Institute of Engineering & Technology
An Autonomous Institution
Accredited by NAAC with " A" Grade, Accredited by NBA (ECE, CSE.EEE & MECH)
Approved by A.I.C.T.E. & Permanently Affiliated to J. N. T. U. Gurajada, VIZIANAGARAM
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LAB MANUAL

Name of the Faculty : **Dr. P. JANAKI**

Name of the laboratory : **POWER SYSTEMS & SIMULATION**

LAB

Regulation : **R20**

Subject Code : **R20EEE-PC3204**

Branch : **Electronics and Electronics Engineering**

Year & Semester : **III B.Tech- II Semester**

INSTITUTE
VISION

Produce globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

Department of Electrical and Electronics Engineering

VISION

To be a hub for imparting knowledge, skills, and behavior for exemplary contributions in the field of Electrical and Electronics Engineering.

MISSION

- To impart Technical Education through the state-of-the-art infrastructure facilities, laboratories and instruction.

- To inculcate industry oriented learning through industrial visits, internships, projects at Industries, MOUs, to make students' technically skills oriented.

- Creating conducive environment for higher education, employment and entrepreneurship through quality education, professional skills and research.

- To promote societal commitment among students by inculcating moral and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates shall have strong foundation in core and allied Electrical and Electronics Engineering, in sciences and mathematics, to become globally competent in designing, modeling and critical problem solving.

PEO2: Graduates shall involve in research activities in the field of electrical and electronics engineering through lifelong learning and provide solutions to engineering problems for sustainable development of society.

PEO3: Graduates shall have good communication skills and socio-ethical values for getting employment or higher studies by excelling in competitive examinations and be able to work in supportive and leadership roles.

PROGRAM OUTCOMES (POs)

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-Long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop, test, verify and implement electrical and electronics engineering systems and products.

PSO2: Succeed in national and international competitive examinations for successful higher studies and employment.

COURSE OUTCOMES

S. No.	DESCRIPTION
C328.1	Determine the Sequence Impedance of Alternator and Transformer. (L5)

C328.2	Determine the Transmission Line Parameters.(L3)
C328.3	Design & Simulation of Load Frequency Controllers and Load Flow Studies of Power System Network.(L3)
C328.4	Simulation of Transient Response of RLC circuits.(L3)
C328.5	Simulation of Single Phase Full Converter & Voltage Controller.(L3)

POWER SYSTEMS & SIMULATION LAB

III Year – II SEMESTER

T	P	C
0	**3**	**2**

Course Objectives:

- To evaluate the Sequence Impedance of Transformer and Alternator.
- To determine ABCD Parameters of Transmission line.
- To analyze of Load Frequency Controllers & Load Flow Studies of Power System Network.
- To analyze Transient Response of RLC circuits using Simulation
- To design of Single Phase Full Converter & Voltage Controller in Simulation.

Course Outcomes: After completion of the course, the student will be able to
1. Determine the Sequence Impedance of Alternator and Transformer (L5)
2. Determine the Transmission Line Parameters (L3)
3. Design & Simulation of Load Frequency Controllers and Load Flow Studies of Power System Network (L3)
4. Simulation of Transient Response of RLC circuits (L3)
5. Simulation of Single Phase Full Converter & Voltage Controller (L3)

Any 10 of the Following Experiments are to be conducted:
1. Sequence Impedances of 3 Phase Transformer.
2. Sequence Impedances of 3 Phase Alternator by Fault Analysis.
3. Sequence Impedances of 3 Phase Alternator by Direct method.
4. ABCD parameters of Transmission line.
5. Load flow studies using Gauss-Seidel method
6. Load Flow Studies using N-R method.
7. Load Frequency Control of Two Area with & without control
8. Economic Load Dispatch with & without Losses
9. Transient analysis of Single Machine Connected to Infinite Bus (SMIB).
10. Modelling of Transformer and simulation of Lossy Transmission Line.
11. Simulation of Transient Response of RLC circuits.
a. Response to Pulse Input.
b. Response to Step Input.
c. Response to Sinusoidal Input.
12. Simulation of Single Phase Full Converter using RLE Loads and Single Phase AC Voltage Controller using RL Loads.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE INFORMATION SHEET

PROGRAM: EEE	**DEGREE:**B.Tech
LAB COURSE: POWER SYSTEMS & SIMULATION LAB	**SEMESTER:** III-II CREDITS: 3
LAB COURSE CODE: C328 **REGULATION:** R20	**COURSE TYPE:** PROFESSIONAL CORE
COURSE AREA/DOMAIN: POWER SYSTEMS	**CONTACT HOURS:** 3 hours/Week.

SYLLABUS:

EXP	DETAILS	HOURS
I	Demonstration of lab Experiments	**3**
II	Sequence Impedances of 3 Phase Transformer.	**3**
III	Sequence Impedances of 3 Phase Alternator by Fault Analysis.	**3**
IV	Sequence Impedances of 3 Phase Alternator by Direct method.	**3**
V	ABCD parameters of Transmission line.	**3**
VI	Load flow studies using Gauss-Seidel method	**3**
VII	Practice of Experiments	**3**
VIII	Load Frequency Control of Two Area with & without control	**3**
IX	Transient analysis of Single Machine Connected to Infinite Bus (SMIB).	**3**
X	Modelling of Transformer and simulation of Lossy Transmission Line.	**3**
XI	Simulation of Transient Response of RLC circuits. a. Response to Pulse Input. b. Response to Step Input. c. Response to Sinusoidal Input.	**3**
XII	Simulation of Single Phase Full Converter using RLE Loads and Single Phase AC Voltage Controller using RL Loads.	**3**
XIII	Unsymmetrical Fault Analysis	**3**
XIV	Ferranti Effect of Transmission Line	**3**
XV	Practice of Experiments	**3**
	TOTAL HOURS	**45**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T_1	Modern Power system Analysis – by I.J.Nagrath&D.P.Kothari: Tata McGraw–Hill Publishing Company, 2nd edition.
R_1	Power System Analysis by HadiSaadat – TMH Edition
R_2	MATLAB/SIMULINK user`s manual – Mathworks, USA.
R_3	MATLAB – Control system tool box – Mathworks, USA

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
C317	Power System Analysis	Students learn to determine the various fault currents for different Faults of Distribution System, find out the sequence components of currents for any unbalanced power system network, and also learn about to analyze the steady state, transient stability concepts of a power system	III-II

COURSE OBJECTIVES:

1	To evaluate the Sequence Impedance of Transformer and Alternator.
2	To determine ABCD Parameters of Transmission line..
3	To analyze Load Frequency Controllers & Load Flow Studies of Power System Network.
4	To analyze Transient Response of RLC circuits using Simulation
5	To design Single Phase Full Converter & Voltage Controller in Simulation. .

COURSE OUTCOMES:

S.NO	DESCRIPTION	PO(1..12) MAPPING	PSO(1,2) MAPPING
C328.1	Determine the Sequence Impedance of Alternator and Transformer	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12	PSO1,PSO2
C328.2	Determine the Transmission Line Parameters.	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12	PSO1,PSO2
C328.3	Design & Simulation of Load Frequency Controllers and Load Flow Studies of Power System Network	PO1,PO2,PO5,PO8, PO9,PO10,PO12	PSO1,PSO2
C328.4	Simulation of Transient Response of RLC circuits	PO1,PO2,PO5,PO8, PO9,PO10,PO12	PSO1,PSO2
C328.5	Simulation of Single Phase Full Converter & Voltage Controller	PO1,PO2,PO3,PO4, PO5,PO8,PO9,PO10,PO1 2	PSO1,PSO2
COURSE OVERALL PO/PSO MAPPING: PO1,PO2,PO3,PO4, PO5,PO6, PO7,PO8, PO9,PO10, PO11,PO12/PSO1,PSO2			

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

S.NO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
C328.1	3	3	3	2	-	2	2	2	3	2	1	2	3	3
C328.2	3	3	3	2	-	2	2	2	3	2	1	2	3	2
C328.3	3	3	-	-	3	-	-	2	2	2	-	2	2	2
C328.4	3	3	-	-	3	-	-	2	2	2	-	2	2	2
C328.5	3	3	3	2	3	-	-	2	2	2	-	2	3	2
C328*	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**1**	**2**	**3**	**2**

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop, test, verify and implement electrical and electronics engineering systems and products
PO2	Problem Analysis	PO8	Ethics	PSO2	Succeed in national and international competitive examinations for successful higher studies and employment
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

COs VS POs MAPPING JUSTIFICATION:

SNO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
C328.1	PO1	3	Properly determined sequence impedances ensure correct relay settings, preventing mis-operations and enhancing power system security.
	PO2	3	Accurate modeling of grounding systems is essential for determining zero sequence impedances, which are critical for ground fault analysis and stability studies.
	PO3	3	Sequence impedances are needed to interpret the measured sequence components and identify the sources of unbalance.
	PO4	2	Enables complex problem investigations, particularly fault analysis and unbalanced conditions.
	PO6	2	Supports reliable protection systems, minimizing safety hazards and societal disruptions.
	PO7	2	Contributes to sustainable development by reducing losses and environmental impact.
	PO8	2	Aligns with ethical engineering practice by ensuring accurate modeling and analysis.
	PO9	3	Facilitates effective teamwork and multidisciplinary collaboration in complex projects.
	PO10	2	Enables clear communication of analysis results and technical information.
	PO11	1	Determination of Sequence impedance values are important to the do the project work under the concept of fault analysis.

	PO12	2	Promotes lifelong learning in response to evolving power system technologies.
	PSO1	3	Implement the sequence Impedance of Alternator and Transformer to analyse positive, negative and zero sequence impedance parameters.
	PSO2	3	Utilize the concept of sequence Impedance of Alternator and Transformer to succeed moderately in national and international competitive exams.
C328.2	PO1	3	Complex problem solving is required for using transmission line parameters.
	PO2	3	Analysis of complex voltage and current relationships in transmission lines is necessary.
	PO3	3	Involves Design of transmission line compensation systems and voltage control.
	PO4	2	Investigation of ABCD parameters of transmission line parameters is required.
	PO6	2	Assessment of societal and safety implications of voltage stability is necessary
	PO7	2	Contribution to sustainable development through efficient transmission line design.
	PO8	2	Needs Adherence to ethical principles and professional responsibilities.
	PO9	3	Requires Effective teamwork and multidisciplinary collaboration.
	PO10	2	Involves Clear communication of analysis results and technical information.
	PO11	1	Awareness of project cost implications related to transmission line parameters is necessary.
	PO12	2	Lifelong learning in response to evolving transmission line technologies is required.
	PSO1	3	Implement the ABCD experimentation to determine the Transmission Line Parameters.
	PSO2	2	Utilize the concept of Transmission Line Parameters to succeed moderately in national and international competitive exams.
C328.3	PO1	3	Design and simulation of load frequency controllers (LFC) and load flow studies involve extensive understanding and application of electrical engineering principles.
	PO2	3	Involves the use of advanced mathematical models and tools for simulation, to solve complex system problems, particularly in load frequency control and power flow analysis.
	PO5	3	Design of LFCs and load flow studies requires the integration of engineering tools and software to analyze and simulate system behaviors under different conditions.

	PO8	2	Involves understanding real-world constraints like system stability, operational limits, and performance, which can be used to develop solutions that meet societal needs.
	PO9	2	Load frequency control and load flow studies in power systems play an important role in energy management and optimization, contributing to sustainable power generation.
	PO10	2	Design the optimized constraints for safety, helping to develop awareness of ethics and social responsibilities in electrical engineering practices.
	PO12	2	Analyze the functioning of complex power systems, and improve their efficiency, directly contributes to lifelong learning and continuous improvement in the field of electrical engineering.
	PSO1	2	Implement the simulation of Load Frequency Controllers and Load Flow Studies to analyse power system network.
	PSO2	2	Utilize the concept of Load Frequency Controllers and Load Flow Studies to succeed moderately in national and international competitive exams.
C328.4	PO1	3	Simulation of transient responses in RLC circuits requires a strong understanding of electrical engineering principles such as circuit analysis, differential equations.
	PO2	3	Involves mathematical modeling and simulation of RLC circuits under various transient conditions, which requires problem-solving skills.
	PO5	3	Simulation of RLC circuits requires the use of specialized simulation software (such as SPICE, MATLAB), to apply modern engineering tools.
	PO8	2	Provides insights into the behavior of RLC circuits, its direct relevance to societal needs, environmental concerns, or large-scale infrastructure is limited.
	PO 9	2	Simulation of transient responses helps to understand how RLC circuits behave under real-world conditions.
	PO10	2	Simulation techniques in circuit design, which promotes accuracy and reliability in engineering practice.
	PO12	2	Simulation of transient response of RLC circuits encourages lifelong learning.
	PSO1	2	Simulate the Transient Response of RLC circuits to verify the output of RLC circuit for different input signals.
	PSO2	2	Utilize the concept of Transient Response of RLC circuits to succeed moderately in national and international competitive exams.
C328.5	PO1	3	Simulation of a single-phase full converter and voltage controller requires a deep understanding of electrical engineering principles.

