%) → Click on "Run AWG1."

Activation of Scope:

Click on the Scope in the main WaveForms screen. Go to Run → Autoset → Measure → Add → Channel 1 Vertical → Frequency → Add Selected Measurement → Close Add Instrument.

Make sure the transient waveform of $V_C(t)$ is clearly displayed while the capacitor is charging and discharging. *Hint: Click on the AutoSet button to automatically rescale the scope axes.*

Figure 6 shows the Digilent Analog Discovery WaveGen setup.

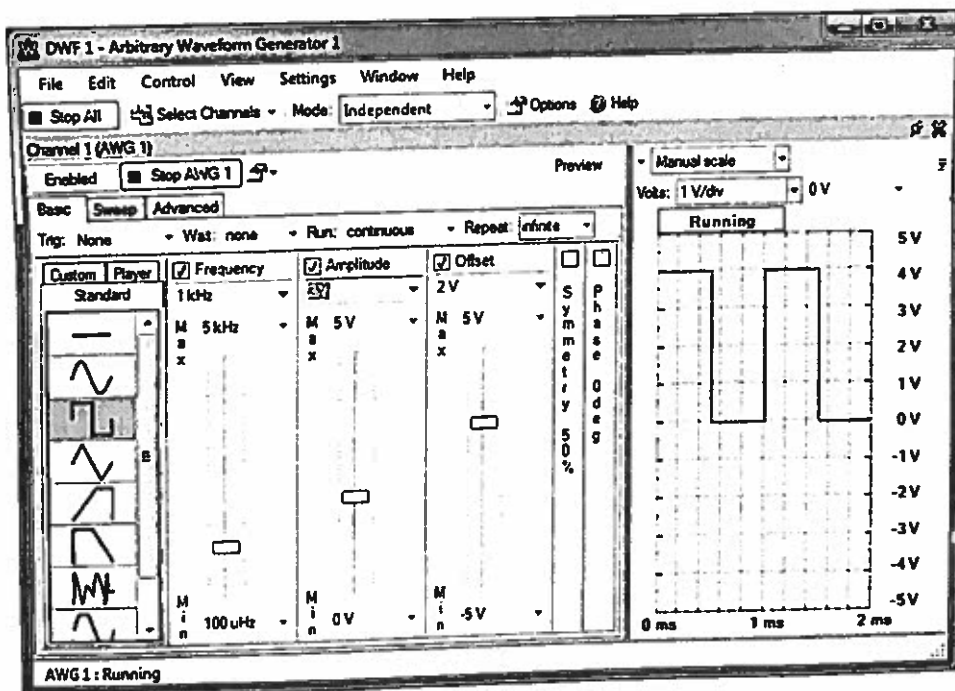


Figure 6: WaveGen Setup

Step 3:

Observe the input and output waveforms. The input and output waveforms are shown in Figure 7. Draw the input and output waveforms of the RC circuit (you can export the scope waveforms into a spreadsheet

and plot the input and output waveforms). Measure the time constants of the charging and discharging of the capacitor.

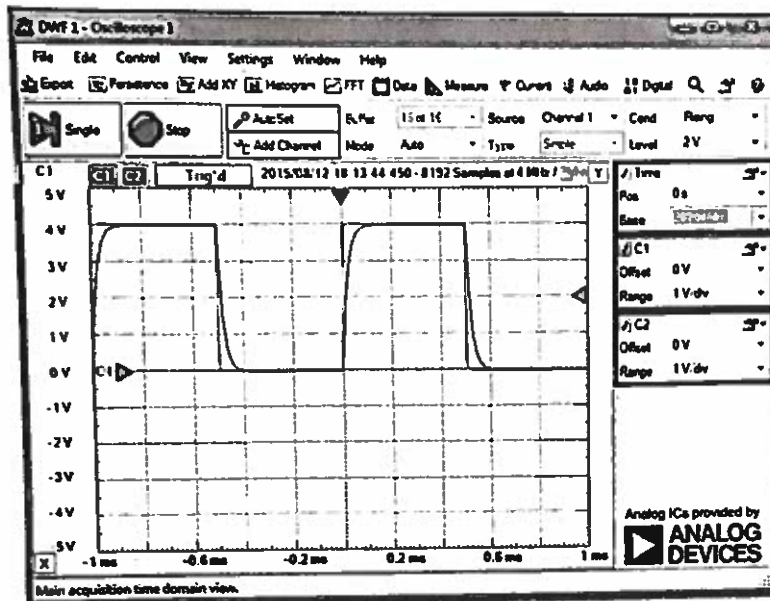


Figure 7: The Input and Output Waveforms

Step 4:

