

COURSE BINDER

ROY G. PERRY COLLEGE OF ENGINEERING

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT**

PRAIRIE VIEW A&M UNIVERSITY

ASSESSMENT REPORT COVER PAGE

ELEG 4301 ENERGY CONVERSIONS

SPRING 2022 SEMESTER

NAME OF INSTRUCTOR: Dr. John Fuller

Revised: 08/05/2019

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Assignments assessing students' ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately. (outcome "6")

1- Teach students the fundamental concepts of electrical power and electrical machines (DC and AC machines and transformers)

Anticipated Outcome: Student will have an understanding of electrical power systems and the design and operation of electrical machines

2- To teach students how to analyze different type of machines.

Anticipated Outcome: Student will acquire the ability to select the appropriate machine to be used for a specific operation and how to apply this knowledge on a global level.

3- To teach students the use of modern engineering tools such as Matlab and FPGA programming.

Anticipated Outcome: Student will be able to use modern engineering tools and exhibit a 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 4301 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 4301 Section 1 CRN: 20180
2.	Credits and contact hours:	3 credit hours; 3 contact hours * Subject Area: Engineering Science
3.	Instructor's or course coordinator's name:	Dr. John Fuller
4.	Text book: Title:	Electric Machinery and Power systems
	Author:	S. T. Chapman
	Publisher, Year & Edition:	McGraw Hill. N.Y. 2002. ISBN: 978-0-07-229135-3
	a. Other Supplemental material	Electric Machines. S. Sarma 2/ed. West Publishing Co. 1994. 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 4301 Electromechanical Energy Conversion: 3 semester hours. Electric and magnetic devices, force and torque measurements, iron core transformers, single phase and poly-phase power circuit analysis. Introduction to per unit system.
	b. Prerequisites or Co-requisites	ELEG 3013 Network theory II ELEG 4173 Advanced Math
	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. Students will understand the fundamental concepts of electrical power and electric machines (DC and AC machines and transformers).	Outcome 1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. Outcome 6 An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
	2. Student will be able to analyze different types of machines.	
	3. Students will be knowledgeable in the use of modern engineering tools such as Matlab and FPGA programming.	Outcome 6 An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7	Brief list of topics to be covered	1. Rotational Motion 2. Magnetic Fields and Circuits. 3. Faraday's and Lenz's 4. Voltage. 5. Force 6. Real, Reactive, and Apparent Power 7. Generation of Three-Phase Voltages 8. Power in Three Phase 9. Three Phase Analysis 10. Ideal Transformers 11. Transformers 12. Equivalent Transformer Circuits 13. Per Unit System 14. Voltage Regulation 15. Rotating Magnetic field 16. Force and Flux 17. Induced Voltage 18. Basic Principles 19. Synchronous Generators 20. Synchronous Motors 21. Starting Synchronous Motors 22. Generator and Motor Principles 23. Basic Induction Motor 24. Equivalent circuit 25. Power and Torque 26. Fundamentals of DC Motors 27. Force, Induced Voltage and Torque 28. Commutation 29. Shunt and Series Motors

- * 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

Please hide all of the row and column lines when done.

Detailed Course Syllabus

ELEG 4301 Energy Conversions

Spring 2022

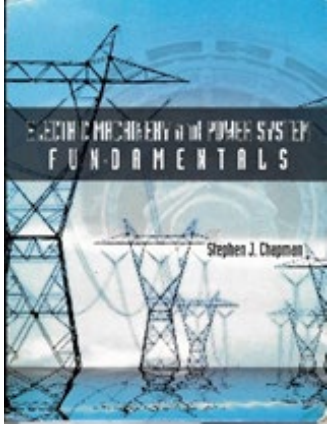
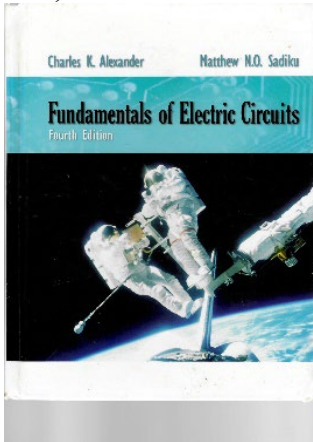
Detailed Syllabus



PRAIRIE VIEW
A&M UNIVERSITY

General Course Information

Information Item	Information
Instructor:	Dr. John Fuller
Section # and CRN:	ELEG 4301 Section 1 CRN: 20180
Office Location:	344 Electrical Engineering Building
Office Phone:	936-261-9923
Email Address:	jhfuller@pvamu.edu
Office Hours:	10:00 – 12:00 MWF 1:00 – 2:30 pm TR
Mode of Instruction:	Face to Face
Course Location:	Electrical Engineering Rm 117
Class Days & Times:	8:00 am – 9:20 am TTR
Catalog Description:	<i>[ELEG 4013 Electromechanical Energy Conversion: 3 semester hours.</i> Electric and magnetic devices, force and torque measurements, iron core transformers, single phase and poly-phase power circuit analysis. Introduction to per unit system.
Prerequisites:	Prerequisites: ELEG 3013 and MATH 4173 .
Co-requisites:	
Required Text(s):	Electric Machinery and Power Systems. Chapman S. T., McGraw Hill. N.Y. 2002. ISBN: 978-0-07-229135-3

	
Recommended Text(s):	Electric Machinery, Fitzgard. A., Kingsley, C., Jr., Umans. S., McGraw Hill, N.Y. 1983. Electric Machines. Sarma S., 2/ed. West Publishing Co. 1994. Fundamentals of Electric Circuits, Charles Alexander, Matthew Sadiku, McGraw Hill, ISBN 978-0-07-352855-4 

General Course Information Table

Student Learning Outcomes:

Upon successful completion of this course, students will be able to: [NOTE: BEGIN each outcome with a VERB]:	Program Learning Outcome Alignment	Core Curriculum Outcome Alignment [Delete this column for graduate courses]
1. understand the fundamental concepts of electrical power and electric machines (DC and AC machines and transformers)		
2. understand how to analyze different types of machines		
3. knowledgeable in the use of modern engineering tools such as Matlab and FPGA programming.		

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Student Learning Outcomes Table

Add other objectives or specialized accrediting agency requirements as needed.

Course Objectives:

- 1- Teach students the fundamental concepts of electrical power and electric machines (DC and AC machines and transformers)

Anticipated Outcome: Student will have an understanding of electrical power systems and the design and operation of electrical machines

- 2- To teach students how to analyze different types of machines.

Anticipated Outcome: Student will acquire the ability to select the appropriate machine to be used for a specific operation.

- 3- To teach students the use of modern engineering tools such as Matlab and FPGA programming.

Anticipated Outcome: Student will be able to use modern engineering tools and exhibit a competency in the use of simulation tools.

Major Course Requirements

Method of Determining Final Course Grade

Course Grade Requirement [Name each major requirement]	Value	Total
1.First Exam	100	
2. Midterm	100	
3. Third Exam	100	
4. Project /Reports	50	
5. Homework/ Quizzes	50	
6. Final Exam	150	
Total:		550 points

Course Grade Requirement Table

Grading Criteria and Conversion:

A = (495 points and above)

B = (440 - 494)

C = (385 – 439)

D = (330 – 384)

F = (0 – 329)

From the following table listing of topics to be covered, the above listed exams will be given on subjects of

First Exam – Topics 1 -9

Midterm Exam – Topics 10 - 14

Third Exam – Topics 15 – 25

Final Exam- All topics

Quizzes will be given as needed throughout the semester

Detailed Description of Major Assignments:

Assignment Title or Grade Requirement	Description
1. Rotational Motion 2. Magnetic Fields and Circuits. 3. Faraday's and Lenz's 4. Voltage. 5. Force 6. Real, Reactive, and Apparent Power	1. Newton's Law and Power 2. Energy losses in a Ferromagnetic Core 3. Fundamental Laws. 4. Voltage on a conductor moving in a magnetic field 5. Force on a current carrying conductor in a magnetic field. 6. Power relationships
7. Generation of Three-Phase Voltages and Currents 8. Power in Three Phase	Three Phase circuits analysis

9. Three Phase Analysis	
10. Ideal Transformers 11. Transformers,) 12. Equivalent Transformer Circuits 13. Per Unit System 14. Voltage Regulation	Single phase and three phase, rating, regulation; special types e.g. Current transformers. Problems involving transformer use in power transmission systems.
15. Rotating Magnetic field 16. Force and Flux 17. Induced Voltage	AC Machine Fundamentals
18. Basic Principles 19. Synchronous Generators 20. Synchronous Motors 21. Starting Synchronous Motors 22. Generator and Motor Principles-The rectangular rotation loop.	Synchronous Machines
23. Basic Induction Motor 24. Equivalent circuit 25. Power and Torque	Induction Motors
26. Fundamentals of DC Motors 27. Force, Induced Voltage and Torque 28. Commutation 29. Shunt and Series Motors	DC Motors
30. Power Electronics	Introduction to Diodes, Thyristors, PNP, SCR, GTO etc.

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.

[NOTE: If there are any special instructions relating to assignment submissions, formatting, or other course policies, they should be included here. Include individual policies on tardiness, cell phones, and other class disruptions. If you have additional classroom rules that do not fit on a single page, consider posting them in eCourses instead.]

Semester Calendar

Chapter 1

1. **Rotational Motion**, Newton's Law and Power
2. **Magnetic Fields and Circuits**. Energy losses in a Ferromagnetic Core
3. **Faraday's** and **Lenz's** Laws.
4. **Voltage** on a conductor moving in a magnetic field.
5. **Force** on a current carrying conductor in a magnetic field.
6. **Real, Reactive, and Apparent Power**

2 wks

DR. MARTIN LUTHER KING HOLIDAY: (Monday, January 17)

FIRST CLASS DAY: January 18

TUITION AND FEES PAYMENT DUE DATE: January 18

LATE REGISTRATION/LATE REGISTRATION FEE BEGINS (\$50.00):
January 18-January 24

ATTENDANCE REPORTING PERIOD. STUDENTS WHO DO NOT ATTEND CLASS DURING THIS PERIOD WILL HAVE THEIR COURSES REMOVED AND FINANCIAL AID REDUCED OR CANCELLED: January 18 – January 26

12th CLASS DAY: Tuesday, February 2, Census Date

WITHDRAWAL FROM COURSES WITH ACADEMIC RECORD ("W") BEGINS: February 3

DROP FOR NON-PAYMENT OF TUITION AND FEES@ 5:00 pm, February 8

FINAL DATE TO APPLY FOR SPRING 2021 GRADUATION (March 28)

FINAL DAY TO DROP/WITHDRAW FROM COURSE WITHOUT ACADEMIC RECORD: February 2 (a financial record will still exist)

LAST DAY TO WITHDRAW FROM COURSE WITH AUTOMATIC "W"
(Wednesday: February 2)

Chapter 2

2 wks

7. **Generation of Three-Phase Voltages and Currents**
8. **Power in Three Phase**
9. **Three Phase Analysis**

First Exam

Chapter 3

Transformers

2 wks

10. **Ideal Transformers**

11. **Transformers**, single phase and three phase, rating, regulation; special types e.g. Current transformers. Problems involving transformer use in power transmission systems. (2 weeks)
12. **Equivalent Transformer Circuits**
13. **Per Unit System**
14. **Voltage Regulation**

MID- SEMESTER EXAMINATION Mar 10 – Mar 12

GOOD FRIDAY (NO CLASSES): April 15

FINAL DAY TO WITHDRAW FROM COURSES WITH ACADEMIC RECORD (“W”):

April 6

Chapter 4 **2 wks**
AC Machine Fundamentals

15. **Rotating Magnetic field**
16. **Force and Flux**
17. **Induced Voltage**

Chapter 5 **2 ½ wks**
Synchronous Machines

18. **Basic Principles**
19. **Synchronous Generators**
20. **Synchronous Motors**
21. **Starting Synchronous Motors**
22. **Generator and Motor Principles**-The rectangular rotation loop.

Chapter 7 **1 ½ wks**
Induction Motors

23. **Basic Induction Motor**
24. **Equivalent circuit**
25. **Power and Torque**

Third Exam

Chapter 8 **1 ½**
DC Motors

26. **Fundamentals of DC Motors**
27. **Force, Induced Voltage and Torque**
28. **Commutation**
29. **Shunt and Series Motors**

Power Electronics **1 ½ wks**
30. Power Electronics - Introduction. The Diode, Thyristor (PNPN, SCR, GTO etc.)
Converters, Inverters, and Choppers. Use of these in motor drives. (1 week)

FINAL DAY TO WITHDRAW FROM THE UNIVERSITY (FROM ALL COURSES) FOR THE SEMESTER: May 3

LAST CLASS DAY FOR SPRING 2022 SEMESTER: May 4

FINAL EXAM PERIOD: May 5-May 13, Thursday- Thursday

**LAST CLASS DAY FOR Spring 2022 SEMESTER: Wednesday,
Dec 02**

**LAST DAY TO WITHDRAW FROM THE UNIVERSITY (FROM ALL
COURSES) FOR THE SEMESTER: Wednesday, May 4**

Student Support and Success

John B. Coleman Library

The library and its partners have as their mission to provide resources and instructional material in support of the evolving curriculum, as a partner in Prairie View A&M University's mission of teaching, research, and service and to support the University's core values of access and quality, diversity, leadership, relevance, and social responsibility through emphasis on ten key areas of service. It maintains library collections and access both on campus, online, and through local agreements to further the educational goals of students and faculty. Phone: 936-261-1500; Website: [J. B. Coleman Library](#).

Academic Advising Services

Academic Advising Services offers students a variety of services that contributes to student success and leads 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 the student is unsure of the best resource for their needs. Some students are supported by faculty advisors 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. You can find your advisor's location by academic major at the [Academic Advising Website](#), 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 is offered face-to-face in the [UTC, in virtual face-to-face sessions](#), and through [online sessions at 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: [University Tutoring Center](#).

The Writing Center

The Writing Center provides well-trained peer tutors that 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. Student must register for Grammarly by using their student email address. In addition, students have access to face-to-face as well as virtual tutoring services either asynchronously via email or synchronously via Zoom. Location: J. B. Coleman Library, Rm. 209; Phone: 936-261-3724; Website: [The Writing Center](#); [Grammarly Registration](#).

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 Alert helps 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 PVPlace and click on Academic Early Alert on the left sidebar. Phone: 936-261-5902; Website: [Academic 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 provides assistance to 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: [Student Counseling Services](#).

Office of Testing Services

Testing Services serves to create opportunities by offering 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: [Testing Services](#).

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 hardware and software, adapted furniture, proctoring of 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: [Disability Services](#).

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-assisted and 2-way video course delivery. For more details and contact information, visit: [CIITS Student Webpage](#); Phone: 936-261-3283.

Veteran Affairs

Veteran 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: [Veteran Affairs](#).

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: [Office for Student Engagement](#).

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: [Career Services](#).

University Rules and Procedures

Academic Misconduct (See Student Planner)

You are expected to practice academic honesty in every aspect of this course and all other courses. Make sure you are familiar with your Student Planner, especially the section on academic misconduct (see *University Administrative Guidelines on Academic Integrity*). Students who engage in academic misconduct are subject to university disciplinary procedures. As listed in the PVAMU Undergraduate Catalog, Graduate Catalog, and the Student Planner, 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 or to have attempted to commit the following academic misconduct may also be subject to disciplinary review and action as outlined in the PVAMU Student Planner.

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. **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.
4. **Conspiracy**: Agreeing with one or more persons to commit an act of academic/scholastic dishonesty.
5. **Fabrication of Information/Forgery**: Use or submission of contrived, invented, forged, or altered information in any assignment, laboratory exercise, or test; tampering with or production of a counterfeit document, particularly documents which make up the student's academic record. Examples: making up a source or citing nonexistent publication or article; representing made up data as real for an experiment in a science laboratory class; forging a change of grade or student withdrawal record; falsifying any document related to a student academic exercise.

Nonacademic Misconduct (See Student Planner)

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, or (2) the ability of students to benefit from the instructional program, or (3) the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. Such incidents will be adjudicated by the Office for Student Conduct 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 the [Title IX Webpage](#) 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 condition, 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. More information can be found at this [webpage](#).

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 936-261-1744 or 1792.

Class Attendance Policy (See Catalog for Full Attendance Policy)

Prairie View A&M University requires regular class attendance. Attending all classes supports 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 internet. Excessive absenteeism, whether excused or unexcused, may result in a student's course grade being reduced or in 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 rests 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 Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint. Students can file Academic Complaints and/or Grade Appeals at this [webpage](#).

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

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

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

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

- Sending and receiving emails
- 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 discussions 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 session. Before class session begins, test audio, video and lighting to alleviate technology issues.

Technical Support

Students should go to the [Password Reset Tool](#) 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 (CIITS) 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 take place in a seminar fashion. This will be accomplished by the use of the discussion board. The exact use of discussion will be determined by the instructor.

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 COVID-19 pandemic, Prairie View A&M University has adopted policies and practices for the Fall 2020 academic term to limit virus transmission. Students must observe the following practices while participating in face-to-face courses and course-related activities (office hours, help sessions, transitioning to and between classes, study spaces, academic services, etc.):

- **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.) must be properly worn in all non-private spaces including 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 difficult to reliably maintain.
- **Physical Distancing** - Physical distancing must be maintained between students, instructors, and others in course and course-related activities.
- **Classroom Ingress/Egress** - Students must follow marked pathways for entering and exiting classrooms and other teaching spaces. Students should leave classrooms promptly after course activities have concluded, should not congregate in hallways and should maintain 6-foot physical distancing when waiting to enter classrooms and other instructional spaces.
- **Face-to-face Class** - To attend a face-to-face class, students must wear a face covering (or a face shield if they have an exemption letter). If a student refuses to wear a face covering, the instructor should ask the student to leave and join the class remotely. If the student does not leave the class, the faculty member should report that student to the Office for Student Conduct for adjudication. Additionally, the faculty member may choose to teach that day's class remotely for all students.
- **COVID-19 Guidelines for Student Conduct Adjudication** - The mandatory COVID-19 Training/Certification taken by all students serves as the 1st Warning for violation of COVID-19 Guidelines.
 - 1st incident: upon review of Incident Report and finding of responsibility — Conduct Probation
 - 2nd incident: upon review of Incident Report and finding of responsibility — Suspension
 - Consult the Code of Student Conduct in the Student Planner or [Student Conduct website](#) for additional information on Conduct Probation and Suspension.

Personal Illness and Quarantine - Students required to quarantine must 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

CLASS ATTENDANCE POLICY

Effective September 1, 1998

Class Attendance

Prairie View A&M University requires regular class attendance. Attending all classes supports full academic development of each learner whether classes are taught with the instructor physically present or via distance learning technologies such as interactive video. Excessive absenteeism, whether EXCUSED or UNEXCUSED, may result in a student's course grade being reduced or in a student's being assigned 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.

Excused Absences

Students are required to attend all class meetings. Absences due to illness, attendance at university approved activities, and family or other emergencies constitute EXCUSED ABSENCES and must be supported by documentation presented to the instructor prior to or

immediately upon the student's return to class. Students are responsible for all oral and written examinations as well as all assignments (e.g., projects, papers, reports) whether absence is Excused or Unexcused.

Unexcused Absences

Accumulation of one week of unexcused absences (for the number of clock hours equivalent to the credit for the course) constitutes excessive absenteeism. The instructor is not required to accept assignments as part of the course requirement when the student's absence is unexcused. Each course syllabus will include a clear statement relative to whether late or past due assignments will be accepted toward satisfying the course requirements.

A student who believes that the penalty received following violation of this attendance policy is unjust may first confer with his/her academic advisor. If necessary, the matter may be appealed in writing to the course instructor, the instructor's department head, and finally, to the instructor's dean who must refer the matter to the Chair, Admissions and Academic Standards Committee if it cannot be resolved within the college offering the course.

Absences on Religious Holy Days

In accordance with Texas Education Code, Section 61.003, subdivision (7), a student may be absent from classes for the observance of a religious holy day and will be permitted to take missed examinations and complete missed assignments provided the student has notified the instructor of the planned absence in writing and receipt of that notice has been acknowledged by the instructor in writing. "A religious holy day means a holy day observed by a religion whose place of worship is exempt from property taxation under the Texas Tax Code, Section 11.20."

End of Semester Course Assessment Report

This summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance **(stated as %)** in each course outcome assessed in this class and the **two previous times course was assessed.**
- The acceptable class average for the class in each outcome area as set by your Department. **You cannot use any number of your choice**
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

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

3. Perceived Problems

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

4. New Plans for Addressing Problems

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

5. Overall Trend over last three assessment periods

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

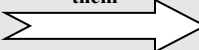
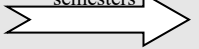
5. Were Expectations Met?

- 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 4301-001 ENERGY CONVERSIONS
Spring 2022 SEMESTER

Report Prepared by: Dr. John Fuller

Report Date: May 23, 2022

Semester	Analysis Type	Number of Students	Sub-Outcome 6.1 Teach students the fundamental concepts of electrical power and electrical machines (DC and AC machines and transformers)				Sub-Outcome 6.2 To teach students how to analyze different type of machines				Sub-Outcome 6.3 To teach students the use of modern engineering tools such as Matlab and FPGA programming			
			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	65	47	75	70	68	63	75	70	81	84
Fall 2021	Direct	24	75	70	55	38	75	70	64	33	75	70	100	96
Spring 2021	direct	6	75	70	75	83	75	70	67	25	75	70	90	80
Fall 2020	Direct	24	75	70	81	75	75	70	93	96	75	70	91	75
Fall 2019	Direct	9	75	70	84.8	100	75	70	69.7	0	75	70	68.9	45
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		This is the second semester of face to face teaching and there was improvement, but overall students are falling below expected average. Students did not meet the expected class average and 47% of the students were above the expected average of 70%.				Class average was below expected level with 63% of students scoring above the expected class average.				No perceived problem with Students using engineering tools such as Matlab.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		Exams show the students are still below the expected class average but did show improvement from previous semester. Low scores are attributed to students that do not show up for class are not taking the class seriously.				This outcome shows improvement from the previous semester of Fall 2021 where the average was 64 % and for Spring 2022 the average is 68 %. While there is improvement, the average is slightly below previously Non- Covid teaching semesters.				With students having access to university computer systems and availability of instructor for assistance, the software and lab skills are not a problem.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 		Online instruction started a downward trend in the class average with the Fall 2021 semester having the greatest decrease. The Spring 2022 semester has a significant increase in performance but students are below early and pre Covid averages.				The average for outcome 6.2 has been low for online instruction and for face to face for the Fall of 2021 and Spring of 2022 semesters.				Directly following the use of computers for online instruction and at home software use, the students are well acclimated to software usage, and had no problem solving assigned homework.			
Were Expectations Met?			NO				NO				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**

ELEG 4301 ENERGY CONVERSIONS
Spring 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)

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
ENERGY CONVERSIONS
Spring 2022
Instructor: Dr. John Fuller**

Title of Assignment

First Exam

Outcome Measured Using this Assignment

Outcome 1

An ability to identify, formulate, and solve **complex engineering problems** by applying principles of engineering, science, and mathematic.

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

Brief justification of why this assignment is suitable for this outcome

The questions on this first exam tests the student's ability to identify relevant laws and equations, formulate the solution methodology, and solve the resulting engineering equations in power systems.

First exam

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ABOVE AVERAGE

ELEG 4301 Energy Conversions

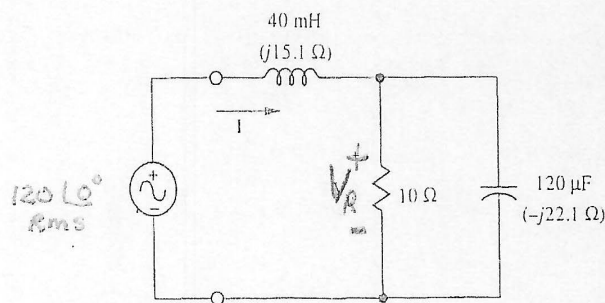
First Exam

Spring 2022

Name Breland Walker Date _____

40 points Cell phones should not be visible, show all steps in calculating, no in and out during exam, no sharing calculators

- 20 I. The following circuit has element values of $R = 10 \Omega$, $L = 40 \text{ mH}$, $C = 120 \mu\text{F}$ and a supply voltage of 120 volts RMS at 60 Hz. For the circuit Calculate



- 4 a) Impedance Z as seen by the voltage source

$$\begin{aligned}
 Z &= 15.1 + \left(\frac{10 \times -j22.1}{10 - j22.1} \right) \\
 &= 15.1 + \left(\frac{-j22.1 \times 10}{100 + (22.1)^2} \right) (10 + j22.1) \\
 &= j15.1 + \left(\frac{-j22.1}{100 + (22.1)^2} \right) 10 + j22.1 \\
 &= j15.1 - j3.7558 + 8.300
 \end{aligned}$$

$$Z = 8.300 + j4.3442$$

30
~~35~~
40

- ④ d) Average power delivered by the voltage source

$$P = V_{rms} I_{ms} \cos(\theta_v - \theta_i)$$

$$P = (120) \times 8.5372 \cos(0^\circ - 53.808^\circ)$$

$$P = 604.927$$

- ④ e) Real and Reactive Power (complex power) delivered by the voltage source.

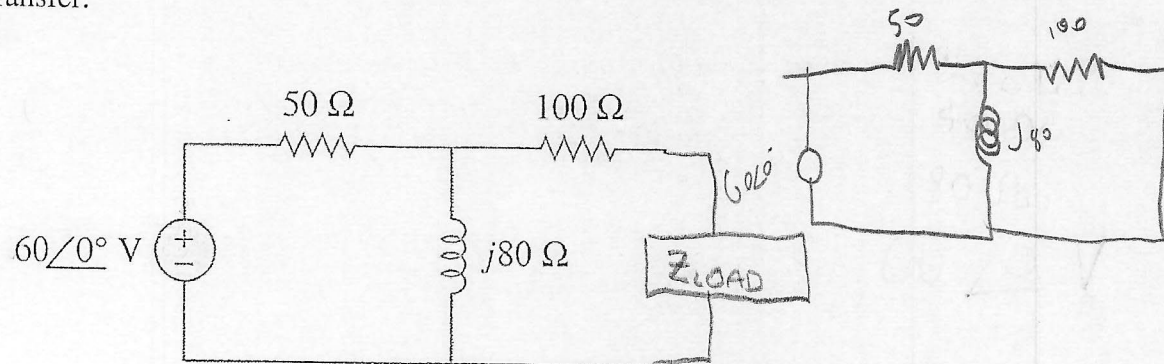
$$8.53729 \times 120 \times \cos(53.8)$$

Real Power = 605.060 Watts

$$8.537 \times 120 \sin(53.8)$$

$$= 826.71 \text{ var}$$

II. Solve for the impedance Z in the following circuit that results in maximum power transfer.



$$Z = 100 + (50 \times j80)$$

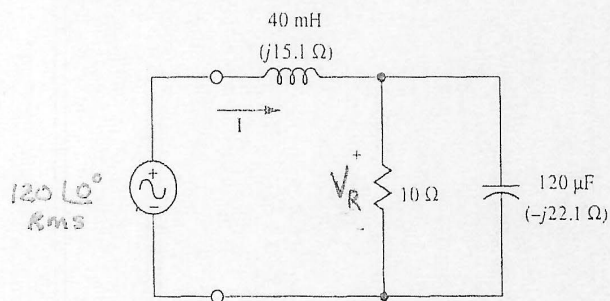
$$Z = 100 + \frac{50 \times j80}{50 + j80}$$

$$Z = 100 + 35.95 + 22.42j$$

$$Z = 135.95 + 22.42j$$

$$Z = 135.95 - 22.42j$$





④ b) Current I delivered by the voltage source

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

✓

$$= \frac{120\angle 0^\circ}{14.056\angle 53.809^\circ} \quad \times$$

How did you get the right impedance here and wrong on port a ??

$$I = 8.531\angle -53.809^\circ$$

④ c) Voltage V_R

$$V = IR$$

$$V = 8.531(j15.1) \quad \times$$

USE VOLTAGE DIVIDER

$$V = 128.909$$

- 4

AVERAGE

ELEG 4301 Energy Conversions

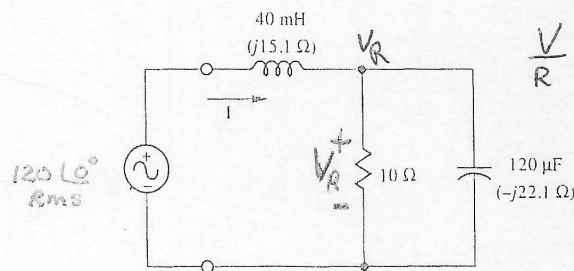
First Exam

Spring 2022

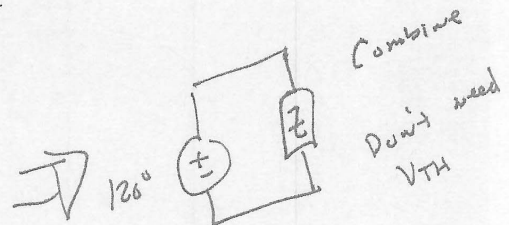
Name Olusola Adamilola Olayinka Date _____

40 points Cell phones should not be visible, show all steps in calculating, no in and out during exam, no sharing calculators

- 20 I. The following circuit has element values of $R = 10 \Omega$, $L = 40 \text{ mH}$, $C = 120 \mu\text{F}$ and a supply voltage of 120 volts RMS at 60 Hz. For the circuit Calculate



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



$$V = IR$$

$$\frac{V}{I} = \boxed{Z = -3.26 - j4.69}$$

$$\frac{V}{V_R} = \frac{30.8701 - j14.7169}{10}$$

- 4 a) Impedance Z as seen by the voltage source

~~$$Z = 3.08701 - j14.7169$$~~

$$\frac{V_1 - 120 \angle 0}{15.1 \Omega} + \frac{V_1}{10 \Omega} + \frac{V_1}{-j22.1 \Omega} = 0$$

$$\frac{V_1}{15.1 \Omega} - \frac{120 \angle 0}{15.1 \Omega} + \frac{V_1}{10 \Omega} + \frac{V_1}{-j22.1 \Omega} = 0$$

$$V_1 \left[\frac{1}{j15.1 \Omega} + \frac{1}{10 \Omega} + \frac{1}{-j22.1 \Omega} \right] = \frac{120}{15.1 \Omega}$$

$$\frac{V_1 [0.1 - j0.20976] = -7.9470j}{0.1 - j0.20976}$$

$$V_1 = \frac{-j7.9470}{0.1 - j0.20976}$$

$$V_1 = 30.8701 - j14.7169$$

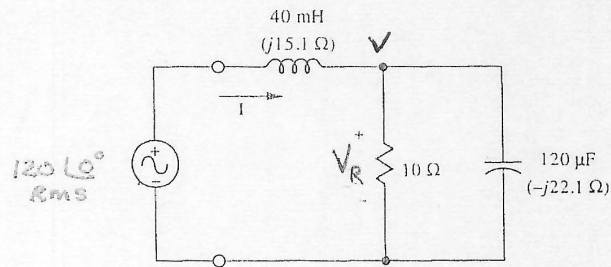
$$Z = R$$

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

$$V$$

$$\frac{V}{I} = \frac{30.8701 - j14.7169}{-0.974629 + j5.41}$$

$$Z = ?$$



④ b) Current I delivered by the voltage source

$$I = -0.974629 + j5.90264$$

$$\frac{V_s - 120\angle 0}{j15.1\Omega + Z_{(10||-j22.1)}}$$

$$\frac{30.8701 - j14.7169 - 120\angle 0}{j15.1\Omega} = -0.974629 + j5.90264$$

✓ 2

④ c) Voltage V_R

$$V_R = 30.8701 - j14.7169 \quad ?$$

✓ 4

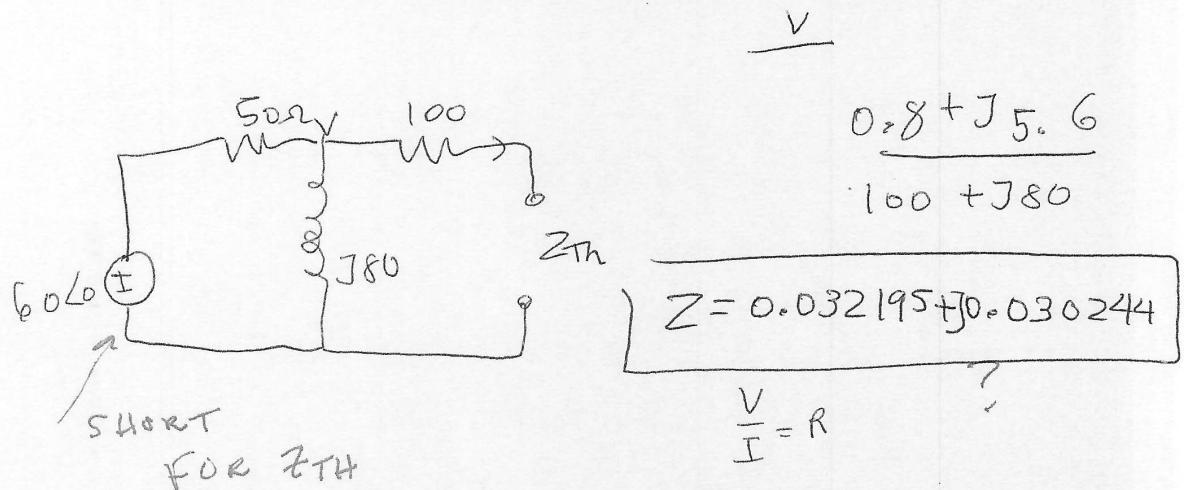
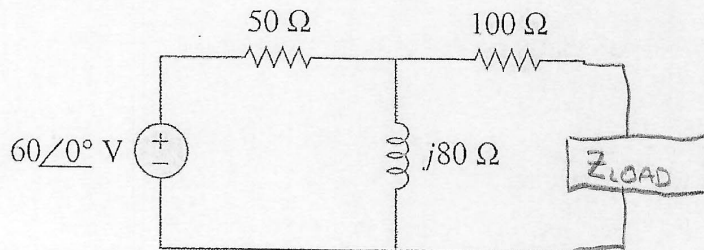
④ d) Average power delivered by the voltage source

— 4

④ e) Real and Reactive Power (complex power) delivered by the voltage source.