	PO2	3	Involves mathematical modeling, the application of conversion techniques, and using simulation tools to analyze the behavior of the full converter and voltage controller.
	PO3	3	Simulation of circuits like single-phase full converter and voltage controller, involves developing and analytical skills to interpret the results accurately.
	PO4	2	Design of the full converter and voltage controller requires consideration of practical aspects such as cost and component specifications.
	PO5	3	Simulation of the systems like voltage regulator requires the use of advanced engineering tools (e.g., MATLAB/Simulink, PSpice) for modeling and analysis.
	PO8	2	Simulation of the electrical systems like voltage regulator requires the knowledge of power conversion, which are important to society.
	PO9	2	Improved power conversion techniques can indirectly contribute to energy efficiency and sustainability in practical applications.
	PO10	2	Ethical considerations are important in electrical engineering practices, such as ensuring the reliability and safety of converters and controllers.
	PO12	2	Requires the use of advanced simulation techniques and understanding of the latest technologies in voltage regulation circuits.
	PSO1	3	Simulate of Single Phase Full Converter & Voltage Controller to verify the voltage levels of the circuits.
	PSO2	2	Utilize the concept of Single Phase Full Converter & Voltage Controller to succeed moderately in national and international competitive exams.

ADDITIONAL EXPERIMENTS:

S.NO	TOPIC NAME	COs	POs/PSOs
1	Unsymmetrical Fault Analysis	CO1	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12,PSO1,PSO2
2	Ferranti Effect of Transmission Line	CO2	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12, PSO1,PSO2
3	Load Flow Studies using N-R method.	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
4	Economic Load Dispatch with & without Losses	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2

WEB SOURCE REFERENCES:

1	http://www.electrical4u.com/electrical-power-system-analysis
2	www.electronicshub.org

3	nptel.ac.in/courses/108107028/module4/lecture6/lecture6.pdf
4	https://www.mathworks.com/support/learn-with-matlab-tutorials.html

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☐STUD. ASSIGNMENT	☑ WEB RESOURCES	☐ NPTEL/OTHERS
☐ LCD/SMART BOARDS	☐STUD. SEMINARS	☐ ADD-ON COURSES	☐ WEBNIARS

ASSESSMENT METHODOLOGIES-DIRECT:

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☑ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT:

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by | **Approved by**

Dr. P Janaki & Mr. T Karthik | **H.O.D, EEE**

LIST OF EXPERIMENTS (Performed in the lab)

S. No	Name of the Experiment
1	Sequence Impedance of 3-Phase Transformer.
2	Sequence Impedance of -Phase Alternator by Fault Analysis
3	Sequence Impedance of 3-Phase Alternator Direct method.
4	ABCD parameters of Transmission network.
5	Load flow studies using Gauss-Seidel method
6	Transient analysis of Single Machine Connected to Infinite Bus (SMIB).
7	Load Frequency Control of Two Area with & without control
8	Modelling of Transformer and simulation of Lossy Transmission Line.
9	Simulation of Transient Response of RLC circuits. a. Response to Pulse Input. b. Response to Step Input. c. Response to Sinusoidal Input.
10	Simulation of Single Phase Full Converter using RLE Loads and Single Phase AC Voltage Controller using RL Loads
Additional Experiments:	
1	Unsymmetrical Fault Analysis
2	Ferranti Effect of Transmission Line
3	Load Flow Studies using N-R method.
4	Economic Load Dispatch with & without Losses

INDEX SHEET

S. No	Name of the Experiment	CO	PO/PSO
1	Sequence Impedances of 3 Phase Transformer.	CO1	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12,PSO1,PSO2
2	Sequence Impedances of 3 Phase Alternator by Fault Analysis.	CO1	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12,PSO1,PSO2
3	Sequence Impedances of 3 Phase Alternator by Direct method.	CO1	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12,PSO1,PSO2
4	ABCD parameters of Transmission line.	CO2	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12, PSO1,PSO2
5	Load flow studies using Gauss-Seidel method	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
6	Load Frequency Control of Two Area with & without control	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
7	Transient analysis of Single Machine Connected to Infinite Bus (SMIB).	CO4	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
8	Modelling of Transformer and simulation of Lossy Transmission Line.	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
9	Simulation of Transient Response of RLC circuits. a. Response to Pulse Input. b. Response to Step Input. c. Response to Sinusoidal Input.	CO4	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
10	Simulation of Single Phase Full Converter using RLE Loads and Single Phase AC Voltage Controller using RL Loads.	CO5	PO1,PO2,PO3,PO4,PO5,PO8,PO9,PO10,PO12, PSO1,PSO2
Additional Experiments			
1	Unsymmetrical Fault Analysis	CO1	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12,PSO1,PSO2
2	Ferranti Effect of Transmission Line	CO2	PO1,PO2,PO3,PO4, PO6, PO7,PO8, PO9,PO10, PO11,PO12, PSO1,PSO2
3	Load Flow Studies using N-R method.	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2
4	Economic Load Dispatch with & without Losses	CO3	PO1,PO2,PO5,PO8,PO9,PO10,PO12,PSO1,PSO2

1. SEQUENCE IMPEDANCE OF 3-PHASE TRANSFORMER

AIM: To determine Sequence Impedance i.e. Positive, Negative and Zero-Sequence Impedance of a
3-Phase Transformer.

APPARATUS REQUIRED:

S. No	Item	Type	Range	Quantity
1	Transformer	3-Phase	230/230V, 2KVA	1
2	Voltmeter	Digital	(0-600)V	1
3	Ammeter	Digital	(0-10)A	1
4	Variac	3-Phase	(0-440)V	1
5	Wattmeter	UPF	(0-600) V/10A	1
6	Connecting Wires	-	-	Needed

CIRCUIT DIAGRAM:

Measurement of Positive and Negative SequenceImpedance:

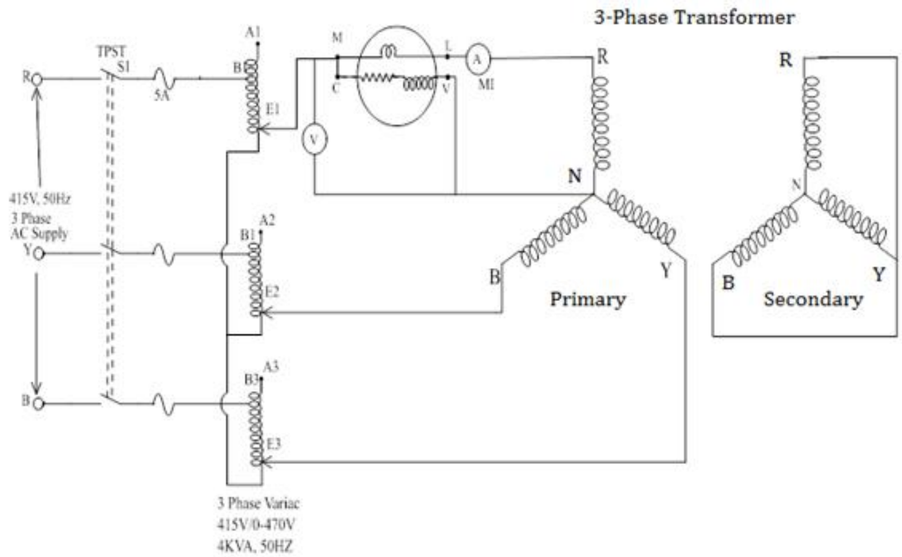


Fig. Circuit diagram for Positive and Negative Sequence

Measurement of Zero Sequence Impedance:

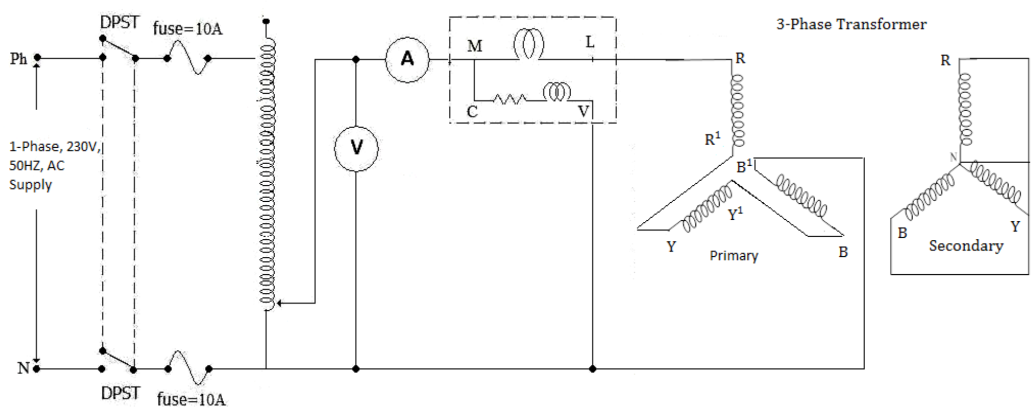


Fig. Circuit diagram for Zero Sequence

THEORY:

The sequence Impedances of equipment or a component of power system are the positive, negative and zero sequence impedances. They are defined as follows: The positive sequence impedance of equipment is the impedance offered by the equipment to the flow of positive sequence currents. The negative or zero sequence impedance of the equipment is the impedance offered by the equipment to the flow of corresponding sequence current. For a 3-Phase symmetrical static circuit without internal voltages like transformers and transmission lines, the impedances of the currents of any sequence are the same in the three phases; also the currents of a particular sequence will produce drop of the same sequence or a voltage of a particular sequence will be produce current of the same sequence only, which means there is no, mutual coupling between the sequence networks .Since for a static device, the sequence has no significance, the positive and negative sequence impedances are equal; the zero sequence impedance which includes the impedance of the return path through the ground, in the general case, is different from the positive and negative sequence impedance.

PROCEDURE:

Measurement of Positive and Negative Sequence Impedance:

1. Connect the circuit as shown in Circuit Diagram
2. By using 3-Phase variac, apply the rated current of the primary and note down the voltage,
   Current and power

Measurement of Zero Sequence Impedance:

1. Connect the circuit as shown in the circuit diagram
2. By using 1-Phase variac apply the rated current to the primary of the transformer and note down the voltage, current and power.

PRECAUTIONS:

1. Avoid loose and wrong connections
2. Ensure that the auto transformer is at minimum position before powering the circuit.
3. Do not exceed the rated current of transformer while conduction experiment.

OBSERVATION TABLE:

Positive and Negative Sequence Impedance:

Voltage(V)(Volts)	Current(I)(Amps)	Power(W)(Watts)

Zero Sequence Impedance:

Voltage(V)(Volts)	Current(I)(Amps)	Power(W)(Watts)

CALCULATIONS:

Positive and Negative Sequence Impedance:

$Z_1 = Z_2 = \frac{V}{I}=$

$R_1 = \frac{W}{I^2}$=

$X_1 = X_2 = \sqrt{Z_1^2 - R_1^2}$=

Zero Sequence Impedance:

$Z_0 = \frac{V}{3I}$=

$R_0 = \frac{W}{3I^2}$=

$X_0 = \sqrt{Z_0^2 - R_0^2}$ =

RESULT:

OUTCOMES:

APPLICATIONS:

1. Power transformers can alter from one voltage to another at high power levels. These transformers are used in various electronic circuits and also available in various types and applications.
2. Power transformers are used in the high voltage transmission network to step up and step down the voltage. These transformers are generally used for the purpose of transmission of heavy loads.
3. These transformers are big in size compared with distribution transformers, that are used in producing station and transmission substation. Power transformers are used in the transmission n/w. So they do not connect directly connect to the consumers. So load fluctuations of transformer are less.

QUESTIONS FOR SELF ASSESSMENT:

1. Define symmetrical components.
2. What is the importance of sequence impedances?
3. The impedances of rotating machines to currents of the three sequences will generally be
   a) Same for each sequence
   b) Different for each sequence
4. What is the utility of three-phase three-winding transformer?
5. Why is tertiary winding connected in delta?

2. SEQUENCE IMPEDANCE OF 3-PHASE ALTERNATOR BY FAULT ANALYSIS

AIM: To determine the Sequence Impedances of Alternator by creating different faults (without fault impedance).