If the frequency of the square wave generator is increased to 10 KHz, while keeping the $R = 1 \text{ K}\Omega$ and $C = 0.022 \mu\text{F}$, draw the input and output waveforms.

Step 5:

Replace the $0.022 \mu\text{F}$ capacitor by $1.0 \mu\text{F}$ capacitor, and keep the $R = 1 \text{ K}\Omega$ and the frequency of the square wave at 1 KHz. Draw the input and output waveforms of the RC circuit.

(E) Post-Lab Questions

- (i) Is the time-constant measured in Step #3 equal to that calculated and shown in Table 2?
- (ii) Why is the output waveform obtained in Step #4 different from that of Step #3?
- (iii) Why is the output waveform obtained in Step #5 different from that of Step #3?
- (iv) For the square wave input signal with $R = 1 \text{ K}\Omega$ and $C = 1.0 \mu\text{F}$, estimate the period (and hence frequency) of the square wave that will make the both output waveform almost a square-wave? Give reasons for your estimated frequency.

BELOW AVERAGE

Electric Circuits Laboratory

ELEG 2011

Experiment 10

RC Circuits

Jordan Joubert

Submitted: December 3, 2021

Performed: November 8, 2021

7

- No theoretical calculations
- Results are not consistent with outcome characteristics

- **Objective**

- This lab introduces the RC circuit.
- Observe the behavior of a RC circuit

- **Introduction (Background & Theory)**

In this laboratory, you will explore the behavior of RC circuit by using the Analog Discovery Module.

(i) Equations for Charging and Discharging of a Capacitor

For an RC circuit, the expression for charging the capacitor is given as:

and that for discharging of the capacitor is:

where,

$V_c(0)$ = initial voltage across the capacitor

(ii) Square Wave Generator:

One can quickly charge and discharge a capacitor by using a function generator to generate the square wave. The output of function generator is shown in Figure 1.

One can control the amplitude of the generator and the period T . The period and the repetition frequency are related by the expression $f = 1/T$.

(ii) The Time Constant

For RC circuit, the time constant is given as $\tau = RC$. The time constant determines the rate of charging or discharging of a capacitor. After τ seconds, the voltage will have decreased to e^{-1} (about .368) of its initial value. After 2τ

seconds, it will have decreased to e^{-2} (0.135) its initial value, and after 2τ seconds, the voltage will have decreased to 0.0067 of the initial value.

(iii) Introduction to Analog Discovery Module

The Analog Discovery Module (ADM) is a USB-powered portable instrument that can be used to measure and record voltages from electric and electronic circuits. The ADM plus its wire harness is shown in Figure 2.

The Diligent Waveforms software is a suite of virtual instruments available to your Personal Computer Desktop. Waveforms software connects to the Analog Discovery Module and provides easy to use graphical interface for the virtual instruments. When the Waveforms software is launched, the opening window seen on the computer screen in Figure 3.

- **Equipment**

- Multisim

- **Procedure**

- Build the Circuit:

1. Use breadboard to build the circuit shown in Figure 5. Connect AWG1 (yellow wire) to node 1 of the circuit. Also, connect Scope Channel 1 positive (orange wire) to node 1. In addition, connect the Ground (black wire) to node 0 of the circuit. Moreover, connect the Scope Channel 1 negative (orange-white wire) to node 0. Furthermore, connect Scope

Channel 2 positive (blue wire) to node 2, and the Scope Channel 2 negative (blue-white wire) to node 0.

2. Generation of Square Wave: Click on the WaveGen in the main Waveforms screen. Go to Basic → Square → Frequency (set to 1 KHz) → Amplitude (set to 2 V) → Offset (set to 2V) → Symmetry (set to 50%) → Click on “Run AWG1.”