— 4

II. Solve for the impedance Z in the following circuit that results in maximum power transfer.



10
 $60 + 50\Omega$

$$\frac{V - 60\angle 0}{50\Omega} + \frac{V}{j80} + \frac{V}{100} = 0$$

$$\frac{1}{50} - \frac{j}{80} + \frac{1}{100} = \frac{60\angle 0}{50}$$

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

$$\frac{1}{50} - \frac{j}{80} + \frac{1}{100} = \frac{60\angle 0}{50}$$

$$V = 0.03 - 0.0215j = 1.2$$

$$V = 0.03 - 0.0215j = \frac{60\angle 0}{50}$$

$$V = \frac{1.2}{0.03 - 0.021j}$$

$V = 0.8 + j6.7$

BELOW AVERAGE

ELEG 4301 Energy Conversions

First Exam

Spring 2022

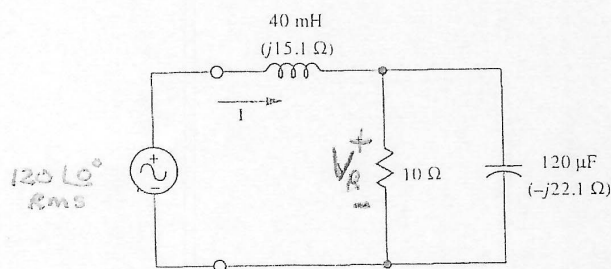
Name Bryce Lovejoy

Date 2/10/22

7
40

40 points Cell phones should not be visible, show all steps in calculating, no in and out during exam, no sharing calculators

- (20) I. The following circuit has element values of $R = 10 \Omega$, $L = 40 \text{ mH}$, $C = 120 \mu\text{F}$ and a supply voltage of 120 volts RMS at 60 Hz. For the circuit Calculate



- (4) a) Impedance Z as seen by the voltage source

$$Z_{TH} = (j15.1 \Omega + 10 \Omega) \parallel -j22.1 \Omega \Rightarrow \frac{(10 \Omega + j15.1 \Omega)(-j22.1 \Omega)}{(10 \Omega + j15.1 \Omega) + (-j22.1 \Omega)}$$

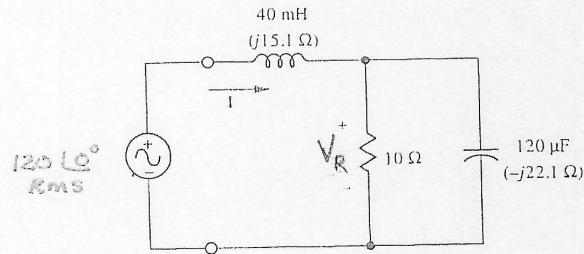
$$j15.1 + 10 \parallel (-j22.1)$$

$$= 32.779 + j0.845$$

$$Z_{TH} = Z_L$$

$$\therefore Z_L = 32.779 + j0.845$$

- 4



④ b) Current I delivered by the voltage source

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

$$I = \frac{120 \angle 0^\circ}{32.779 + j0.845}$$

$$I = 3.658 - j0.094 \text{ A}$$

④ c) Voltage V_R

$$V_R = IR$$

$$= (3.658 - j0.094)(10 \angle 0^\circ \parallel -j22.1 \Omega)$$

$$= (3.658 - j0.094) \frac{(10 \Omega)(-j22.1 \Omega)}{(10 \Omega) + (-j22.1 \Omega)} - 2$$

$$= (3.658 - j0.094)(8.301 - j3.756)$$

$$V_R = 30.612 - j14.520 \text{ V}$$

- ④ d) Average power delivered by the voltage source

$$P = V_{rms} I_{rms} \cos(\theta_v - \theta_i) \\ = (120 \angle 0^\circ) (3.658 - j0.094) \text{ (p.t.)}$$

$$P_{avg} = 438.96 - j11.28 \text{ W} \quad -3$$

- ④ e) Real and Reactive Power (complex power) delivered by the voltage source.

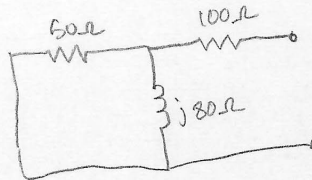
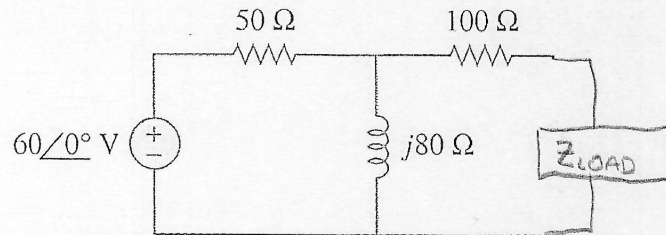
$$P = \frac{1}{2} V_{rms} I_{rms} \\ = \frac{1}{2} (438.96 - j11.28) \quad ?$$

$$P = 219.48 - j5.64 \text{ W}$$

$$Q = V_{rms} I_{rms} \sin(\theta_v - \theta_i)$$

-3

II. Solve for the impedance Z in the following circuit that results in maximum power transfer.



$$50 \parallel j80$$

$$(\cancel{50\Omega} + j80\Omega) + (100\Omega) = Z_{TH}$$

$$150 + j80\Omega = Z_{TH}$$

$$Z_{TH} = Z_L$$

$$\therefore Z_L = 150 + j80\Omega$$

- 20

ASSIGNMENTS FOR OUTCOME 6.1

Teach students the fundamental concepts of electrical power and electric machines (DC and AC machines and transformers)

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
ENERGY CONVERSIONS
Spring 2022
Instructor: Dr. John Fuller**

Title of Assignment

Midterm Exam

Outcome Measured Using this Assignment

Outcome 6.1

Teach students the fundamental concepts of electrical power and electric machines (DC and AC machines and transformers)

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
	has significant consequences in a range of contexts
Assignment problem involves the application of the principles of	
X	engineering
X	science
X	mathematics

Brief justification of why this assignment is suitable for this outcome

The questions on the midterm exam test the students ability to identify relevant laws and equations, formulate the solution methodology, and solve the resulting engineering equations in power circuits.

Above Average

ELEG 4013
ENERGY CONVERSIONS
MIDTERM EXAM

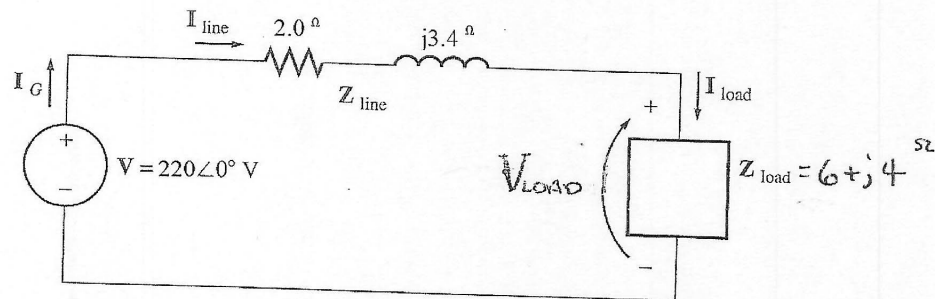
89
100

NAME George Polk

March 10, 2022

No sharing calculators, no cell phones should be visible, do your own work, No in and out during test time
100 points

- (20) I. A single phase power system consists of a 220-V 60 Hz generator supplying a load $Z_{Load} = 6 + j4$ ohms through a transmission line of impedance $Z_{line} = 2.0 + j3.4$ ohms. For the circuit shown in the following diagram determine
- Value of the Generator current I_G
 - Power delivered by the 220 volt source to the circuit



$$I_G = \frac{V}{Z_{line} + Z_{load}}$$

$$= \frac{220 \angle 0^\circ}{2.0 + j3.4 + 6 + j4} = \frac{(220 \angle 0)}{7.4j + 8} = 20.1877 \angle -42.76^\circ$$

$$P = (I_G)^2 \times R_L \quad R_L = 6$$

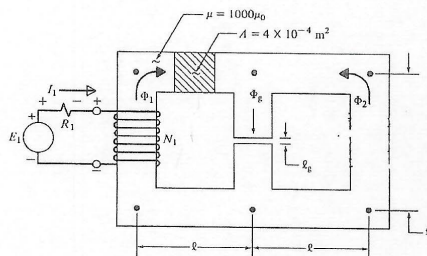
$$= (20.1877)^2 (6)$$

$$= 2445.26 \text{ or } 2.445 \text{ KW}$$

3

20

II. The following magnetic circuit has the properties of $\ell = 10 \text{ cm}$, $\ell_g = .04 \text{ cm}$, $N_1 = 200$ turns, $A = \text{uniform cross sectional area of core}$ ($4 \times 10^{-4} \text{ m}^2$), $I_1 = 2 \text{ amps}$ and $\mu_r = 1000$. For the circuit do the following (neglect fringing)



$$\mu_r = 1000$$

$$N_1 = 200$$

$$A_c = 4 \times 10^{-4} \text{ m}^2$$

$$= 4 \times 10^{-2} \text{ m}$$

$$\ell = 10 \text{ cm} = 0.1 \text{ m}$$

$$\ell_g = 0.4 \text{ cm} = .004 \text{ m}$$

- Draw the equivalent circuit in terms of Reluctances and sources (calculate values)
- Compute the value of the flux Φ_1 in the left leg



$$\mathcal{F} = N I$$

$$= (200)(2)$$

$$= 400$$

$$\Phi_1 = \frac{400}{R_{eq}}$$

$$R_1 = \frac{\ell}{\mu_0 \mu_r A} = \frac{0.1 \text{ m}}{(1000)(4 \times 10^{-2})}$$

$$R_g = \frac{\ell}{\mu_0 \mu_r A} = \frac{.004 \text{ m}}{(1000)(4 \times 10^{-2})}$$

$$R_c = \frac{\ell}{\mu_0 \mu_r A} =$$

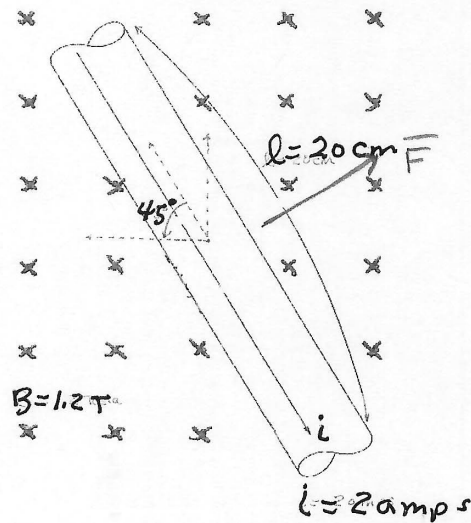
$$R_2 = \frac{\ell}{\mu_0 \mu_r A} =$$

$$R_{eq} =$$

10

(20)

III. . If a conductor is carrying a current of $i = 2$ amps (top to bottom of figure below) with length $l = 20\text{cm}$, in a magnetic field of $B = 1.2$ Tesla as shown into the page. What is the magnitude and direction (show on diagram) of resulting force on the wire?



$$\vec{F} = i(\vec{l} \times \vec{B})$$

$$= i l B \sin(90)$$

$$= (2)(0.2)(1.2) \sin(90)$$

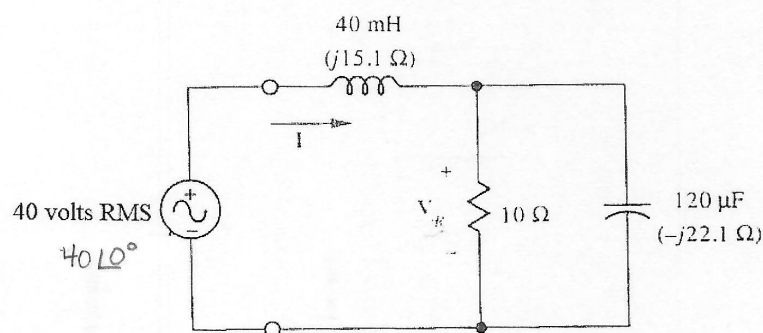
$$= 0.48$$

$$l = 20\text{cm} = 0.2\text{m}$$

20

IV. The following circuit has element values of $R = 10 \Omega$, $X_L = j15.1 \text{ Ohms}$, $X_C = -j22.1$ ohms and a supply voltage of 40 volts RMS at 60 Hz. For the circuit determine

- Impedance Z as seen by the voltage source
- Current I delivered by the source
- Is the supply current leading or lagging. Explain



$$Z = j15.1 + \left(\frac{10 \cdot (-j22.1)}{10 - j22.1} \right)$$

$$= j15.1 + (8.300 - 3.7558j)$$

$$= 18.300 + 11.344j \text{ or } 14.056 \angle 53.807^\circ$$

$$I = \frac{V}{Z} = \frac{40 \angle 0^\circ}{(14.056 \angle 53.807^\circ)}$$

$$= \underline{2.84576 \angle -53.807^\circ}$$

Lagging ∇

(20)

V. Write True or False for the following questions

F A leading power factor results when a circuit is more inductive than capacitive.T The phase voltage and line voltage for a delta connected generator will have the same value.T A high permeability value indicates a good magnetic material.F Phase angles for a three phase power generation system are separated by 90 (120) degreesF The return current to a neutral connection of a three phase power generation system with balanced loads is one half the value of each phase.

(10)

Bonus problem

A single phase generator delivers at its terminals a voltage of 600 Volts rms and a current of 30 Amps rms. The real power delivered to a load from its terminals is $P = 11.5 \text{ kW}$. Find the reactive power Q .

$$P = 11.5 \text{ kW}$$

$$V = 600$$

$$S = P + jQ$$

$$i = 30$$

$$S = V_i \cos \theta + V_j \sin \theta$$

$$= (600)(30) \sin(50.291)$$

$$Q = 461.58j$$



$$S = 11.5K + 461.58j$$

$$P = V_i \cos \theta$$

$$11500 = (600)(30) \cos \theta$$

$$\frac{11500}{18000} = \frac{18000 \cos \theta}{18000}$$

$$0.6389 = \cos \theta$$

$$\cos^{-1}(0.6389) = \theta$$

$$50.291 = \theta \quad \checkmark$$

Average

ELEG 4013
ENERGY CONVERSIONS
MIDTERM EXAM

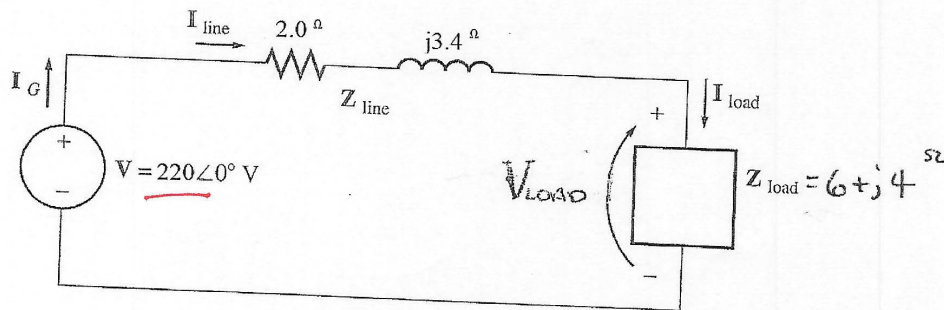
75
100

NAME Oluwadamilola Oboye

March 10, 2022

No sharing calculators, no cell phones should be visible, do your own work, No in and out during test time
100 points

- (20) I. A single phase power system consists of a 220-V 60 Hz generator supplying a load $Z_{\text{Load}} = 6 + j4$ ohms through a transmission line of impedance $Z_{\text{line}} = 2.0 + j3.4$ ohms. For the circuit shown in the following diagram determine
- Value of the Generator current I_G
 - Power delivered by the 220 volt source to the circuit



$$\frac{220 \angle 0^\circ}{6 + j4 + 2 + j3.4}$$

$$\frac{220 \angle 0^\circ}{10.89 \angle 42.7^\circ}$$

$$10.89 \angle 42.7^\circ$$

$$I_G = 1.472 - j1.358 \text{ Amps}$$

$$(20 \cdot 20^2 \times 6) ?$$

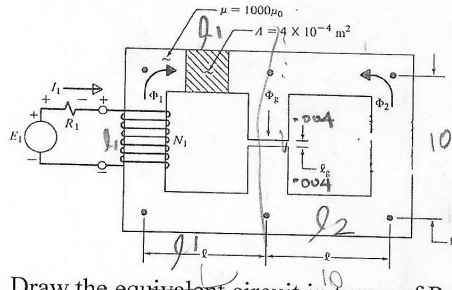
$$P = 2448.72 \text{ convert to kilo}$$

$$P = 2.448 \text{ kW}$$

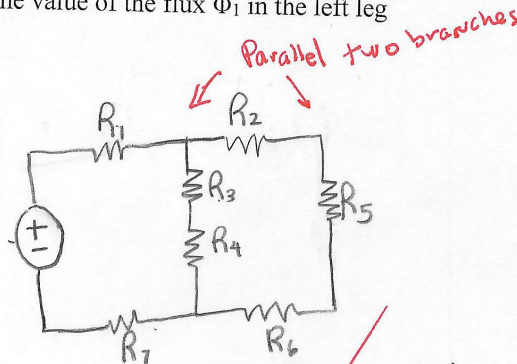
- 5

20

II. The following magnetic circuit has the properties of $\ell = 10 \text{ cm}$, $\ell_g = .04 \text{ cm}$, $N_1 = 200$ turns, $A = \text{uniform cross sectional area of core}$ ($4 \times 10^{-4} \text{ m}^2$), $I_1 = 2 \text{ amps}$ and $\mu_r = 1000$. For the circuit do the following (neglect fringing)



- Draw the equivalent circuit in terms of Reluctances and sources (calculate values)
- Compute the value of the flux Φ_1 in the left leg



$\ell = 10 \text{ cm} \rightarrow 0.1 \text{ m}$
 $\ell_g = 0.4 \text{ cm} \rightarrow 0.004 \text{ m}$
 $N_1 = 200 \text{ turns}$
 $A = 4 \times 10^{-4} \rightarrow 0.0004 \text{ m}^2$
 $I_1 = 2 \text{ amps}$
 $\mu_r = 1000$

$$R_1 = \frac{\ell_1}{\mu_r \mu_0 A} = \frac{0.10}{(1000) 4\pi \times 10^{-7} (0.0004)} = 198,944 \quad (1)$$

$$R_2 = \frac{\ell_2}{\mu_r \mu_0 A} = \frac{0.10}{(1000) 4\pi \times 10^{-7} (0.0004)} = 198,944 \quad (2)$$

$$R_3 = \frac{\ell_3}{\mu_0 A} = \frac{0.004}{(4\pi \times 10^{-7}) (0.0004)} = 7.95775 \times 10^6 \rightarrow 7957750 \quad (3)$$

$$R_4 = \frac{\ell_4}{\mu_r \mu_0 A} = \frac{0.10}{(1000) (4\pi \times 10^{-7}) (0.0004)} = 198,944$$

$$R_5 = \frac{\ell_5}{\mu_r \mu_0 A} = \frac{0.10}{(1000) (4\pi \times 10^{-7}) (0.0004)} = 198,944 \quad (3)$$

$$R_6 = \frac{\ell_6}{\mu_r \mu_0 A} = \frac{0.10}{(1000) (4\pi \times 10^{-7}) (0.0004)} = 198,944 \quad (4)$$

$$R_7 = \frac{\ell_7}{\mu_r \mu_0 A} = \frac{0.10}{(1000) 4\pi \times 10^{-7} (0.0004)} = 198,944 \quad (5)$$

$198,944 \times 5 = 994,720$
 $+ 15,915,500$
 $R_{eq} = 9,151,414$

$N i$

$\Phi = \frac{N i}{R} \quad -5$

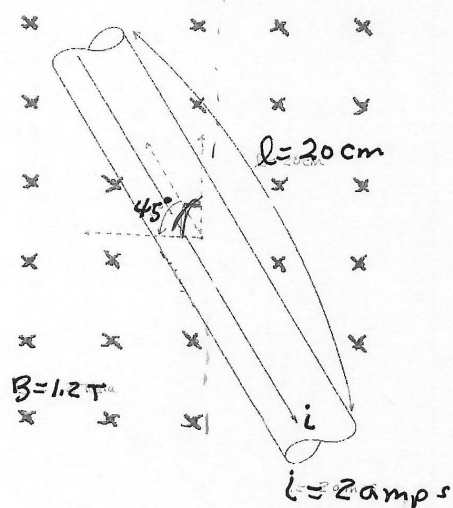
$\frac{N i}{200 \times 2} = 400 \text{ A}$

$= \frac{400}{8554582} \times$

$\Phi = 0.000047 \text{ webber} \quad \times$

20

III. . If a conductor is carrying a current of $i = 2$ amps (top to bottom of figure below) with length $l = 20\text{cm}$, in a magnetic field of $B = 1.2$ Tesla as shown into the page. What is the magnitude and direction (show on diagram) of resulting force on the wire?



$$F = i \cdot (l \times B)$$

$$2 (20 \times 1.2) \rightarrow 20 \times 10^{-2} \rightarrow 0.20$$

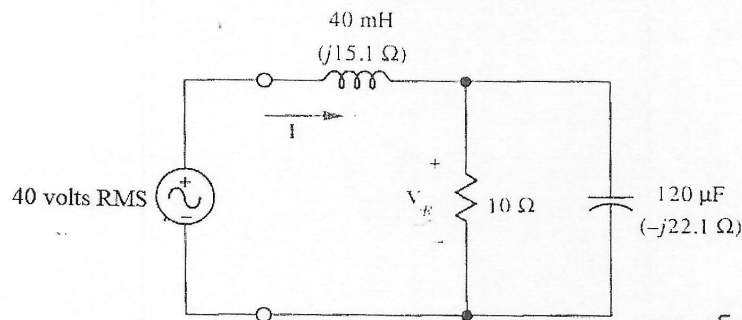
$$2 (.20 \times 1.2) \sin(45^\circ) = .34\text{ F}$$

$$2 (.169) = \boxed{.34\text{ F}}$$

20

IV. The following circuit has element values of $R = 10 \Omega$, $X_L = j15.1 \text{ Ohms}$, $X_C = -j22.1 \text{ ohms}$ and a supply voltage of 40 volts RMS at 60 Hz. For the circuit determine

- Impedance Z as seen by the voltage source
- Current I delivered by the source
- Is the supply current leading or lagging. Explain



$$\begin{aligned}
 a) \quad &= 15.1j + \frac{10(-j22.1)}{10 - (j22.1)} \\
 &= 15.1 + 8.3005 - j3.7558 \\
 &= 23.4005 - j3.7558
 \end{aligned}$$

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

$$V = 40$$

$$23.4005 - j3.7558$$

c) Supply is leading

lagging

$$\hat{I} = 1.66644 + j0.267465$$

- 6

(20) V. Write True or False for the following questions

F A leading power factor results when a circuit is more inductive than capacitive.

T The phase voltage and line voltage for a delta connected generator will have the same value.

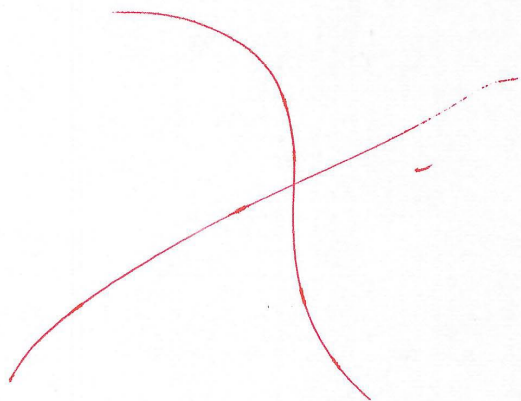
T A high permeability value indicates a good magnetic material.

F Phase angles for a three phase power generation system are separated by 90 degrees

4 X T The return current to a neutral connection of a three phase power generation system with balanced loads is one half the value of each phase.

(10) Bonus problem

A single phase generator delivers at its terminals a voltage of 600 Volts rms and a current of 30 Amps rms. The real power delivered to a load from its terminals is $P = 11.5 \text{ kW}$. Find the reactive power Q .



Below Average

ELEG 4013
ENERGY CONVERSIONS
MIDTERM EXAM

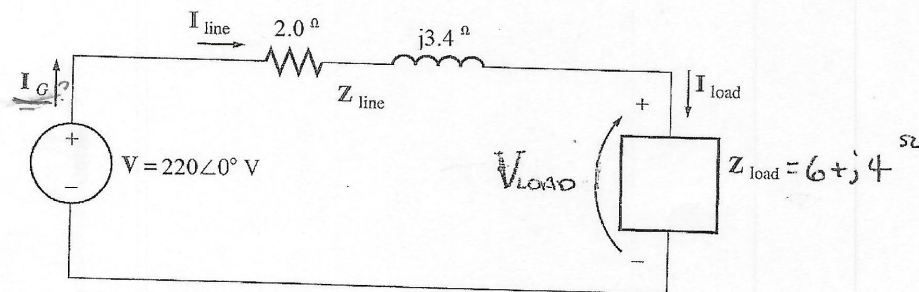
NAME Hillel Lands

March 10, 2022

No sharing calculators, no cell phones should be visible, do your own work, No in and out during test time
100 points

57
100

- (20) I. A single phase power system consists of a 220-V 60 Hz generator supplying a load $Z_{\text{Load}} = 6 + j4$ ohms through a transmission line of impedance $Z_{\text{line}} = 2.0 + j3.4$ ohms. For the circuit shown in the following diagram determine
- Value of the Generator current I_G
 - Power delivered by the 220 volt source to the circuit



$$I_G = \frac{V}{Z_{\text{line}} + Z_{\text{load}}}$$

$$I_G = \frac{220 \angle 0}{(2.0 + j3.4) + (6 + j4)}$$

$$I_G = \frac{220 \angle 0}{10.89 \angle 42.76^\circ}$$

$$I_G = 20.20 \angle -42.76^\circ \text{ Amps}$$

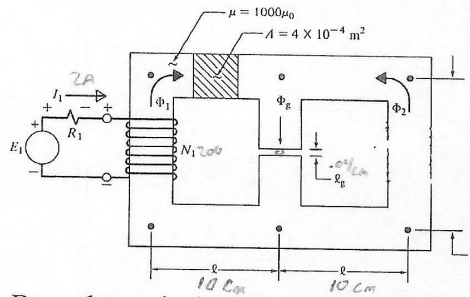
$$P = (I_G)^2 \times R_L$$

$$P = (20.20)^2 \times 6$$

$$P = 2448.72$$

$$P = 2.448 \text{ kWatts}$$

- 20 II. The following magnetic circuit has the properties of $\ell = 10 \text{ cm}$, $\ell_g = .04 \text{ cm}$, $N_1 = 200$ turns, $A =$ uniform cross sectional area of core ($4 \times 10^{-4} \text{ m}^2$), $I_1 = 2 \text{ amps}$ and $\mu_r = 1000$. For the circuit do the following (neglect fringing)

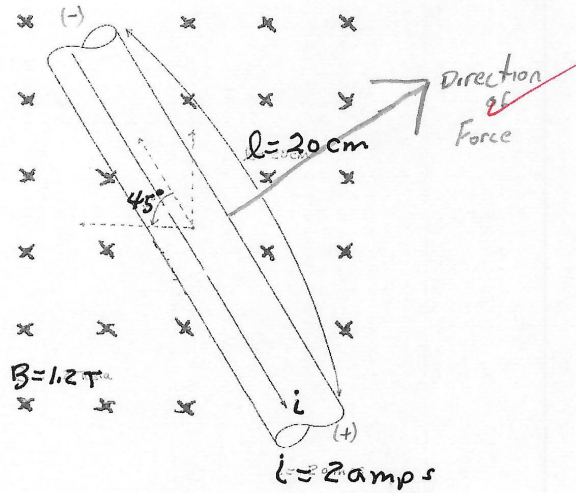


- Draw the equivalent circuit in terms of Reluctances and sources (calculate values)
- Compute the value of the flux Φ_1 in the left leg

20

(20)

III. . If a conductor is carrying a current of $i = 2$ amps (top to bottom of figure below) with length $l = 20\text{cm}$, in a magnetic field of $B = 1.2$ Tesla as shown into the page. What is the magnitude and direction (show on diagram) of resulting force on the wire?



$$F = BIl \sin \theta$$

$$1.2\text{T} \cdot 2\text{A} \cdot 20\text{cm} \sin 45^\circ = 0.3394$$

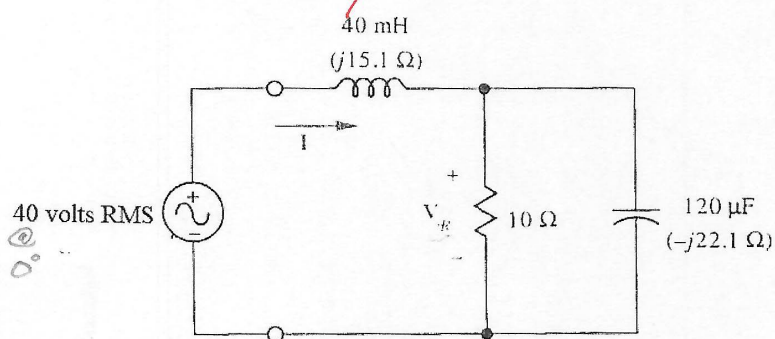
Force on wire is shown on diagram.

-5

20

IV. The following circuit has element values of $R = 10 \Omega$, $X_L = j15.1 \text{ Ohms}$, $X_C = -j22.1$ ohms and a supply voltage of 40 volts RMS at 60 Hz. For the circuit determine

- Impedance Z as seen by the voltage source
- Current I delivered by the source
- Is the supply current ~~leading~~ or lagging. Explain



Impedance Z

$$\begin{aligned}
 Z &= 15.1j + \frac{10 \times (-j22.1)}{10 - j22.1} \\
 &= \frac{151j + 733.71 - 221j}{10 - j22.1} \quad ?? \\
 &= \frac{(373.71 - 70j)(10 + j22.1)}{(10 - j22.1) \times (10 + j22.1)} \\
 &= \frac{(373.71 - 70j)(10 + j22.1)}{100 + 488.41}
 \end{aligned}$$

$$Z = 18.21 - 3.819j$$

$$I = ?$$

$$-10$$

(20) V. Write True or False for the following questions

~~T~~ A leading power factor results when a circuit is more inductive than capacitive.

~~F~~ The phase voltage and line voltage for a delta connected generator will have the same value.

T A high permeability value indicates a good magnetic material.

F Phase angles for a three phase power generation system are separated by 90 degrees

T The return current to a neutral connection of a three phase power generation system with balanced loads is one half the value of each phase.

(10) Bonus problem

A single phase generator delivers at its terminals a voltage of 600 Volts rms and a current of 30 Amps rms. The real power delivered to a load from its terminals is $P = 11.5 \text{ kW}$. Find the reactive power Q.

$$\bar{S} = P + jQ$$

$$\bar{S} = VI \cos \theta + jVI \sin \theta$$

$$\bar{S} = 11.5 \text{ kW} + j(600)(30) \sin 90^\circ$$

$$Q = ?$$

ASSIGNMENTS FOR OUTCOME 6.2

To test students' knowledge of basic power systems and how to analyze different type of machines

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
ENERGY CONVERSIONS
Spring 2022
Instructor: Dr. John Fuller**

Title of Assignment

Final Exam

Outcome Measured Using this Assignment

Outcome 6.2

**To test the students fundamental knowledge of power systems
and how to analyze different types of machines**

Brief justification of why this assignment is suitable for this outcome

To give the students the knowledge of the fundamental operation of power systems and various AC and DC machines and their operation in various situations.

ABOVE AVERAGE

ELEG 4301 Energy Conversions

Final Exam

150
150

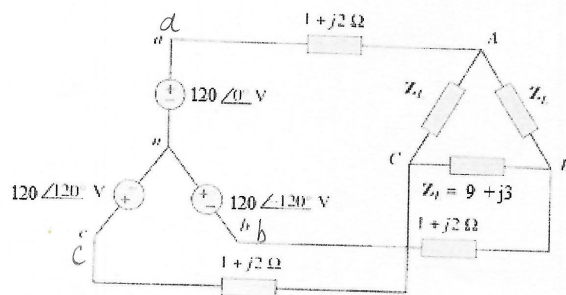
Name Christopher Rollerson

May 10, 2022

150 Points Cell phones should not be visible, show all steps in calculations, no in and out during exam, no sharing of calculators

- I. For the following three phase system obtain the line current for segment b-B. The system has a balanced Wye generator with a voltage of 120 volts and a balanced Delta three phase load of $Z_L = 9 + j3$ ohms and line impedances of $Z_L = 1 + j2$ ohms.