APPARATUS:

S. No	Item	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1
2	Ammeter	MI	(0-5)A	1
3	Ammeter	MC	(0-2)A	1
4	Rheostats	WW	300Ω/1.5A	3
5	SPST Switch	-	-	1
6	Tachometer	Digital	(0-9999)RPM	1
7	Connecting Wires	-	-	Needed

CIRCUIT DIAGRAM:

For L-G Fault:

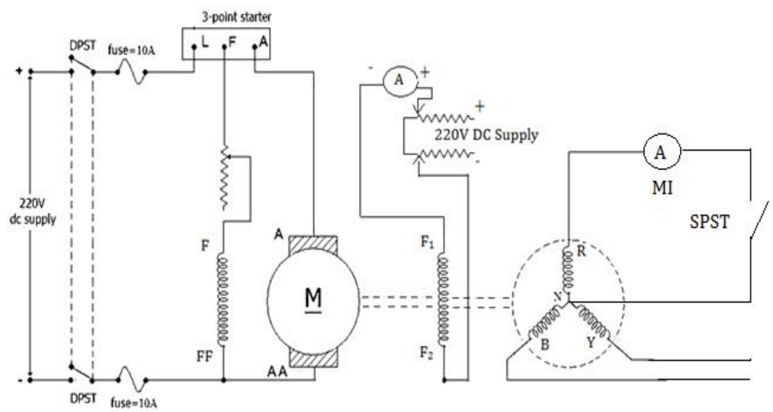


Fig Circuit diagram for L-G fault

For L-L Fault:

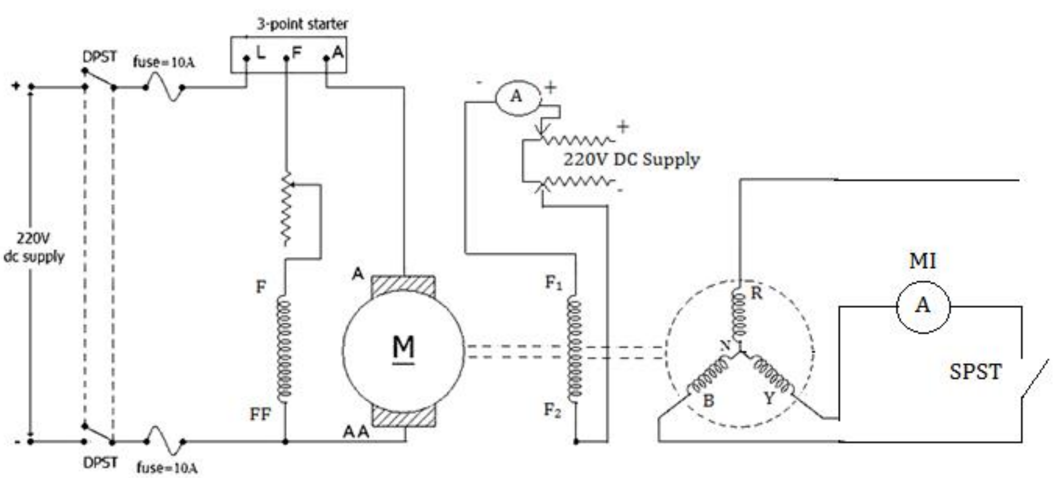


Fig Circuit diagram for L-L fault

For L-L-G Fault:

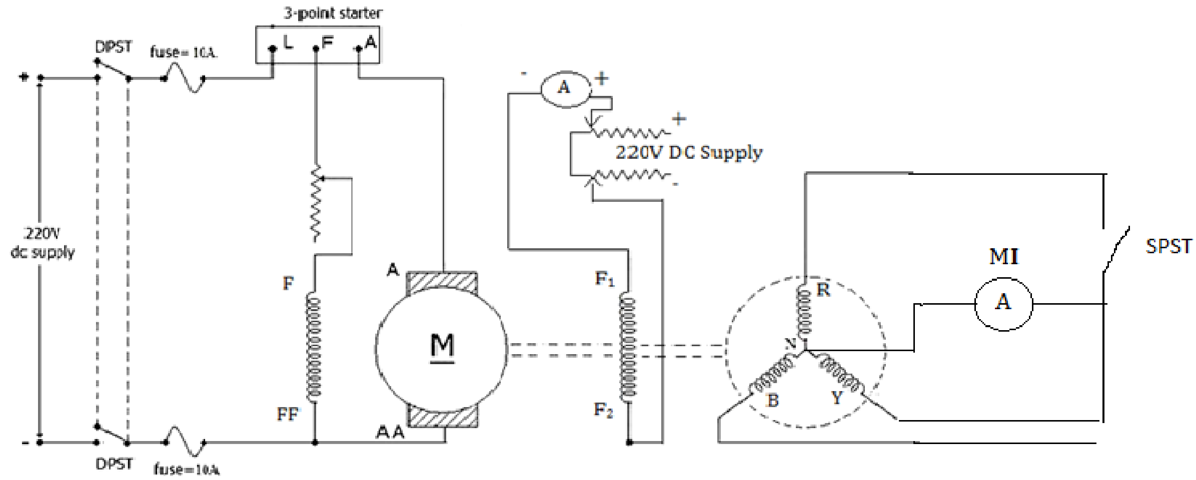


Fig Circuit diagram for L-L-G fault

THEORY: In general the faults can be classified as

1. Shunt Faults (Short Circuits)
2. Series Faults (Open Conductor)

Shunt type faults involves power conductor or conductors-to-ground or short circuit between conductors. When circuits are controlled by fuses or any device which does not open all three phases, one or two phases of the circuit may be opened while the other phases or phase is closed.

These are called series type of faults. These faults may also occur with one or two broken conductors. Shunt faults are characterized by increasing in current and fall in voltage and frequency whereas series faults are characterized by increase in voltage and frequency and fall in the faulted phases. Shunt type of faults are classified as:

1. Line – to – Ground Fault
2. Line – to – Line Fault
3. Double Line – to – Ground Fault
4. 3-Phase Fault

Of these, the first three are the unsymmetrical faults as the symmetry is disturbed in one or two phases. The method of symmetrical components will be utilized to analyze the unbalancing in the system. The 3-phase fault is a balanced fault which could also be analyzed using symmetrical components.

The series faults are classified as:

1 One open conductor,

2. Two open conductors

These faults also disturb the symmetry in one or two phases and are, therefore, unbalanced faults. The method of symmetrical components can be used for analyzing such situations in the system.

PROCEDURE:

1. Connect the circuit as shown in Figure
2. Adjust the speed of the motor to rated speed
3. Vary the excitation of alternator to minimum position and close the Alternator MCB switch

4. Slowly increase the excitation until the fault current is equal to rated current of alternator and note down the line and phase voltages.
5. The above procedure is repeated for different types of faults.

PRECAUTIONS:

1. Pre fault voltage should be low.
2. Do the connections properly at fault analyzer

OBSERVATION TABLE:

Type of Fault	I_a	I_b	Field Current(I_f)	Prefault Voltage(E_a)
LG				
LLG				
LL				

MODEL CALCULATIONS:

For L-L-G Fault:

$$I_a = \frac{E_a}{z_1 + \left(\frac{1}{z_2} + \frac{1}{z_0}\right)}$$

$Z_1 + \left(\frac{1}{Z2} + \frac{1}{Z0}\right) = E_a/I_a=$

For L-L Fault:

$$I_{a1} = \frac{E_a}{Z_1 + Z_2} \; and \; I_{a1} = \frac{1}{3}(\lambda - \lambda^2)I_b$$

$$\lambda - \lambda^2 = -j\sqrt{3} \qquad \therefore I_{a1} = \frac{I_b}{\sqrt{3}}$$

$$Z_1 + Z_2 = \frac{E_a \times \sqrt{3}}{I_b} = \qquad \text{---------------------} \; (1)$$

For L-G Fault:

$$I_{a1} = \frac{E_a}{Z_1 + Z_2 + Z_0}$$

$$I_a = I_{a1} + I_{a2} + I_{a0} \quad But \; I_{a1} = I_{a2} = I_{a0}$$

$$\therefore \; I_{a1} = \frac{I_a}{3}$$

$$Z_1 + Z_2 + Z_0 = \frac{E_a}{I_{a1}} = \frac{E_a \times 3}{I_a}$$

$$Z_1 + Z_2 + Z_0 = \frac{3E_a}{I_a} =$$

$$100 \pm Z_0 = \quad , Z_0 =$$

Z_1*Z_0+Z_1Z_2+Z_2Z_0=6.67*(Z_2+Z_0) ------------------------- (2)

From equation 1 &2,

Z_2=

Z_1=

RESULT:

OUTCOME:

APPLICATIONS:

1. Most power generation stations use synchronous machines as their generators. Connection of these generators to the utility grid requires synchronization conditions to be met.
2. The traction alternator usually incorporates integral silicon diode rectifiers to provide the traction motors with up to 1200 volts DC (DC traction, which is used directly) or the common inverter bus (AC traction, which is first inverted from dc to three-phase ac).
3. Alternators are used in modern automobiles to charge the battery and to power the electrical system when its engine is running.

QUESTIONS FOR SELF ASSESSMENT:

1. What are different types of faults? Give classification
2. Which one is severe fault?
3. What are symmetrical components? Why only 3 sets?
4. How do you recognize a type of fault from given sequence component?
5. What is the frequency of Positive, Negative and zero sequence component of current, how they affect machine performance?

3. SEQUENCE IMPEDANCE OF 3-PHASE ALTERNATOR

AIM: To determine experimentally Positive, Negative and Zero Sequence Impedances of 3-Phase Alternator by using direct method.

APPARATUS REQUIRED:

S. No	Item	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1
2	Ammeter	MI	(0-5)A	1
3	Ammeter	MC	(0-2)A	1
4	Rheostats	WW	300Ω/1.5A	3
5	Variac	1-Phase	(0-270)V,10A	1
6	Wattmeter	UPF	0-600V/10A	1
7	Tachometer	Digital	(0-9999)RPM	1
8	Connecting Wires	-	-	Required

CIRCUIT DIAGRAM:

Measurement of Positive Sequence Impedance:

Open Circuit test:

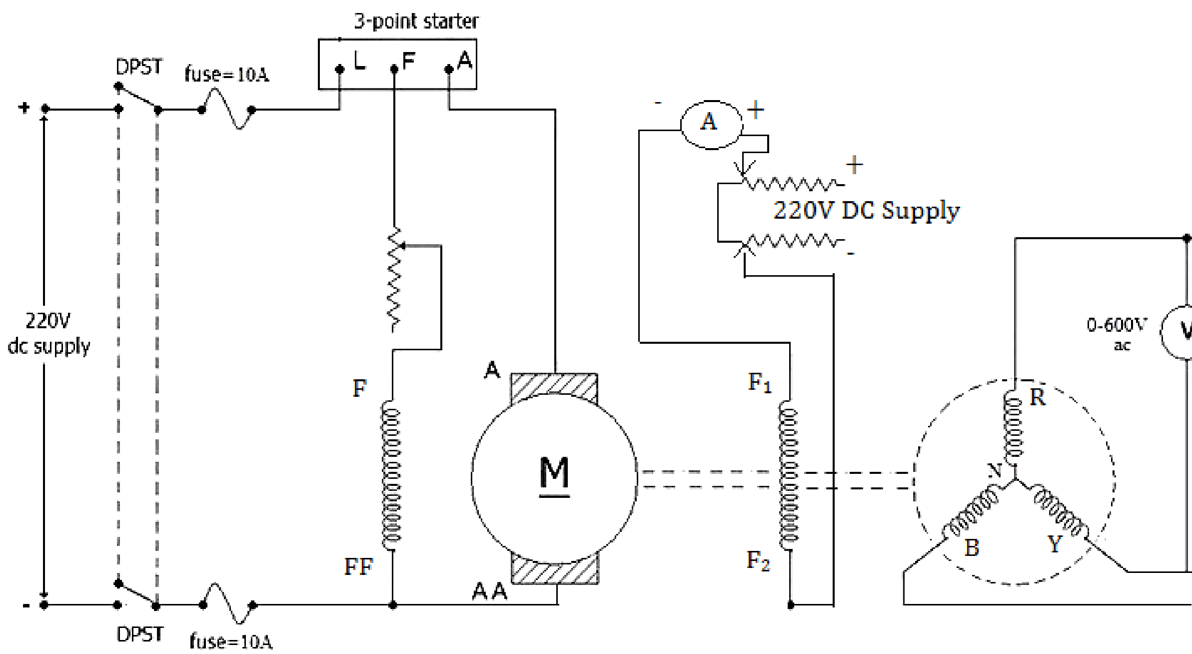


Fig. Positive Sequence Diagram for Open Circuit Test

Short circuit test:

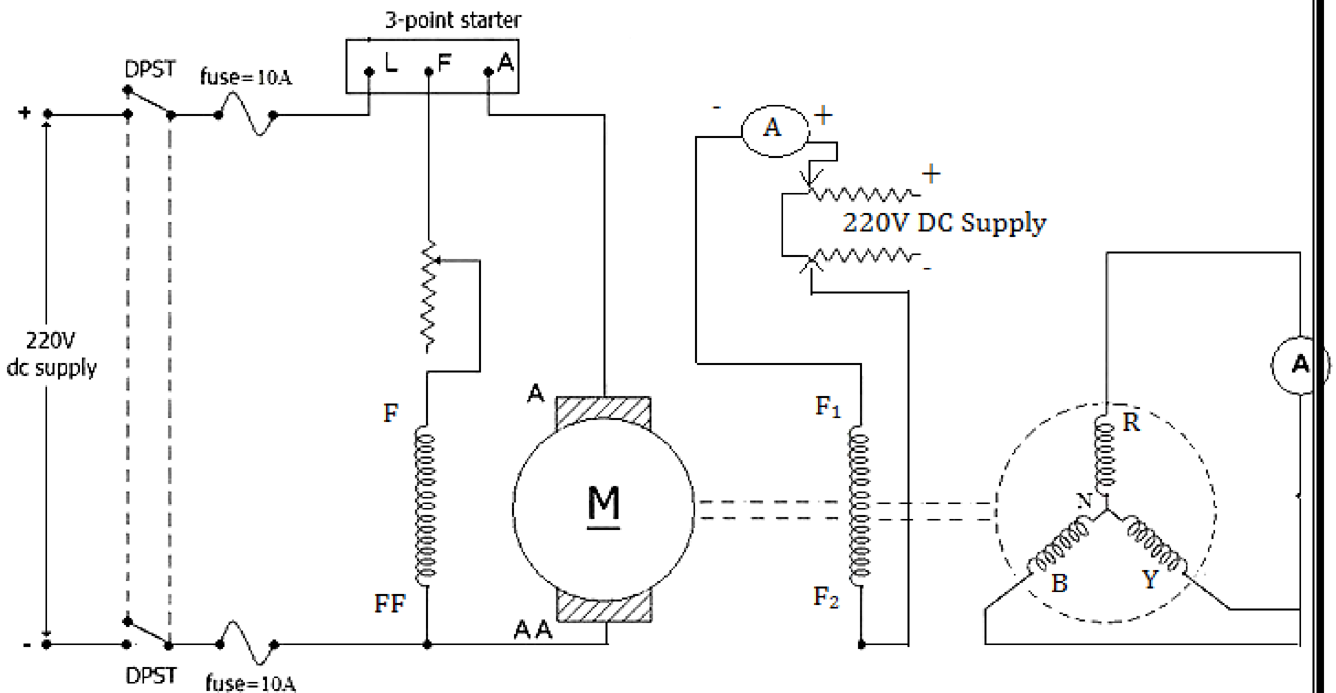


Fig. Positive Sequence Diagram for Short Circuit Test

Measurement of Negative Sequence Impedance:

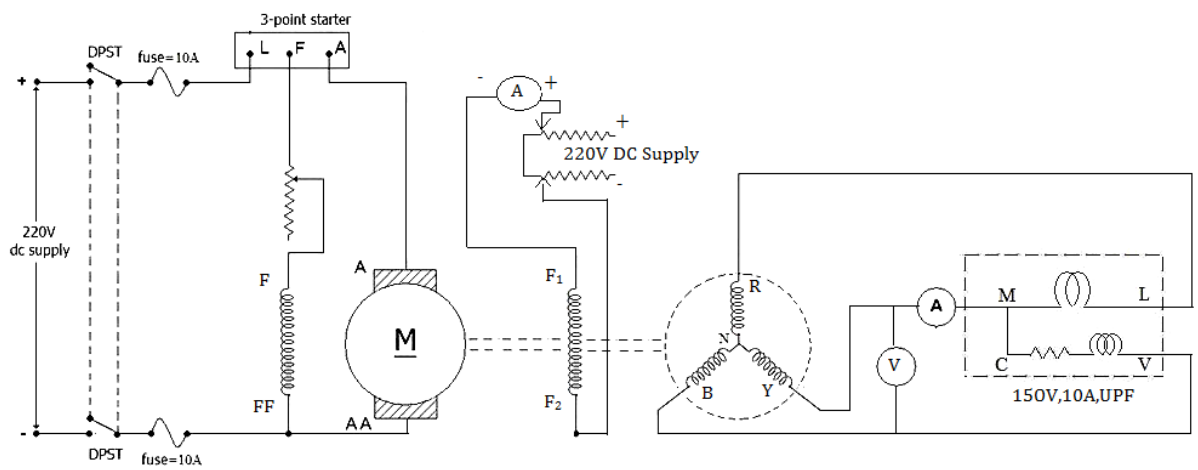


Fig. Circuit diagram for Negative Sequence

Measurement of Zero Sequence Impedance:

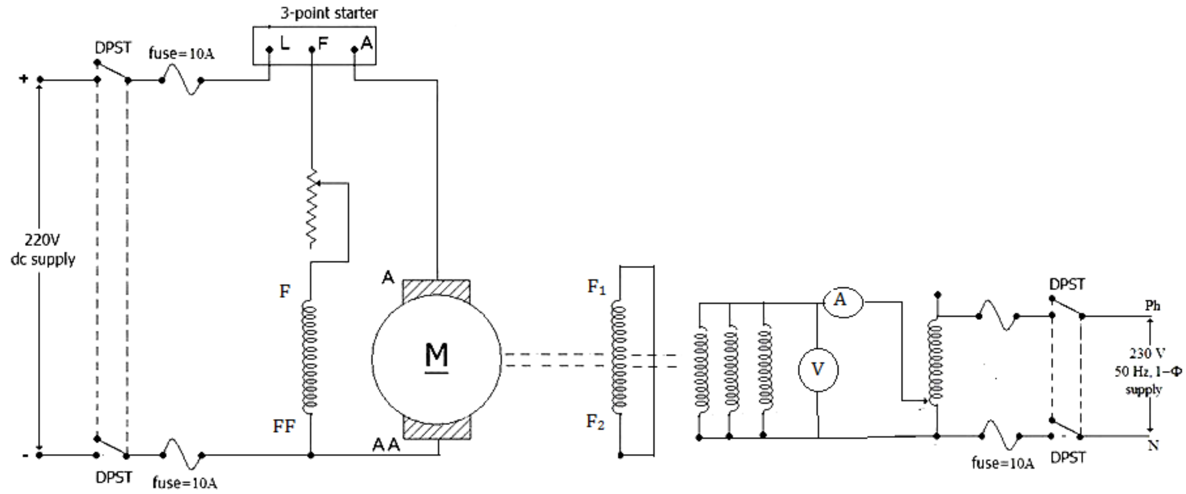


Fig. Circuit diagram for Zero Sequence

THEORY:

The sequence Impedances of equipment or a component of power system are the positive, negative and zero sequence impedances. They are defined as follows:

1. The positive sequence impedance of an equipment is the impedance offered by the equipment to the flow of positive sequence currents.
2. The negative or zero sequence impedance of the equipment is the impedance offered by the equipment to the flow of corresponding sequence current.
3. In a symmetrical rotating machines the impedances met by armature currents of a given sequence are equal in the three phases. Since by definition the inductance, which forms a part of impedances, is the flux linkages per ampere, it will depend up on the phase order of the sequence current relative to the direction of rotation of the rotor; positive, negative and zero sequence impedances are unequal in the general case.

In fact for a rotating machine, the positive sequence impedance varies, having minimum value immediately following the fault and then increases with time until steady state conditions are reached when the positive sequence impedance corresponds to the synchronous impedance.

The positive sequence impedance depends up on the working of the machine, i.e., whether it is working under sub transient, transient or steady state condition. The impedance under steady state condition is known as the synchronous impedance measured by the well known open circuit and short circuit tests.

$$Z_1 = Z_S = \frac{E_0(Per\ Phase\ Open\ Circuit\ Voltage)}{I_{SC}(Per\ Phase\ Short\ Circuit\ Current)}$$

For the measurement of Negative sequence impedance, the machine is driven at rated speed and a reduced voltage is applied to circulate approximately the rated current. It is to be noted here that since negative sequence currents flow in this case, there is possibility of hunting which will results in oscillation of the pointer of the ammeter. The mean reading may be taken.

The Negative Sequence Impedance is given by $Z_2 = \frac{V/\sqrt{3}}{I}$

Zero Sequence Impedance is quite variable and depends upon the distribution i.e., the pitch and breadth factors. If the windings were uniformly distributed so that each phase produced a sinusoidal distribution of the mmf then the superposition of the three phases with equal instantaneous currents cancel each other and produce zero filed and consequently zero reactance except for slot and end-connection fluxes. In general zero sequence impedance is much smaller than positive and negative sequence impedances. The machine must, of course, be star connected for otherwise the term zero sequence has no significance as no zero- sequence currents can flow. The machine is at standstill and a reduced voltage is applied.

The zero sequence impedance is given by $Z_0 = \frac{V}{I/3}$

PROCEDURE:

Measurement of Positive Sequence Impedance (Z_1):

OC (Open Circuit) Test:

1. Connect the Alternator set as shown in the circuit diagram and start the motor and adjust the speed to the rated value
2. Switch ON the DC supply to the field of the Alternator
3. By increasing the excitation gradually note the field current I_f and generated voltage pf the Alternator.
4. Record the readings and plot the OC Characteristics as shown in the Model Graph.

SC (Short Circuit) Test:

1. Keeping the previous connections unchanged replace voltmeter by ammeter and short the other two phase with neutral as shown in the circuit diagram.
2. Run the Alternator set at rated speed and note down the excitation current with respect to short circuit current.
3. Plot the curve filed current versus Short circuit current on the same graph drawn for Open circuit test.

Measurement of Negative Sequence Impedance (Z_2):

1. Connect the machine as shown in figure.
2. Run the machine at rated speed.
3. Gradually increase the excitation such that the short circuit does not exceed full load value.
4. Note down the readings of Voltage, Current and Power

Measurement of Zero Sequence Impedance (Z_0):

1. Connect the armature windings in parallel as shown in the circuit diagram.
2. Short circuit the Alternator field winding.
3. In this case machine need not be in running condition
4. Apply rated current to each phase winding which are connected in parallel through a single phase variac.
5. Take readings of voltage and current.

PRECAUTIONS:

1. Avoid loose and wrong connections
2. Ensure that the auto transformer is at minimum position before powering the circuit.
3. Do not exceed the rated current of transformer while conduction experiment.

OBSERVATION TABLE:

Open circuit Test for Positive Sequence:

S.No	Field Current(I_f) in Ampere	Open Circuit Voltage(E_0) in Volts
1		
2		
3		
4		
5		
6		

Short circuit Test for Positive Sequence:

S.No	Field Current(I_f) in Ampere	Short Circuit Current(I_{SC}) in Ampere
1		
2		
3		
4		

Negative Sequence:

S. No	Voltage (V)	Current(A)	$Z_2(\Omega)$	Power(W)
1				
2				
3				
4				

Zero Sequence:

S.No	Voltage (V)	Current(A)

MODEL GRAPH:

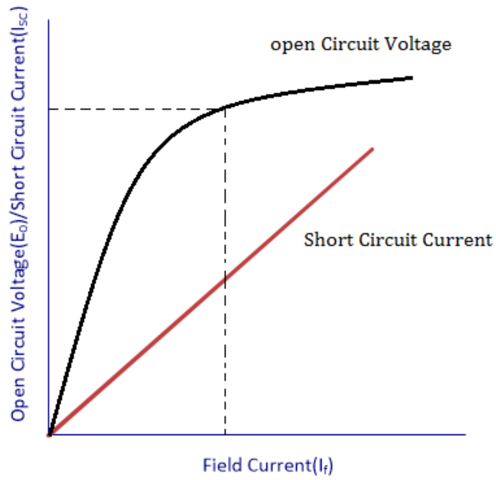


Fig Open and Short circuit characteristics

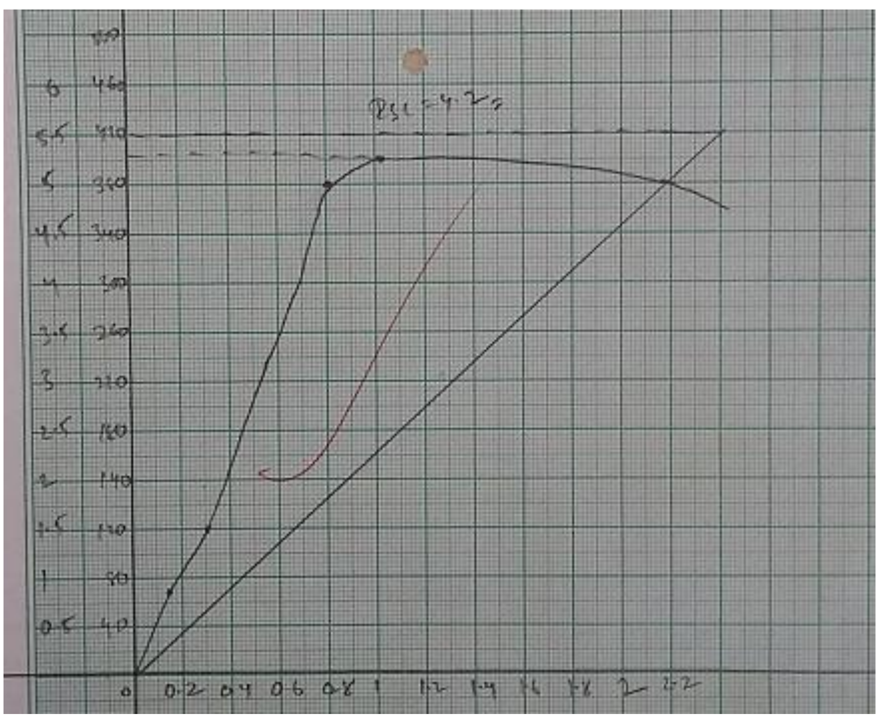
CALCULATIONS:

Positive Sequence:

Positive Sequence Impedance

$$Z_1 = Z_S = \frac{E_0(Per\ Phase\ Open\ Circuit\ Voltage)}{I_{SC}(Per\ Phase\ Short\ Circuit\ Current)} =$$

Graph:



Negative Sequence:

Negative Sequence Impedance, $Z_2 = \frac{V/\sqrt{3}}{I} =$

Wattmeter reading W=VI Sinθ

Sinθ=W/VI

Therefore Negative Sequence Reactance $X_2 = Z_2 Sin\theta$

Zero Sequence:

Zero Sequence Impedance $Z_0 = \frac{V}{I/3} =$

RESULTS: Hence conducted the experiment on 3 phase alternator and obtained the positive, negative and zero sequence impedance and the values are tabulated below

S. No	Impedance	Value (Ω)
1	Positive sequence impedance	
2	Negative sequence impedance	
3	Zero sequence impedance	

OUTCOME: By conducting sequence impedance of 3-Phase Alternator, course outcome- CO1, program outcomes- PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 and PSO2 are attained.

APPLICATIONS:

1. Most power generation stations use synchronous machines as their generators. Connection of these generators to the utility grid requires synchronization conditions to be met.
2. Alternators are used in modern automobiles to charge the battery and to power the electrical system when its engine is running.
3. The traction alternator usually incorporates integral silicon diode rectifiers to provide the traction motors with up to 1200 volts DC (DC traction, which is used directly) or the common inverter bus (AC traction, which is first inverted from dc to three-phase ac).
4. High frequency alternators of the variable-reluctance type were applied commercially to radio transmission in the low-frequency radio bands.

QUESTIONS FOR SELF ASSESSMENT:

1. What are symmetrical components? Why only 3 sets?
2. What is the frequency of Positive, Negative and Zero sequence component of current, how they affect machine performance?

4. DETERMINATION OF ABCD CONSTANTS OF SHORT, MEDIUM AND LONG LINES.

AIM: To determine ABCD constants of Transmission lines for R=4 OHMS, L=80mH, C=0.44 µf.