Activation of Scope:

Click on the Scope in the main Waveforms screen. Go to Run → Autoset → Measure → Add → Channel 1 Horizontal → Frequency → Add Selected Measurement → Close Add Instrument.

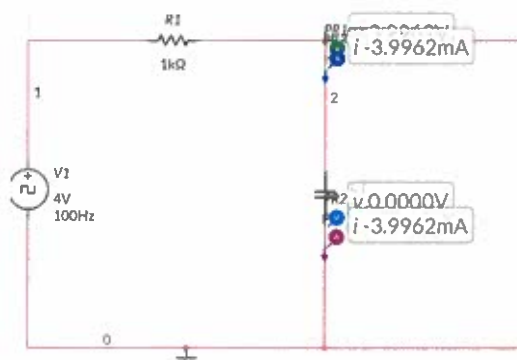
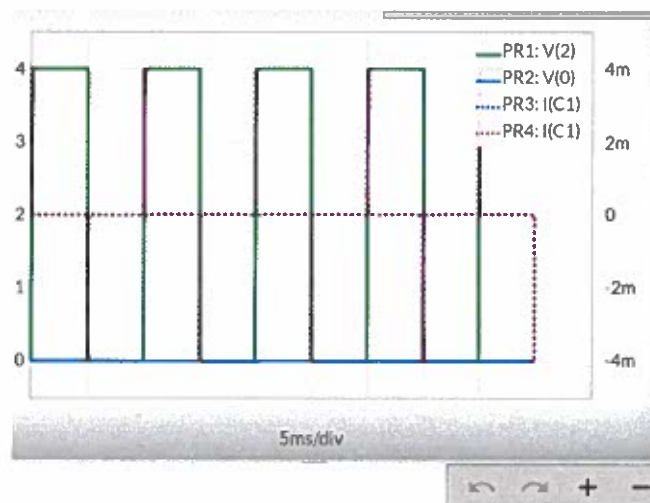
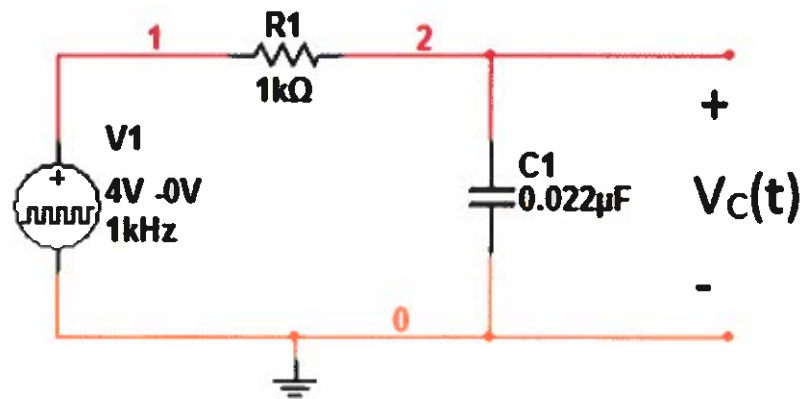
Make sure the transient waveform of $V_C(t)$ is clearly displayed while the capacitor is charging and discharging. Hint: Click on the AutoSet button to automatically rescale the scope axes.