(20)



$$Z_Y = \frac{Z_\Delta}{3}$$

$$\frac{9+j3}{3} = 3+j$$

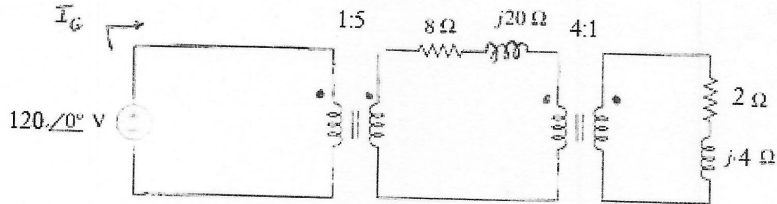
$$I_b = \frac{V_b}{Z_{line} + Z_{load}} = \frac{120 \angle -120}{(1+j2) + (3+j)} = \frac{120 \angle -120}{4+j3} = \frac{120 \angle -120}{5 \angle 36.87}$$

$$I_b = 24 \angle -156.87^\circ \text{ A}$$



- II. Solve for the current I_G in the following two transformer circuit using the per unit system. Set $V_{base} = 120$ and $S_{base} = 1,200$

30



$V_{b1} = 120 \text{ V}$	$V_{b2} = 600 \text{ V}$	$V_{b3} = 150 \text{ V}$
$S_{b1} = 1200 \text{ VA}$	$S_{b2} = 1200 \text{ VA}$	$S_{b3} = 1200 \text{ VA}$
$I_{b1} = \frac{1200}{120} = 10 \text{ A}$	$I_{b2} = \frac{1200}{600} = 2 \text{ A}$	$I_{b3} = \frac{1200}{150} = 8 \text{ A}$
$Z_{b1} = \frac{120}{10} = 12 \Omega$	$Z_{b2} = \frac{600}{2} = 300 \Omega$	$Z_{b3} = \frac{150}{8} = 18.75 \Omega$

Region 1

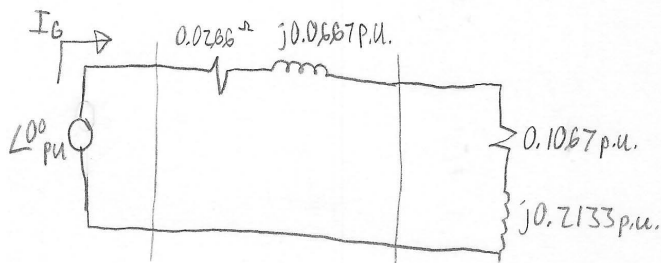
$$P.U. = \frac{120 \angle 0^\circ}{120} = 1 \angle 0^\circ \text{ P.U.}$$

Region 2

$$P.U. = \frac{8 + j20}{300} = 0.0266 + j0.0667 \text{ P.U.}$$

Region 3

$$P.U. = \frac{2 + j4}{18.75} = 0.1067 + j0.2133$$

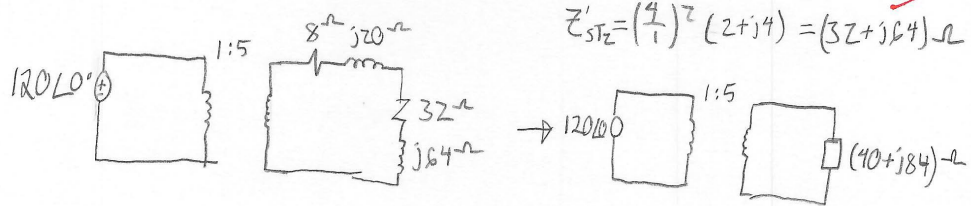
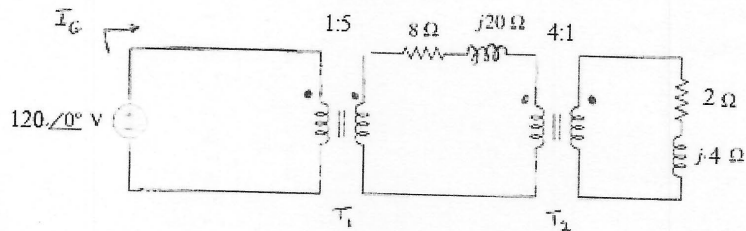


$$I_{G \text{ P.U.}} = \frac{1 \angle 0^\circ}{0.0266 + j0.0667 + 0.1067 + j0.2133} = 3.225 \angle -84.54^\circ \text{ P.U.}$$

$$I_G = (3.225 \angle -84.54^\circ)(10) = \boxed{32.25 \angle -84.54^\circ \text{ A}}$$

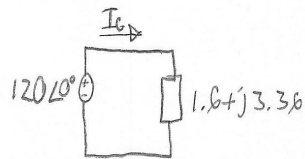
- III. A repeat of problem one is to solve for the current I_G by using the transfer of impedance method. $Z' = a^2 Z_s$

(30)



$$Z'_{sT_2} = \left(\frac{4}{1}\right)^2 (2 + j4) = (32 + j64) \Omega$$

$$Z'_{sT_1} = \left(\frac{1}{5}\right)^2 (40 + j84) = 1.6 + j3.36$$



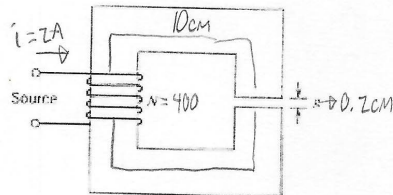
$$I_G = \frac{120 \angle 0^\circ}{1.6 + j3.36} = \boxed{32.25 \angle -64.54^\circ \text{ A}}$$

- IV. (20) The magnetic circuit as shown below has an iron core with permeability of 5,000. The core dimensions are:

Core area = $A_c = 4$ centimeters square

Air gap length = $l_g = 0.2$ cm

Length of core = $l_c = 10$ cm



$$\mu = 5000$$

$$A_c = 4 \times 10^{-4} \text{ m}^2$$

$$l_{ag} = 0.002 \text{ m}$$

$$l_c = 0.1 \text{ m}$$

$$\mu_0 = 4\pi \times 10^{-7}$$

$$F = Ni = 400(2) = 800$$

The coil has 400 turns and draws a current $i = 2$ A from the source. Neglect magnetic leakage and fringing and calculate the total magnetic flux in the core.

$$R_g = \frac{0.002}{(4\pi \times 10^{-7})(4 \times 10^{-4})} = 3.98 \times 10^6$$

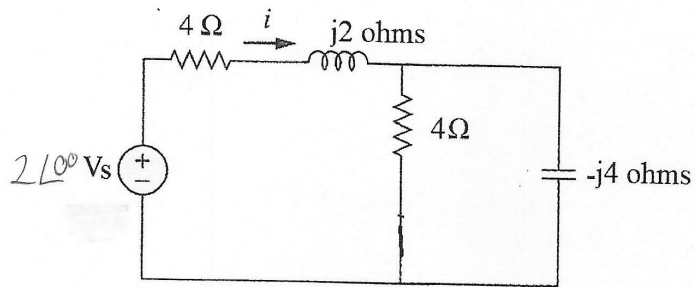
$$R_i = \frac{0.1}{(5000)(4\pi \times 10^{-7})(4 \times 10^{-4})} = 39.79 \times 10^3$$

$$R_{eq} = R_g + R_i = (3.98 \times 10^6) + (39.79 \times 10^3) = 4.02 \times 10^6$$

$$\phi = \frac{F}{R_{eq}} = \frac{800}{4.02 \times 10^6} = 199.005 \times 10^{-6}$$

V. In the following RLC circuit the voltage source has a value of $V_s = 2 \angle 0^\circ$ volts RMS, determine the value of

- (10) a) Current i
 (10) b) Power delivered by the voltage source



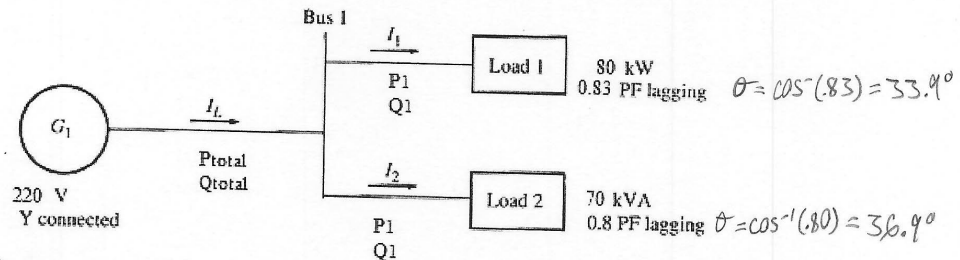
$$Z_L = (4 + j2) + \left(\frac{4(-j4)}{4 - j4} \right) = 4 + j2 + 2 - j2 = 6 \Omega$$

$$I = \frac{V}{R} = \frac{2}{6} = 0.33 \text{ A}$$

$$P = I^2 R = (0.33)^2 (6) = 0.653 \text{ W}$$

VI. Shown as follows is a line diagram of a three phase power system containing a 220 volt (line voltage) generator supplying two loads with power values as indicated. Assume the transmission lines are lossless, with the supply voltage directly applied line to line to the loads. Both loads are wye connected. Calculate the following.

- (15) a) Current I_L supplied by the generator
 (15) b) Calculate the Real and Reactive power supplied by the Generator to the loads.



$$a) I_1 = \frac{P_1}{\sqrt{3} V_L \cos \theta} = \frac{80 \text{ kW}}{\sqrt{3} (220) (0.83)} = 252.95 \text{ A}$$

$$I_2 = \frac{S_2}{\sqrt{3} V_L} = \frac{70 \text{ kVA}}{\sqrt{3} (220)} = 183.70 \text{ A}$$

$$I_L = I_1 + I_2 = 436.65 \text{ A}$$

$$b) P_1 = 80 \text{ kW}$$

$$P_2 = S_2 \cos \theta_2 \\ = 70 \text{ kVA} \cdot 0.8 \\ = 56 \text{ kW}$$

$$P_{\text{Tot}} = P_1 + P_2 = 80 \text{ k} + 56 \text{ k} = 136 \text{ kW}$$

$$Q_1 = P_1 \tan(\theta) = 80 \text{ kW} \times \tan(33.9) \\ = 53.758 \text{ KVAR}$$

$$Q_2 = S_2 \sin(\theta) = 70 \text{ kVA} \cdot \sin(36.9) \\ = 42.029 \text{ KVAR}$$

$$Q_{\text{Tot}} = 53.758 + 42.029 = 95.787 \text{ KVAR}$$

Average

ELEG 4301 Energy Conversions

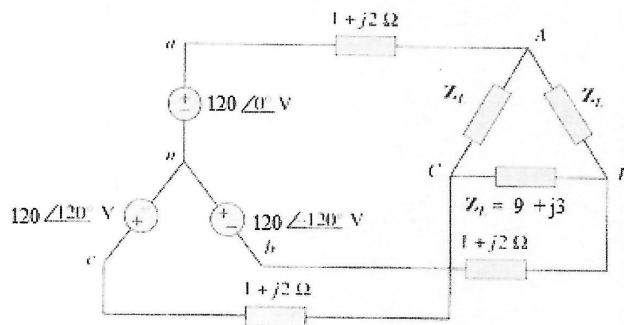
Final Exam

Name Bryce Lovejoy

May 10, 2022

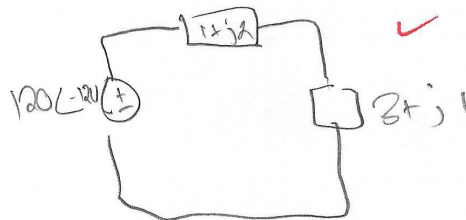
150 Points Cell phones should not be visible, show all steps in calculations, no in and out during exam, no sharing of calculators

- I. For the following three phase system obtain the line current for segment b-B. The system has a balanced Wye generator with a voltage of 120 volts and a balanced Delta three phase load of $Z_L = 9 + j3$ ohms and line impedances of $Z_L = 1 + j2$ ohms.



$$Z_y = \frac{9 + j3}{3} = 3 + j1$$

$$1 + j2 + 3 + j1 = 4 + j3$$



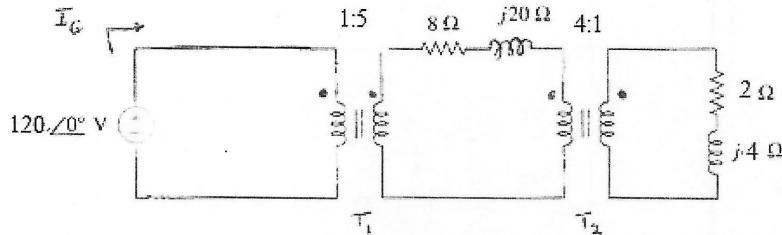
$$I_L = \frac{120 \angle -120^\circ}{4 + j3}$$

$$I_L = 22.07 \angle -96.87^\circ$$

$$\text{or } 22 \angle -96.87^\circ \text{ A}$$

- II. Solve for the current I_G in the following two transformer circuit using the per unit system. Set $V_{base} = 120$ and $S_{base} = 1,200$

(30)



$$S_{base1} = 1,200$$

$$V_{base1} = 600 \text{ V}$$

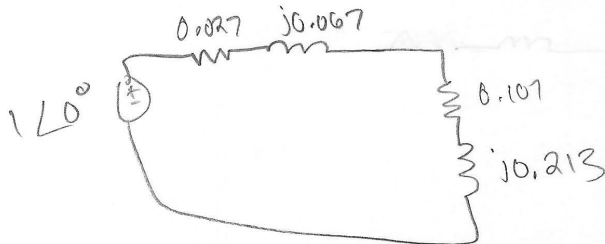
$$I_{base} = \frac{1200}{600} = 2 \text{ A}$$

$$I_1 = 2 \text{ A}$$

$$Z_{base1} = \frac{600 \text{ V}}{2 \text{ A}} = 300 \Omega$$

$$\frac{120 \angle 0^\circ \text{ V}}{120} = 1 \angle 0^\circ$$

$$\text{Region 1} = \frac{8 + j20}{300} = 0.027 + j0.067$$



$$S_{base2} = 1,200$$

$$V_{base2} = 150 \text{ V}$$

$$I_{base2} = \frac{1200}{150} = 8 \text{ A}$$

$$Z_{base2} = \frac{150 \text{ V}}{8 \text{ A}} = 18.75 \Omega$$

$$\text{Region 2} = \frac{2 + j4}{18.75}$$

$$= 0.107 + j0.213$$

$$I_{G \text{ P.U.}} = \frac{1 \angle 0^\circ}{0.027 + j0.067 + 0.107 + j0.213}$$

$$I_{G \text{ P.U.}} = 1.841 - j2.406 \text{ or } 3.223 \angle -64.426^\circ$$

$$I_1 = \text{P.U.} \times \text{base}$$

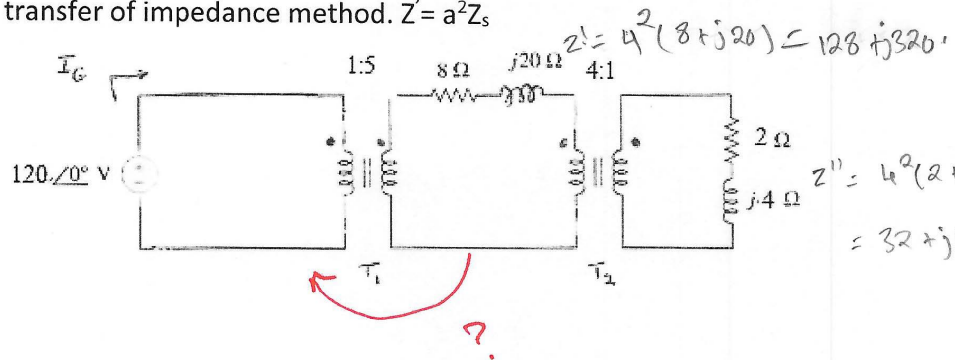
$$= (3.223 \angle -64.426^\circ) (2 \text{ A})$$

$$= 6.446 \angle -64.426^\circ \text{ P.U.}$$

3

- III. A repeat of problem one is to solve for the current I_G by using the transfer of impedance method. $Z' = a^2 Z_s$

(30)



$$I_G = \frac{120 \angle 0^\circ}{128 + j320 + 32 + j64} = \frac{120 \angle 0^\circ}{160 + j384}$$

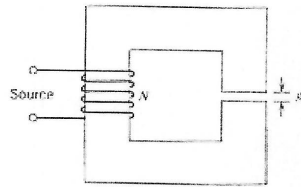
$$I_G = 0.11 - j0.27$$

or $0.29 \angle -67.38^\circ$

-13

- IV. The magnetic circuit as shown below has an iron core with permeability of 5,000. The core dimensions are:

Core area = $A_c = 4$ centimeters square $= 0.0004 \text{ m}^2$
 Air gap length = $l_g = 0.2 \text{ cm} = 0.002 \text{ m}$
 Length of core = $l_c = 10 \text{ cm} = 0.1 \text{ m}$



The coil has 400 turns and draws a current $i = 2 \text{ A}$ from the source. Neglect magnetic leakage and fringing and calculate the total magnetic flux in the core.

$$R_c = \frac{l}{\mu \mu_0 N^2} = \frac{0.1 \text{ m}}{(5,000)(4\pi \times 10^{-7})(0.0004)} = 39,788.736 \text{ A-turns/Wb}$$

$$R_g = \frac{l}{\mu_0 N^2} = \frac{0.002}{(4\pi \times 10^{-7})(0.0004)} = 3,978,873.6 \text{ A-turns/Wb}$$

$$R_{\text{tot}} = 4,018,662.36 \text{ A-turns/Wb}$$

$$\Phi F = Ni = (400)(2 \text{ A})$$

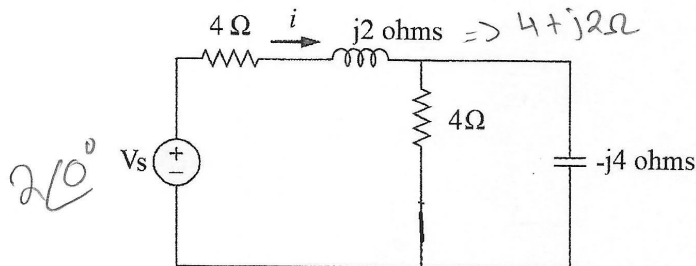
$$= 800 \text{ Wb}$$

$$\phi = ?$$

— 8

V. In the following RLC circuit the voltage source has a value of $V_s = 2 \angle 0^\circ$ volts RMS, determine the value of

- (10) a) Current i
(10) b) Power delivered by the voltage source



$$4 + j2\Omega + 4\Omega \parallel -j4\Omega$$

$$\frac{4 + j2\Omega + (4 \times -j4)}{4 - j4} = 4 + j2\Omega + 2 - j2 = 6 + j \quad \times$$

$$a) i = \frac{V}{Z} = \frac{2 \angle 0^\circ}{6 + j} = 0.32 - j0.05 \text{ or } 0.32 \angle -9.46^\circ \text{ A}$$

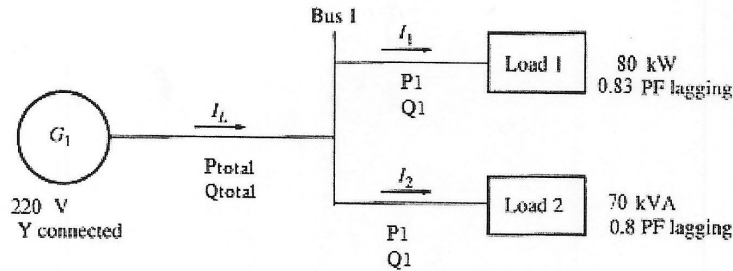
$$b) P = I^2 R = (0.32 - j0.05)^2 (6 + j)$$

$$P = 0.63 - j0.09 \text{ W}$$

11

- VI. Shown as follows is a line diagram of a three phase power system containing a 220 volt (line voltage) generator supplying two loads with power values as indicated. Assume the transmission lines are lossless, with the supply voltage directly applied line to line to the loads. Both loads are wye connected. Calculate the following.

- (15) a) Current I_L supplied by the generator
(15) b) Calculate the Real and Reactive power supplied by the Generator to the loads.



$$a) I_1 = \frac{P_1}{\sqrt{3} V_L \cos \phi_1} = \frac{80 \text{ kW}}{\sqrt{3} \times 220 \times 0.83} = 252.94 \text{ A} \quad \checkmark$$

$$I_2 = \frac{P_2}{\sqrt{3} V_L \cos \phi_2} = \frac{70 \text{ kW}}{\sqrt{3} \times 220} = 183.7 \text{ A} \quad \text{X}$$

$$I_L = I_1 + I_2 = 252.94 + 183.7 = 436.64 \text{ A}$$

b) $P_1 = 80 \text{ kW}$
 $P_2 = 82 \cos \phi_2$
 $= 70 \text{ k} \times 0.8$
 $P_2 = 56 \text{ kW}$

$$P_{\text{tot}} = P_1 + P_2$$

$$P_{\text{tot}} = 80 \text{ k} + 56 \text{ k}$$

$$P_{\text{tot}} = 136 \text{ k}$$

$$Q_1 = P_1 \tan \phi_1$$

$$= 80 \text{ k} \tan 63$$

$$= 53.757 \text{ kVAR}$$

$$Q_2 = \sqrt{S^2 - P^2}$$

$$= \sqrt{(70 \text{ k})^2 - (70 \times 0.8)^2}$$

$$= 42 \text{ kVAR}$$

$$Q_{\text{tot}} = Q_1 + Q_2$$

$$= 53.757 \text{ kVAR} + 42 \text{ kVAR}$$

$$Q_{\text{tot}} = 95.757 \text{ kVAR}$$

BELOW AVERAGE

ELEG 4301 Energy Conversions

Final Exam

Name Temin: Folbrunn

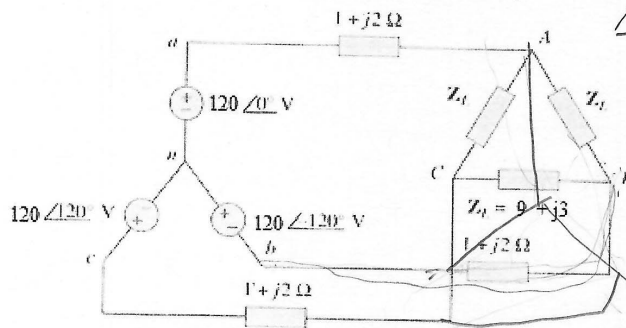
May 10, 2022

150 Points Cell phones should not be visible, show all steps in calculations, no in and out during exam, no sharing of calculators

90
150

- I. For the following three phase system obtain the line current for segment b-B. The system has a balanced Wye generator with a voltage of 120 volts and a balanced Delta three phase load of $Z_L = 9 + j3$ ohms and line impedances of $Z_L = 1 + j2$ ohms.

20



Step 1:

$\Delta \rightarrow$ WYE

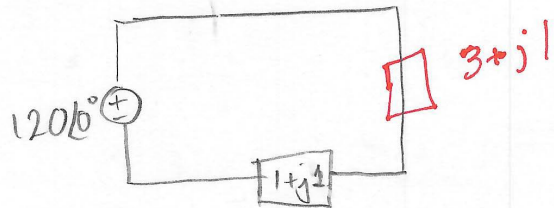
START!

$$= \frac{Z}{3} = \frac{9 + j3}{3} = 3 + j1$$

$$Z_{line} = 1 + j2$$

$$\sqrt{2} / 45^\circ ?$$

Sol.



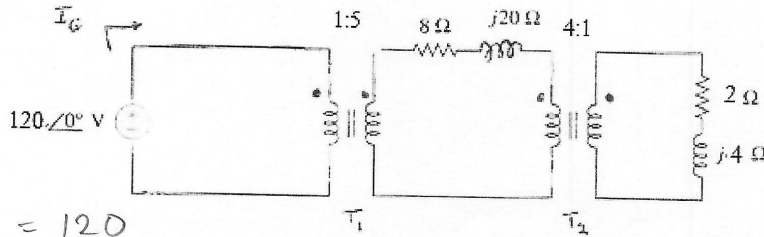
$$I = \frac{V}{Z}$$

$$I = \frac{120 \angle 0}{\sqrt{2} / 45^\circ} = 84.853 \angle -45^\circ \text{ A}$$

-10

- II. Solve for the current I_G in the following two transformer circuit using the per unit system. Set $V_{base} = 120$ and $S_{base} = 1,200$

(30)



$$V_{base} = 120$$

$$S_{base} = 1200$$

$$V_{base}$$

$$S_{base}$$

$$Z' = a^2 Z_s$$

Region 1 : Region 2 : Region 3 -16

$$Z_b = \frac{S}{V}$$

$$Z_b = \frac{S}{V} \quad V=600$$

$$Z_b = \frac{S}{V}$$

$$Z_b = \frac{1200}{120} = ?$$

$$= \frac{1200(5)}{120} \times$$

$$= \frac{1200(5)}{120 \times 4} \quad V=750$$

$$Z_{b1} = 10 \quad I=10$$

$$Z_{b2} = 50 \times$$

$$Z_{b3} = 12.5 \times$$

$$I_{b1} = \frac{V}{Z} = \frac{120}{10}$$

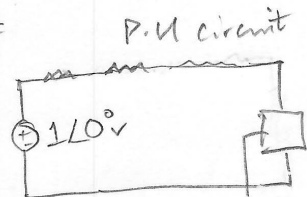
$$I_{b2} = \frac{120}{50}$$

$$I_{b3} = \frac{120}{12.5}$$

$$= 12 \quad Z=12$$

$$= 6$$

$$= 9.6 \times$$



P.U :

$$V = \frac{\text{Actual}}{\text{Base}} = \frac{120}{120}$$

$$V_{pu} = 1.0$$

$$I_{G,pu} = \frac{1.0}{0.359 \angle 67.37^\circ}$$

$$I_{pu} = 2.79 \angle -67.37^\circ$$

Per unit value?

$$Z = 8 + 2 + j20 + j4 \quad I_G = ?$$

need p.u. 10 + 50 + 12.5 X

$$Z_{pu} = \frac{10 + j24}{72.5} = 0.138 + j0.331$$

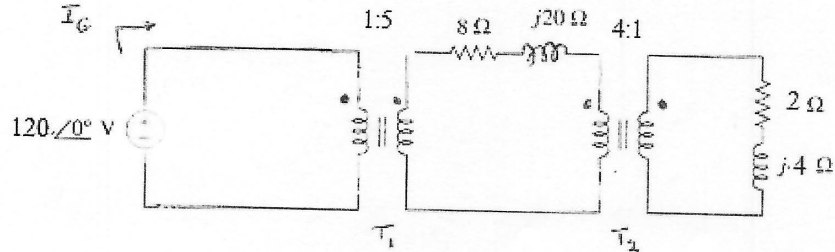
$$\approx 0.359 \angle 67.37^\circ$$

$$I_G = \frac{12 + 6 + 9.6}{2.79 \angle -67.37^\circ} = \frac{27.6}{2.79 \angle -67.37^\circ}$$

$$I_G = 9.892 A$$

- III. A repeat of problem one is to solve for the current I_G by using the transfer of impedance method. $Z' = a^2 Z_s$

(30)



$$V_{base} = 120$$

$$S_{base} = 1200$$

Reg-1 :
 $Z_s = 0$

$$Z' = a^2 Z_s$$

$$a = \frac{N_p}{N_s} = \frac{1}{5}$$

$$Z' = \left(\frac{1}{5}\right)^2 (8 + j20) + 32 + j64 = 32 + j64$$

$$Z' = \frac{8}{25} + j\frac{4}{5} \quad \text{or} \quad \frac{8}{5} + j4$$

$$Z' = \frac{8 + j20}{5}$$

Step 1

$$\frac{N_p}{N_s} = a = \left(\frac{4}{1}\right)$$

$$Z' = (4)^2 (2 + j4)$$

$$I_G = ? = \frac{V}{Z}$$

$$I_G = \frac{120 \angle 0}{\left(\frac{8 + j4}{25} + \frac{32 + j64}{5}\right)} = \frac{120 \angle 0}{\frac{8 + j4}{5} + 32 + j64} = \frac{120 \angle 0}{40 + j84}$$

$$I_G = \frac{120 \angle 0}{93.04 \angle 64.5} = 1.289 \angle -64.5^\circ$$

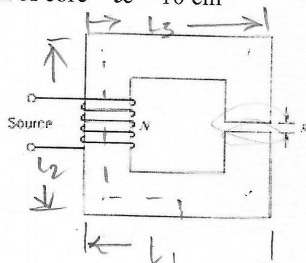
10

- IV. The magnetic circuit as shown below has an iron core with permeability of 5,000. The core dimensions are:

Core area = $A_c = 4$ centimeters square

Air gap length = $l_g = 0.2$ cm

Length of core = $l_c = 10$ cm



(3 sides)
 (II) $R_{eq} = \frac{3L}{\mu\mu_0 A} = 375,000 \frac{A}{Wb}$

The coil has 400 turns and draws a current $i = 2$ A from the source. Neglect magnetic leakage and fringing and calculate the total magnetic flux in the core.

$$A_c = 4 \text{ cm}^2 = 4 \times 10^{-4} \text{ m}^2 = 0.0004 \text{ m}^2$$

$$l_g = 0.002 \text{ m}$$

$$l_c = 0.1 \text{ m}$$

$$i = 2 \text{ A}$$

$$\Phi = ?$$

$$(II) R_{eq} = \frac{l}{\mu\mu_0 A} = \frac{4(0.1)}{(4 \times 10^3)(5 \times 10^{-3})(0.0004)} = 500,000 \frac{A}{Wb}$$

$$- R_{lg} = \frac{0.002}{(5 \times 10^3)(1)(0.0004)} = 1 \times 10^{-3} \frac{A}{Wb} \quad \text{[negligible]}$$

$$(I) \mathcal{F} = Ni \Rightarrow 400 \times 2$$

$$= \underline{\underline{800}}$$

$$(III) \therefore \text{Flux } \Phi = \frac{\mathcal{F}}{R} = \frac{800}{500000} = \underline{\underline{1.6 \times 10^{-3} \text{ Wb}}}$$

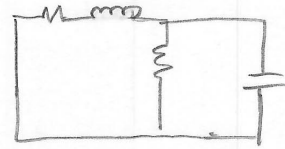
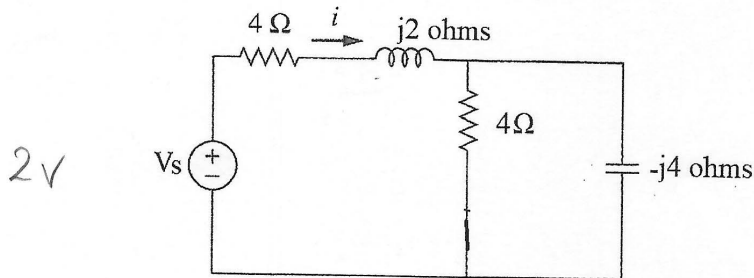
- 5

V. In the following RLC circuit the voltage source has a value of $V_s = 2 \angle 0^\circ$ volts RMS, determine the value of

(10) a) Current i

(10) b) Power delivered by the voltage source

$$V_{rms} I_{rms} \cos \theta_v - \theta_i$$



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

$$= \frac{2}{8} = 0.25 A$$

$$\begin{aligned} \textcircled{a} \quad i &= \frac{V}{Z} = \frac{2 \angle 0}{(4 + j2) \times (4 - j4)} \\ &= \frac{2 \angle 0}{8 - j2} \quad \text{(in parallel)} \\ &= \frac{2 \angle 0^\circ}{8.25 \angle -14.04^\circ} \end{aligned}$$

$$\begin{aligned} \textcircled{b} \quad P &= V_{rms} I_{rms} \cos(\theta_v - \theta_i) \\ &= (2)(0.24) \cos(0 - 14.04^\circ) \\ &= 0.48 \times \cos(-14.04^\circ) \\ &= 0.466 W \end{aligned}$$

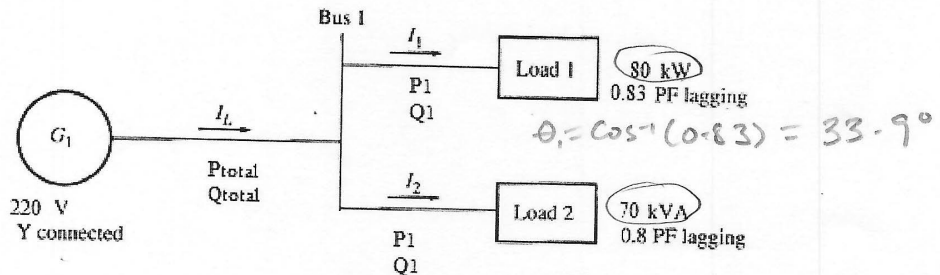
$$i = 0.24 \angle 14.04^\circ A$$

$$P = I^2 R \quad \text{Wss}$$

-10

- VI. Shown as follows is a line diagram of a three phase power system containing a 220 volt (line voltage) generator supplying two loads with power values as indicated. Assume the transmission lines are lossless, with the supply voltage directly applied line to line to the loads. Both loads are wye connected. Calculate the following.

- a) Current I_L supplied by the generator
b) Calculate the Real and Reactive power supplied by the Generator to the loads.



$$V_{line} = 220V$$

$$V_{phase} = \frac{V}{\sqrt{3}} = \frac{220}{\sqrt{3}} = 127.02V$$

$$Z = \frac{S}{V}$$

$$S = VA$$

$$A = \frac{S}{V}$$

$$I_1 = \frac{80000}{127.02}$$

$$= 629.82A$$

$$I_2 = \frac{70000}{127.02}$$

$$= 551.09A$$

for phase

VA not
WATTS

$$P = VI \cos(\theta_r - \theta_i)$$

$$P = S \cos \theta \Rightarrow 80,000 \times 0.83 = 66400$$

$$Q = S \sin \theta \Rightarrow 70,000 \times \sin 36.87^\circ = 42000$$

$$P = 66400 W_{ms}$$

$$Q = 42000 VA_{ms}$$

ASSIGNMENTS FOR OUTCOME 6.3

**To teach students the use of modern engineering tools such as Matlab
and FPGA programming**

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
ENERGY CONVERSIONS
Spring 2022
Instructor: Dr. John Fuller**

Title of Assignment

Matlab Program on development of motor stator generated magnetic rotating field

Outcome Measured Using this Assignment

Outcome 6.3

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Check the communication problem characteristics related to this assignment

Brief justification of why this assignment is suitable for this outcome

Computer programming of rotating magnetic field as generated by the stator winding. The rotating field is fundamental to motor operation and the understanding of permanent magnet motors as presently used in automobiles. This project involves the mathematics to set up a rotating field and the simulation of that field using computer programming

Above Average

**ELECTRICAL AND COMPUTER ENGINEERING
PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING**



ELEG 4301-P01-Spring 2022

Electromechanical Energy Conversion

Simulation of Rotational Magnetic Field Using MATLAB

Submitted by:

Akanimo Etokebe

Course Instructors: Dr. John Fuller

Date of Submission: May 10, 202

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1. Introduction
2. Theory applied to Generator magnetic fields
3. Matlab program and results for counterclockwise B_{net} field
4. Hand calculations for rotating field
5. Matlab program and results for clockwise rotating magnetic field
6. Hand calculations for clockwise rotating field
7. Conclusion

Introduction

The purpose of this project was to carry out the simulation of the rotational magnetic field created by the application of three phase voltages to the stator of an AC machine. This simulation was executed on MATLAB software through drawing lines that correspond to the net magnitude field. The second part of the project involved interchanging two of the windings and then record the direction of rotation. Both parts of the project instructed us to execute the MATLAB program and then observe the behavior of the Bnet.

Theory applied to Generator magnetic fields

Alternating current machines tend to function within three-phase set of currents, each of equal magnitude while differing in phase by 120 degrees; yet flows in a three-phase winding.

As a result, this produces a rotating magnetic field of constant magnitude.

Its three-phase winding consists of three separate windings spaced 120 electrical degrees apart around the surface of the machine [1].