APPARATUS:

1. Digital Ammeter, 20A, AC - 02 Nos.
2. Digital Voltmeter, 0-600V, AC – 02 Nos.
3. Connecting Wires
4. ABCD Parameters of Transmission line kit

CIRCUIT DIAGRAM:

Short Distance Transmission Line:

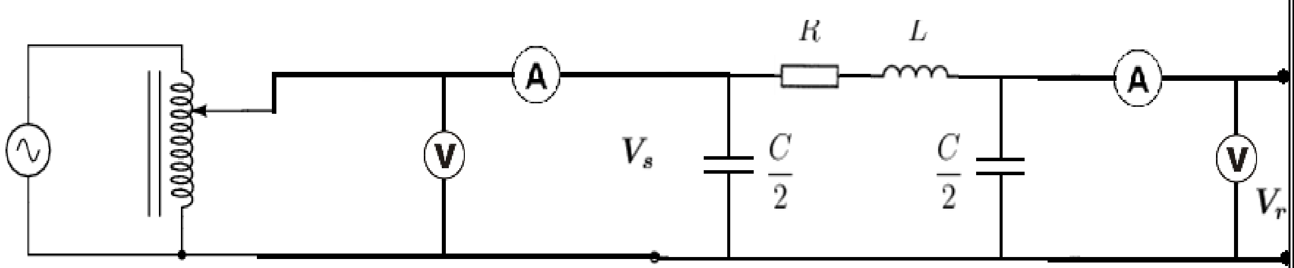


Fig. Circuit Diagram for Short Transmission Line

MediumTransmission Line:

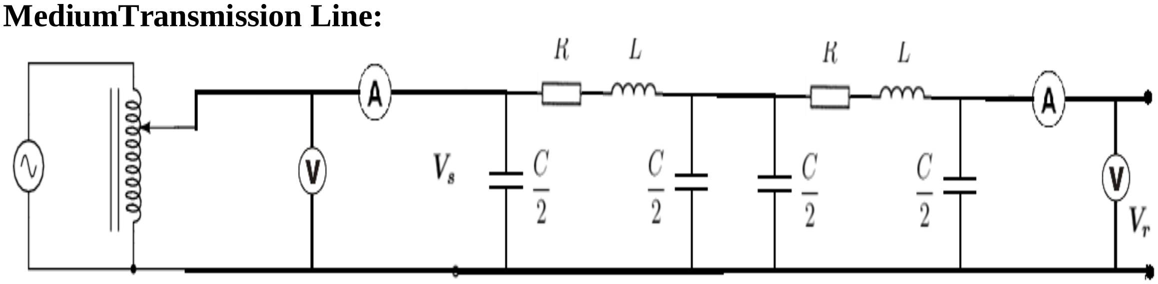


Fig. Circuit Diagram for Medium Transmission Line

Long transmission line:

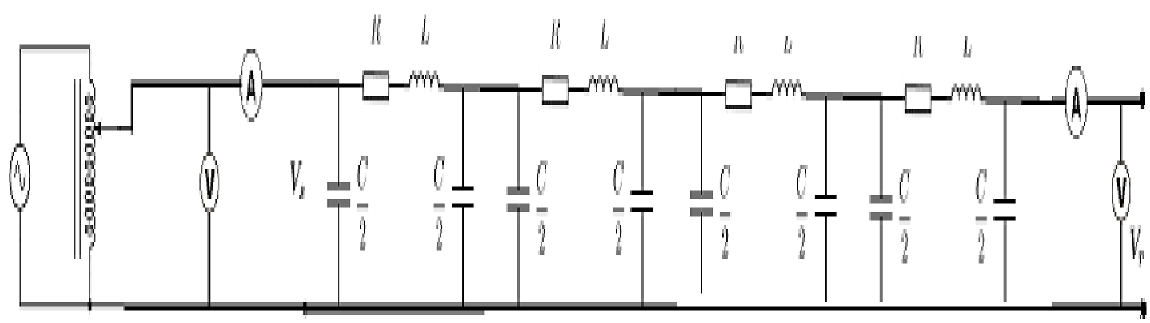


Fig. Circuit Diagram for Long Transmission Line

ABCD Transmission line KIT:

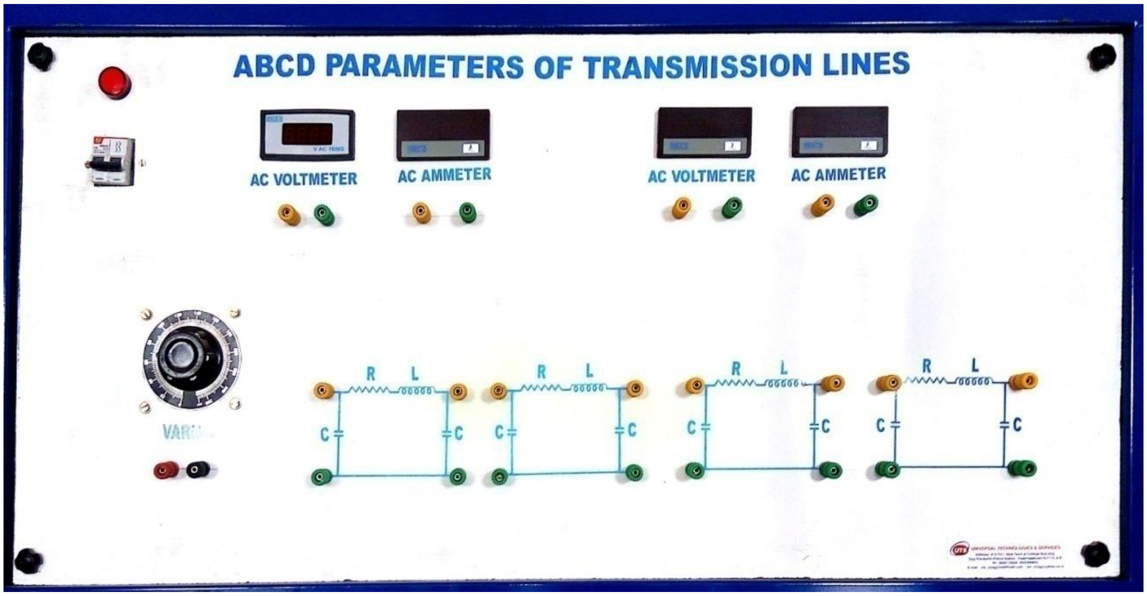


Fig. Transmission Line Front Panel Diagram

THEORY: Transmission line is the long conductor with special design (bundled) to carry bulk amount of generated power at very high voltage from one station to another as per variation of the voltage level.In transmission line determination of voltage drop, transmission efficiency, line loss etc. are important things to design. These values are affected by line parameter R, L and C of the transmission line. Length wise transmission lines are three types.

1. Short Transmission Line
2. Medium Transmission Line
3. Long Transmission Line

Short Transmission Line: The short line approximation is normally used for lines less than 50 miles long. For a short line, only a series impedance *Z* is considered, while *C* and *G* are ignored. The final result is that A = D = 1 per unit, B = Z Ohms, and C = 0. The associated transition matrix for this approximation is therefore:

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

Medium Transmission Line: The medium line approximation is used for lines between 50 and 150 miles long. In this model, the series impedance and the shunt (current leak) conductance are considered, with half of the shunt conductance being placed at each end of the line. This circuit is often referred to as a "nominal π (pi)" circuit because of the shape (π) that is taken on when leak conductance is placed on both sides of the circuit diagram. The analysis of the medium line brings one to the following result

$$A=D= 1+\frac{YZ}{2}$$

$$B=Z\ \Omega$$

$$C= 1+\frac{YZ}{4}\ \mho$$

LONG Transmission Line: The long line model is used when a higher degree of accuracy is needed or when the line under consideration is more than 150 miles long. Series resistance and shunt conductance are considered as distributed parameters, meaning each differential length of the line has a corresponding differential resistance and shunt admittance.

PROCEDURE:

Short transmission line:

Open circuit test:

1. Make connections as per circuit diagram.
2. Switch ON the trainer.
3. Set the input voltage as 40 volts by adjusting Variac
4. Note down the readings of VS, VR and IS in the digital meters.

Short circuit test:

1. Now short the output terminals of the transmission line.
2. Switch ON the trainer.
3. Set the input voltage as 10 volts by adjusting variac
4. Note down the readings of V_S, I_S and I_R in the digital meters.
5. Now repeat the above procedure (i.e conducting OC test and SC test) for medium transmission line and longtransmission line.

OBSERVATION TABLE:

OC test on short transmission line:

S. No	V_s (V)	V_r (V)	I_s (A)	A	C
1	40	42	0.03	0.95	0.00071

SC test on short transmission line:

S. No	V_s (V)	I_s (A)	I_r (A)	B	D
1	10.2	0.2	0.24	42.5	0.833

OC test on Medium transmission line:

S.	V_s (V)	V_r (V)	I_s (A)	A	C

SC test on Medium transmission line:

S. No	V_s (V)	I_s (A)	I_r(A)	B	D

THEORITICAL CALCULATIONS:

Short Transmission Line:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$$

So A=1, B=Z, C=0 and D=1

Z=R+JX

R=Transmission line resistance + internal resistance of Inductor =

AC equivalent resistance=

$Z= [R^2+(\omega L)^2]^{1/2}=$

B=

$\begin{bmatrix} A & B \\ C & D \end{bmatrix}=$

Medium Transmission Line:

$I=I_R+I_{C1}, I_S=I+I_{C2}, V_S=V_R+I_Z =V_R+(I_Z+I_{C1})Z$

$=V_R+I_RZ+V_R(Y/2)Z$

$V_S=V_R(1+ZY/2)+I_RZ$

A=1+ZY/2 and B=Z

Z=

$Y=2\pi FC=$

A=

A=D=1+(ZY/2)=

B=44.11 Ω

$I_S=I+I_{C2} =I_R+I_{C1}+I_{C2}$

$I_S=I_R+V_R(Y/2)+V_S(Y/2)$

$I_S=I_R+(V_SY/2)+(V_RY(1+(YZ/2))+(I_RZ))Y/2$

$I_S=I_R(1+(YZ/2))+V_RY(1+(YZ/4)$

SO C=Y(1+(ZY/4))

=

$\begin{bmatrix} A & B \\ C & D \end{bmatrix}=$

As two Circuits are Cascaded,

$\begin{bmatrix} A & B \\ C & D \end{bmatrix}=\begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} A & B \\ C & D \end{bmatrix}=$

$A=V_S/V_R$ at $I_R=0$

$B=V_S/I_R$ at $V_R=0$

$C=I_S/V_R$ at $I_R=0$

$D=I_S/I_R$ at $V_R=0$

RESULT:

OUTCOME:

APPLICATIONS:

1. Providing accurate real-time model for better monitoring and control of the trans- mission grid.
2. Assessing power system grid stability in near real-time with respect to overloads, static voltage limits and voltage collapse.
3. Enabling you to evaluate network control actions under a wide variety of hypothesized conditions.
4. Maintaining historical cases for after-the- fact analysis.
5. Electrical transmission system is that means of transmitting power from generating station to different load centers

QUESTIONS FOR SELF ASSESSMENT:

1. What is meant by Ferranti Effect?
2. What are the lengths and voltage ratings of short and medium transmission lines?
3. What is the condition for symmetrical and reciprocal network in terms of ABCD parameters?
4. What are ABCD values if neglecting the capacitance in the short transmission line?

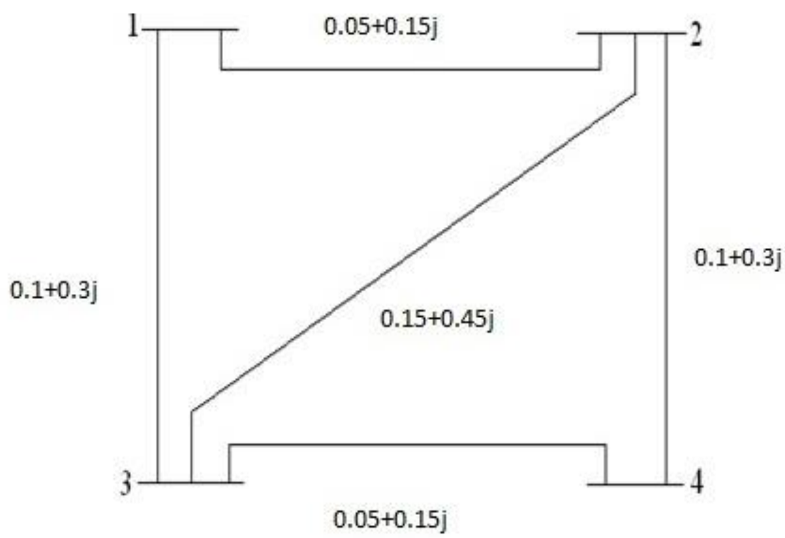
5. LOAD FLOW SOLUTION BY USING GAUSS-SEIDEL METHOD

AIM: To find load flow solution of the given power system using Gauss-Seidel method theoretically for one iteration and obtain full solution using MATLAB.

PROBLEM:

For the sample power system shown below, the generators are connected at all the four buses, while loads are at buses 2 and 3. Values of real and reactive powers are listed in the table. All buses other than the slack are PQ type. Assuming a flat voltage start, find the voltages and bus angles at the three buses at the end of first GS iteration.