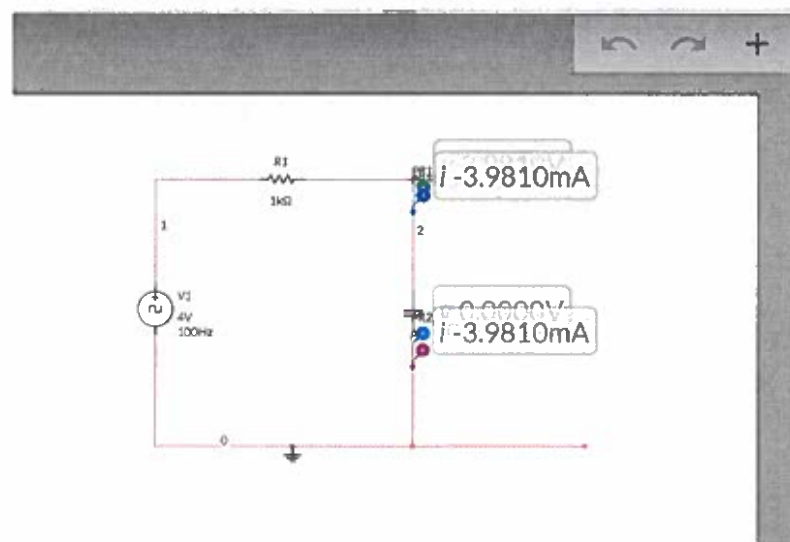
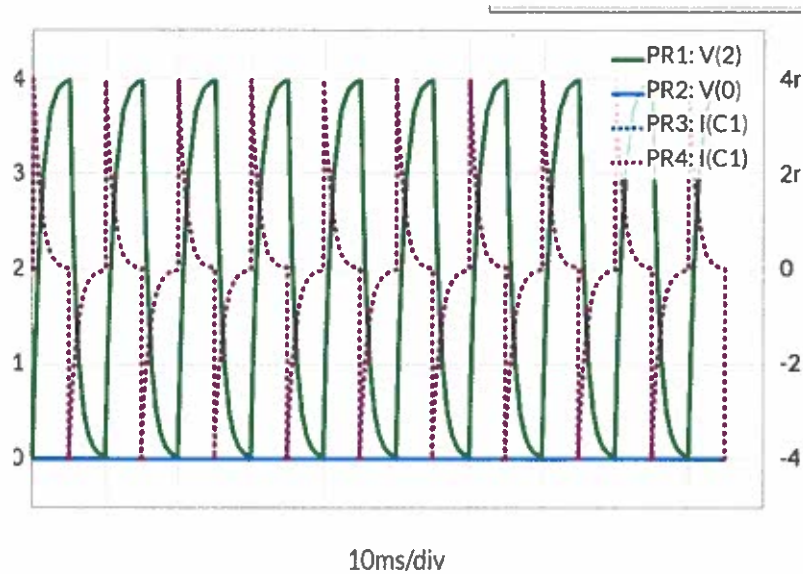
Figure 6 shows the Digilent Analog Discovery WaveGen setup.

3. Observe the input and output Waveforms. The input and output Waveforms are shown in Figure 7. Draw the input and output Waveforms of the RC circuit (you can export the scope Waveforms into a spreadsheet and plot the input and output Waveforms). Measure the time constants of the charging and discharging of the capacitor.
4. If the frequency of the square wave generator is increased to 10 KHz, while keeping the $R = 1\text{ K}\Omega$ and $C = 0.022\text{ }\mu\text{F}$, draw the input and output Waveforms.

5. Replace the $0.022\ \mu\text{F}$ capacitor by $1.0\ \mu\text{F}$ capacitor, and keep the $R = 1\ \text{k}\Omega$ and the frequency of the square wave at $1\ \text{KHz}$. Draw the input and output Waveforms of the RC circuit.

- Circuit





- **Answer**

Is the time-constant measured in Step #3 equal to that calculated and shown in Table 2? Yes, you can see once you compare the constants.

Why is the output waveform obtained in Step #4 different from that of Step #3? It is different due to the increase in frequency.

Why is the output waveform obtained in Step #5 different from that of Step #3? It changes due to the change in capacitance.

For the square wave input signal with $R = 1\text{ K}\Omega$ and $C = 1.0\text{ }\mu\text{F}$, estimate the period (and hence frequency) of the square wave that will make the both output waveform almost a square-wave? Give reasons for your estimated frequency.

- **Data/ Calculations**

NUMBER	1	2	3	4	5
FREQUENCY	100	500	1000	5000	10000
PERIOD	0.01	0.002	0.001	2E-4	1E-4

#	1	2
R	1000 OHMS	1000 OHMS
C	0.022 μF	1.0 μF
T	2.2E-5	0.001
5T	1.1E-4	0.005

- **Conclusion**

The purpose of the lab was to introduce various operational amplifiers to a DC circuit. We also observed how each amplifier produced different voltage input and output results.