Counterclockwise Rotational Magnetic Field Codes and Results

```
% M-file: mag_field.m
% M-file to calculate the net magnetic field produced
% By a three-phase stator.

% Set up the basic conditions
bmax = 1;           % Normalize bmax to 1
freq = 60;          % 60 Hz
w = 2*pi*freq;      % Angular velocity (rad/s)

% First, generate the three component magnetic fields
t = 0:1/6000:1/60;
Baa = sin(w*t) .* (cos(0) + j*sin(0));
Bbb = sin(w*t-2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));
Bcc = sin(w*t+2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));

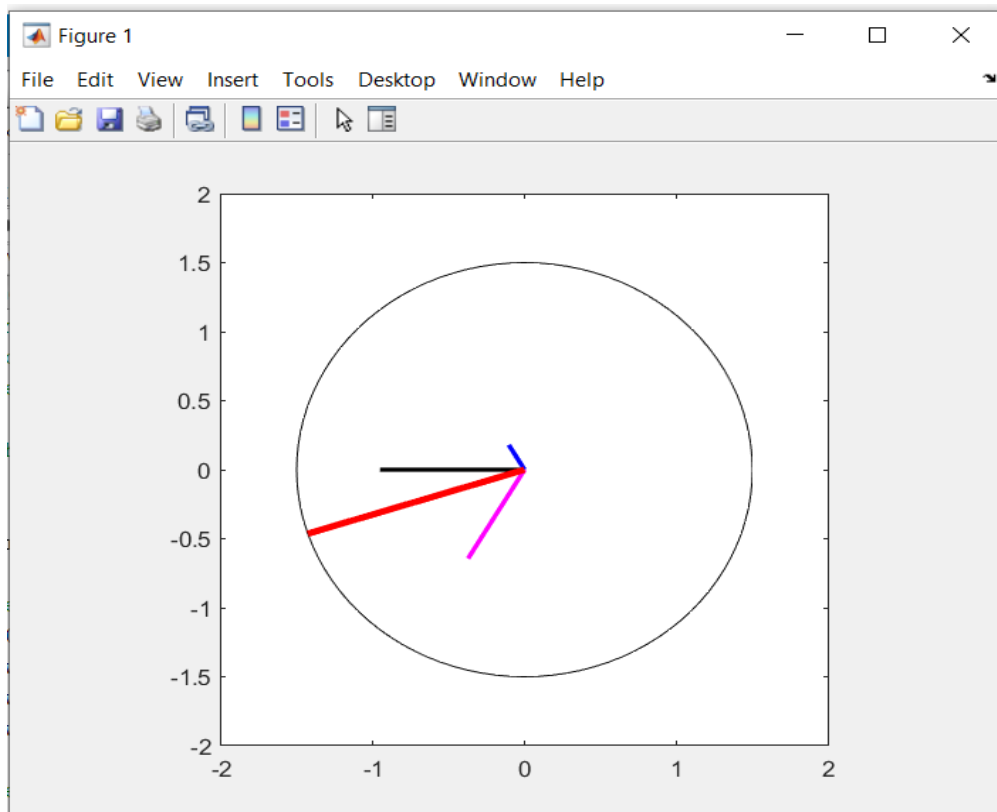
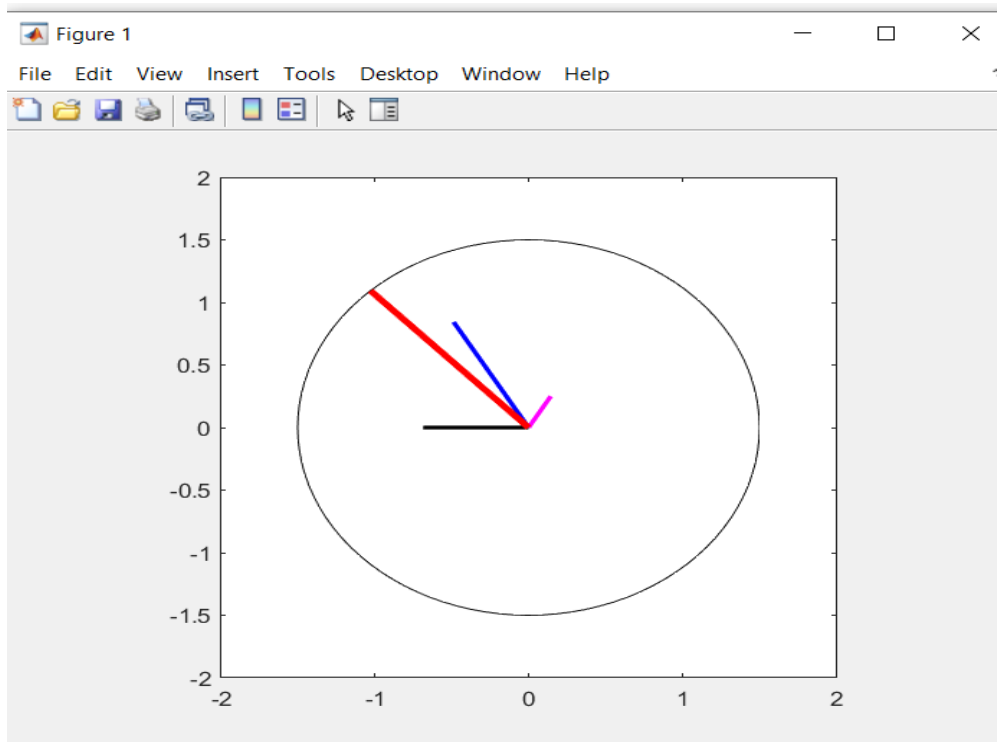
% Calculate Bnet
Bnet = Baa + Bbb + Bcc;

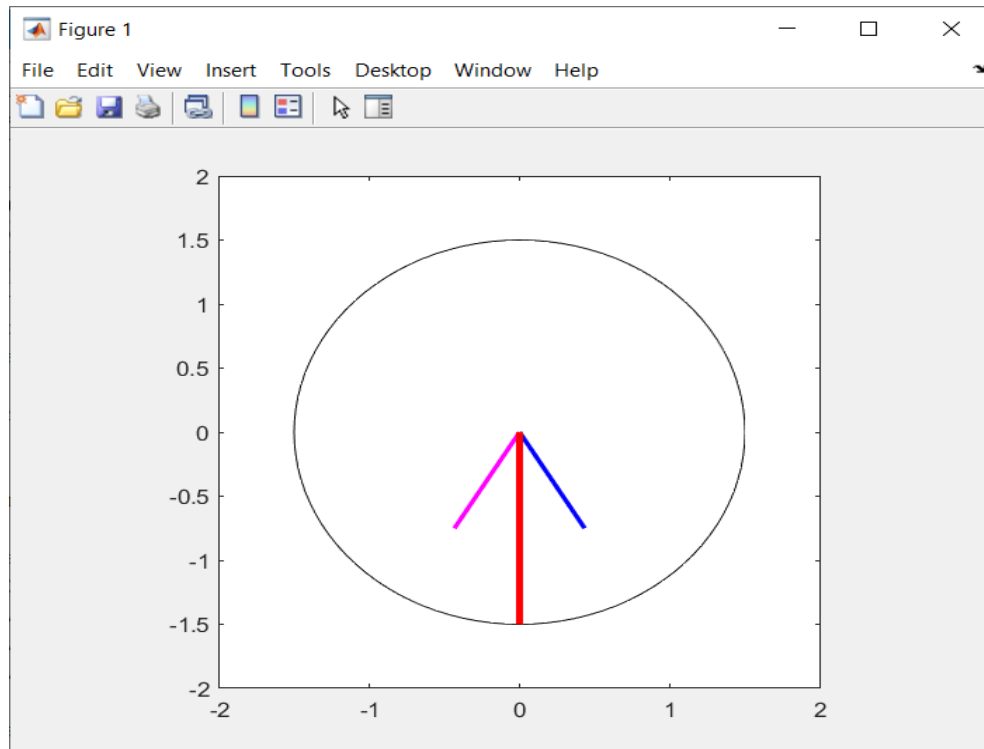
% Calculate a circle representing the expected maximum value of
Bnet
circle = 1.5 * (cos(w*t) + j*sin(w*t));

% Plot the magnitude and direction of the resulting magnetic
fields.
% Note that Baa is black, Bbb is blue, Bcc is magenta, and Bnet
is red.
for ii = 1:length(t)

    % Plot the reference circle
    plot(circle, 'k');
    hold on;

    % Plot the four magnetic fields
    plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
    plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
    plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
    plot([0 real(Bnet(ii))],[0
imag(Bnet(ii))],'r','LineWidth',3);
    axis square;
    axis([-2 2 -2 2]);
    drawnow;
    hold off;
end
```





Hand Calculations for Rotating Field

Proof of the Rotating Magnetic Field Concept

The net magnetic flux density in the stator is given by

$$B_{\text{net}}(t) = B_{ad'}(t) + B_{bb'}(t) + B_{cc'}(t) \\ = B_M \sin \omega t \angle 0^\circ + B_M \sin(\omega t - 120^\circ) \angle 120^\circ + B_M \sin(\omega t - 240^\circ) \angle 240^\circ$$

Each of the three component magnetic fields broken down into its x and y components:

$$B_{\text{net}}(t) = B_M \sin \omega t \hat{x} - [0.5 B_M \sin(\omega t - 120^\circ)] \hat{x} + \left[\frac{\sqrt{3}}{2} B_M \sin(\omega t - 120^\circ) \right] \hat{y} \\ - [0.5 B_M \sin(\omega t - 240^\circ)] \hat{x} - \left[\frac{\sqrt{3}}{2} B_M \sin(\omega t - 240^\circ) \right] \hat{y}$$

Combining x and y components yields:

$$B_{\text{net}}(t) = [B_M \sin \omega t - 0.5 B_M \sin(\omega t - 120^\circ) - 0.5 B_M \sin(\omega t - 240^\circ)] \hat{x} \\ + \left[\frac{\sqrt{3}}{2} B_M \sin(\omega t - 120^\circ) - \frac{\sqrt{3}}{2} B_M \sin(\omega t - 240^\circ) \right] \hat{y}$$

By the angle-addition trigonometric identities:

$$B_{\text{net}}(t) = \left[B_M \sin \omega t + \frac{1}{4} B_M \sin \omega t + \frac{\sqrt{3}}{4} B_M \cos \omega t + \frac{1}{4} B_M \sin \omega t - \frac{\sqrt{3}}{4} B_M \cos \omega t \right] \hat{x} \\ + \left[-\frac{\sqrt{3}}{4} B_M \sin \omega t - \frac{3}{4} B_M \cos \omega t + \frac{\sqrt{3}}{4} B_M \sin \omega t - \frac{3}{4} B_M \cos \omega t \right] \hat{y}$$

$$B_{\text{net}}(t) = (1.5 B_M \sin \omega t) \hat{x} - (1.5 B_M \cos \omega t) \hat{y}$$

Clockwise Rotational Magnetic Field Codes and Results

```
% M-file: mag_field.m
% M-file to calculate the net magnetic field produced
% By a three-phase stator.

% Set up the basic conditions
bmax = 1;           % Normalize bmax to 1
freq = 60;          % 60 Hz
w = 2*pi*freq;      % Angular velocity (rad/s)

% First, generate the three component magnetic fields
t = 0:1/6000:1/60;
Baa = sin(w*t) .* (cos(0) + j*sin(0));
Bbb = sin(w*t+2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));
Bcc = sin(w*t-2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));

% Calculate Bnet
Bnet = Baa + Bbb + Bcc;

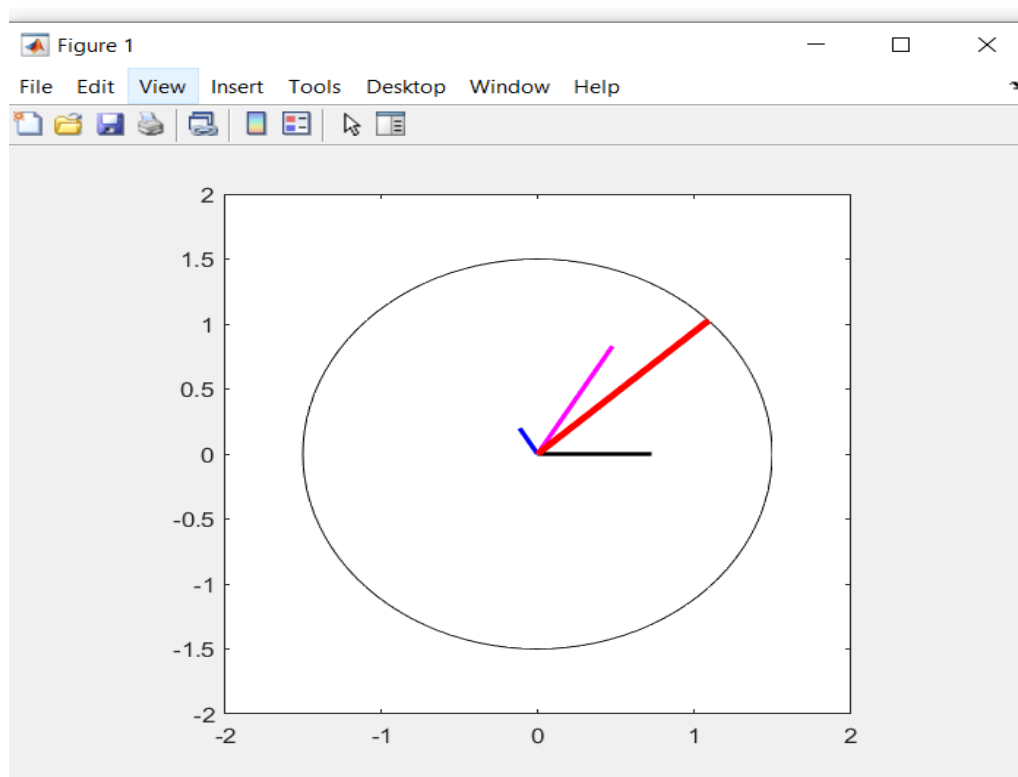
% Calculate a circle representing the expected maximum value of
Bnet
circle = 1.5 * (cos(w*t) + j*sin(w*t));

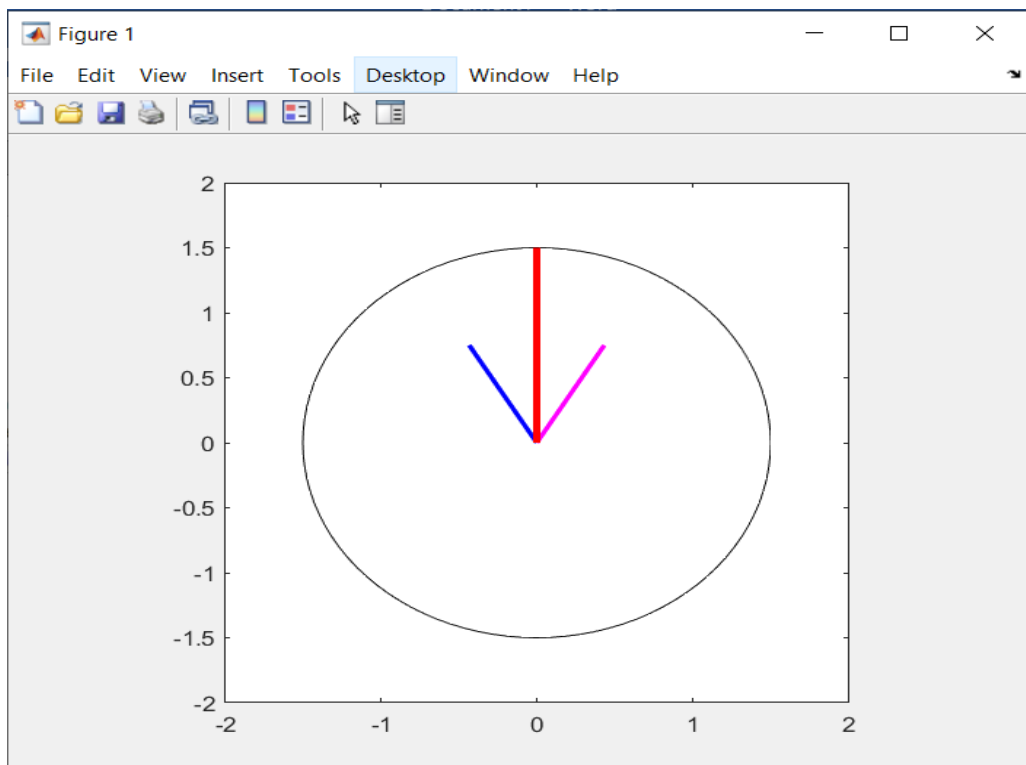
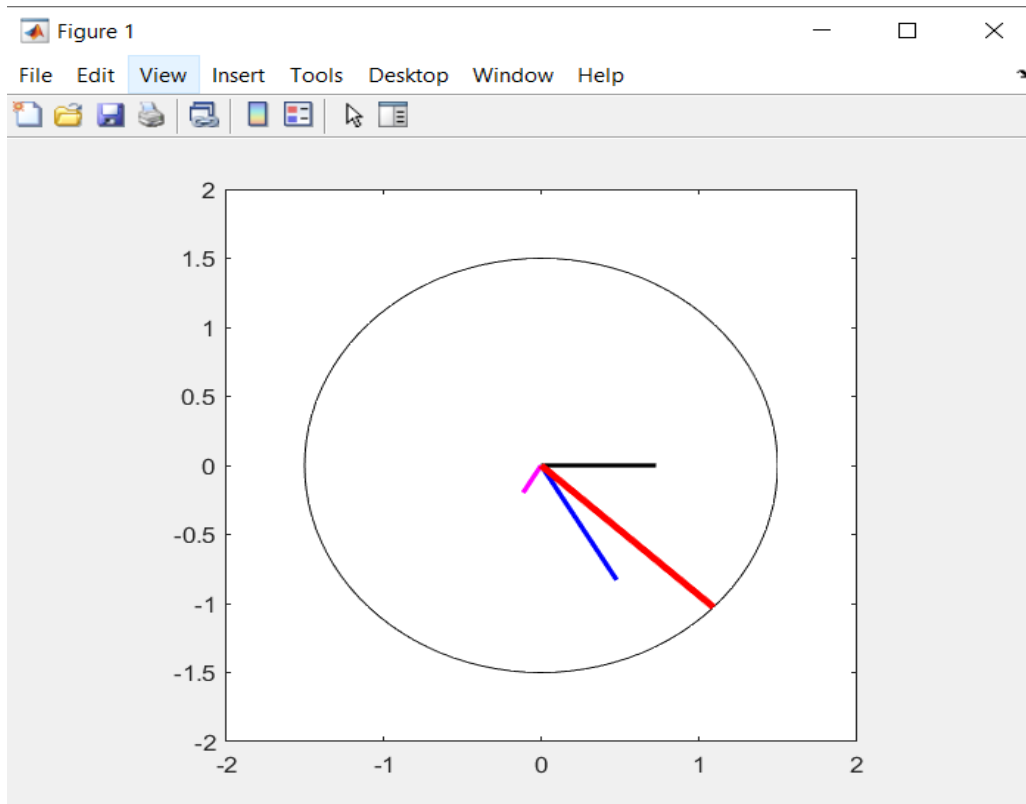
% Plot the magnitude and direction of the resulting magnetic
fields.
% Note that Baa is black, Bbb is blue, Bcc is magenta, and Bnet
is red.
for ii = 1:length(t)

    % Plot the reference circle
    plot(circle, 'k');
    hold on;

    % Plot the four magnetic fields
    plot([0 real(Baa(ii))],[0 imag(Baa(ii))], 'k', 'LineWidth', 2);
    plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))], 'b', 'LineWidth', 2);
    plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))], 'm', 'LineWidth', 2);
    plot([0 real(Bnet(ii))],[0
imag(Bnet(ii))], 'r', 'LineWidth', 3);
    axis square;
    axis([-2 2 -2 2]);
    drawnow;
    hold off;
```


end





Hand Calculations for Clockwise Rotating Field

Reversing the Direction of Magnetic Field Rotation

The net magnetic flux density in the stator is given by

$$B_{\text{net}}(t) = B_{aa'}(t) + B_{bb'}(t) + B_{cc'}(t)$$

$$= B_M \sin \omega t \angle 0^\circ + B_M \sin(\omega t - 240^\circ) \angle 120^\circ + B_M \sin(\omega t - 120^\circ) \angle 240^\circ \text{ T}$$

Each of the three component magnetic fields broken down into its x and y components:

$$B_{\text{net}}(t) = B_M \sin \omega t \hat{x} - [0.5 B_M \sin(\omega t - 240^\circ)] \hat{x} + \left[\frac{\sqrt{3}}{2} B_M \sin(\omega t - 240^\circ) \right] \hat{y} \\ - [0.5 B_M \sin(\omega t - 120^\circ)] \hat{x} - \left[\frac{\sqrt{3}}{2} B_M \sin(\omega t - 120^\circ) \right] \hat{y}$$

Combining x and y components yields:

$$B_{\text{net}}(t) = [B_M \sin \omega t - 0.5 B_M \sin(\omega t - 240^\circ) - 0.5 B_M \sin(\omega t - 120^\circ)] \hat{x} \\ + \left[\frac{\sqrt{3}}{2} B_M \sin(\omega t - 240^\circ) - \frac{\sqrt{3}}{2} B_M \sin(\omega t - 120^\circ) \right] \hat{y}$$

By the angle-addition trigonometric identities:

$$B_{\text{net}}(t) = \left[B_M \sin \omega t + \frac{1}{4} B_M \sin \omega t - \frac{\sqrt{3}}{4} B_M \cos \omega t + \frac{1}{4} B_M \sin \omega t + \frac{\sqrt{3}}{4} B_M \cos \omega t \right] \hat{x} \\ + \left[-\frac{\sqrt{3}}{4} B_M \sin \omega t + \frac{3}{4} B_M \cos \omega t + \frac{\sqrt{3}}{4} B_M \sin \omega t + \frac{3}{4} B_M \cos \omega t \right] \hat{y}$$

$$\boxed{B_{\text{net}}(t) = (1.5 B_M \sin \omega t) \hat{x} + (1.5 B_M \cos \omega t) \hat{y}}$$

Conclusion

The MATLAB simulation results is congruent with my hand calculation for both the counterclockwise rotating Bnet field and the clockwise rotating Bnet field.

Basically, the counterclockwise rotating magnetic field rotated a full cycle before attaining Bnet at 90 degrees towards the top part of the circle. Likewise, clockwise rotating magnetic field rotated a full cycle before attaining Bnet at 90 degrees towards the bottom of the circle.

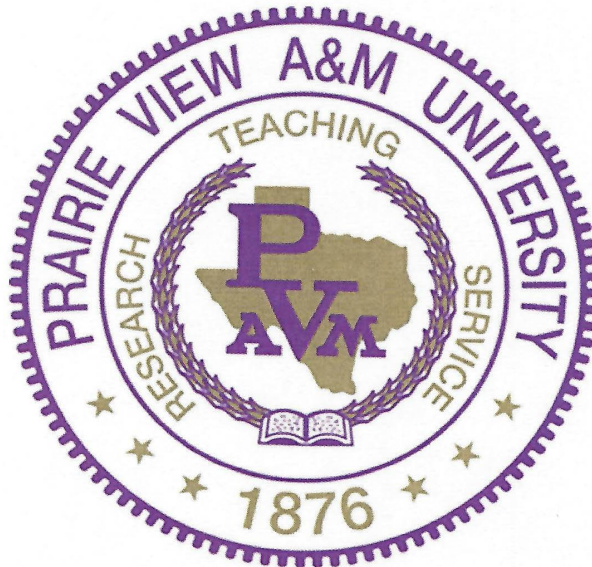
Reference

1. Chapman, S. J. (2012). Electric machinery fundamentals fifth edition.

AVERAGE

ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

PRAIRIE VIEW A&M UNIVERSITY



Electromechanical Energy Conversions

ELEG4301 - Spring 2022

Rotating Magnetic Field

Date Assigned: 04/27/2022

Date Due: 05/09/2022

Student Assigned:

Bryce Lovejoy

Submitted to:

Professor Fuller

25

No information
on reversing
field

Abstract: In the following report I will be presenting the supporting steps and results acquired while conducting the Rotating Magnetic Field MATLAB assignment, which is essentially a program tool that models the behavior of a rotating magnetic field such as the three-phase vector magnetic field shown below in **Figure 1**. During this experiment, proper procedures also call for calculating the values by hand on paper so that one can refer back to and compare the data I receive from the simulation within the MATLAB program to calculated outcome done by hand initially.

Figure 4-2 | (a) The vector magnetic field in a stator at time $\omega t = 0^\circ$. (b) The vector magnetic field in a stator at time $\omega t = 90^\circ$.

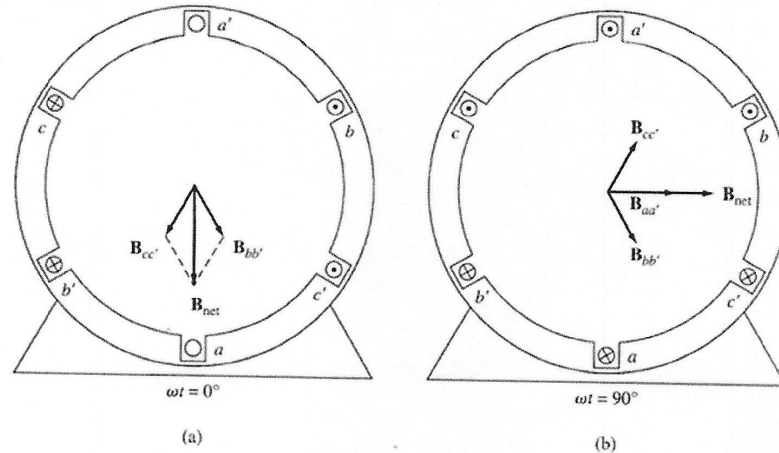


Figure 1: How the vector magnetic field should look

Continuing on while referring to **Figure 2** so that you can see by following the example in the book, during the experiment I was able to successfully run the desired program within MATLAB and calculate B_{net} for both 0° and 90° . In order to complete these calculations I took from the necessary equations mentioned in the book previously which ultimately helped me acquire the necessary solutions I was searching for.


```

Assignment1.m
1 % M-file:mag_field.m
2 % M file to calculate the net magnetic field produced
3 % by a three-phase stator.
4
5 % Set up the basic conditions
6 bmax = 1; % Normalize bmax to 1
7 freq = 60; % 60 Hz
8 w = 2*pi*freq; % angular velocity (rad/s)
9
10 % First, generate the three components magnetic fields
11 t = 0:1/6000:1/60;
12 Baa = sin(w*t) .* (cos(0) + j*sin(0));
13 Bbb = sin(w*t-2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));
14 Bcc = sin(w*t+2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));
15
16 % Calculate Bnet
17 Bnet = Baa + Bbb + Bcc;
18
19 % Calculate a circle representing the expected maximum
20 % Value of Bnet
21 circle = 1.5 * (cos(w*t) + j*sin(w*t));
22
23 % Plot the magnitude and direction of the resulting magnetic
24 % fields. Note that Baa is black, Bbb is blue, Bcc is
25 % magenta, and Bnet is red.
26 for ii = 1:length(t)
27     % Plot the reference circle
28     plot(circle,'k');
29     hold on;
30
31     % Plot the four magnetic fields
32     plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
33     plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
34     plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
35     plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
36     axis square;
37     axis([-2 2 -2 2]);
38     drawnow;
39     hold off;
40 end

```

Figure 3: Code utilized to generate vector field

The results received from the simulation program can be viewed in both **Figures 4** and **5**. These results received are not only identical to our desired values from the hand calculations previously discussed in this document and shown in **Figure 2**, but the results from our experiment also confirm that the program was able to successfully run at the end of the day and provided us with our desired results.

Conclusion: To conclude, after successfully building the code and generating the program on MATLAB, the program was able to be properly executed within MATLAB so that I could then analyze the newly obtained data which resulted in showing that the field is in fact rotating in the counterclockwise direction which confirmed the initial findings with the hand calculations. Recalling back to those calculations completed prior to properly running the simulation, and within the problem the magnitude of the field was found to be a constant $1.5B_m$ and that the angle was changing continuously in the counterclockwise direction. This data also further supported previous calculations which illustrated that when I ran the MATLAB program Bnet was inevitably found to be constantly rotating counterclockwise.

References: Electric Machinery and Power Fundamentals by Chapman

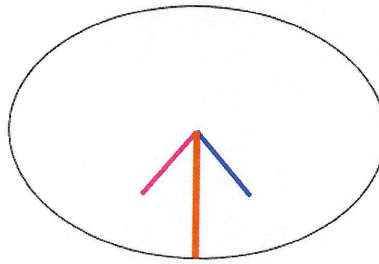


Figure 4: Results when wt is 0

In **Figure 4** you can find the results for when wt is 0 and correlate match the desired results mentioned in the book.

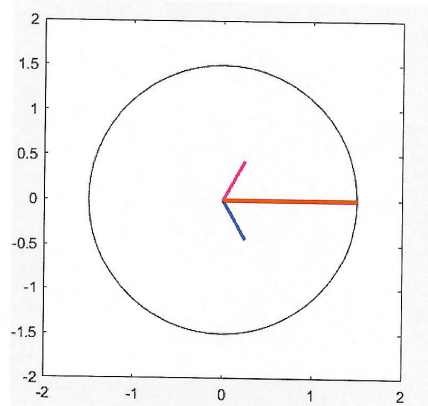
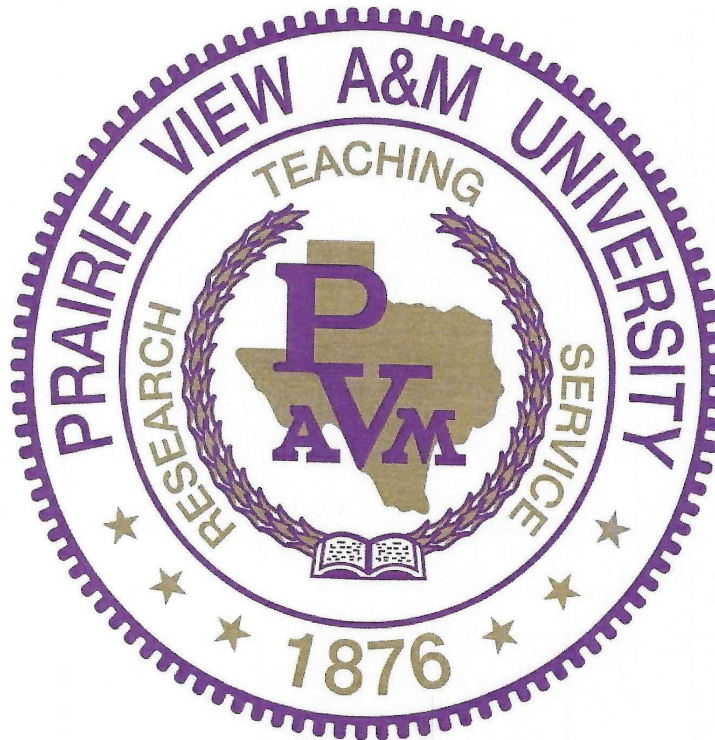


Figure 5: Results when wt is 90

In **Figure 6** one can find the results received when wt was set equal to 90 degrees. It is also noted here that the results once again match the desired results in the book which provided further clarification for moving along in the experiment.

BELOW AVERAGE

PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING



Ahmad Yakuba

Project: simulation of the rotational magnetic field

Instructor: Dr Fuller.

Software: Matlab

24

No information
on reversing —
field
minimal
rotational
pictures

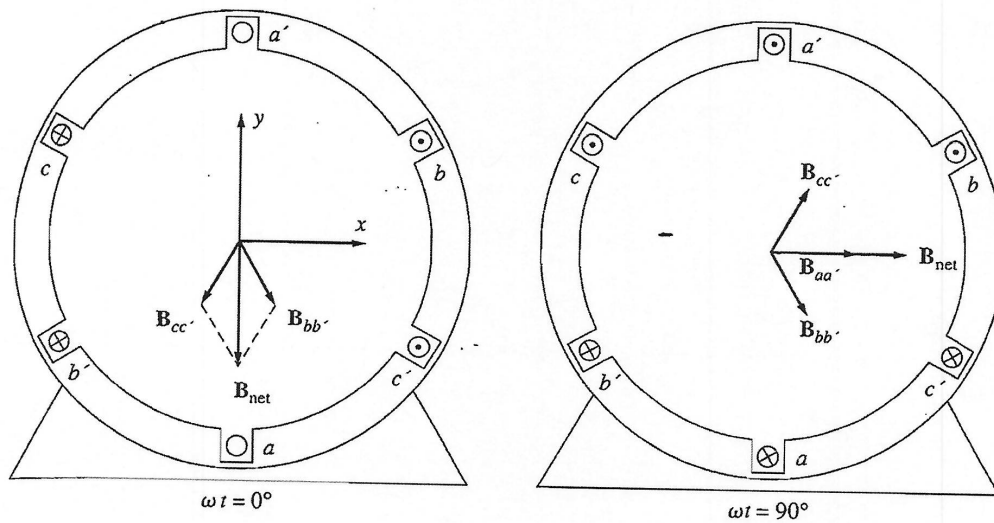
Introduction

Rotating magnetic fields in three-phase electrical machines has been one of the hardest topics to convey to our students in the area of energy conversion, because these fields are transformed into phasors that rotate in space around the stator of the electrical machine.

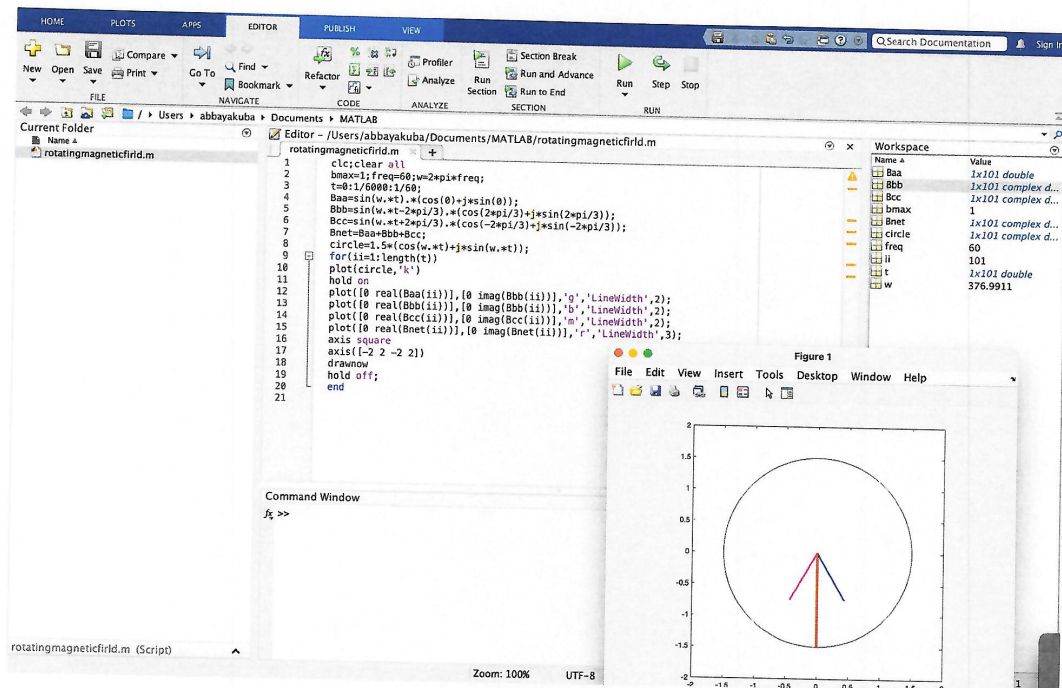
Procedures

- 1) first we have generated all the three components of magnetic field.
- 2) then we have calculated the value of B_{net}
- 3) further calculate the value of circle representing expected maximum value of B_{net} .
- 4) plot the magnitude and direction.