Input data:



BUS	P_i, pu	Q_i, pu	V_i, pu	remarks
1	-	-	$1.04\angle 0^{0}$	Slack bus
2	0.5	-0.2	-	PQ bus
3	-1	0.5	-	PQ bus
4	0.3	-0.1	-	PQ bus

For the above system, the bus admittance matrix is

$$Y_{BUS} = \begin{bmatrix} 3-j9 & -2.00+j6 & -1.00+j3 & 0 \\ -2+j6 & +3.666-j11 & -0.666+j2 & -1+j3 \\ -1+j3 & -0.666+j2 & +3.666-j11 & -2+j6 \\ 0 & -1.00+j3 & -2.00+j6 & +3-j9 \end{bmatrix}$$

Theoretical calculations:

$$V_p = 1/y_{PP}\left[\frac{Pp - jQp}{Vp*} - \sum_{q=1top}^{n} YpqVq\right]; p = 2,3,....n$$

$v_2^{(1)}=1/Y_{22}\ [(P_2\text{-}jQ_2)/(V_2^0)^*\text{-}Y_{21}V_1\text{-}Y_{23}V_3\text{-}Y_{24}V_4]$

$v_2^{(1)}$=1/(3.66-j11)[(0.5+j0.2)/(1-j0)-1.04(-2+j6)-(-0.66+j2)-(-1+j3)]

$v_2^{(1)}$=1.019+j0.046 p.u

$v_3^{(1)}= 1/Y33\ [(P_3\text{-}jQ_3)/(V_3^0)^*\text{-}Y_{31}V_1^1\text{-}Y_{32}V_2^1\text{-}Y_{34}V_4^0]$

$v_3^{(1)}$=1/(3.66-j11)[(- 1-j0.5)/(1-j0) -(-1+j3)1.04-(-0.66+j2)(1.019+j0.046) -(-2+j6)]

$v_3^{(1)}$=1.028-j0.087 p.u

$v_4^{(1)}= 1/Y44\ [(P_4\text{-}jQ_4)/(V_4^0)^*\text{-}Y_{41}V_1^1\text{-}Y_{42}V_2^1\text{-}Y_{43}V_3^1]$

$v_4^{(1)}$=1/(3-j9)[(0.3+j0.1)/(1-j0)-(-1+j3)(1.019+j0.046)- (-2+j6)(1.028-j0.087)]

$v_4^{(1)}$=1.025-j0.0092

APPARATUS: MATLAB SOFTWARE

THEORY:
Load flow analysis is the study conducted to determine the steady state operating condition of the given system under given conditions. A large number of numerical algorithms have been developed and Gauss Seidel method is one of such algorithm.

Problem Formulation
The performance equation of the power system may be written of
[I bus] = [Y bus][V bus] …………..(1)

Selecting one of the buses as the reference bus, we get (n-1) simultaneous equations. The bus loading equations can be written as
Ii = Pi-jQi / Vi* (i=1,2,3,…………..n)……………… (2)

Where
Pi=Re $\sum_{K=1}^{n}$ Vi ∗ Yik Vk] …………… (3)

Qi= -Im [$\sum_{K=1}^{n}$ Vi ∗ Yik Vk]. ………….(4)

$$\sum_{K=1}^{n} \text{Vi} * \text{Yik Vk}$$

The bus voltage can be written in form of

Vi=(1.0/Yii)[Ii- Σ YijVj] ………….(5)
j=1
j≠i(i=1,2,…………n)&i≠slack bus

Substituting Ii in the expression for Vi, we get
n
Vi new=(1.0/Yii)[Pi-JQi / Vio* - Σ YijVio]…….. (6)
J=1
The latest available voltages are used in the above expression, we get
nn
Vi new=(1.0/Yii)[Pi-JQi / Voi* - Σ YijVjn- Σ YijVio] ----------(7)
J=1 j=i+1

Algorithm

Step1: Read the data such as line data, specified power, specified voltages, Q limits at the generator buses and tolerance for convergences
Step2: Compute Y-bus matrix.
Step3: Initialize all the bus voltages.
Step4: Iter=1
Step5: Consider i=2, where i' is the bus number.
Step6: check whether this is PV bus or PQ bus. If it is PQ bus goto step 8 otherwise go to next step.
Step7: Compute Qi check for q limits violation. QGi=Qi+QLi.
7).a).If QGi>Qi max, equate QGi = Qimax. Then convert it into PQ bus.
7).b).If QGi<Qi min, equate QGi = Qi min. Then convert it into PQ bus.
Step8: Calculate the new value of the bus voltage using gauss seidal formula.
i=1: n
Vi= (1.0/Yii) [(Pi-j Qi)/(V_i^0)*- $\sum_{j=1}^{n}$ Yij Vj − Σ YijVj0]
J=1 J=i+1
Adjust voltage magnitude of the bus to specify magnitude if Q limits are not violated.
Step9: If all buses are considered go to step 10 otherwise increments the bus no. i=i+1 and Go to step6.
Step10: Check for convergence. If there is no convergence goes to step 11 otherwise go to step12.
Step11: Update the bus voltage using the formula.
Vinew=Vi old+ α(vinew-Viold) (i=1,2,…..n) i≠ slackbus ,α is the acceleration factor=1.4
Step12: Calculate the slack bus power, Q at P-V buses real and reactive give flows real and reactance line losses and print all the results including all the bus voltages and all the bus angles.
Step13: Stop

PROCEDURE:

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File.
3. Type and save the program in the editor Window.
4. Execute the program by pressing Tools – Run.
5. View the results.

MATLAB PROGRAM FOR GAUSS SEIDAL METHOD:

```
% Load flow using gauss seidel method
clc
clear
n=4;
V=[1.04 1 1 1];
Y=[3-j*9 -2+j*6 -1+j*3 0
-2+j*6 3.666-j*11 -0.666+j*2 -1+j*3
-1+j*3 -0.666+j*2 3.666-j*11 -2+j*6
0 -1+j*3 -2+j*6 3-j*9];
type=ones(n,1);
typechanged=zeros(n,1);
Qlimitmax=zeros(n,1);
Qlimitmin=zeros(n,1);
Vmagfixed=zeros(n,1);
type(2)=2;
Qlimitmax(2)=1.0;
Qlimitmin(2)=-0.2;
Vmagfixed(2)=1.04;
diff=10;
noofiter=1;
Vprev=V;
while (diff>0.00001 | noofiter==1),
abs(V);
abs(Vprev);
Vprev=V;
P=[inf 0.5 -1 0.3];
Q=[inf -0.3 0.5 -0.1];
S=[inf 0.5-j*0.2 -1.0+j*0.5 0.3-j*0.1];
for i=2:n,
if type(i)==2 |typechanged(i)==1,
if (Q(i)>Qlimitmax(i)| Q(i)<Qlimitmin(i))
if (Q(i)<Qlimitmin(i))
Q(i)=Qlimitmin(i);
else
Q(i)=Qlimitmax(i);
end
type(i)=1;
typechanged(i)=1;
else
type(i)=2;
typechanged(i)=0;
end
end
sumyv=0;
for k=1:n,
if(i~=k)
```

```
sumyv=sumyv+Y(i,k)*V(k);
end
end
V(i)=(1/Y(i,i))*((P(i)-j*Q(i))/conj(V(i))-sumyv)
if type(i)==2 &typechanged(i)~=1,
V(i)=PolarTorect(Vmagfixed(i),angle(V(i)*180/pi))
end
end
diff=max(abs(abs(V(2:n))-abs(Vprev(2:n))));
noofiter=noofiter+1
end
```

EXPECTED OUTPUT:

No of Iterations	V_1	V_2	V_3	V_4

RESULT:

OUTCOME:

QUESTIONS FOR SELF ASSESSMENT:

1. What are the information's that are obtained from a load flow study?
2. What is the need for load flow study?
3. What are the different types of buses?
4. What are the iterative methods used for solution of load flow problems?
5. What are the advantages of GS method?

6. TRANSIENT STABILITY ANALYSIS SINGLE MACHINE CONNECTED TO INFINITE BUS (SMIB)

AIM: To determine transient stability of single machine connected to infinite bus by point by point method

APPARATUS: MATLAB software with PC compatibility

THEORY:

Stability of power system is its ability to return to normal or stable operating conditions after having been subjected to some form of disturbance. Increase in load is a kind of disturbance. Causes for disturbances are

1. Change in load
2. Loss of excitation
3. Switching operation
4. Fault conditions

PROBLEM:

A 20 MVA, 50 HZ generator delivers 18MW over a double circuit line to an infinite bus. The generator has kinetic energy of 2.52MJ/MVA at rated speed. The generator transient reactance is X^1_d =0.35pu. Each transmission circuit has R=0 and reactance of 0.2pu on a 20MVA base. $|E^1|$=1.1pu and infinite bus voltage (V)= $1.0<0^0$. A 3-ø short circuit occurs at midpoint of one of transmission lines. Plot swing curve for 0.25cycles.

CALCULATION:

Base MVA =20

Inertia constant M(pu) = $GH/180^0f$ =1*2.52/(180*50) =$2.8*10^{-4}S^2$/elec.degree

Pre fault:

X_L=0.35 +0.2/2 =0.45

Pe_1=$p_{max1}\sin\delta$

= 1.11*1/0.45 sin δ

=2.44 sin δ

Pre fault power transfer=18/20 =0.9pu

Initial power angle is given by

$$2.44 \sin\delta_0 = 0.9$$

$$\delta_0 = 21.64^0$$

During fault:

X_{11} = ((0.35*0.1)+(0.2*0.1)+(0.35*0.2))/0.1

= 1.25 PU

$Pe_{11} = p_{max11} \sin\delta$

= 1.11*1/ (1.25) sin δ

= 0.88 sin δ

Past fault:

X_{111} = 0.35 +0.2 =0.55

$Pe_{111} = p_{max111} \sin\delta$

= 1.11*1/(0.55) sin δ

= 2 sin δ

Let us choose $\Delta t = 0.05$sec

$P_a(n-1) = P_m - P_{max} \sin \delta (n-1)$

$\Delta\delta_n = \Delta\delta_{n-1} + (\Delta t)^2/m \; P_a(n-1)$

$\delta_n = \delta_{n-1} + \Delta\delta_n$

P_a for first interval

$P_a(O) = \Delta P_u$ and $P_a(o_+) = 0.99 - 0.88 \sin(21.64^0)$

$= 0.576$ pu

$P_a(o_{avg}) = (0+0.576)/2$

$= 0.288$ Pu

$\delta(0.15S) = \delta(0.15) + \Delta\delta(0.15S)$

$= 31.59^0 + 11.33^0$

$= 42.89^0$

PROGRAM:

```
clear
t=0
tf=0
tfinal=0.5
tc=0.1250
tstep=0.0500
m=2.52/(180*50)
i=2
delta=21.64*pi/180
ddelta=0
time(1)=0
ang(1)=21.64
pm=0.9
pmaxbf=2.44
pmaxdf=0.88
pmaxaf=2.00
while t<tfinal
if(t==tf)
paminus=0.9-pmaxpf*sin(delta)
paplus=0.9-pmaxaf+sin(delta)
paav=(paminus+paplus)/2
pa=paav
end
if(t==tc)
paminus=0.9-pmaxpf*sin(delta)
paplus=0.9-pmaxaf+sin(delta)
paav=(paminus+paplus)/2
pa=paav
end
if(t>tf&t<tc)
pa=pm-pmaxdf*sin(delta)
end
if(t>tc)
pa=pm-pmaxdf*sin(delta)
```

```
end
t,pa
ddelta=ddelta+(tstep*tstep*pa/m)
delta=(delta*180/pi+ddelta)*pi/180
deltadeg=delta*180/pi
   t=t+tstep
pause
time(i)=t
ang(i)=deltadeg
   i=i+1
end
axis=((0.06 0.160)
plot(time,ang,'k0-')
```

OBSERVATION TABLE:

t(sec)	P_{max}(pu)	sinδ	$P_e = P_m \sin\delta$(Pu)	P_a=0.9-P_e (Pu)	$(\Delta t)^2/m\ P_a$	Δδ (deg)	Δ (deg)

RESULT: Swing curve for the given problem is observed using MATLAB software program **s**wing equation, $M\ d^2\delta/dt = P_a$

OUTCOME: By doing MATLAB program on transient stability analysis, course outcome- CO4, program outcomes PO1, PO2, PO5, PO8, PO9, PO10, PO12, PSO1 and PSO2 are attained.

QUESTIONS FOR SELF ASSESSMENT:

1. Define stability.
2. What is meant by transient stability?
3. Define synchronizing or stiffness coefficient.
4. What is the use of swing curve?
5. List the methods of improving the transient stability limit of a power system.
6. State Equal area criterion.

7 (a) MODELING OF TRANSFORMER

AIM: To simulate the single phase transformer by using PSPICE Software

SIMULATION TOOLS REQUIRED:

- PC with PSPICE Software

THEORY:

Electrical power transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level. The working principle of transformer is very simple. It depends upon Faraday's law of electromagnetic induction. Actually, mutual induction between two or more winding is responsible for transformation action in an electrical transformer.