(B) Pre-Lab Calculations

For a square wave generator, given the repetition frequencies shown in Table 1, determine the corresponding period.

Table 1 Frequency vs. Period of a Square-wave Generator shown in Figure 1

Number	1	2	3	4	5
Frequency (Hz)	100	500	1000	5000	10000
Period (s)					

For the RC circuit, shown in Figure 4, calculate the time constant for the various values of R and C, shown in Table 2.

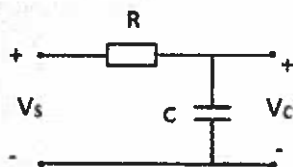


Figure 4: RC Circuit

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τ (s)		
5 τ (s)		

(C) Equipment and Materials Needed:

0.022 μF , and 1.0 μF Capacitors
1 K Ω resistor,
Bread Board

(D) Experiment

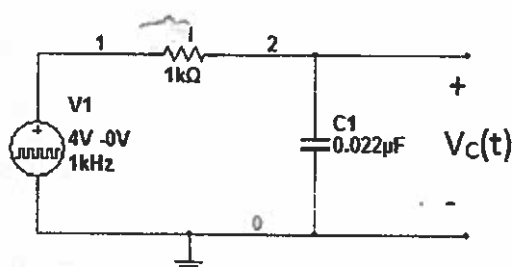


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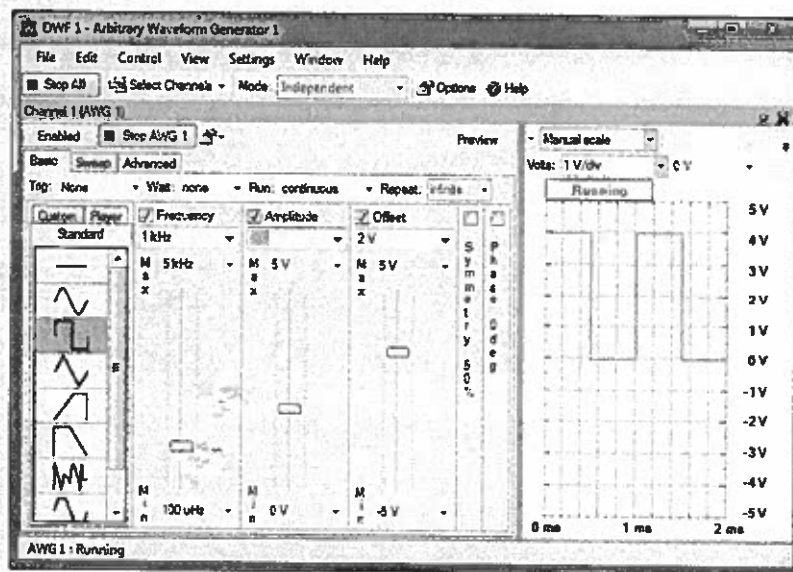


Figure 6: WaveGen Setup

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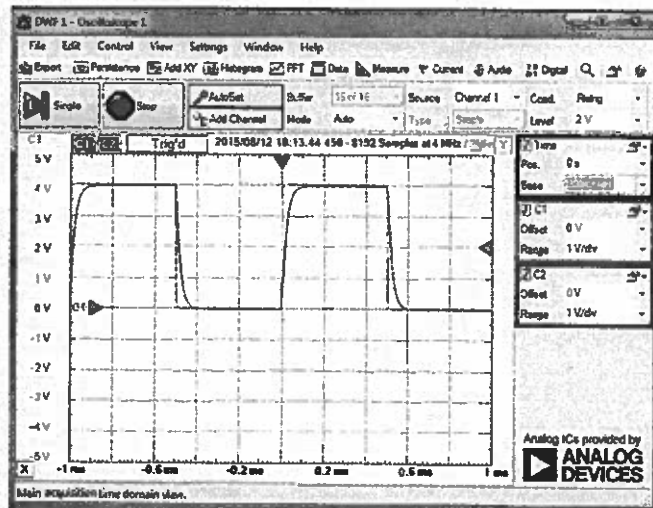


Figure 7: The Input and Output Waveforms

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