Baa- red , Bbb- magenta , Bcc- blue , Bnet- Black



output



Code :

```

bmax = 1;
freq = 60;
w = 2*pi*freq;
t = 0.1/6000:1/60;
Baa = sin(w*t).*(cos(0)+j*sin(0));
Bbb = sin(w*t-2*pi/3).*(cos(2*pi/3)+j*sin(2*pi/3));
Bcc = sin(w*t+2*pi/3).*(cos(-2*pi/3)+j*sin(-2*pi/3));
Bnet= Baa+Bbb+Bcc;
circle = 1.5*(cos(w*t)+j*sin(w*t));
for a = 1:length(t)
plot(circle,'r');
hold on;
plot([0 real(Baa(a))],[0 imag(Baa(a))],'r','LineWidth',2);
plot([0 real(Bbb(a))],[0 imag(Bbb(a))],'m','LineWidth',2);
plot([0 real(Bcc(a))],[0 imag(Bcc(a))],'b','LineWidth',2);
plot([0 real(Bnet(a))],[0 imag(Bnet(a))],'k','LineWidth',2);
axis square;
axis ([-2 2 -2 3]);
drawnow;
hold off;
end

```

conclusion

Matlab is a very powerful simulation package that we are trying to include in our energy conversion curriculum. The effect that this simulation has had in our students is great, due to the fact that they get very motivated to continue studying our electric machines and looking forward to perform simulations that would match their homework or concepts explained in class. For further research we will look into the rotating phasors for synchronous machines operating at different power factors

ABOVE AVERAGE

140
1.50

ELEG 4305
ENERGY CONVERSIONS
FINAL EXAM

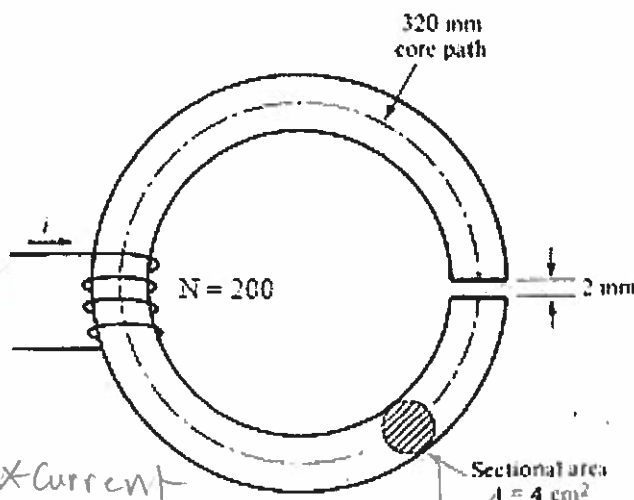
NAME Franky Williams DECEMBER 6, 2021

150 points Closed notes and books, no cell phones should be visible, show all steps in deriving a solution, no in and out during test.

- I. For the toroidal core shown in the following figure, find the current needed to produce a flux density of $B = 2.0$ Tesla.

Let $N = 200$, $\mu = 4000$ in the iron, core path = 320 mm, and air gap = 2 mm

The iron cross sectional area is $A = 4 \text{ cm}^2$ Hint: $\phi = BA$ and $\phi = \mathcal{F}/\mathcal{R}$



* $R = \frac{\ell}{\mu_r \mu_0 A}$ material

$R = \frac{320 \times 10^{-3}}{4000 \times 4\pi \times 10^{-7} \times 4 \times 10^{-4}}$

$R = 159235.668 \Omega$ iron

$R_{\text{air gap}} = \frac{\ell}{\mu_0 A}$ air gap

$R_{\text{air gap}} = \frac{2 \times 10^{-3}}{4\pi \times 10^{-7} \times 4 \times 10^{-4}}$

$R_{\text{air gap}} = 3980891.72 \Omega$

$R_{\text{eq}} = R_{\text{iron}} + R_{\text{air gap}}$

$R_{\text{eq}} = 159235.668 + 3980891.72$

$R_{\text{eq}} = 4140127.388 \Omega$

* Current

$\mathcal{F} = NI$

$I = \frac{\mathcal{F}}{N}$

$I = \frac{R\phi}{N} = \frac{RBA}{N}$

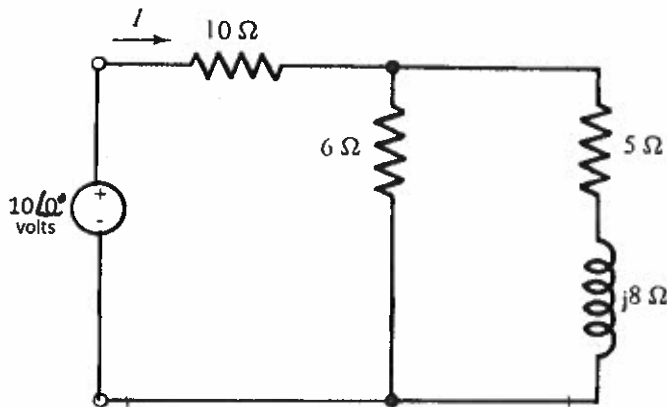
$I = \frac{R_{\text{eq}} BA}{N}$

$I = \frac{(4140127.388)(2)(4 \times 10^{-4})}{200}$

$I = 4.14 \text{ A}$

II. For the following RL circuit calculate

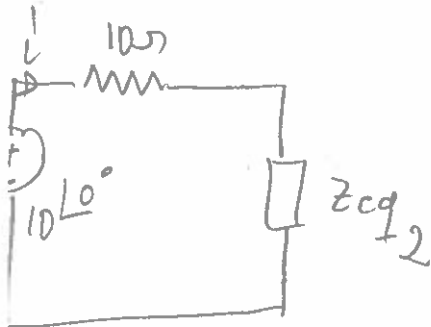
- Generator current I
- Power supplied by the generator
- Power factor for circuit



$$P = \frac{1}{2} V I \cos \theta$$

$$Z_{eq1} = 5 + j8$$

$$Z_{eq2} = \frac{5 + j8 \times 6}{5 + j8 + 6}$$



$$Z_{eq2} = \begin{cases} 3.859 + j1.556 \\ 4.162 \angle 21.967^\circ \end{cases}$$

$$Z_{eq} = \frac{10 \angle 0^\circ}{10 + 3.859 + j1.556}$$

$$= 0.717 \angle -6.405^\circ$$

A

b) Calculate the power

$$P = \frac{1}{2} V I \cos(\theta_v - \theta_i)$$

$$P = \frac{1}{2} (10) (0.717) \cos(0 + 6.405)$$

$$P = 3.563 \text{ W}$$

- power factor of the circuit

$$PF = \cos(\theta_v - \theta_i)$$

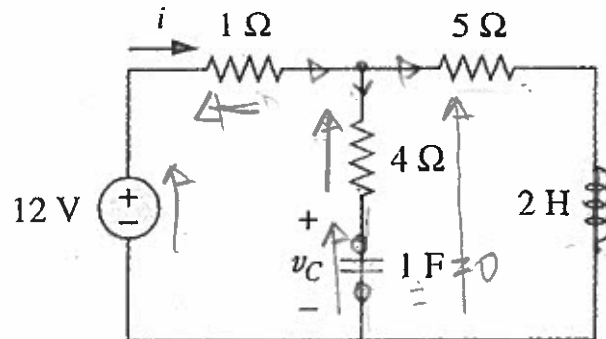
$$PF = \cos(0 + 6.405)$$

$$PF = 0.99$$

O.K. BUT Rm < V.Rm

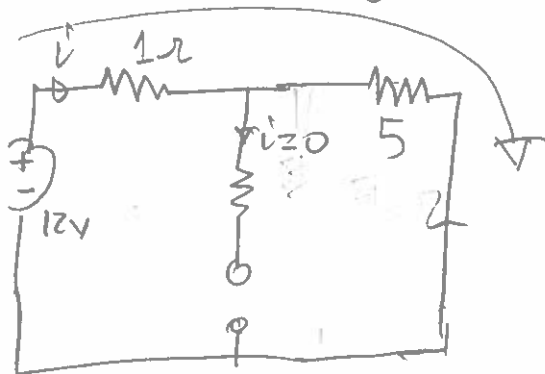
$\theta =$
 $\cos \theta =$

- III. The following circuit has the DC voltage source applied for a long time. Under this DC condition what is the value of the current i and voltage V_c .



$$Z_{eq1} = 5 + j\omega L = 0$$

$$Z_{eq2} = 4 + \frac{1}{j\omega C} = 0$$



$$i = \frac{12}{1+5} = 2.4A$$

$$i = 6A$$

$$+12V - Ri - 4i - V_c = 0$$

$$V_c = 12 - Ri - 4i$$

$$= 12 - (R+4)i$$

$$= 12 - i(1+4)$$

$$= 12 - 6(1+4)$$

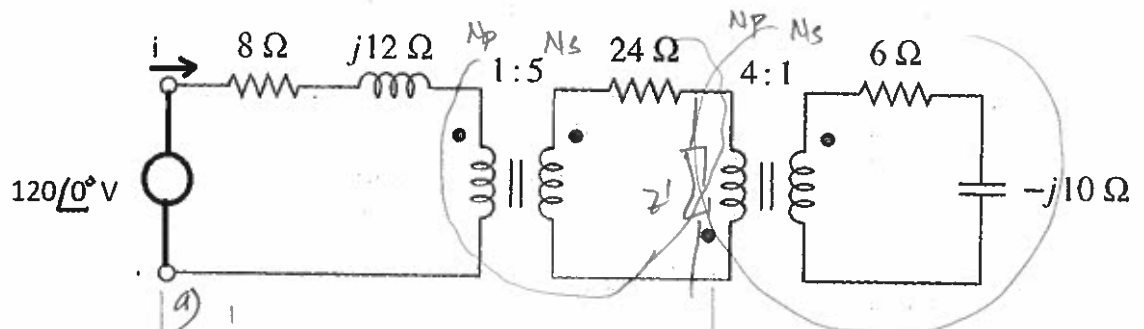
$$\underline{\underline{V_c = -18V}}$$

-3

IV. For the following two transformer circuit calculate the value of

- Equivalent impedance as seen by the 120 volt source
- Supply current i
- Power supplied by the voltage source.

$$a = \frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$$



$$Z' = a^2 Z_{load}$$

$$Z' = \left(\frac{4}{1}\right)^2 [6 - j10]$$

$$Z' = 96 - j160$$

$$186.59 \angle -59.036^\circ$$

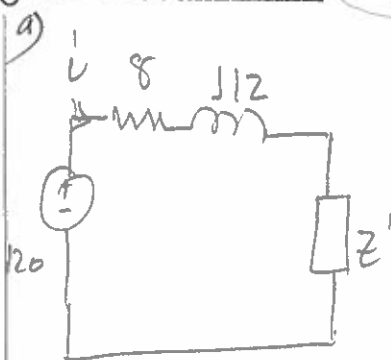
$$Z'' = a^2 [Z_L + Z']$$

$$Z'' = \left(\frac{1}{5}\right)^2 [24 + 96 - j160]$$

$$Z'' = 4.8 - j6.4$$

$$8 \angle -53.130^\circ$$

$$i = \frac{V \angle 0^\circ}{8 + j12 + Z'}$$



$$i = \frac{120 \angle 0^\circ}{8 + j12 + 4.8 - j6.4}$$

$$8 + j12 + 4.8 - j6.4$$

$$i = 7.868 - j3.442$$

$$8.588 \angle -23.63^\circ$$

$$i = 8.588 \angle -23.63^\circ \text{ A}$$

c) Calculate Average

$$P = VI \cos(\theta_v - \theta_i)$$

$$= (120)(8.588) \cos(0 + 23.63)$$

$$P = 944.15 \text{ W}$$

$$S \propto VI \quad I \propto \frac{S}{V} \quad Z \propto \frac{V^2}{S} \quad Z \propto \frac{V}{I} \quad Z \propto \frac{V^2}{S}$$

$$\frac{NP}{NS} \propto \frac{VP}{VS} \Rightarrow VS \propto \frac{NS}{NP} \frac{VP}{NP}$$

$$per u = \frac{Actual\ Value}{Base\ Value}$$

V. For the same circuit as used in problem four, solve for the current i using the per unit system. Start by selecting base values for voltage and volt amps.

* Selected

$$S_{base} = 10 \text{ kVA}$$

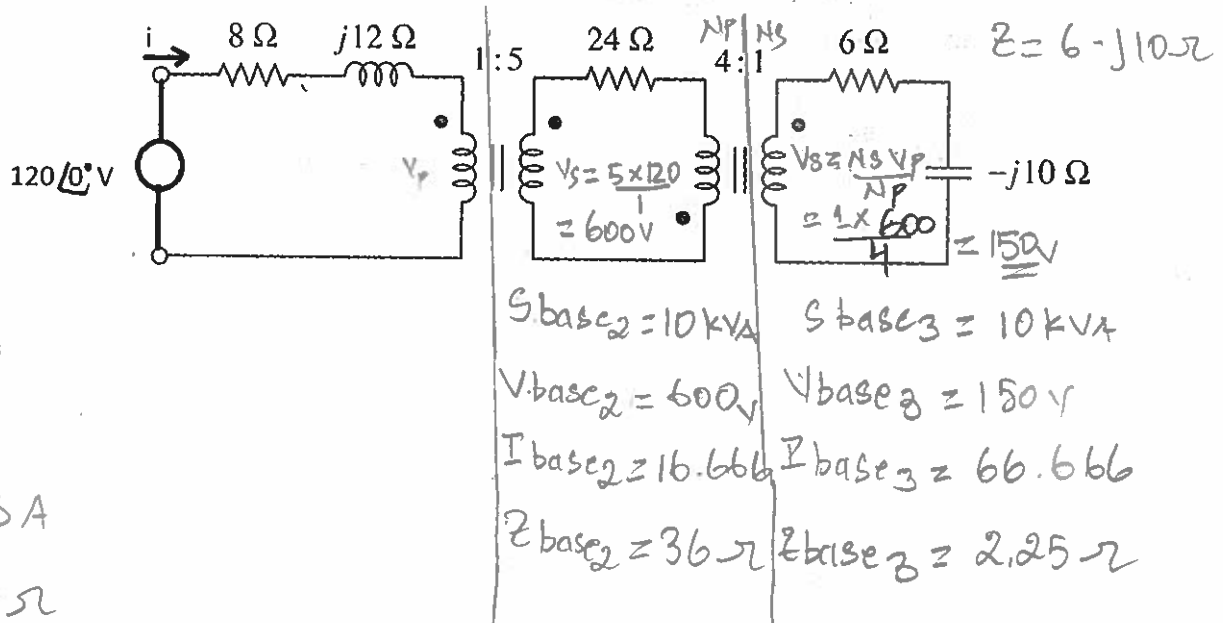
$$V_1 = 120$$

$$S_{base1} = 10 \text{ kVA}$$

$$V_{base1} = 120$$

$$I_{base1} = 83.33 \text{ A}$$

$$Z_{base1} = 1.44 \Omega$$



Per unit Current and Impedance

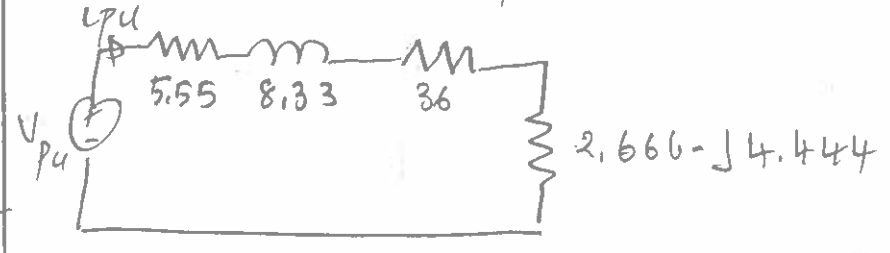
$$Z_{base2} \text{ pu} = \frac{24}{36}$$

$$Z_{base3} \text{ pu} = \frac{6 - j10 \Omega}{2.25}$$

$$Z_{base2} \text{ pu} = 0.666$$

$$Z_{base3} \text{ pu} = 2.666 - j4.44$$

Equivalent circuit per unit



$$Z_{base1} \text{ pu} = \frac{8 + j12}{1.44}$$

$$Z_{base1} \text{ pu} = 5.555 + j8.333$$

$$I_{pu} = \frac{1 \angle 0^\circ}{5.555 + j8.333 + 0.666 + 2.666 - j4.444}$$

$$I_{pu} = 0.1031 \angle -23.63^\circ \text{ A}$$

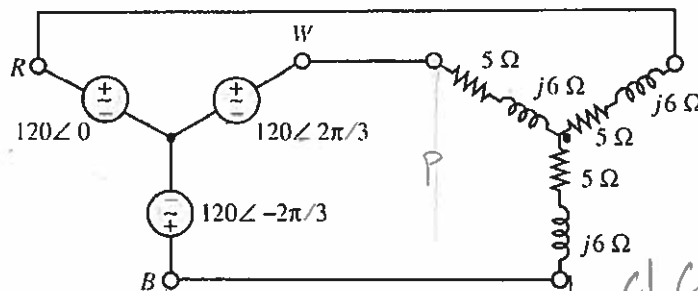
* Calculate the Actual Value $I_{actual} = I_{pu} \times I_{base}$

$$I_{actual} = (0.1031 \angle -23.63^\circ) \times (83.33) = 8.591 \angle -23.63^\circ \text{ A}$$

- VI. The wye – wye circuit shown as follows is representative of a three phase motor load connected to an ideal three-phase power source of 120 volts (angle in Radians). Assume given values are RMS values.

For the circuit determine

- Current flowing in the R leg
- The total power supplied to the motor.
- The power factor of the load



$$Z = \left(\frac{V}{I}\right)^2 \left[3 \left(\frac{V}{I}\right)^2 = 3 \frac{V^2}{I^2} \right]$$

$$P = 3VI \cos \theta$$

$$a) I_R = \frac{120 \angle 0}{5 + j6}$$

$$I_R = 15.364 \angle -50.19^\circ \text{ A}$$

$$I_W = \frac{120 \angle 120}{5 + j6}$$

$$I_W = 15.364 \angle 69.81^\circ \text{ A}$$

$$I_B = \frac{120 \angle -120}{5 + j6}$$

$$I_B = 15.364 \angle -170.19^\circ \text{ A}$$

b) The Total Power

$$P = 3 I^2 Z$$

$$P = 3 V I \cos \theta$$

$$P = 3 (5 + j6) (15.364)^2$$

$$P = 5530.88 \angle 50.19$$

$$P = 5530.88 \text{ W}$$

c) Calculate the Power Factor

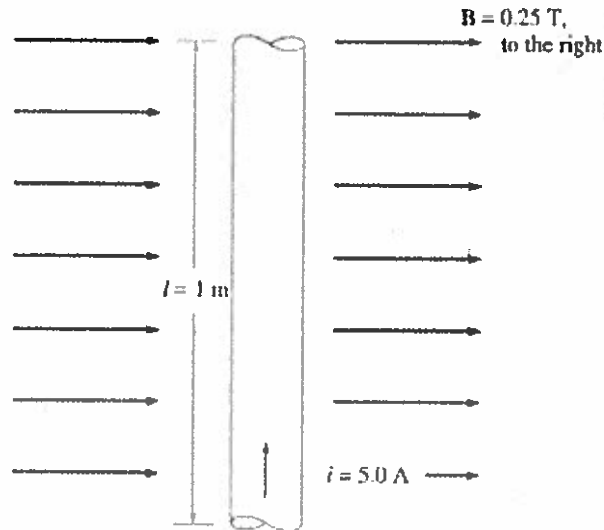
$$P = 3 V I \cos \theta$$

$$\cos \theta = \frac{P}{3 V I}$$

$$\cos \theta = \frac{5530.88}{3 (120) (15.364)}$$

$$\cos \theta = 0.99$$

- VII. A wire of length one meter as shown in the following figure is carrying a 5.0 amp current in the presence of a magnetic field of $B = 0.25$ Tesla. If there is a resulting force on the wire, calculate the magnitude and direction of the force.



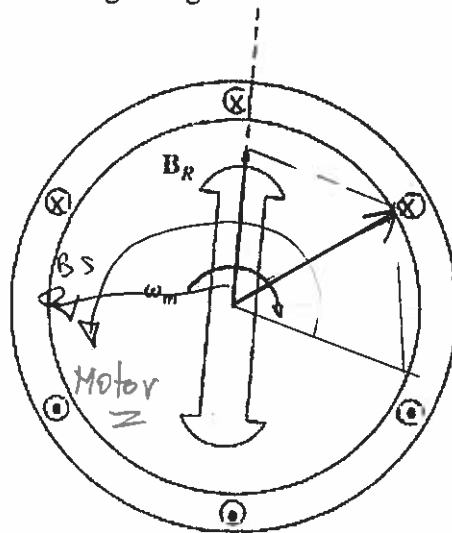
$$\vec{F} = B i l \sin \theta$$

$$F = 0.25 \times 5 \times 1$$

$$F = 1.25\text{ N}$$

the direction of the force
perpendicular to the plane

- VIII. Shown below is a synchronous machine with rotor magnetic field as shown. The machine has a rotor (with field) position as shown, with current into stator winding indicated with an x, and current out of stator as indicated with a dot. If the rotor is rotating in a clockwise direction determine
- Approximate position and direction of resultant three phase Stator Field B_s (show on graph)
 - Is this machine acting as a generator or a motor? Explain below.



CCW motor

CW Generator

-10

Acting as "Motor" because the rotation of the magnetic field is on the opposite direction of ω_m



FORMULAS ELEG 4013

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

Reluctance ($\mathcal{R}$)

$$\mathcal{R} = \frac{l}{\mu \mu_0 A} \quad \begin{array}{l} \text{mean path length} \\ \text{relative \times free space permeability \times cross sectional area} \end{array}$$

Flux density (B)

$$B = \mu H = \frac{\mu N i}{l_c} \quad \text{where } H = \frac{N i}{l_c} \quad \begin{array}{l} \text{turns \times current} \\ \text{mean path length} \end{array}$$

length
units are
in meters

Flux (Φ)

$$\Phi = B A \quad \text{flux density times area}$$

magnetomotive force ($\mathcal{F}$)

$$\mathcal{F} = N i \quad \text{turns times current}$$

also flux equals

$$\Phi = \frac{\mathcal{F}}{\mathcal{R}} \quad \begin{array}{l} \text{magnetomotive force} \\ \text{Reluctance} \end{array} \quad \begin{array}{l} \text{Reluctances} \\ \text{combine like} \\ \text{resistors} \end{array}$$

Induced force on a wire

$$\vec{F} = i(\vec{l} \times \vec{B}) \quad \text{direction of } \vec{l} \text{ is direction of current}$$

Induced voltage on a conductor

$$e_{\text{ind}} = (\vec{v} \times \vec{B}) \cdot \vec{l} \quad \begin{array}{l} \text{velocity cross with } B \text{ field} \\ \text{this result dotted with } \vec{l} \text{ (length} \\ \text{of conductor)} \end{array}$$

For three phase Y connection

$$V_{LL} = \sqrt{3} V_{\phi} \quad \text{Line voltage is } \sqrt{3} \text{ times phase voltage}$$

$$I_{LL} = I_{\phi}$$

For three phase A connection

$$I_{LL} = \sqrt{3} I_{\phi} \quad \text{Line current is } \sqrt{3} \text{ times phase current}$$

$$V_{LL} = V_{\phi}$$

Table 2-1 | Summary of relationships in Y and A connections

	Y connection	A connection
Voltage magnitudes	$V_L = \sqrt{3} V_{\phi}$	$V_L = V_{\phi}$
Current magnitudes	$I_L = I_{\phi}$	$I_L = \sqrt{3} I_{\phi}$
and phase sequence	V_{ϕ} leads V_L by 30°	I_{ϕ} lags I_L by 30°
and phase sequence	V_L lags V_{ϕ} by 30°	I_L leads I_{ϕ} by 30°

Three phase
power
equations

$$P = 3 V_{\phi} I_{\phi} \cos \theta$$

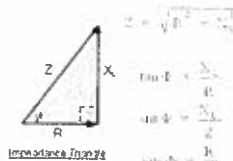
$$Q = 3 V_{\phi} I_{\phi} \sin \theta$$

$$S = 3 V_{\phi} I_{\phi}$$

$$P = 3 I_{\phi}^2 Z \cos \theta$$

$$Q = 3 I_{\phi}^2 Z \sin \theta$$

$$S = 3 I_{\phi}^2 Z$$



$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

AVERAGE

ELEG 4305
ENERGY CONVERSIONS
FINAL EXAM

169
150

NAME Francisco Hernandez

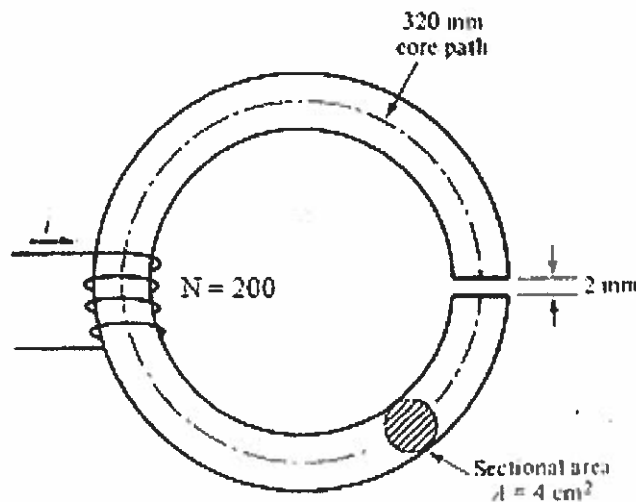
DECEMBER 6, 2021

150 points Closed notes and books, no cell phones should be visible, show all steps in deriving a solution, no in and out during test.

- I. For the toroidal core shown in the following figure, find the current needed to produce a flux density of $B = 2.0$ Tesla.

Let $N = 200$, $\mu = 4000$ in the iron, core path = 320 mm, and air gap = 2 mm

The iron cross sectional area is $A = 4 \text{ cm}^2$ Hint: $\phi = BA$ and $\phi = \mathcal{F}/\mathcal{R}$



$320 \times 4 = 1280$

$\phi = BA$

-10

$\phi = \mathcal{F}/\mathcal{R}$

$\Rightarrow (2T)(4 \text{ cm})$

$\Rightarrow 8$

$\mu_r = 4\pi \times 10^{-7}$

$\mu_r = 4000$

$\mathcal{G} = (2T)(4) = 8$

$\mathcal{F} = 200 \times 8 = 1600$

$\mathcal{R}_c = ?$
 $\mathcal{R}_g = ?$

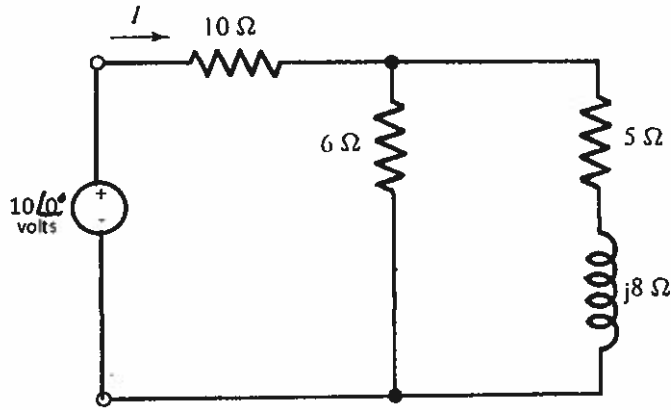
$\frac{1600}{1243} = 1.28$

$\mathcal{R}_1 = \frac{8}{(4000)(4\pi \times 10^{-7})(128)}$

$\mathcal{R}_1 = 12.43 \text{ k (units/wb)}$

II. For the following RL circuit calculate

- Generator current I
- Power supplied by the generator
- Power factor for circuit



$$(9) \frac{6 \times (5 + j8)}{6 + 5 + j8} = 3.89 + j1.55 \Omega$$

$$Z_1 + 10 \Omega$$

$$= (13.859 + j1.557) \Omega$$

$$I = \frac{10 \angle 0^\circ}{13.859 + j1.557} = 0.717 \angle -6.40^\circ \quad \checkmark$$

generator current =

$$I = 0.717 \angle -6.40^\circ \text{ A}$$

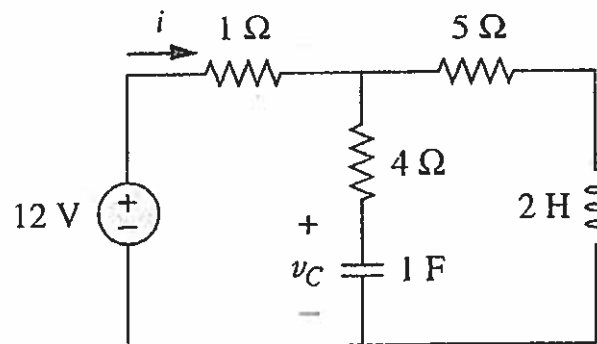
$$(b) S_1 = V I^* = 10 \angle 0^\circ \times 0.717 \angle 6.40^\circ$$

$$V_1 = 7.17 \angle -6.40^\circ$$

$$(c) \cos(-6.40^\circ)$$

$$PF = .994$$

- III. The following circuit has the DC voltage source applied for a long time. Under this DC condition what is the value of the current i and voltage V_C .



KVL :

$$-12 + 1 + 5i = 0$$

$$6i = 12$$

$$i = 2 \text{ A}$$

KVL :

$$-v_C + 5i = 0$$

$$v_C = 5i$$

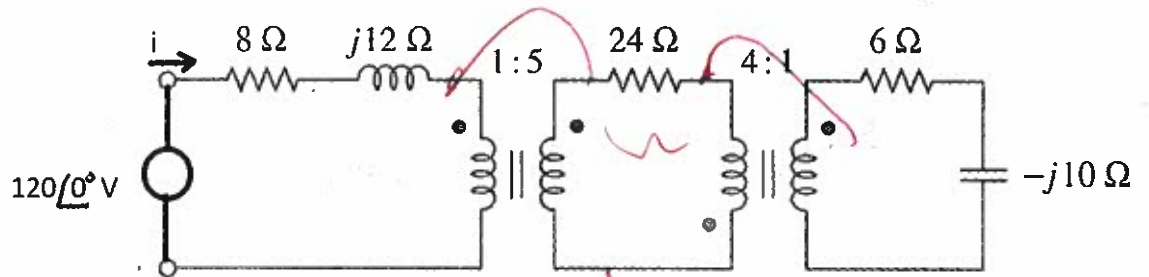
$$v_C = 5(2)$$

$$v_C = 10 \text{ V}$$

IV.

For the following two transformer circuit calculate the value of

- Equivalent impedance as seen by the 120 volt source
- Supply current i
- Power supplied by the voltage source.



Solution:

$$I_L = \frac{120 \angle 0^\circ}{(8 + j12) + (6 - j10)}$$

$$I_L = \frac{120 \angle 0^\circ}{14 + j2}$$

$$I_L = \frac{120 \angle 0^\circ}{14.14 \angle 8.1^\circ}$$

$$I_L = 8.49 \angle -8.1^\circ \text{ A}$$

$$V_L = (8.49 \angle -8.1^\circ)(6 - j10)$$

$$V_L = (8.49 \angle -8.1^\circ)(11.66 \angle -59.9^\circ)$$

$$V_L = 98.99 \angle -67.1^\circ \text{ V}$$

$\rightarrow 10$

$$Z'_{load} = (a^2)(Z_{load})$$

$$Z'_{load} = \left(\frac{4}{1}\right)^2 (6 - j10)$$

$$Z'_{load} = 96 - j160$$

$$Z'_{eq} = a^2 Z_{eq}$$

$$a^2 (Z_{line} + Z'_{load}) \quad \text{what about about 24}\Omega \text{ Need middle section.}$$

$$Z'_{eq} = .32 + j.48 + 3.84 + j$$

$$Z'_{eq} = 4.16 - j5.92$$

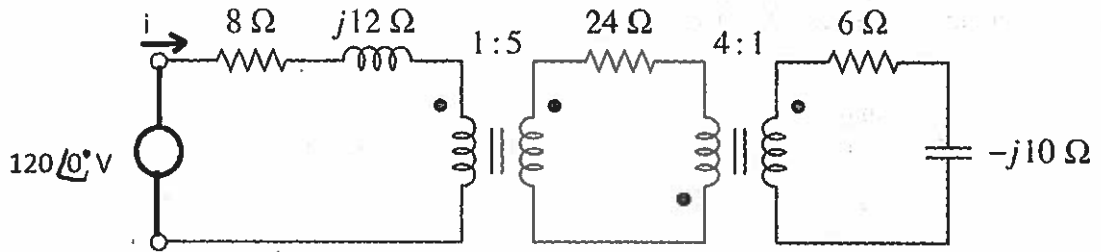
$$Z'_{eq} = 7.24 \angle -54.9^\circ$$

$$I_L = \frac{V}{Z'_{eq}}$$

$$I_L = \frac{120 \angle 0^\circ}{7.24 \angle -54.9^\circ}$$

$$I_L = 16.57 \angle 54.9^\circ$$

- V. For the same circuit as used in problem four, solve for the current $\mathbf{i}$ using the per unit system. Start by selecting base values for voltage and volt amps.