Consider a ring of ferromagnetic specimen of circumference L meter, cross - sectional area a m2 and N turns of insulated wire as shown in the picture beside, Let us consider, the current flowing through the coil is I amp, Magnetizing force,

$$H = \frac{NI}{L} \ or \ I = \frac{HL}{N}$$

Let, the flux density at this instant is B, Therefore, total flux through the ring, Φ = BXa Wb As the current flowing through the solenoid is alternating, the flux produced in the iron ring is also alternating in nature, so the emf (e′) induced will be expressed as,

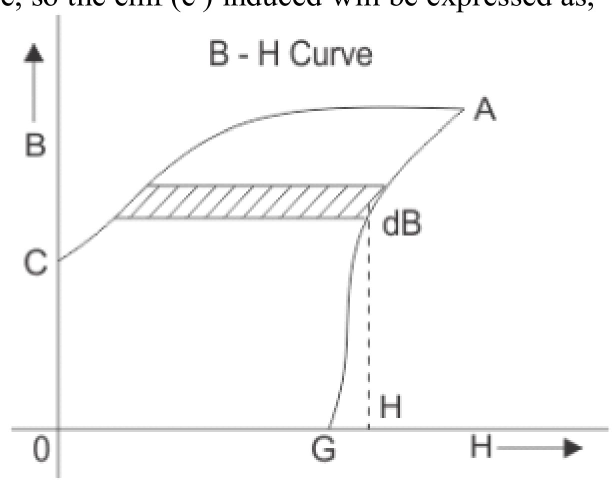


Fig: B-H CURVE

$$e' = -N\frac{d\phi}{dt}$$

$$= -N\frac{d(Ba)}{dt}$$

$$= -Na\frac{dB}{dt}$$

According to Lenz's law this induced emf will oppose the flow of current, therefore, in order to maintain the current I in the coil, the source must supply an equal and opposite emf. Hence applied emf ,

$$e = e' = Na\frac{dB}{dt}$$

Energy consumed in short time dt, during which the flux density has changed, $= e.I.dt$

$$= Na\frac{dB}{dt} \times I \times dt$$

$$= Na\frac{dB}{dt} \times \frac{HL}{N} \times dt = a.L.H.dB \; joules$$

Thus, total work done or energy consumed during one complete cycle of magnetism,

$$W = aL\int_0^{Bmax} H.dB$$

Now aL is the volume of the ring and H.dB is the area of elementary strip of B - H curve shown in the figure above,

$$\int H \cdot dB = Total\ area\ enclosed\ by\ Hysteresis\ Loop$$

Therefore, Energy consumed per cycle = volume of the ring X area of hysteresis loop. In the case of transformer, this ring can be considered as magnetic core of transformer. Hence, the work done is nothing but the electrical energy loss in transformer core and this is known as hysteresis loss in transformer.

CIRCUIT DIAGRAMS:

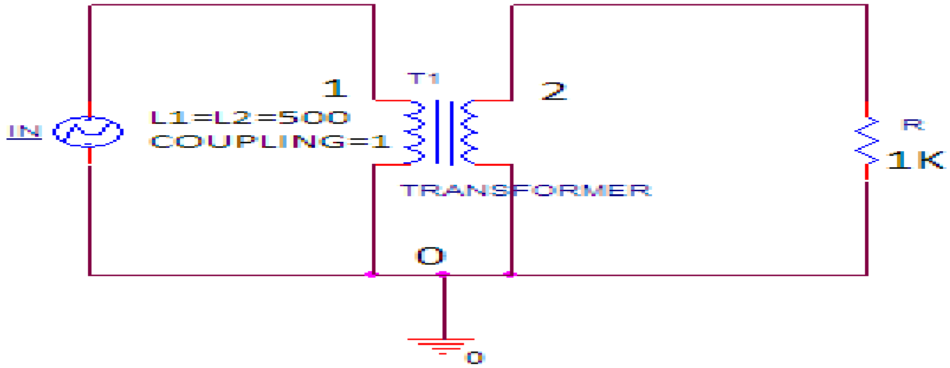


Fig: MODELING OF TRANSFORMER-CIRCUIT DIAGRAM

SPECIFICATIONS:

L1=L2=500H, K12=0.9999, AREA=2.0, PATH=62.73, GAP=0.1, MS=1.6E6, A=1E3, C=0.5 K=1500

PROGRAMS:

```
MODELING OF TRANSFORMER
IN 1 0 PWL(0 0 1 -15 2 15 3 -15)
L1 1 0 500
L2 2 0 500
```

```
R2 2 0 1000
K12 L1 L2 0.9999 CMOD
.MODEL CMOD CORE(AREA=2.0 PATH=62.73 GAP=0.1 MS=1.6E6  A=1E3 C=0.5
K=1500)
.TRAN 0.05 3
.PROBE
.END
```

PROCEDURE:

1. Write the program in a new text file in PSPICE AD.
2. Save the file using the notation filename.cir.
3. Activate the file by opening it.
4. Run the simulation process using blue button.
5. By clicking Add Trace icon, get the required waveform.

PRECAUTIONS:

1. Avoid typing, floating errors,
2. Study the all observations very carefully,
3. Save the file with extension .cir,
4. Don't tamper with settings of software.

MODEL GRAPTH

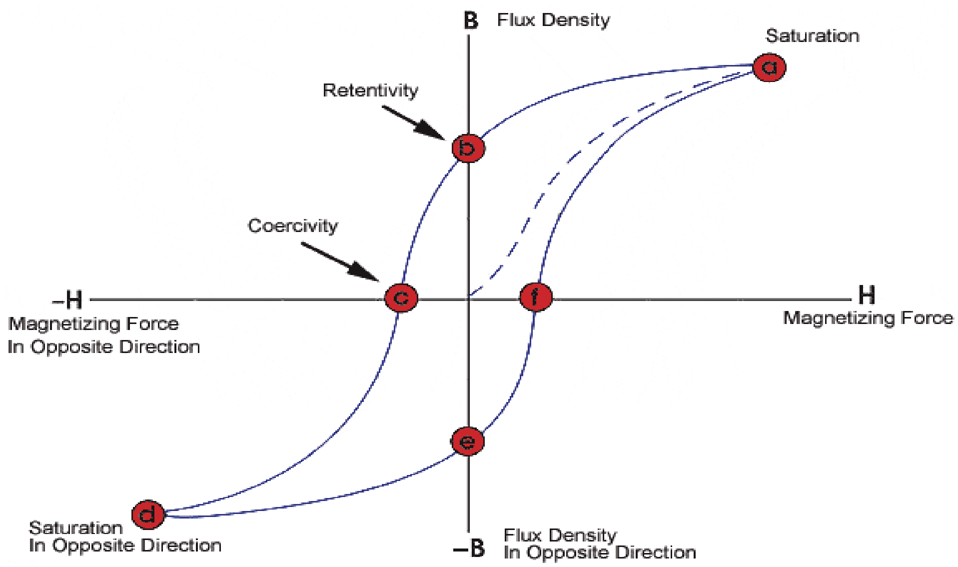


Fig: B-H CURVE

SIMULATION RESULTS:

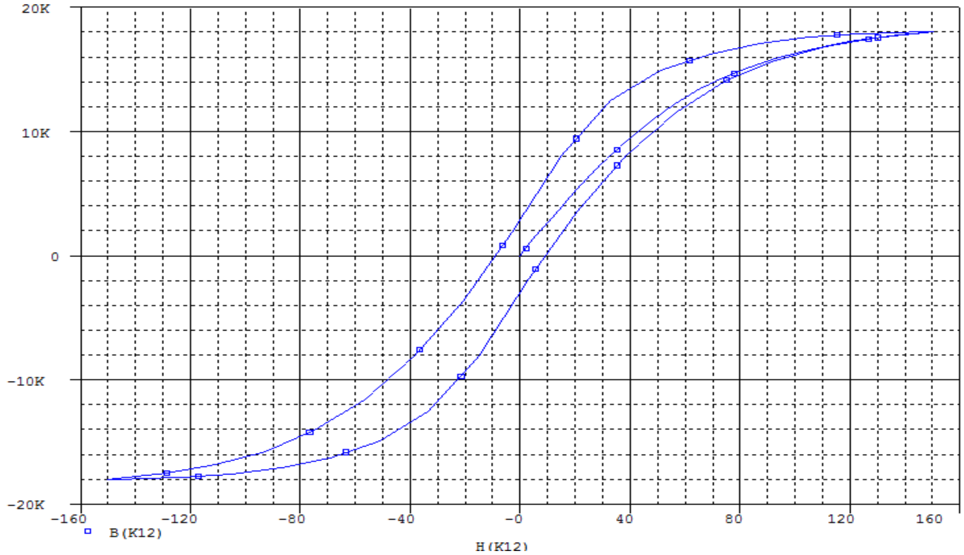


Fig: B-H CURVE

RESULT:

OUTCOME:

VIVA QUESTIONS:

1. What is transformer?
2. What are different types of magnetic materials?
3. What is significance of B-H curve?
4. How B-H curve differs from ordinary transformers to Amorphous Transformer?

7(b) SIMULATION OF A LOSSY TRANSMISSION LINE

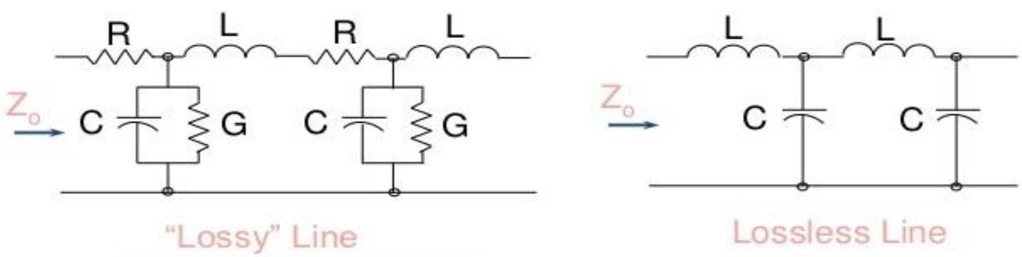
Aim: To simulate lossy transmission line parameters using PSPICE Software.

SIMULATION TOOLS REQUIRED:

- PC with PSPICE Software

THEORY

A Transmission line is a pair of conductors which have a cross which remains constant with distance. For example, a coaxial cable transmission line has a cross section of a central rod and an outer concentric cylinder. Similarly a twisted pair transmission line has two conducting rods or wires which slowly wind around each other. A cross section made at any distance along the line is the same as a cross section made at any other point on the line. We want to understand the voltage - Current relationships of transmission lines. The distributed model is in contrast to the simpler lumped element model, which assumes that the transmission line parameters (resistance, conductance, capacitance, and inductance) are lumped into ideal electrical components that are connected by perfectly conducting wires. This approach requires a finite number (usually large) of line segments in order to accurately model the behavior of the transmission line. The more line segments that are used the better the lumped element model will match the actual behavior of the transmission line. This usually leads to very large net lists and long simulation times. Unlike the lumped model, the distributed model does not require the determination of the correct number of line segments.



$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$Z_o = \sqrt{\frac{L}{C}}$$

Fig: TRANSMISSION LINE DISTRIBUTED MODEL

The uniform constant-parameter distributed transmission line model can be used to model the following types of lines:

- RLC (uniform transmission lines with series loss only)
- RC (uniform RC lines)
- LC (lossless transmission lines)
- RG (distributed series and parallel conductance).

We have been approximating loss transmission lines as lossless (R= G= 0)

CIRCUIT DIAGRAM:

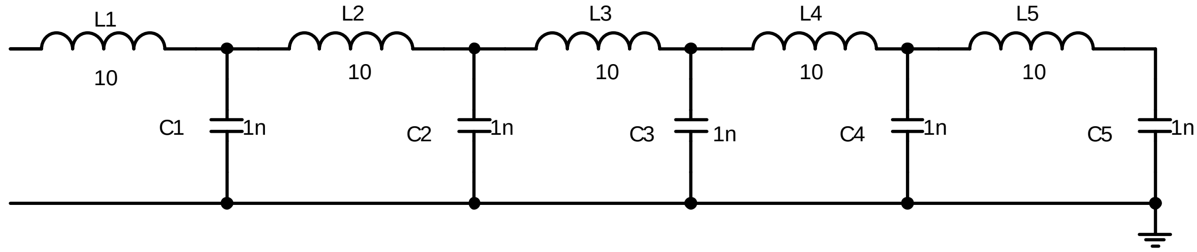


Fig: LOSS LESS TRANSMISSION LINE

SPECIFICATIONS:

V_{OFF} = 0V, V_{AMPL} = 169.7V, FREQ = 50 Hz.

PROGRAM:

PROGRAM FOR LOSS LESS TRANSMISSION LINE:

```
LOSS LESS TRANSMISSION LINE
VS 1 0 SIN (0 169.7 50)
L1 1 2 10H
L2 2 3 10H
L3 3 4 10H
L4 4 5 10H
L5 5 6 10H
C1 2 0 1NF
C2 3 0 1NF
C3 4 0 1NF
C4 5 0 1NF
C5 6 0 1NF
.TRAN 1US 2MS
.PROBE
.END
```

PROGRAM FOR LOSSSY TRANSMISSION LINE:

```
LOSSY TRANSMISSION LINE
VS 1 0 SIN (0 169.7 50)
.LIB TLINE.LIB
T1 1 0 2 0 LEN=1 R=.311 L=10 G=6.27u C=1N
T2 2 0 3 0 LEN=1 R=.311 L=10 G=6.27u C=1N
T3 3 0 4 0 LEN=1 R=.311 L=10 G=6.27u C=1N
T4 4 0 5 0 LEN=1 R=.311 L=10 G=6.27u C=1N
.TRAN 1US 20MS
.PROBE
.END
```

PROCEDURE:

1. Write the program in a new text file in PSPICE AD.
2. Save the file using the notation filename.cir.

3. Activate the file by opening it.
4. Run the simulation process using blue button.
5. By clicking Add Trace icon, get the required waveform.

PRECAUTIONS:

1. Avoid typing, floating errors,
2. Study the all observations very carefully,
3. Save the file with extension .cir,
4. Don't tamper with settings of software.