Region 1:

$$V_{Base1} = 120 \angle 0^\circ \text{ V}$$

$$S_{Base1} = 10 \text{ kVA}$$

$$I_{Base1} = \frac{S_{Base1}}{V_{Base1}}$$

$$\rightarrow = \frac{10 \text{ kVA}}{120 \angle 0^\circ \text{ V}} = 83.33 \text{ A}$$

$$Z_{Base1} = \frac{V_{Base1}}{I_{Base1}}$$

$$\rightarrow = \frac{120 \text{ V}}{83.33} = 1.44 \, \Omega$$

Convert per-unit system:

$$V_{pu} = \frac{V_{Base1}}{V_{Base1}}$$

$$\rightarrow = \frac{120 \angle 0^\circ}{120 \angle 0^\circ} = 1 \angle 0^\circ \text{ p.u.}$$

$$I_{pu} = 1 \angle 0^\circ$$

$$\downarrow (1.22 + j.33 + 2.67 - j4.44)$$

$$I_{pu} = \frac{1 \angle 0^\circ}{2.89 \angle 55.5^\circ} = 1.2 \angle 55.5^\circ$$

Region 2:

$$V_{Base2} = \frac{120 \text{ V}}{\left(\frac{1}{5}\right)} = 600 \text{ V}$$

$$S_{Base2} = 10 \text{ kVA}$$

$$I_{Base2} = \frac{S_{Base2}}{V_{Base2}}$$

$$\rightarrow = \frac{10 \text{ kVA}}{600} = 16.67 \text{ A}$$

$$Z_{Base2} = \frac{V_{Base2}}{I_{Base2}}$$

$$\rightarrow = \frac{600 \text{ V}}{16.67 \text{ A}} = 36 \, \Omega$$

Convert per-unit system:

$$Z_{line, pu} = \frac{Z_{line}}{Z_{Base2}}$$

$$\rightarrow = \frac{8 + j12}{36 \, \Omega}$$

$$\rightarrow .22 + j.33 \text{ p.u.}$$

Region 3:

$$V_{Base3} = \frac{600 \text{ V}}{\left(\frac{4}{1}\right)} = 150 \text{ V}$$

$$S_{Base3} = 10 \text{ kVA}$$

$$I_{Base3} = \frac{S_{Base3}}{V_{Base3}}$$

$$\rightarrow = \frac{10 \text{ kVA}}{150} = 66.67 \text{ A}$$

$$Z_{Base3} = \frac{V_{Base3}}{I_{Base3}}$$

$$\rightarrow = \frac{150 \text{ V}}{66.67 \text{ A}} = 2.25 \, \Omega$$

Convert per-unit:

$$Z_{load, pu} = \frac{Z_{load}}{Z_{Base3}}$$

$$\rightarrow = \frac{6 - j10}{2.25}$$

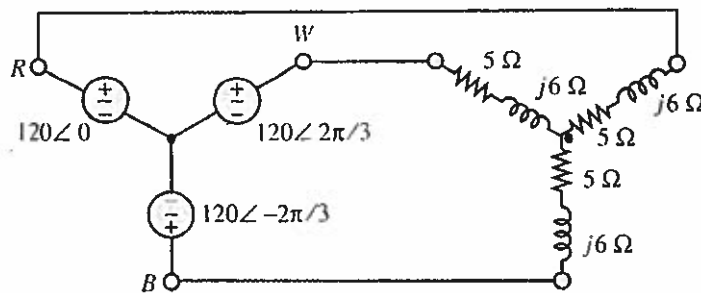
$$\rightarrow 2.67 - j4.44$$

$$\text{Power Factor} = \cos \theta$$

VI. The wye – wye circuit shown as follows is representative of a three phase motor load connected to an ideal three-phase power source of 120 volts (angle in Radians). Assume given values are RMS values.

For the circuit determine

- Current flowing in the R leg
- The total power supplied to the motor.
- The power factor of the load



Line to line voltage

$$V_{ab} = V_{an} - V_{bn}$$

$$V_{ba} = V_{bn} - V_{an}$$

$$V_{ca} = V_{cn} - V_{an}$$

$$I_L = \frac{V}{Z_{line}}$$

$$I_L = \frac{120 \angle 0^\circ}{5 + j6}$$

$$I_L = \frac{120 \angle 0^\circ}{7.8 \angle 50.19^\circ}$$

$$I_L = 15.38 \angle -50.19^\circ$$

negative

$$V_{IL} = (15.38 \angle -50.19^\circ) (5 + j6) \quad ?$$

$$V_{\phi L} = (15.38 \angle -50.19^\circ) (7.8 \angle 50.2^\circ)$$

$$V_{\phi L} = 120^\circ \angle 0^\circ$$

$$V_{LL} = (\sqrt{3}) (120^\circ)$$

$$V_{LL} = 207.8 \angle 0^\circ \quad ?$$

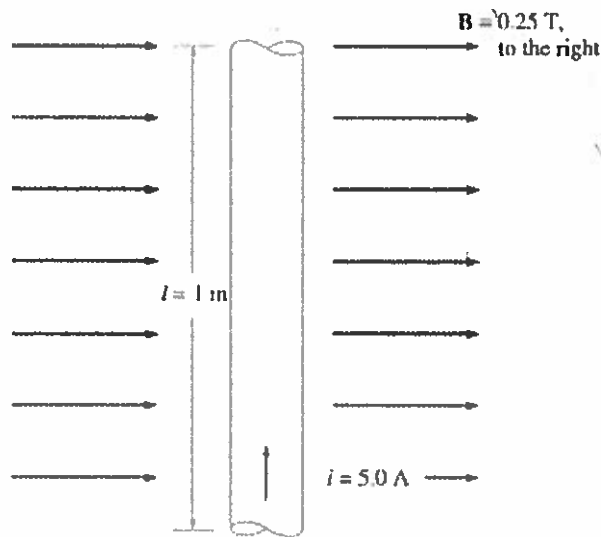
$$P = VI \cos \theta$$

$$P.F. = \cos \theta$$

$$\theta = 50.19^\circ$$

-10

- VII. A wire of length one meter as shown in the following figure is carrying a 5.0 amp current in the presence of a magnetic field of $B = 0.25$ Tesla. If there is a resulting force on the wire, calculate the magnitude and direction of the force.



$$F = i l B \sin \theta$$

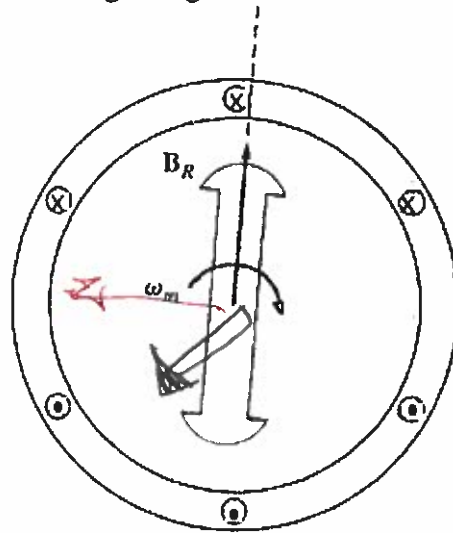
$$F = (5\text{ A})(1\text{ m})(0.25\text{ T}) \sin 90^\circ$$

$$F = 1.25\text{ N}$$

direction
- S

VIII. Shown below is a synchronous machine with rotor magnetic field as shown. The machine has a rotor (with field) position as shown, with current into stator winding indicated with an x, and current out of stator as indicated with a dot. If the rotor is rotating in a clockwise direction determine

- Approximate position and direction of resultant three phase Stator Field B_s (show on graph)
- Is this machine acting as a generator or a motor? Explain below.



-5

The stator is following the rotor magnetic field.
Hence, its a ~~motor~~

FORMULAS ELEG 4013

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

Reluctance ($\mathcal{R}$)

$$\mathcal{R} = \frac{l}{\mu \mu_0 A} \quad \begin{array}{l} \text{mean path length} \\ \text{relative} \times \text{free space permeability} \times \text{cross sectional area} \end{array}$$

Flux density (B)

$$B = \mu H = \frac{\mu N i}{l_c} \quad \text{where } H = \frac{N i}{l_c} \quad \begin{array}{l} \text{turns} \times \text{current} \\ \text{mean path length} \end{array}$$

length
units are
in meters

Flux (Φ)

$$\Phi = B A \quad \text{flux density times area}$$

magnetomotive force ($\mathcal{F}$)

$$\mathcal{F} = N i \quad \text{turns times current}$$

also flux equals

$$\Phi = \frac{\mathcal{F}}{\mathcal{R}} \quad \begin{array}{l} \text{magnetomotive force} \\ \text{Reluctance} \end{array} \quad \begin{array}{l} \text{Reluctances} \\ \text{combine like} \\ \text{resistors} \end{array}$$

Induced force on a wire

$$\vec{F} = i(\vec{l} \times \vec{B}) \quad \text{direction of } \vec{l} \text{ is direction of current}$$

Induced voltage on a conductor

$$e_{\text{ind}} = (\vec{v} \times \vec{B}) \cdot \vec{l} \quad \begin{array}{l} \text{velocity cross with } B \text{ field} \\ \text{this result dotted with } \vec{l} \text{ (length} \\ \text{of conductor)} \end{array}$$

For three phase Y connection

$$V_{LL} = \sqrt{3} V_{\phi} \quad \text{Line voltage is } \sqrt{3} \text{ times phase voltage}$$

$$I_{LL} = I_{\phi}$$

For three phase Δ connection

$$I_{LL} = \sqrt{3} I_{\phi} \quad \text{Line current is } \sqrt{3} \text{ times phase current}$$

$$V_{LL} = V_{\phi}$$

Table 2-1 | Summary of relationships in Y and Δ connections

	Y connection	Δ connection
Voltage magnitudes	$V_L = \sqrt{3} V_{\phi}$	$V_L = V_{\phi}$
Current magnitudes	$I_L = I_{\phi}$	$I_L = \sqrt{3} I_{\phi}$
abc phase sequence	V_{ab} leads V_{bc} by 30°	I_a lags I_b by 30°
acb phase sequence	V_{ab} lags V_{bc} by 30°	I_a leads I_b by 30°

Three phase
power
equations:

$$P = 3 V_{\phi} I_{\phi} \cos \theta$$

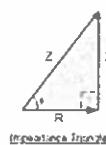
$$Q = 3 V_{\phi} I_{\phi} \sin \theta$$

$$S = 3 V_{\phi} I_{\phi}$$

$$P = 3 I_{\phi}^2 Z \cos \theta$$

$$Q = 3 I_{\phi}^2 Z \sin \theta$$

$$S = 3 I_{\phi}^2 Z$$



$$Z = \sqrt{R^2 + X^2}$$

$$\cos \theta = \frac{R}{Z}$$

$$\sin \theta = \frac{X}{Z}$$

$$\tan \theta = \frac{X}{R}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

BELOW AVERAGE

ELEG 4305
ENERGY CONVERSIONS
FINAL EXAM

76
150

NAME Osesiya Ayen

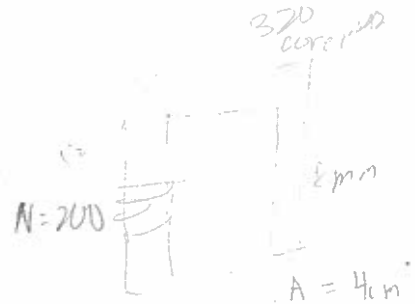
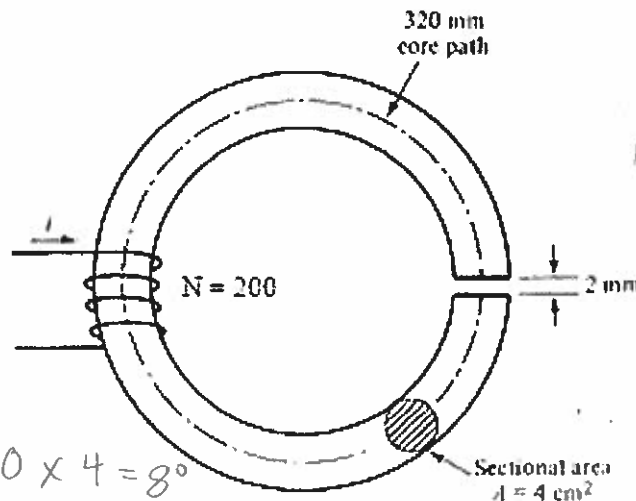
DECEMBER 6, 2021

150 points Closed notes and books, no cell phones should be visible, show all steps in deriving a solution, no in and out during test.

- I. For the toroidal core shown in the following figure, find the current needed to produce a flux density of $B = 2.0$ Tesla.

Let $N = 200$, $\mu = 4000$ in the iron, core path = 320 mm, and air gap = 2 mm

The iron cross sectional area is $A = 4 \text{ cm}^2$ Hint: $\phi = BA$ and $\phi = \mathcal{F}/\mathcal{R}$



$$\phi = BA = 2.0 \times 4 = 8$$

$$\phi = \frac{\mathcal{F}}{\mathcal{R}}$$

magnetomotive force
reluctance

$$B = \mu H = \frac{(\mu_r)(N)(I)}{l_c}$$

what about air gap?

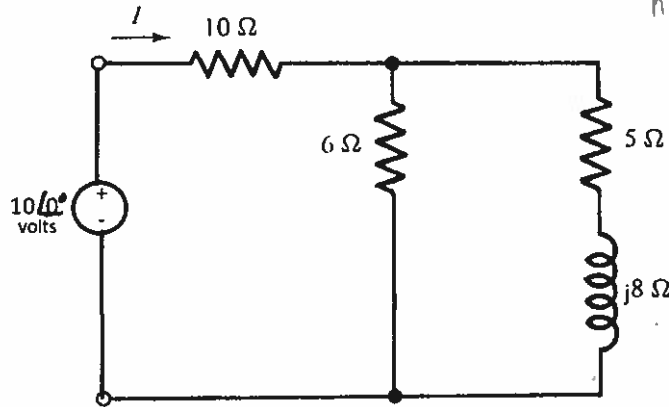
$$2 = \frac{(4000)(200)(I)}{(320 - ?2) \text{ mm}}$$

$$2 = \frac{800,000(I)}{318}$$

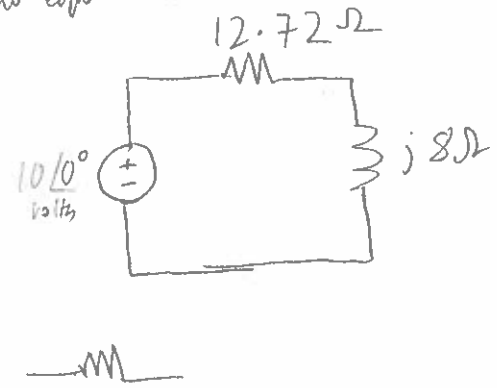
$$(i) 2 = \frac{800,000}{318} = 2515.7232 \text{ A}$$

II. For the following RL circuit calculate

- Generator current I
- Power supplied by the generator
- Power factor for circuit



new equation:



$$I_g = \frac{10 \angle 0^\circ}{12.72 + j8} = \frac{10 \angle 0^\circ}{15 \angle 32.16} = \boxed{0.67 \angle -32.16}$$

$$\frac{6 \times 5}{5 + 6} = 2.727$$

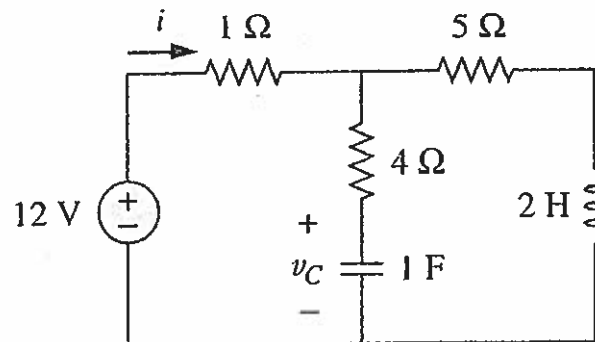
$$P = VI \cos \theta = (10)(0.67)(\cos(-32.16)) = \boxed{5.67 \text{ W}}$$

$$PF = \cos \theta = \cos(-32.16) = \boxed{0.8465}$$

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

— 10

- III. The following circuit has the DC voltage source applied for a long time. Under this DC condition what is the value of the current i and voltage V_c .



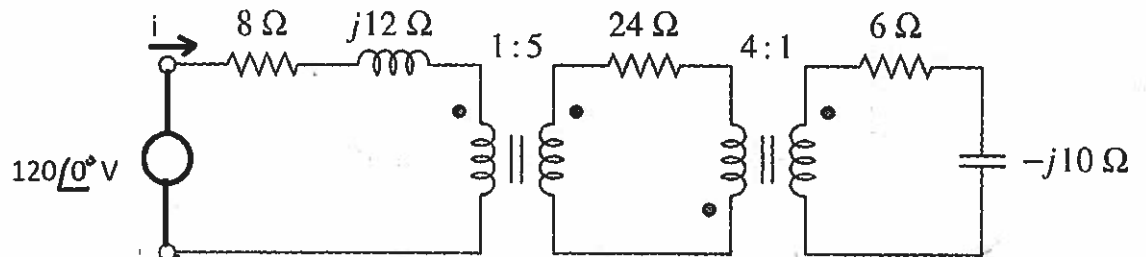
$$C = \frac{-1}{j\omega L} = \frac{-1}{j\omega L} = \frac{-1}{j\omega L}$$

$$I = \frac{10 \angle 0^\circ}{12.72 + j5} =$$

20

IV. For the following two transformer circuit calculate the value of

- Equivalent impedance as seen by the 120 volt source
- Supply current i
- Power supplied by the voltage source.



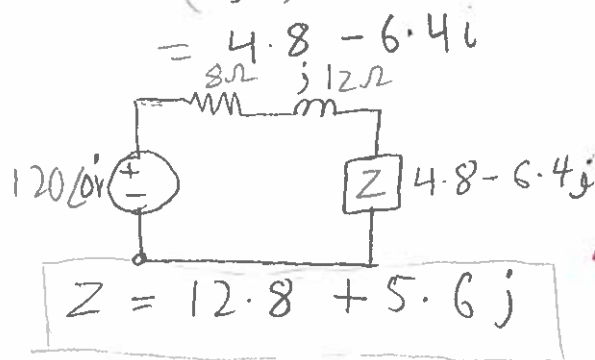
a

$$Z' = a^2 Z = \left(\frac{1}{5}\right)^2 (120 - j160)$$

$$= 4.8 - j6.4$$

$$Z' = a^2 Z = \left(\frac{4}{1}\right)^2 (6 - j10)$$

$$= 96 - j16$$



b

$$I = \frac{V}{Z} = \frac{120 \angle 0^\circ}{12.8 + j5.6} = \frac{120 \angle 0^\circ}{13.97 \angle 66.37^\circ} = 8.59 \angle -66^\circ$$

c

$$P = VI \cos \theta = (120)(8.59) \cos(-66^\circ) = 419.26 \text{ W}$$

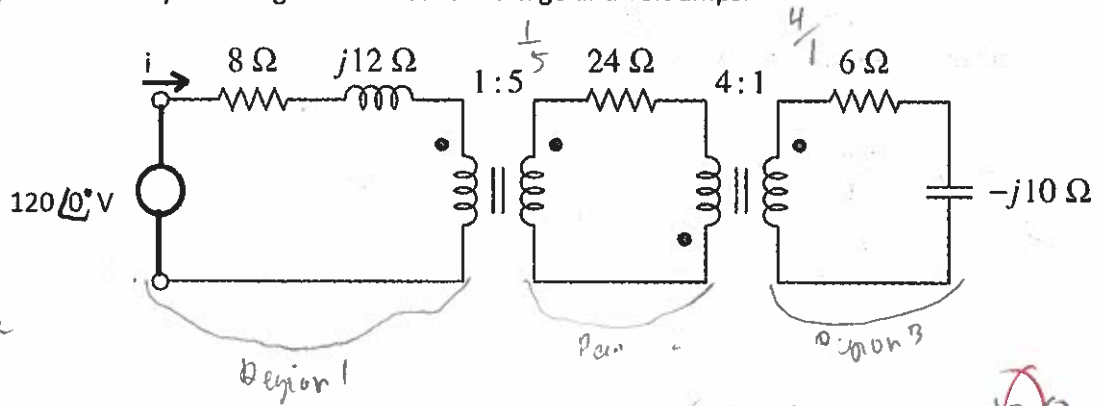
$$I_{\text{actual}} = I_{\text{pu}} \cdot I_{\text{base}}$$

- V. For the same circuit as used in problem four, solve for the current $\mathbf{i}$ using the per unit system. Start by selecting base values for voltage and volt amps.

$$I_{\text{base}} = \frac{S_{\text{base}}}{V_{\text{base}}}$$

$$Z_{\text{base}} = \frac{V_{\text{base}}}{I_{\text{base}}}$$

$$I_{\text{p}} = \frac{\text{Actual value}}{\text{base value}}$$



$$V_{\text{base}} = 120 \text{ volts}$$

$$S_{\text{base}} = 2400$$

$$I_{\text{base}} = \frac{2400}{120} = 20$$

$$Z_{\text{base}} = \frac{120}{20} = 6$$

$$Z_{\text{pu}} = \frac{8 + j12}{6} = 1.3 + 2j$$

$$V_{\text{pu}} = \frac{120 \angle 0^\circ}{120} = 1 \angle 0^\circ$$

$$I_{\text{pu}} = \frac{V_{\text{pu}}}{Z_{\text{line pu}} + Z_{\text{load pu}}} = \frac{1 \angle 0^\circ}{1.3 + 2j + 1 + 1.6j}$$

$$I_{\text{g}} = I_{\text{pu}} \cdot I_{\text{base}} = (0.23 \angle -57.42^\circ) (20)$$

$$I_{\text{g}} = 4.6 \angle -57.42^\circ \text{ A}$$

P.u. circuit

$$V_{\text{pu}} = I_{\text{pu}} \cdot R_{\text{load pu}} = (0.23 \angle -57.42^\circ) (1) = 0.23 \angle -57.42^\circ$$

$$I_{\text{actual}} = ?$$

-6

$$V_{\text{base}} = 600$$

$$S_{\text{base}} = 2400$$

$$I_{\text{base}} = \frac{2400}{600} = 4$$

$$Z_{\text{base}} = \frac{600}{4} = 150$$

$$V_{\text{base}} = 20$$

$$S_{\text{base}} = 2400$$

$$I_{\text{base}} = \frac{2400}{20} = 20$$

$$Z_{\text{base}} = \frac{120}{20} = 6$$

$$Z_{\text{load pu}} = \frac{6 + 10j}{6}$$

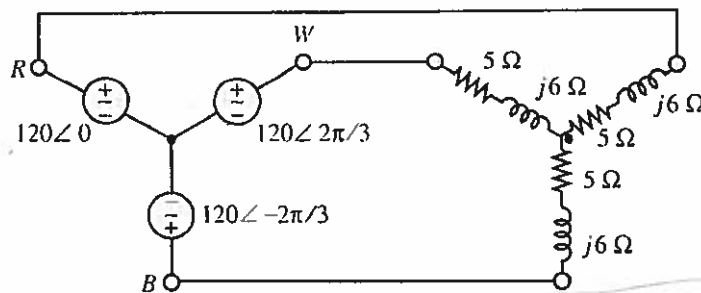
$$= 1 + 1.6j$$

$$= \frac{1 \angle 0^\circ}{1.3 + 3.6j} = \frac{1 \angle 0^\circ}{4.2 \angle 57.42^\circ} = 0.23 \angle -57.42^\circ$$

VI. The wye – wye circuit shown as follows is representative of a three phase motor load connected to an ideal three-phase power source of 120 volts (angle in Radians). Assume given values are RMS values.

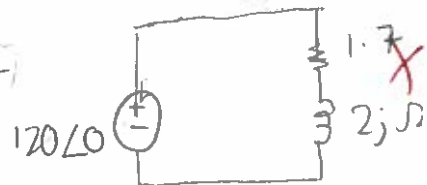
For the circuit determine

- Current flowing in the R leg
- The total power supplied to the motor.
- The power factor of the load



ITS ALREADY A "Y"

$$\Delta \rightarrow Y = \frac{5 + j6\Omega}{3} = 1.7 + j2\Omega$$



①

$$I_A = \frac{120 \angle 0^\circ}{1.7 + j2} = \frac{120 \angle 0^\circ}{2.62 \angle 49.64^\circ} =$$

$$I_A = 46 \angle -49.64^\circ$$

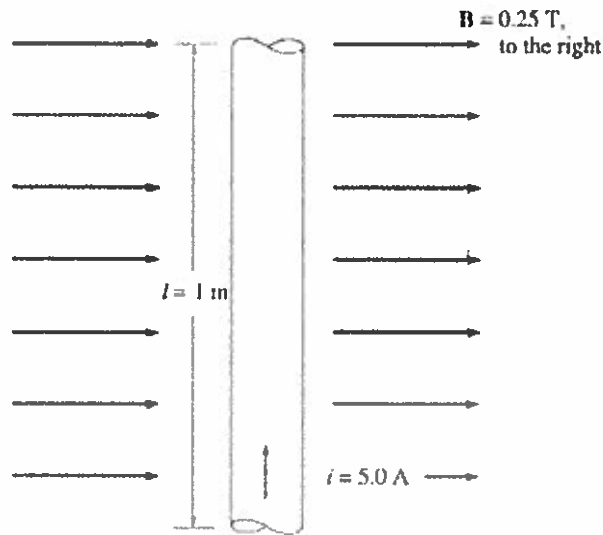
② $P = VI \cos \theta = (120)(46) \cos(-49.64^\circ)$

$$Q = VI \sin \theta = (120)(46) \sin(-49.64^\circ) = -4206 \text{ VAR}$$

③ $PF = \cos \theta$
 $= \cos(-49.64^\circ) = .6475$

— 10

- VII. A wire of length one meter as shown in the following figure is carrying a 5.0 amp current in the presence of a magnetic field of $B = 0.25$ Tesla. If there is a resulting force on the wire, calculate the magnitude and direction of the force.



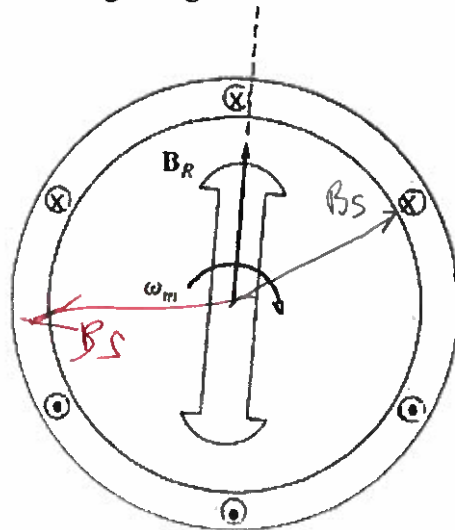
$$\begin{aligned} F &= i(\vec{L} \times \vec{B}) \\ &= B \cdot i \cdot L \sin \theta \\ &= 0.25 \cdot (5.0) \cdot (1) \sin(90) = \boxed{1.25} \end{aligned}$$

The direction of the force is directed downwards.

— 6

VIII. Shown below is a synchronous machine with rotor magnetic field as shown. The machine has a rotor (with field) position as shown, with current into stator winding indicated with an x, and current out of stator as indicated with a dot. If the rotor is rotating in a clockwise direction determine

- Approximate position and direction of resultant three phase Stator Field B_s (show on graph)
- Is this machine acting as a generator or a motor? Explain below.



— 10

© The B_r chases the B_s , It is a ~~Motor~~

ASSIGNMENTS FOR OUTCOME 6.3

To teach students the use of modern engineering tools such as Matlab and FPGA programming

**ELECTRICAL AND COMPUTER ENGINEERING
DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
ENERGY CONVERSIONS
Fall 2021
Instructor: Dr. John Fuller**

Title of Assignment

**Matlab Program on development of motor stator generated
magnetic rotating field**

Outcome Measured Using this Assignment

Outcome 6.3

**An ability to develop and conduct appropriate experimentation, analyze
and interpret data, and use engineering judgment to draw conclusions**

Check the communication problem characteristics related to this assignment

Brief justification of why this assignment is suitable for this outcome

**Computer programming of rotating magnetic field as generated by the stator
winding. The rotating field is fundamental to motor operation and the
understanding of permanent magnet motors as presently used in automobiles. This
project involves the mathematics to set up a rotating field and the simulation of that
field using computer programming**

ASSIGNMENT

ELEG 4013
ENERGY CONVERSIONS
MATLAB program for rotating machine
Computers are available to run the program in the ECE computer laboratory

Accompanying this program assignment is directions on how to use MATLAB to run a software program. Follow the directions for using MATLAB as given by your Instructor or as you have used in your previous classes. Type in the MATLAB program of the rotating machine example as given on page 171(Example 4-1) of your textbook. Also attached with this assignment.

When the program is executed, it should draw lines corresponding to the three component magnetic fields as well as a line corresponding to the net magnitude field. Execute the program and observe the behavior of **Bnet** which should be the same as given in the text.

Be careful in typing the program. In the past there have been a number of recurring errors, such as mistaking the letter L(l) for the alphabet one (1). If you type incorrectly the program will give an error message and by following the directions you should be able to trace where the error occurred.

Compare your MatLab results with hand calculated results (turn in with program). You should include the pictorial views of the magnetic field at various locations (0, 90, 180, etc, degrees). Do enough locations to determine the rotation of the magnetic field. These pictorial views should be included in the report.

Note Print window screen can be used to print the magnetic fields. Use your name to save and run the program.

This program is due on Friday, October 29 to be uploaded to ecourse. Do a thorough report on the assignment with detailed description of your program and your results. This assignment is worth 30 points. Any duplicated efforts will result in a grade of zero for all participating parties.

Save your program, you will use the program on a future project. Neatness of work is always a grading consideration and the flow of information is very important.

```

plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
axis square;
axis([-2 2 -2 2]);
drawnow;
hold off;
end

```

When this program is executed, it draws lines corresponding to the three component magnetic fields as well as a line corresponding to the net magnetic field. Execute this program and observe the behavior of $\mathbf{B}_{\text{net}}$. ■

ABOVE AVERAGE

Franky Williams Lonfo

ELECTROMECHANICAL ENERGY CONVERSIONS: ELEG 4301

[Electromechanical Energy Conversions]



Class Meeting Dates/Times: 8:00am - 8:50 am

Instructor Name: Dr. John Fuller, P.E.

Instructor Email: jhfuller@pvamu.edu

Office Phone #: 936-261-9923

Office Hours: MWF 9:00 - 10:00 am, T 11:10 am - 1:10 pm, R 12:30 pm - 1:30 pm

Office Location: Electrical Engineering Building Room 344

Semester Fall 2021

1-Execution Summary

As was requested by the datasheet, this experiment has been performed according to the following procedure. The system was programmed using MATLAB and the program was about to generate the three-phase magnetic field from 0 ,90,180 and 270 degrees respectively. In addition, using a hand calculation was also requested to obtain the same result as the one from simulation. After this performance, the error has been calculated from the data in process to compare both the analytical method and the measured method

2- Introduction

2-1 Objective

The objective of this Experiment was to introduce students to the electromagnetic field by using MATLAB program and being able to represent the magnetic field at 0,90,180, and 270 degrees respectively. The balanced winding on a three-phase system is usually moved at 120 degrees from each other's and this displaced create a rotating magnetic field which has a constant magnitude and rotate at synchronous speed. In addition, this Experiment, was about to learn how to use a MATLAB and how to operate on it in process to get the exact values as was requested by the Laboratory data sheet. For instance, to measure the magnetic field present in the program and across each value of the degree angle. Comparing the theoretical value of the magnetic field to the measured one was also considered as the goal of this laboratory.

and constant magnitude. Let the phase 'a' represent magnetic field as

$$B_{aa'}(t) = B_M \sin(\omega t) \angle 0^\circ$$

Similarly, the other phases would have magnetic field as

$$B_{bb'}(t) = B_M \sin(\omega t - 120^\circ) \angle 120^\circ$$

$$B_{cc'}(t) = B_M \sin(\omega t - 240^\circ) \angle 240^\circ$$

The net magnetic field in stator would be

$$B_{net} = B_{aa'}(t) + B_{bb'}(t) + B_{cc'}(t)$$

$$B_{net} = B_M \sin(\omega t) \angle 0^\circ + B_M \sin(\omega t - 120^\circ) \angle 120^\circ + B_M \sin(\omega t - 240^\circ) \angle 240^\circ$$

$$B_{net} = B_M \sin(\omega t) \hat{x} + B_M \sin(\omega t - 120^\circ) [-0.5\hat{x} + j0.866\hat{y}]$$

$$+ B_M \sin(\omega t - 240^\circ) [-0.5\hat{x} - j0.866\hat{y}]$$

$$B_{net} = B_M [\sin(\omega t) - 0.5 \sin(\omega t - 120^\circ) - 0.5 \sin(\omega t - 240^\circ)] \hat{x}$$

$$+ B_M [j0.866 \sin(\omega t - 120^\circ) - j0.866 \sin(\omega t - 240^\circ)] \hat{y}$$

$$B_{net} = B_M \left[\sin(\omega t) + \frac{1}{4} \sin(\omega t) - \frac{\sqrt{3}}{4} \cos(\omega t) + \frac{1}{4} \sin(\omega t) - \frac{\sqrt{3}}{4} \cos(\omega t) \right] \hat{x}$$

$$+ B_M \left[-j \frac{\sqrt{3}}{4} \sin(\omega t) - j \frac{3}{4} \cos(\omega t) + j \frac{\sqrt{3}}{4} \sin(\omega t) - j \frac{3}{4} \cos(\omega t) \right] \hat{y}$$

$$B_{net} = \frac{3}{2} B_M \sin(\omega t) \hat{x} - j \frac{3}{2} B_M \cos(\omega t) \hat{y}$$

The magnetic field at 0 degree angle

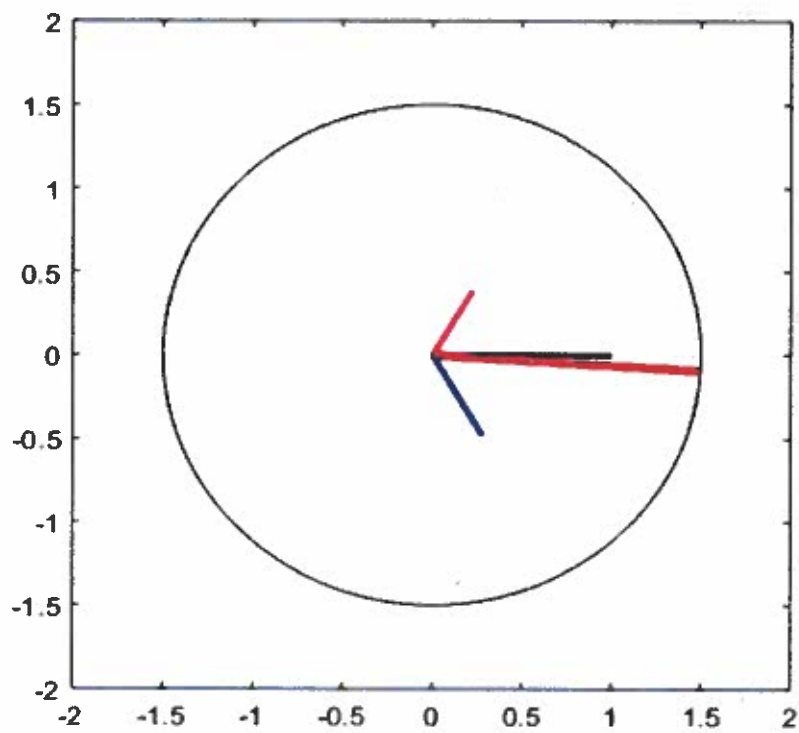
```

+107  Editor - C:\Users\lonfo\OneDrive\Desktop\ENGR 2304 Test 1 FALL 2017 summer class\question 2 projectile at
lonfo_franky_for the final question 4.m  X  Franky_Williams_lonfo mag_field .m  X  generate.m
1      %Franky_williams_Lonfo
2      % M-file: mag_field.m
3      % M-file to calculate the net Magetic field produced
4      % by a three-phase stator.
5      % stet up the basic conditions
6 -    bmax = 1;                % Normalize bmax to 1
7 -    freq = 60;              % 60Hz
8 -    w = 2*pi*freq;
9      % angluar velocity (rad/s)
10     % First, generate the three component magnetic fields
11 -    t = 0:1/6000:1/60;
12 -    Baa = sin(w*t).*(cos(0)+j*sin(0));
13 -    Bbb = sin(w*t-2*pi/3).*(cos(2*pi/3)+j*sin(2*pi/3));
14 -    Bcc = sin(w*t+2*pi/3).*(cos(-2*pi/3)+j*sin(-2*pi/3));
15     % calculate Bnet
16 -    Bnet= Baa+Bbb+Bcc;
17     % calculate a circle representing the expected maximum
18     % value of Bnet
19 -    circle = 1.5*(cos(w*t)+j*sin(w*t));
20     % plot the magnetude and direction of the resulting magnetic
21     % field. Note that Baa is black , Bbb is blue , Bcc is
22     % magneta, and net is red
23 -    for ii = 1:length(t)
24         %plot the reference circle
25 -        plot(circle,'k');
26 -        hold on;
27         % plot the four magnetic fields
28 -        plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
29 -        plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
30 -        plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
31 -        plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
32 -        axis square;
33 -        axis ([-2 2 -2 2]);

```

Command Window

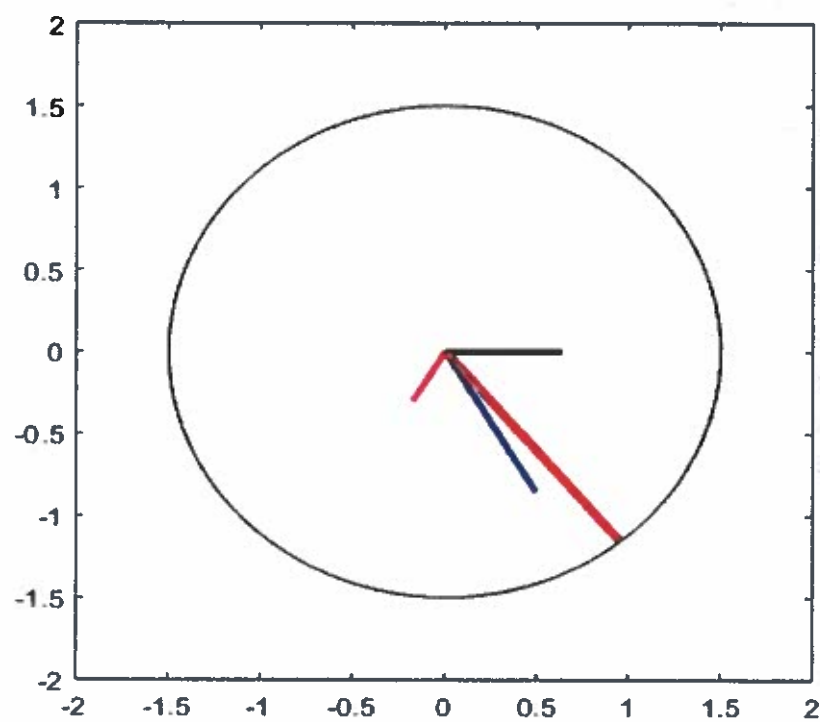
output



The magnetic field at 90-degree angle

```
+107 lonfo_franky_for the final question 4.m X Franky_Williams_lonfo mag_field .m X generate.n
1      %Franky_williams_Lonfo
2      % M-file: mag_field.m
3      % M-file to calculate the net Magnetic field produced
4      % by a three-phase stator.
5      % set up the basic conditions
6 -    bmax = 1;                % Normalize bmax to 1
7 -    freq = 60;              % 60Hz
8 -    w = 2*pi*freq;
9      % angular velocity (rad/s)
10     % First, generate the three component magnetic fields
11 -    t = 0:1/6000:1/60;
12 -    Baa = sin(w*t).*(cos(90)+j*sin(90));
13 -    Bbb = sin(w*t-2*pi/3).*(cos(2*pi/3)+j*sin(2*pi/3));
14 -    Bcc = sin(w*t+2*pi/3).*(cos(-2*pi/3)+j*sin(-2*pi/3));
15     % calculate Bnet
16 -    Bnet= Baa+Bbb+Bcc;
17     % calculate a circle representing the expected maximum
18     % value of Bnet
19 -    circle = 1.5*(cos(w*t)+j*sin(w*t));
20     % plot the magnetude and direction of the resulting magnetic
21     % field. Note that Baa is black , Bbb is blue , Bcc is
22     % magenta, and net is red
23 -    for ii = 1:length(t)
24         %plot the reference circle
25 -        plot(circle,'k');
26 -        hold on;
27         % plot the four magnetic fields
28 -        plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
29 -        plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
30 -        plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
31 -        plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
32 -        axis square;
33 -        axis ([-2 2 -2 2]);
```

output

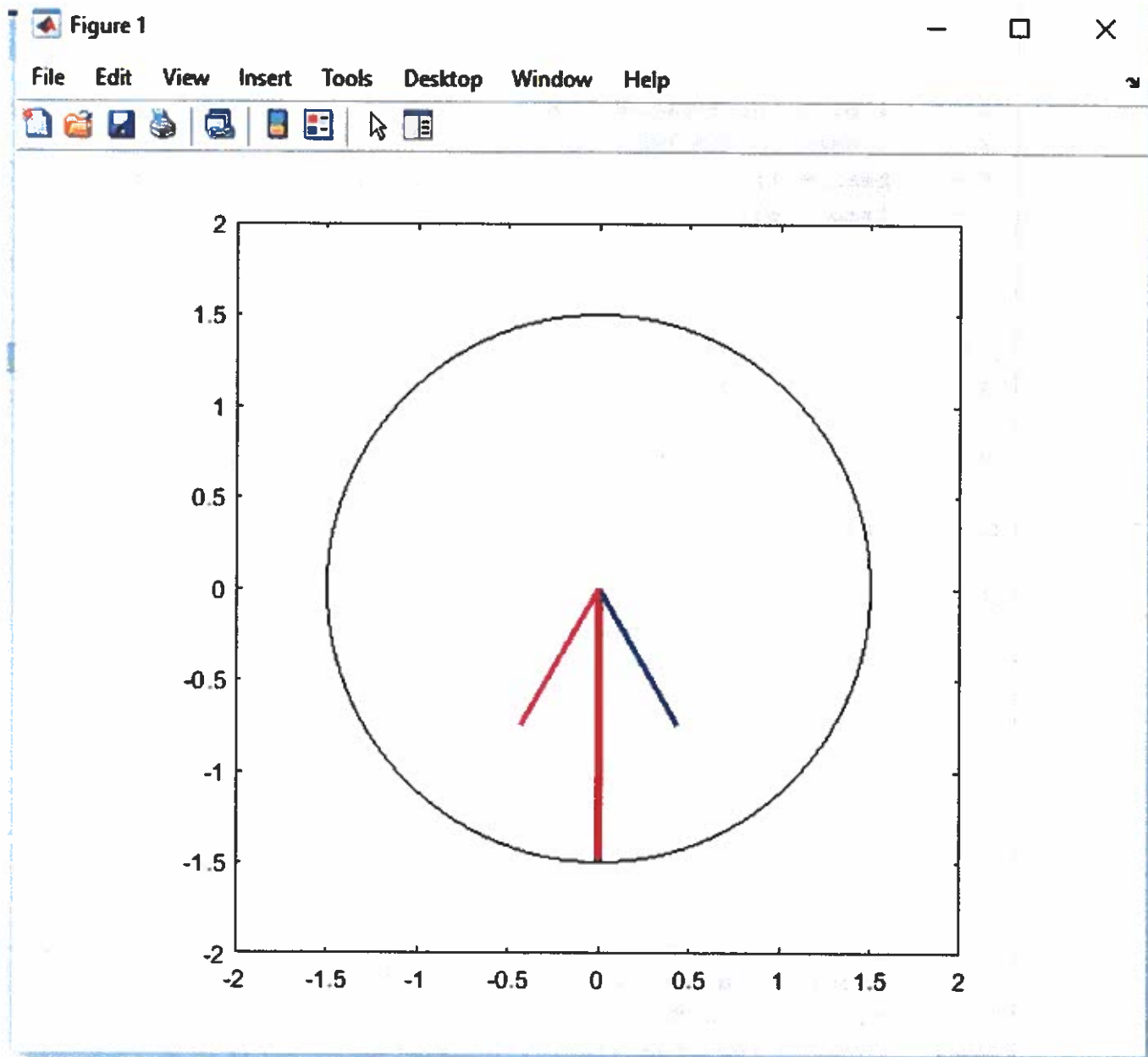



```

+107 lonfo_franky_for the final question 4.m X Franky_Williams_lonfo mag_field .m X generate.m
1      %Franky_williams_Lonfo
2      % M-file: mag_field.m
3      % M-file to calculate the net Magnetic field produced
4      % by a three-phase stator.
5      % set up the basic conditions
6 -    bmax = 1;                % Normalize bmax to 1
7 -    freq = 60;              % 60Hz
8 -    w = 2*pi*freq;
9      % angular velocity (rad/s)
10     % First, generate the three component magnetic fields
11 -    t = 0:1/6000:1/60;
12 -    Baa = sin(w*t).*(cos(270)+j*sin(270));
13 -    Bbb = sin(w*t-2*pi/3).*(cos(2*pi/3)+j*sin(2*pi/3));
14 -    Bcc = sin(w*t+2*pi/3).*(cos(-2*pi/3)+j*sin(-2*pi/3));
15     % calculate Bnet
16 -    Bnet= Baa+Bbb+Bcc;
17     % calculate a circle representing the expected maximum
18     % value of Bnet
19 -    circle = 1.5*(cos(w*t)+j*sin(w*t));
20     % plot the magnetude and direction of the resulting magnetic
21     % field. Note that Baa is black , Bbb is blue , Bcc is
22     % magenta, and net is red
23 -    for ii = 1:length(t)
24         %plot the reference circle
25         plot(circle,'k');
26         hold on;
27         % plot the four magnetic fields
28 -        plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
29 -        plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
30 -        plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
31 -        plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
32 -        axis square;
33 -        axis ([-2 2 -2 2]);

```

Command Window



The magnetic field at 360-degree angle

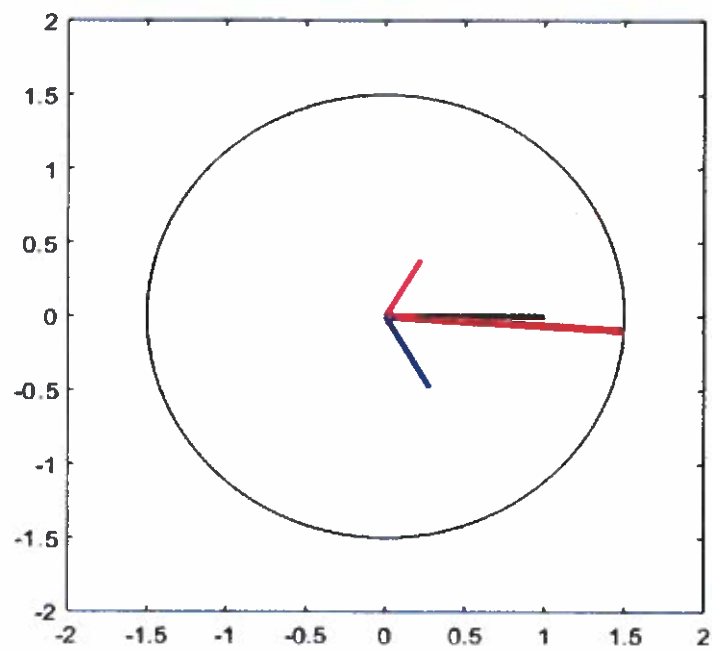
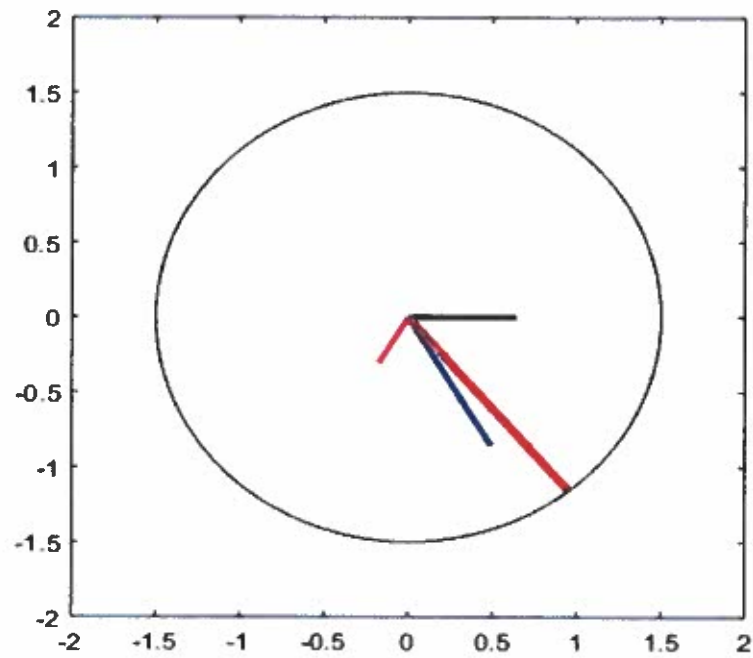
```

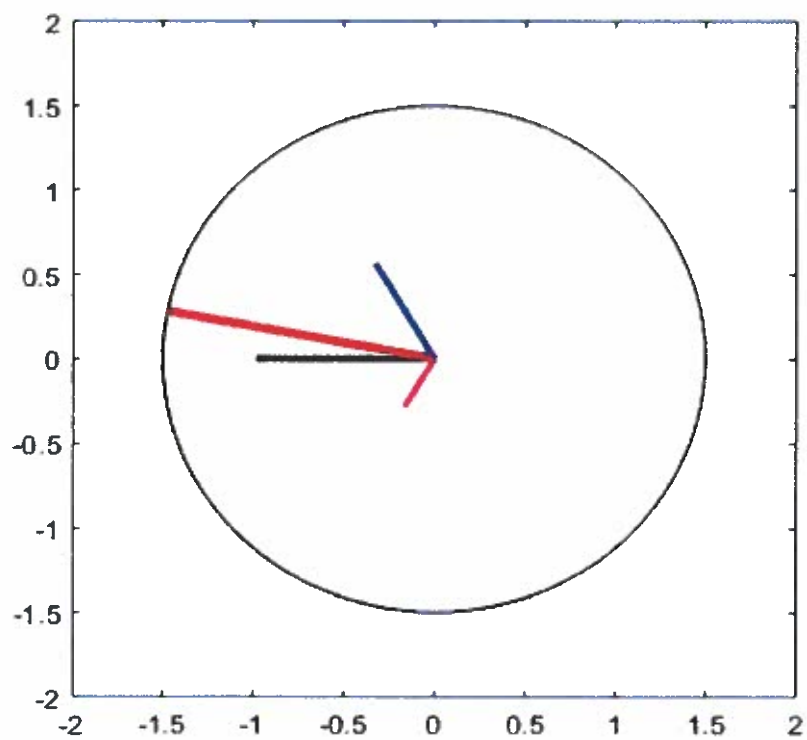
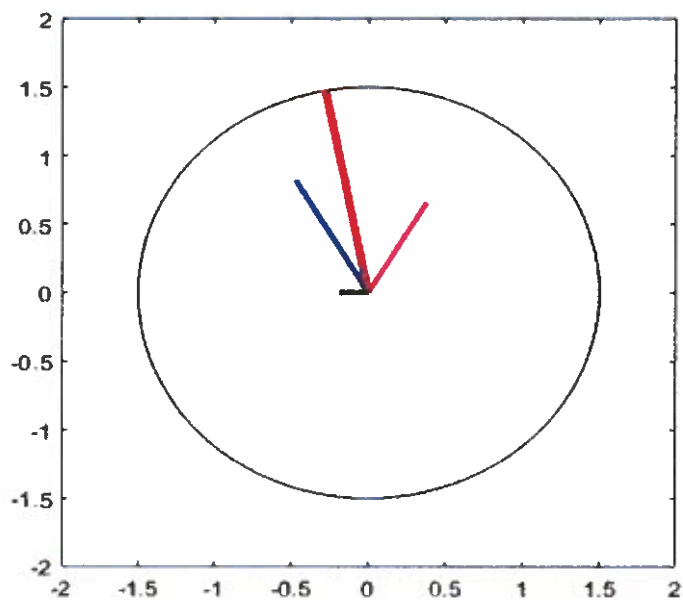
Editor - C:\Users\lonfo\OneDrive\Desktop\ENGR 2304 Test 1 FALL 2017 summer class\question 2 projectile a
+107 lonfo_franky_for the final question 4.m x Franky_Williams_lonfo mag_field .m x generate.m
1      %Franky_williams_Lonfo
2      % M-file: mag_field.m
3      % M-file to calculate the net Magetic field produced
4      % by a three-phase stator.
5      % stet up the basic conditions
6 -    bmax = 1;                % Normalize bmax to 1
7 -    freq = 60;              % 60Hz
8 -    w = 2*pi*freq;
9      % angluar velocity (rad/s)
10     % First, generate the three component magnetic fields
11 -    t = 0:1/6000:1/60;
12 -    Baa = sin(w*t) .* (cos(360)+j*sin(360));
13 -    Bbb = sin(w*t-2*pi/3) .* (cos(2*pi/3)+j*sin(2*pi/3));
14 -    Bcc = sin(w*t+2*pi/3) .* (cos(-2*pi/3)+j*sin(-2*pi/3));
15     % calculate Bnet
16 -    Bnet= Baa+Bbb+Bcc;
17     % calculate a circle representing the expected maximum
18     % value of Bnet
19 -    circle = 1.5*(cos(w*t)+j*sin(w*t));
20     % plot the magnetude and direction of the resulting magnetic
21     % field. Note that Baa is black , Bbb is blue , Bcc is
22     % magneta, and net is red
23 -    for ii = 1:length(t)
24         %plot the reference circle
25         plot(circle,'k');
26         hold on;
27         % plot the four magnetic fields
28 -        plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
29 -        plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
30 -        plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
31 -        plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
32 -        axis square;
33 -        axis ([-2 2 -2 2]);

```

Command Window

Output at 0, 90, 180 and 270 degrees





Hand calculation

Hand Calculation

$$B_{aa'} = B_m \sin \omega t + 120^\circ$$

$$\boxed{B_{aa'} = 0}$$

$$B_{bb'} = B_m \sin(\omega t - 120^\circ) \angle 120^\circ$$

$$\boxed{B_{bb'} = -\frac{\sqrt{3}}{2} B_m \angle 120^\circ}$$

$$\underline{B_m = 1}$$

$$\boxed{B_{bb'} = -\frac{\sqrt{3}}{2} \angle 120^\circ}$$

$$B_{cc'} = B_m \sin(-240^\circ) \angle 240^\circ$$

$$= B_m \sin(-240^\circ) \angle 240^\circ$$

$$B_{cc'} = \frac{\sqrt{3}}{2} (1) \angle 240^\circ$$

$$\boxed{B_{cc'} = \frac{\sqrt{3}}{2} \angle 240^\circ}$$

$$\boxed{B_{net} = B_{aa'} + B_{bb'} + B_{cc'}}$$

$$B_{net} =$$

$$b_{max} = 1 \quad t = 0:1/6000:1/60$$

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

$$\omega = 2\pi f$$

$$B = \sin(\omega t) [\cos(\theta) + j \sin(\theta)]$$

$$B_{aa'} = \sin(\omega t) [\cos(\theta) + j \sin(\theta)]$$

$$\theta = 0 \quad \Rightarrow \quad B_{aa'} = \sin(2\pi \cdot 60 t) [\cos(0) + j \sin(0)]$$

$$= \sin(120\pi t) [1 + 0j]$$

$$= \sin(120\pi t)$$

$$= 0$$

$$\boxed{B_{aa'} = 0} \quad (1)$$

$$B_{bb'} = \sin(\omega t - \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \sin(120\pi \cdot 60 t) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \sin(7200\pi t) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \frac{\sqrt{3}}{2} B_m \angle 120^\circ$$

$$\boxed{B_{bb'} = \frac{\sqrt{3}}{2} \angle 120^\circ} \quad (1) \quad B_{bb'} =$$

$$B_{cc'} = \sin(\omega t + \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \sin(120\pi t + \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$\boxed{B_{cc'} = \frac{\sqrt{3}}{2} \angle -120^\circ} \quad (1)$$

Hand Calculation

$$B_{aa'} = B_m \sin \omega t + 120^\circ$$

$$B_{aa'} = 0$$

$$B_{bb'} = B_m \sin(\omega t - 120^\circ) \angle 120^\circ$$

$$B_{bb'} = -\frac{\sqrt{3}}{2} B_m \angle 120^\circ$$

$$B_m = 1$$

$$B_{bb'} = -\frac{\sqrt{3}}{2} \angle 120^\circ$$

$$B_{cc'} = B_m \sin(-240^\circ) \angle 240^\circ$$

$$= B_m \sin(-240^\circ) \angle 240^\circ$$

$$B_{cc'} = \frac{\sqrt{3}}{2} (1) \angle 240^\circ$$

$$B_{cc'} = \frac{\sqrt{3}}{2} \angle 240^\circ$$

$$B_{net} = B_{aa'} + B_{bb'} + B_{cc'}$$

$$B_{net} =$$

$$b_{max} = 1 \quad t = 0:1/6000:1/60$$

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

$$\omega = 2\pi f$$

$$B = \sin(\omega t) [\cos(\theta) + j \sin(\theta)]$$

$$B_{aa'} = \sin(\omega t) [\cos(\theta) + j \sin(\theta)]$$

$$\text{at } \theta = 0 \quad B_{aa'} = \sin(2\pi \times 60 t) [\cos(0) + j \sin(0)]$$

$$= \sin(120\pi t) [1 + j0]$$

$$= \sin(120\pi t)$$

$$= 0$$

$$\boxed{B_{aa'} = 0} \quad (1)$$

$$B_{bb'} = \sin(\omega t - \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \sin(120\pi \cdot 60 t - \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \sin(7200\pi t - \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \frac{\sqrt{3}}{2} B_m \angle 120^\circ$$

$$\boxed{B_{bb'} = \frac{\sqrt{3}}{2} \angle 120^\circ}$$

$$(1) \quad B_{bb'} =$$

$$B_{cc'} = \sin(\omega t + \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

$$= \sin(120\pi t + \frac{2\pi}{3}) [\cos(\frac{2\pi}{3}) + j \sin(\frac{2\pi}{3})]$$

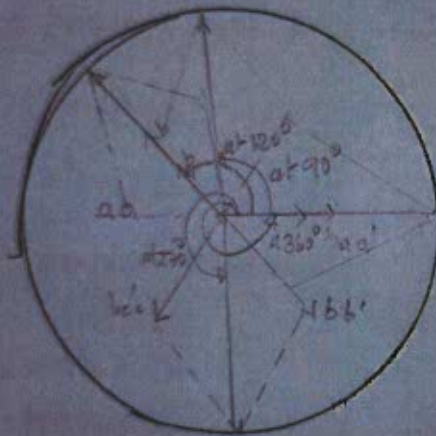
$$\boxed{B_{cc'} = \frac{\sqrt{3}}{2} \angle -120^\circ} \quad (1)$$

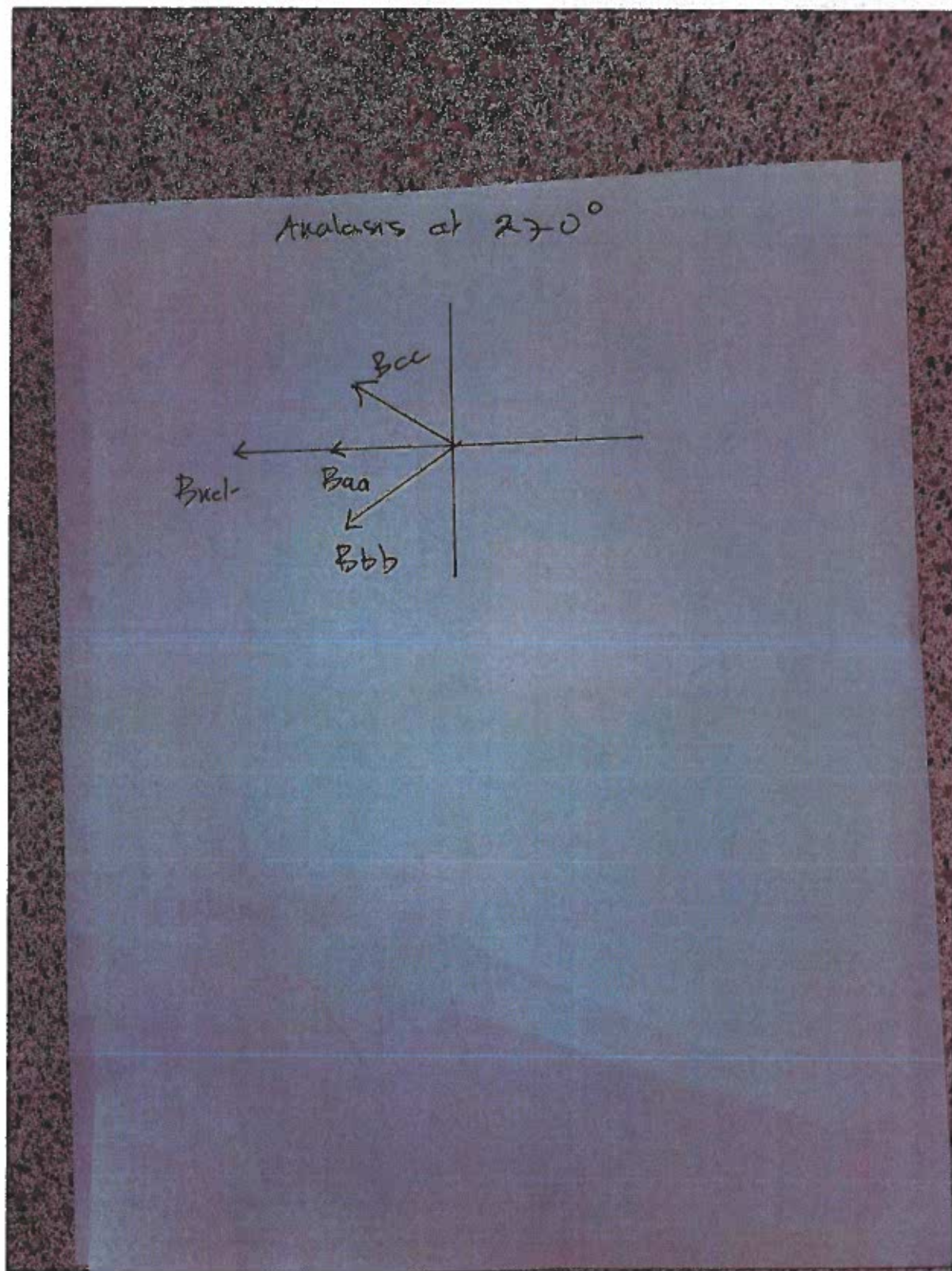
at 0°

$$B_{net} = 0 + \frac{\sqrt{3}}{2} \angle -120^\circ + \frac{\sqrt{3}}{2} \angle 120^\circ$$

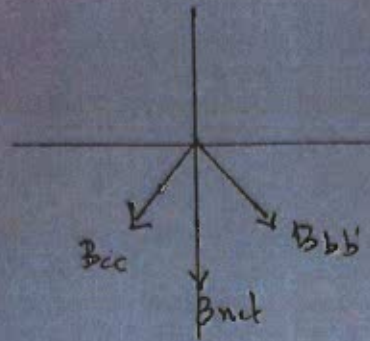
$$|B_{net}| = \frac{\sqrt{3}}{2}$$

$$|B_{net}| = \frac{3}{2} \angle$$

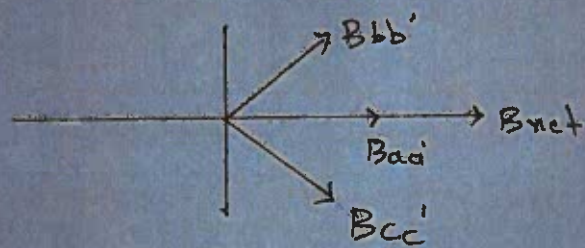




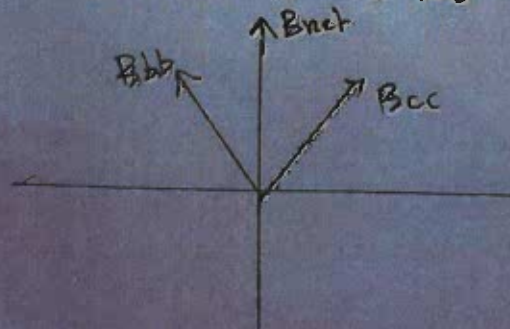
For analysis $\omega t = 0^\circ$



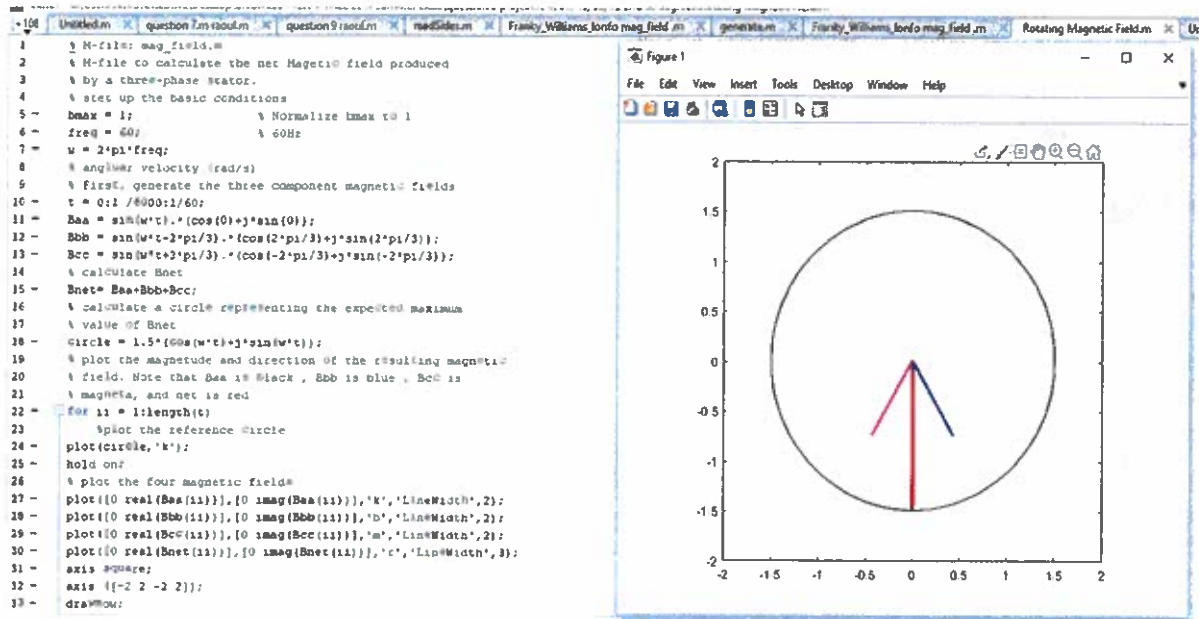
Analysis at $\omega t = 90^\circ$



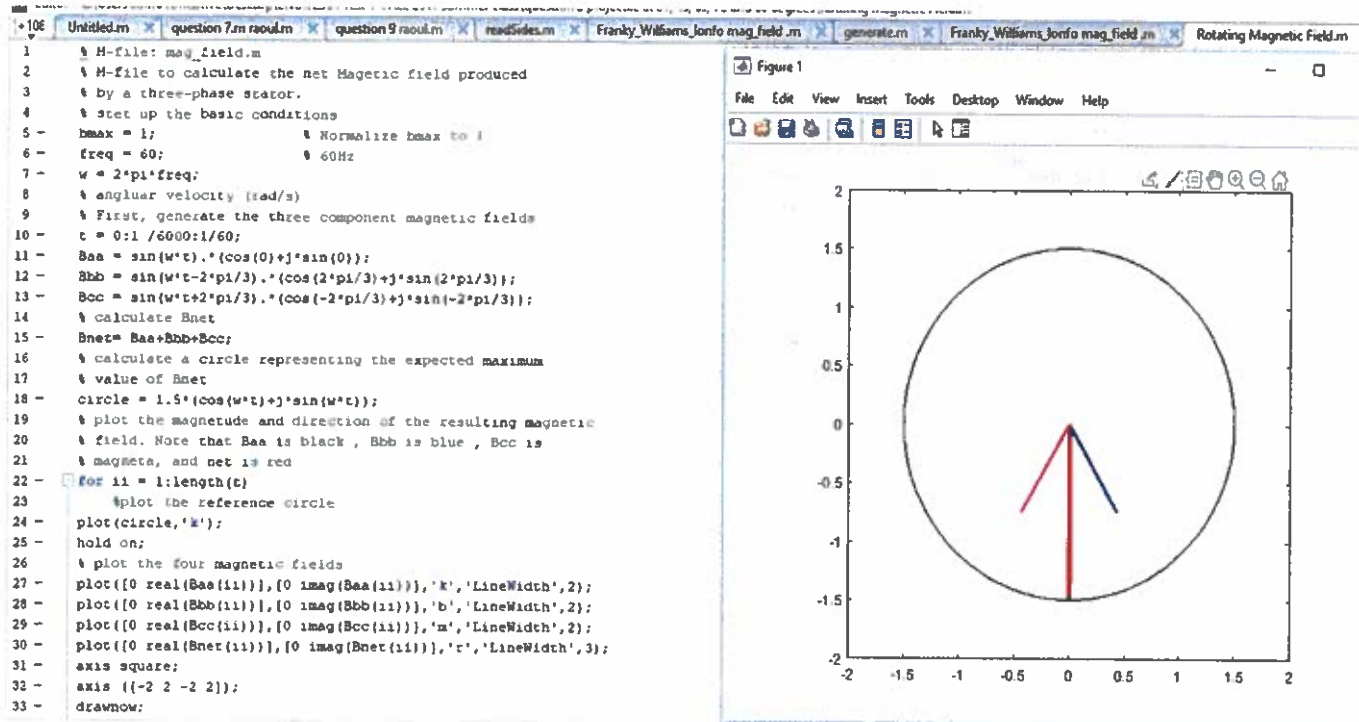
Analysis at $\omega t = 180^\circ$



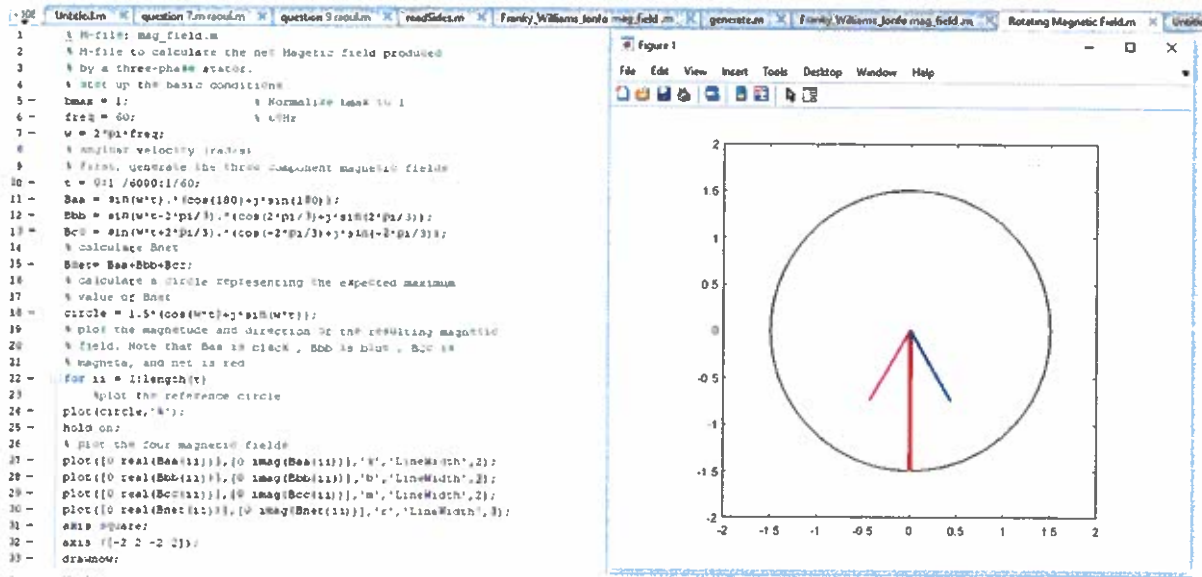
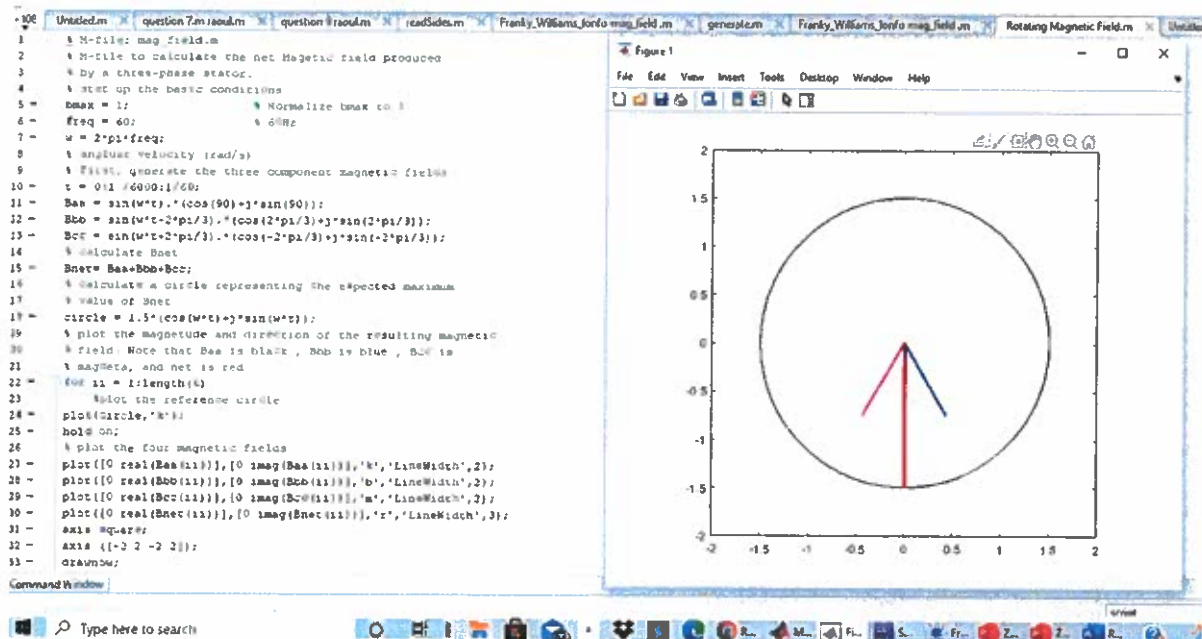
ELECTROMECHANICAL ENERGY CONVERSIONS: ELEG 4301 LABORATORY DOCUMENT



ELECTROMECHANICAL ENERGY CONVERSIONS: ELEG 4301 LABORATORY DOCUMENT



ELECTROMECHANICAL ENERGY CONVERSIONS: ELEG 4301 LABORATORY DOCUMENT



Conclusion

In this experiment, we learned how to measure the magnetic field by adjusting the degree of the sinusoidal signal. by using the MATLAB tool. For instant, learning how to use MATLAB to represent the different graph of the electromagnetic field at $\omega t = 0, 90, 180$ and 270 degree and finding the error between the measured and the calculated value was considering as a good experiment for this chapter. one of our difficult was to monitor the lab but the lab. Finally, I personally found this lab very interesting.

Reference

https://www.youtube.com/results?search_query=electromagnetic+field+theory

<https://www.britannica.com/science/electromagnetic-field>

AVERAGE

Prairie View A&M University

Roy G. Perry College of Engineering



Rotating Magnetic Field

Electromechanical Energy Conversions

ELEG 4301

Instructor: Dr. Fuller

October 28, 2021

Submitted by: Joshua Littleton

Abstract

When a 3-phase winding is energized from a 3-phase supply, a rotating magnetic field is produced. Such a field is such that its poles go on shifting their positions around the stator opposed to remaining in a fixed position on the stator. For this reason, it is called a rotating magnetic field.

A rotating magnetic field, as in the synchronous motor, also forms the basic operating principle of an asynchronous induction motor. Eddy currents are induced in the rotor conductors by the rotating magnetic field resulting in a Lorentz force being produced from the interaction of the eddy currents and the rotating magnetic field. The rotating magnetic field is produced radially around the rotor by the varying currents in the stator windings.

A three-phase induction motor consists of three phases winding as its stationary part called stator. The three-phase stator winding is connected in star or delta. The three-phase windings are displaced from each other by 120° . The windings are supplied by a balanced three phase ac supply. The three-phase currents will flow simultaneously through the windings and are displaced from each other by 120° . Each alternating phase current produces its own flux which is sinusoidal. So, all three fluxes are sinusoidal and are separated from one another by 120° .

The phase sequence of the three-phase voltage applied to the stator winding is a-b-c. If this sequence is changed to a-c-b, it is observed that the direction of rotation of the field is reversed i.e., the field rotates counterclockwise rather than clockwise. However, the number of poles and the speed at which the magnetic field rotates will remain unchanged. Therefore, it is necessary only to change the phase sequence in order to change the direction of rotation of the

magnetic field. For a three-phase supply, this can be done by interchanging any two of the three lines.

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Counterclockwise B_{net} Field	5
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Clockwise B_{net} Field	10
MATLAB Program and Results	10
Hand Calculations	12
Conclusion.....	12
References.....	13

Report Body

Introduction

In the report you will find the comparison between the counterclockwise B_{net} field and the clockwise B_{net} field. These will then be compared to their respective hand calculation results. The objective is to analyze a rotating magnetic field using MATLAB code and comparing it to the handwritten theoretical calculations and compare the change in the clockwise and counterclockwise code.

Theory Applied to Generator Magnetic Fields

A rotating magnetic field is produced by a three-phase current of a stator in a three-phase AC induction motor. The interior stator windings are located 120° apart from one another. So when the rotor is turning a three-phase sinusoidal waveform is produced. The geometry of the loops in the stator are fixed therefore the currents in the loops are shown below in Figure 1.

$$\begin{aligned} i_{aa'}(t) &= I_m \sin \omega t & A \\ i_{bb'}(t) &= I_m \sin(\omega t - 120^\circ) & A \\ i_{cc'}(t) &= I_m \sin(\omega t - 240^\circ) & A \end{aligned}$$

Figure 1: Current Equations

The resulting magnetic flux densities are shown below in Figure 2 along with the total magnetic flux density, B_{net} , shown in Figure 3.

$$\begin{aligned} B_{aa'}(t) &= B_M \sin \omega t \angle 0^\circ & T \\ B_{bb'}(t) &= B_M \sin(\omega t - 240^\circ) \angle 120^\circ & T \\ B_{cc'}(t) &= B_M \sin(\omega t - 120^\circ) \angle 240^\circ & T \end{aligned}$$

Figure 2: Flux Density Equations

$$B_{net}(t) = B_{aa'}(t) + B_{bb'}(t) + B_{cc'}(t)$$

Figure 3: Equation for B_{net}

Counterclockwise B_{net} Field

MATLAB Program and Results

The code shown in Figure 4.1 - 4.2 is the code that was written to generate the visual representation of the rotating magnetic field in the counterclockwise direction.

```

1      % Joshua Littleton, ELEG 4301, October 27, 2021
2      % M-file: _field.m
3      % M-file to calculate the net magnetic field produced by a three-phase
      stator.
4
5      % Set up the basic conditions
6
7      bmax = 1;           % Normalize bmax to 1
8      freq = 60;          % 60 Hz
9      w = 2*pi*freq;      % angular velocity (rad/s)
10
11     % First, generate the three componet magnetic fields

```

Figure 4.1: MATLAB Code for Counterclockwise B_{net} Field

```

12
13 t = 0:1/6000:1/60;
14 Baa = sin(w*t) .* (cos(0) + j*sin(0));
15 Bbb = sin(w*t-2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));
16 Bcc = sin(w*t+2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));
17
18 %Calculate Bnet
19 Bnet = Baa + Bbb + Bcc;
20
21 % Calculate a circle repersenting the expected maximum value of Bnet
22 circle = 1.5 * (cos(w*t) +j*sin(w*t));
23
24 %Plot the magnitude and direction of the resulting magnetic fields.
    Note that Baa is black, Bbb is blue, Bcc is magenta, and Bnet is red.
25 for ii = 1:length(t)
26
27     % Plot the referece circle
28     plot(circle,'k');
29     hold on;
30
31     % Plot the four magnetic fields
32     plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
33     plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
34     plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
35     plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
36     axis square;
37     axis([-2 2 -2 2]);
38     drawnow;
39     hold off;
40 end

```

Figure 4.2: MATLAB Code for Counterclockwise B_{net} Field (cont.)

When this program was run, it produced the visual representation of the magnetic field.

Snapshots of the code running were taken at varied points in time and represent the field at 0° , 90° , 180° , and 270° and can be seen in Figures 5.1, 5.2, 5.3, and 5.4 respectively.

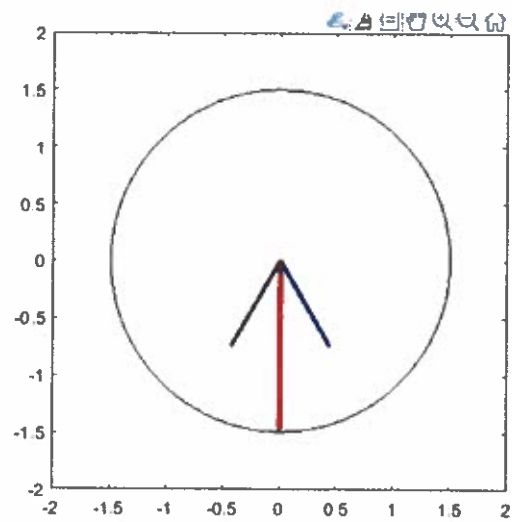


Figure 5.4: Rotating Magnetic Field at 0°

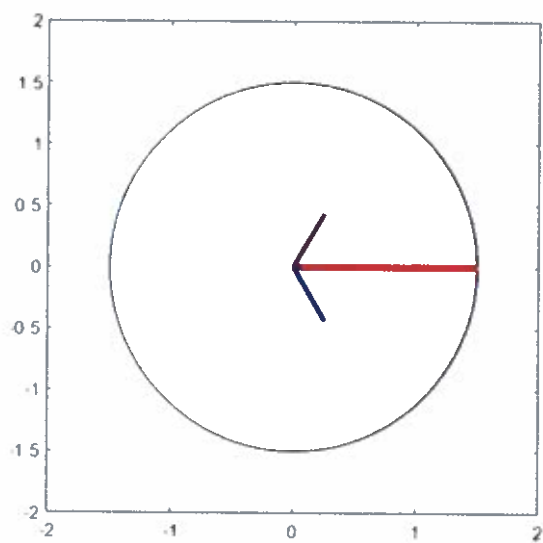


Figure 5.4: Rotating Magnetic Field at 90°

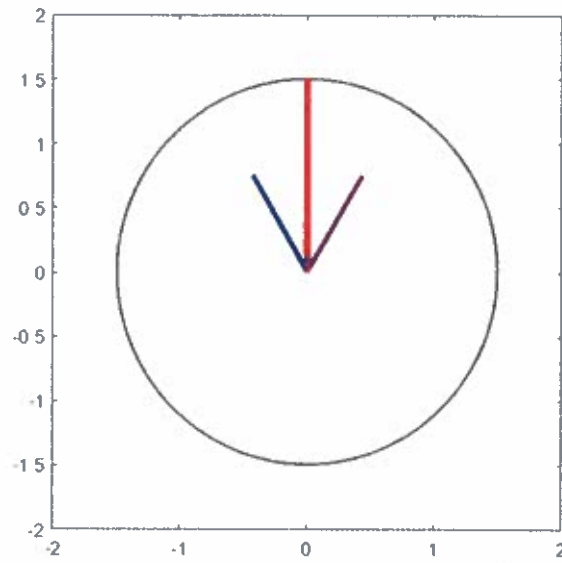


Figure 5.4: Rotating Magnetic Field at 180°

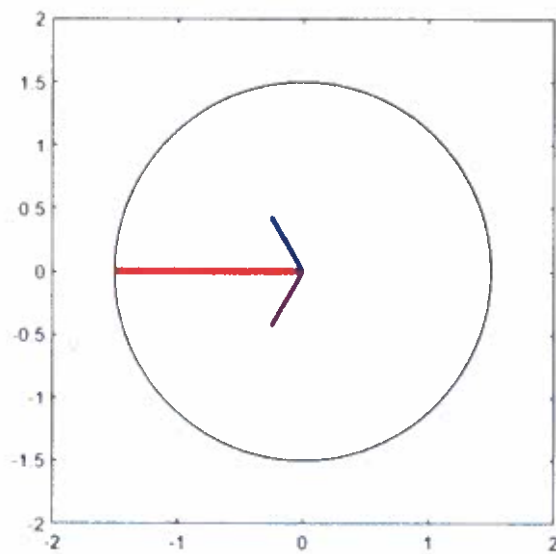


Figure 5.4: Rotating Magnetic Field at 270°

The figures show the flux densities and their summation to form B_{net} .

Hand Calculations

The theoretical calculation of B_{net} was also found through hand calculations. This can be seen in Figure 6.

$$\begin{aligned} B_{net}(t) &= B_{aa'}(t) + B_{ba'}(t) + B_{ca'}(t) \\ &= B_M \sin \omega t \angle 0^\circ + B_M \sin(\omega t - 240^\circ) \angle 120^\circ + B_M \sin(\omega t - 120^\circ) \angle 240^\circ \\ &= [B \sin \omega t - 0.5 B \sin(\omega t - 120^\circ) - 0.5 B \sin(\omega t - 240^\circ)] \hat{x} + \left[\frac{\sqrt{3}}{2} B \sin(\omega t - 120^\circ) - \frac{\sqrt{3}}{2} B \sin(\omega t - 240^\circ) \right] \hat{y} \\ &= (1.5 B_M \sin \omega t) \hat{x} - (1.5 B_M \cos \omega t) \hat{y} \end{aligned}$$

Figure 6: Hand Calculations of B_{net} for the Counterclockwise Direction

Using the same four angles that were captured while running the program earlier, I found the magnitude and orientation of the B_{net} . These calculations are shown in Figures 7.1, 7.2, 7.3, and 7.4 below.

$$\begin{aligned} B_{net}(0^\circ) &= (1.5 B_M \sin(0^\circ)) \hat{x} - (1.5 B_M \cos(0^\circ)) \hat{y} \\ &= -1.5 B_M \hat{y} \end{aligned}$$

Figure 7.1: Hand Calculations of Net Flux Density at 0°

$$\begin{aligned} B_{net}(90^\circ) &= (1.5 B_M \sin(90^\circ)) \hat{x} - (1.5 B_M \cos(90^\circ)) \hat{y} \\ &= 1.5 B_M \hat{x} \end{aligned}$$

Figure 7.2: Hand Calculations of Net Flux Density at 90°

$$\begin{aligned} B_{net}(180^\circ) &= (1.5 B_M \sin(180^\circ)) \hat{x} - (1.5 B_M \cos(180^\circ)) \hat{y} \\ &= 1.5 B_M \hat{y} \end{aligned}$$

Figure 7.3: Hand Calculations of Net Flux Density at 180°

$$B_{net}(0^\circ) = (1.5 B_m \sin(270^\circ)) \hat{x} - (1.5 B_m \cos(270^\circ)) \hat{y} \\ = 1.5 B_m \hat{x}$$

Figure 7.4: Hand Calculations of Net Flux Density at 270°

Conclusion

In conclusion, when the two windings are not interchanged the rotating magnetic field travels in a counterclockwise direction. This is demonstrated in the MATLAB program as well as the hand calculations I made. In the next section I will interchange the windings to see what difference will come of the results.

Clockwise B_{net} Field

MATLAB Program and Results

To simulate a change of the windings, I switched a plus sign to negative and vice versa in the equation for Bbb and Bcc; shown in Figure 8.1. The rest of the code stays the same Figure 8.2

```

1      % Joshua Littleton, ELEG 4301, October 27, 2021
2      % M-file: _field.m
3      % M-file to calculate the net magnetic field produced by a three-phase
      stator.
4
5      % Set up the basic conditions
6
7      bmax = 1;           % Normalize bmax to 1
8      freq = 60;          % 60 Hz
9      w = 2*pi*freq;      % angular velocity (rad/s)
10
11     % First, generate the three componet magnetic fields
12
13     t = 0:1/6000:1/60;
14     Baa = sin(w*t) .* (cos(0) + j*sin(0));
15     Bbb = sin(w*t+2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));
16     Bcc = sin(w*t-2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));

```

Figure 8.1: MATLAB Code for Clockwise B_{net} Field for Interchanged Windings

```

17
18     %Calculate Bnet
19     Bnet = Baa + Bbb + Bcc;
20
21     % Calculate a circle representing the expected maximum value of Bnet
22     circle = 1.5 * (cos(w*t) + j*sin(w*t));
23
24     %Plot the magnitude and direction of the resulting magnetic fields.
25     % Note that Baa is black, Bbb is blue, Bcc is magenta, and Bnet is red.
26     for ii = 1:length(t)
27         % Plot the reference circle
28         plot(circle,'k');
29         hold on;
30
31         % Plot the four magnetic fields
32         plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
33         plot([0 real(Bbb(ii))],[0 imag(Bbb(ii))],'b','LineWidth',2);
34         plot([0 real(Bcc(ii))],[0 imag(Bcc(ii))],'m','LineWidth',2);
35         plot([0 real(Bnet(ii))],[0 imag(Bnet(ii))],'r','LineWidth',3);
36         axis square;
37         axis([-2 2 -2 2]);
38         drawnow;
39         hold off;
40     end

```

Figure 8.2: MATLAB Code for Clockwise B_{net} Field for Interchanged Windings (cont.)

When the program was run it produced the visual for the net magnetic flux density shown in Figure 9.

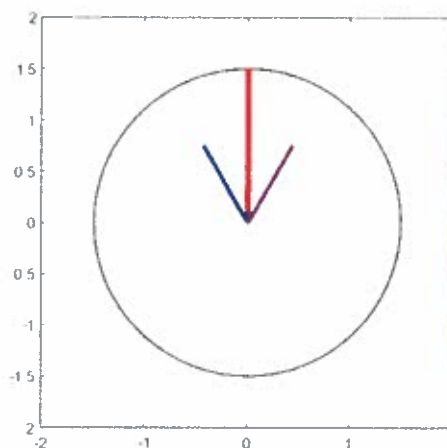


Figure 9: MATLAB Program Running for interchanged windings

Multiple snapshots of the program were not able to be obtained due to the lag of the computer.

However, I visually observed the magnetic field was shown going around in the clockwise direction.

Hand Calculations

The hand calculations show the equation for the net magnetic flux density if the windings were interchanged; shown in Figure 10.

$$\begin{aligned}
 B_{net}(t) &= B_{aa'}(t) + B_{bb'}(t) + B_{cc'}(t) \\
 &= B_m \sin \omega t \angle 0^\circ + B_m \sin(\omega t - 240^\circ) \angle 120^\circ + B_m \sin(\omega t - 120^\circ) \angle 240^\circ \\
 &= [B \sin \omega t - 0.5 B \sin(\omega t - 120^\circ) - 0.5 B \sin(\omega t - 240^\circ)] \hat{x} + \left[\frac{\sqrt{3}}{2} B \sin(\omega t - 120^\circ) + \frac{\sqrt{3}}{2} B \sin(\omega t - 240^\circ) \right] \hat{y} \\
 &= (1.5 B_m \sin \omega t) \hat{x} + (1.5 B_m \cos \omega t) \hat{y}
 \end{aligned}$$

Figure 10: Hand Calculations of B_{net} for the clockwise Direction

Conclusion

In conclusion, when the windings were interchanged, the magnetic field traveled in the clockwise direction. On the other hand, the magnetic field traveled in the counterclockwise direction before the windings were interchanged. This was shown in the MATLAB program that was generated as well as in the hand calculations.

References

Higham, D. J., & Higham, N. J. (2016). *MATLAB guide* (Vol. 150). Siam.

<https://www.sciencedirect.com/topics/engineering/rotating-magnetic-field>

<https://www.cleverfiles.com/howto/notepad-mac.html>

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ROY G. PERRY COLLEGE OF ENGINEERING



Electromechanical Energy Conversion

ELEG 4301

Rotating Magnetic Field Using MATLAB

Submitted by:

Trevor Johnson

Date of Submission: 10/29/21

Date of Performance: 10/27/2021

Department of Electrical and Computer Engineering

Prairie View A&M University

Objective:

The student will simulate a rotating magnetic field using MATLAB and compare the results of the program to initial hand calculations.

Introduction/Theory:

MATLAB (an abbreviation of "Matrix Laboratory") is a proprietary multi-paradigm programming language and numeric computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

Equipment:

MATLAB platform

Procedure:

Click on file, located in the upper left-hand corner, and select "new"
next click on "mfile"

A new screen appears with title of "untitled"

Type the rotating magnetic field program as previously listed in the window

After typing in the program continue with next debugging the program

Now click on "debug" at the top of the display

next click on "save and run"

Save your work with an appropriate title and the program automatically compiles and run

Results should appear in the right command window

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Research and commercial use are prohibited.

Using Toolbox Path Cache. Type "help toolbox_path_cache" for more info.

To get started, select "MATLAB Help" from the Help menu.

Your computer results should coincide with your calculated results.

You have just completed your first MATLAB program for ELEG 4013.

Post your results on Canvas for grading.

Use your name to save and run your program.

Solution:

Handwritten calculations on lined paper showing the derivation of the net magnetic field B_{net} from three phase components $B_{aa'}$, $B_{bb'}$, and $B_{cc'}$.

$$\begin{aligned}
 B_{aa'}(t) &= B_m \sin \omega t \hat{x} \\
 B_{bb'}(t) &= B_m \sin(\omega t - 120^\circ) \hat{y} \\
 B_{cc'}(t) &= B_m \sin(\omega t - 240^\circ) \hat{z}
 \end{aligned}$$

$$\begin{aligned}
 B_{net} &= B_{aa'} + B_{bb'} + B_{cc'} = B_m \sin \omega t \hat{x} + 0 \hat{y} \\
 &\quad - 0.5 B_m \sin(\omega t - 120^\circ) \hat{x} + 0.866 B_m \sin(\omega t - 120^\circ) \hat{y} \\
 &\quad - 0.5 B_m \sin(\omega t - 240^\circ) \hat{x} - 0.866 B_m \sin(\omega t - 240^\circ) \hat{y}
 \end{aligned}$$

$$\begin{aligned}
 B_{net}(t) &= [B_m \sin \omega t - 0.5 B_m \sin(\omega t - 120^\circ) - 0.5 B_m \sin(\omega t - 240^\circ)] \hat{x} \\
 &\quad + [0.866 B_m \sin(\omega t - 120^\circ) - 0.866 B_m \sin(\omega t - 240^\circ)] \hat{y}
 \end{aligned}$$

$$\begin{aligned}
 B_{net}(t) &= (1.5 B_m \sin \omega t) \hat{x} - (1.5 B_m \cos \omega t) \hat{y} \\
 &= 1.5 B_m [\sin \omega t \hat{x} - \cos \omega t \hat{y}]
 \end{aligned}$$

Figure 1: Hand Calculations

Data and Results:

%M-file: mag_field.m

%M-file to calculate the net magnetic field produced by a three-phase
%stator.

%Set up the basic conditions

bmax = 1; %Normalize bmax to 1

freq = 60; %60 Hz

w = 2 * pi * freq; %angular velocity (rad/s)

%First generate the three component magnetic fields

t = 0:1/6000:1/60;

Baa = sin(w*t) .* (cos(0) + j*sin(0));

Bbb = sin(w*t-2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));

Bcc = sin(w*t+2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));

%Calculate Bnet

Bnet = Baa + Bbb + Bcc;

%Calculate a circle representing the expected maximum value of Bnet.

circle = 1.5 * (cos(w*t) + j*sin(w*t));

```

%Plot the magnitude and direction of the resulting magnetic fields.
%Note that Baa is black, Bbb is blue, Bcc is magenta, and Bnet is red.
for ii = 1:length(t)
    %Plot the reference circle
    plot(circle, 'k');
    hold on;

    %plot the four magnetic fields
    plot([0 real(Baa(ii))], [0 imag(Baa(ii))], 'k', 'Linewidth', 2);
    plot([0 real(Bbb(ii))], [0 imag(Bbb(ii))], 'b', 'Linewidth', 2);
    plot([0 real(Bcc(ii))], [0 imag(Bcc(ii))], 'm', 'Linewidth', 2);
    plot([0 real(Bnet(ii))], [0 imag(Bnet(ii))], 'r', 'Linewidth', 3);
    axis square;
    axis([-2 2 -2 2]);
    drawnow;
    hold off;
end

```

Figure 2: MATLAB Code

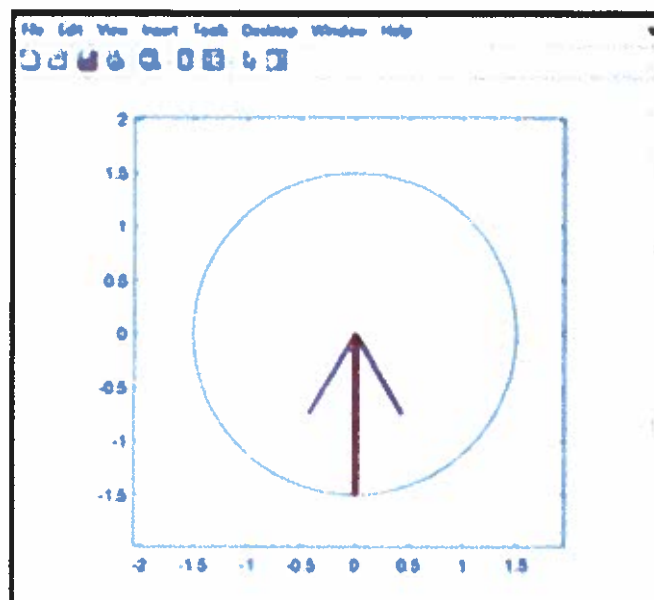


Figure 3: Rotating Magnetic Field Simulation

Conclusion:

Through this experiment, I successfully simulated the rotating magnetic field using MATLAB. I initialized variables at the beginning of the program, then simulated the ratio of the magnetic field. I then generated three magnetic fields, $B_{aa'}$, $B_{bb'}$, and $B_{cc'}$ that sum up to B_{net} . I created a circle that represents the maximum value of B_{net} and installed a loop that would transpose the three magnetic fields as well as B_{net} in a final simulation of a rotating magnetic field.

References:

Chapman, Stephen J. "Electric Machinery and Power System Fundamentals"



ELEG 4013
ENERGY CONVERSIONS
MATLAB program for rotating machine
Computers are available to run the program in the ECE computer laboratory

Accompanying this program assignment is directions on how to use MATLAB to run a software program. Follow the directions for using MATLAB as given by your Instructor or as you have used in your previous classes. Type in the MATLAB program of the rotating machine example as given on page 171(Example 4-1) of your textbook. Also attached with this assignment.

When the program is executed, it should draw lines corresponding to the three component magnetic fields as well as a line corresponding to the net magnitude field. Execute the program and observe the behavior of **Bnet** which should be the same as given in the text.

Be careful in typing the program. In the past there have been a number of recurring errors, such as mistaking the letter L(l) for the alphabet one (1). If you type incorrectly the program will give an error message and by following the directions you should be able to trace where the error occurred.

Compare your MatLab results with hand calculated results (turn in with program). You should include the pictorial views of the magnetic field at various locations (0, 90, 180, etc, degrees). Do enough locations to determine the rotation of the magnetic field. These pictorial views should be included in the report.

Note Print window screen can be used to print the magnetic fields. Use your name to save and run the program.

This program is due on Friday, October 29 to be uploaded to ecourse. Do a thorough report on the assignment with detailed description of your program and your results. This assignment is worth 30 points. Any duplicated efforts will result in a grade of zero for all participating parties.

Save your program, you will use the program on a future project. Neatness of work is always a grading consideration and the flow of information is very important.

■ Solution

The geometry of the loops in this stator is fixed as shown in Figure 4-2. The currents in the loops are

$$i_{aa'}(t) = I_M \sin \omega t \quad \text{A} \quad (4-1)$$

$$i_{bb'}(t) = I_M \sin(\omega t - 120^\circ) \quad \text{A} \quad (4-2)$$

$$i_{cc'}(t) = I_M \sin(\omega t - 240^\circ) \quad \text{A} \quad (4-3)$$

and the resulting magnetic flux densities are

$$\mathbf{B}_{aa'}(t) = B_M \sin \omega t \angle 0^\circ \quad \text{T} \quad (4-7)$$

$$\mathbf{B}_{bb'}(t) = B_M \sin(\omega t - 120^\circ) \angle 120^\circ \quad \text{T} \quad (4-8)$$

$$\mathbf{B}_{cc'}(t) = B_M \sin(\omega t - 240^\circ) \angle 240^\circ \quad \text{T} \quad (4-9)$$

A simple MATLAB program that plots $\mathbf{B}_{aa'}$, $\mathbf{B}_{bb'}$, $\mathbf{B}_{cc'}$, and $\mathbf{B}_{\text{net}}$ as a function of time is shown below.

```
% M-file: mag_field.m
% M-file to calculate the net magnetic field produced
% by a three-phase stator.

% Set up the basic conditions
bmax = 1; % Normalize bmax to 1
freq = 60; % 60 Hz
w = 2*pi*freq; % angular velocity (rad/s)

% First, generate the three component magnetic fields
t = 0:1/6000:1/60;
Baa = sin(w*t) .* (cos(0) + j*sin(0));
Bbb = sin(w*t-2*pi/3) .* (cos(2*pi/3) + j*sin(2*pi/3));
Bcc = sin(w*t+2*pi/3) .* (cos(-2*pi/3) + j*sin(-2*pi/3));

% Calculate Bnet
Bnet = Baa + Bbb + Bcc;

% Calculate a circle representing the expected maximum
% value of Bnet
circle = 1.5 * (cos(w*t) + j*sin(w*t));

% Plot the magnitude and direction of the resulting magnetic
% fields. Note that Baa is black, Bbb is blue, Bcc is
% magenta, and Bnet is red.
for ii = 1:length(t)

    % Plot the reference circle
    plot(circle,'k');
    hold on;

    % Plot the four magnetic fields
    plot([0 real(Baa(ii))],[0 imag(Baa(ii))],'k','LineWidth',2);
```