THEROTICAL CALCULATIONS:

CHARACTERISTIC IMPEDENCE $Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{10}{1n}} = \sqrt{10^{10}} = 0.1M\Omega$

SIMULATION RESULT:

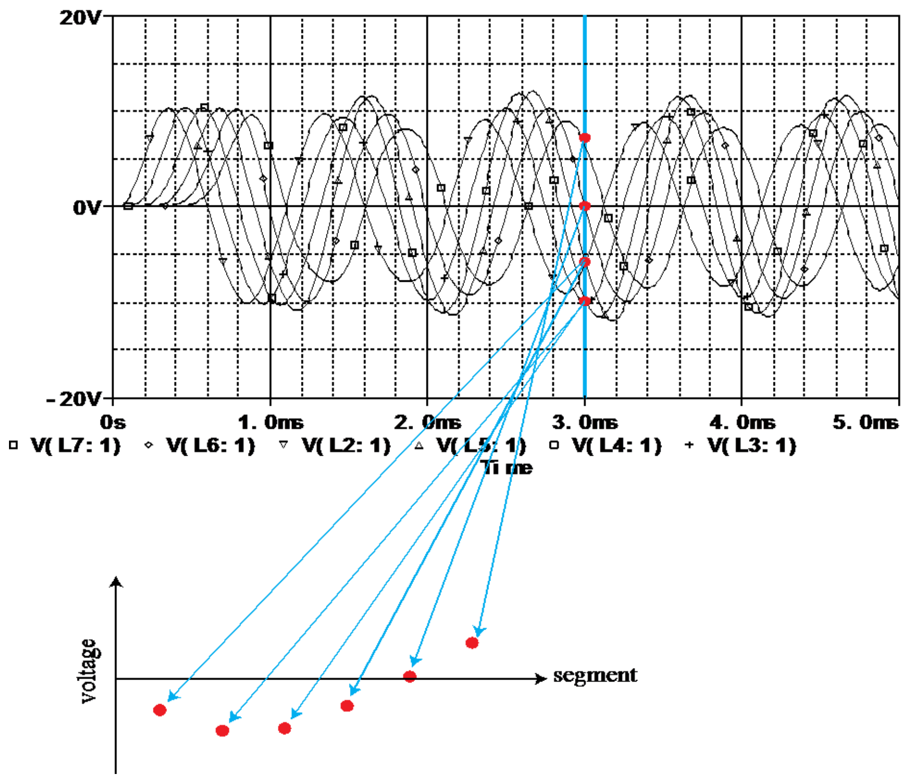


Fig: Voltages Vs Time

RESULT:

OUTCOME:

VIVA QUESTIONS:

1. What is lossy transmission line and lossless transmission line?
2. Condition to lossless transmission line
3. What is propagation delay?
4. What is surge impedance and surge loading?

8. LOAD FREQUENCY CONTROL OF THE TWO AREA SYSTEM WITH AND WITHOUT PI CONTROLLER

AIM: To simulate the two area load frequency control with and without PI Controller using MATLAB/SIMULINK Software

SIMULATION TOOLS REQUIRED:

- PC with MATLAB Software

THEORY:

Load Frequency Control (LFC) provides the control only during normal changes in load which are small and slow. So the nonlinear equations which describe the dynamic behavior of the system can be liberalized around an operating point during these small load changes and a linear incremental model can be used for the analysis thus making the analysis simpler. The linear model of LFC for an interconnected power system is presented in this section. Each area of the power system consists of speed governing system, hydraulic valve actuator (governor), turbine, generator and load.

To simplicity the frequency-domain analyses, transfer functions are used to model each component of the area. Non-reheat steam turbine is represented by the transfer function.

$$G_T(s) = \frac{\Delta P_T(s)}{\Delta P_V(s)} = \frac{1}{1+sT_T} \qquad (1)$$

From the transfer function of a governor is:

$$G_G(s) = \frac{\Delta P_V(s)}{\Delta P_G(s)} = \frac{1}{1+sT_G} \qquad (2)$$

The speed governing system has two inputs ΔP_{ref} & ΔF with one out put $\Delta P_G(s)$ given by

$$\Delta P_G(s) = \Delta P_{ref}(s) - \frac{1}{R}\Delta F(s) \qquad (3)$$

The generator and load is represented by the transfer function

$$G_P(s) = \frac{K_P}{1+sT_P} \qquad (4)$$

Where $K_P = 1/D$ and $T_P = 2H/fD$.

The generator load system has two inputs $\Delta P_T(s)$ & $\Delta P_D(s)$ with one out put $\Delta F(s)$ given by

$$\Delta F(s) = G_P(s)[\Delta P_T(s) - \Delta P_D(s)] \qquad (5)$$

The generator always adjusts its output so as to meet the power demand. In normal steady state, the turbine power P_T keeps balance with the total power demand P_D resulting in zero acceleration and a constant speed or frequency. Perturbations ΔP_T and ΔP_D in these powers will upset the above balance and if the difference power $\Delta P_T - \Delta P_D$ is positive the generator rotor unit will accelerate and vice-versa. The turbine power increment ΔP_T depends on the valve power increment ΔP_V which in turn depends on the governor output command ΔP_G.

CIRCUIT DIAGRAM:

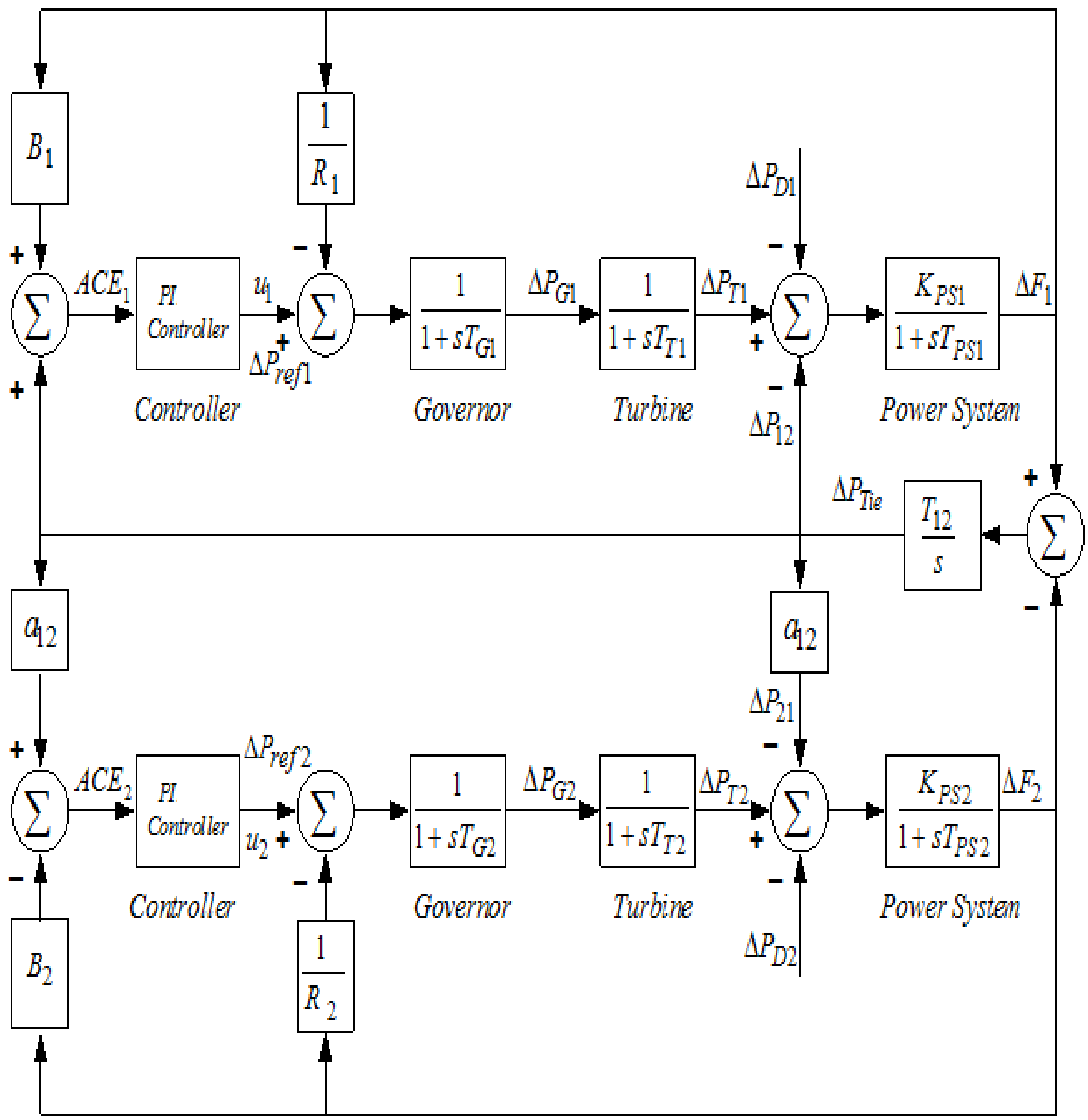


Fig: Load Frequency Control of the two area system

SPECIFICATIONS:

B1=B2=0.425;R1=R2=2.4;a12=-1;
Tg1=Tg2=0.08sec;
Tt1=Tt2=0.3sec;
Kps1=Kps2=120;
Tp1=Tp2=20sec's
tep load change 1% ;

Kp1=0.499;Ki1=-0.50;Kp2=-0.233;Ki2=-0.018;

PROCEDURE:

1. Open Matlab -> Simulink -> File -> New Model
2. Open Simulink library and browse the required components
3. Connects the components as per the circuit diagram
4. Simulate the circuit separately for with and without PI controller
5. Plot the wave forms of frequency deviations of Area 1,2 and Tie line power deviation of area 1- 2.

PRECAUTIONS:

1. Avoid typing, floating errors,
2. Study the all observations very carefully,
3. Save the file with extension .cir,
4. Don't tamper with settings of software.

SIMULATION RESULTS:

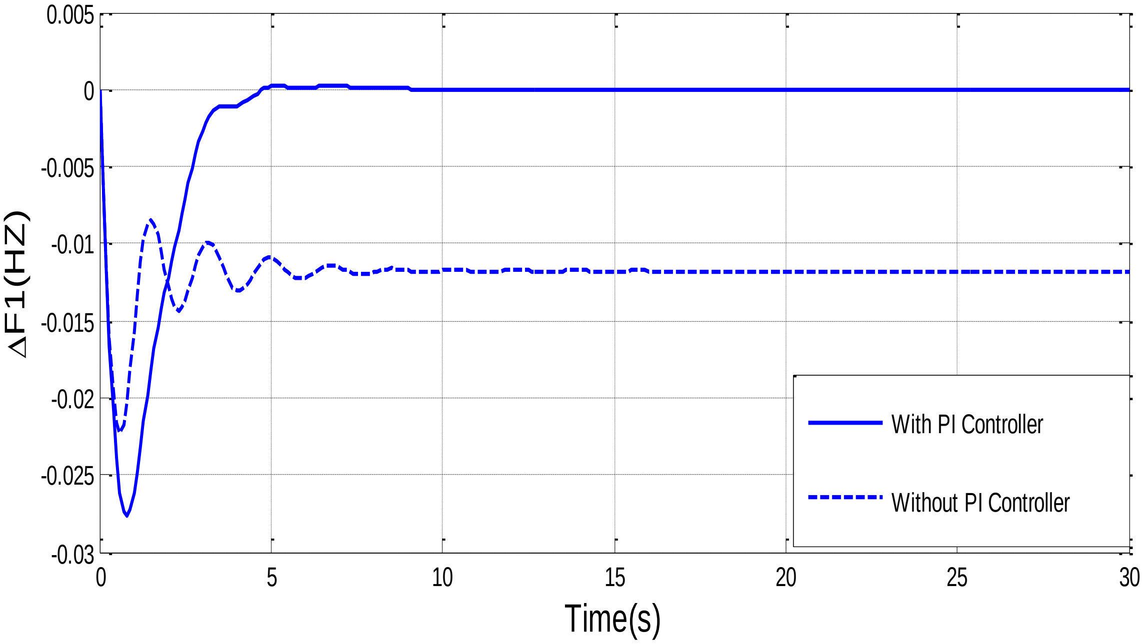


Fig: Frequency deviation of area-1 vs time

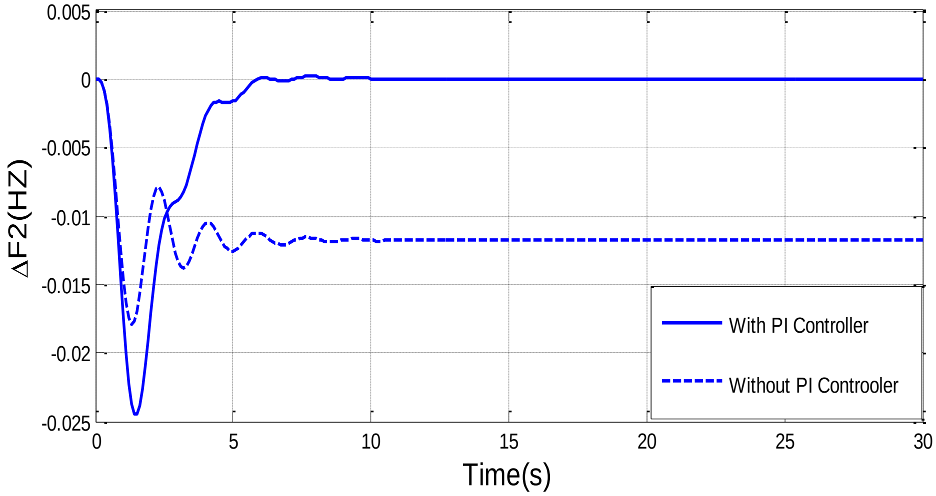


Fig: Frequency deviation of area-2 vs time

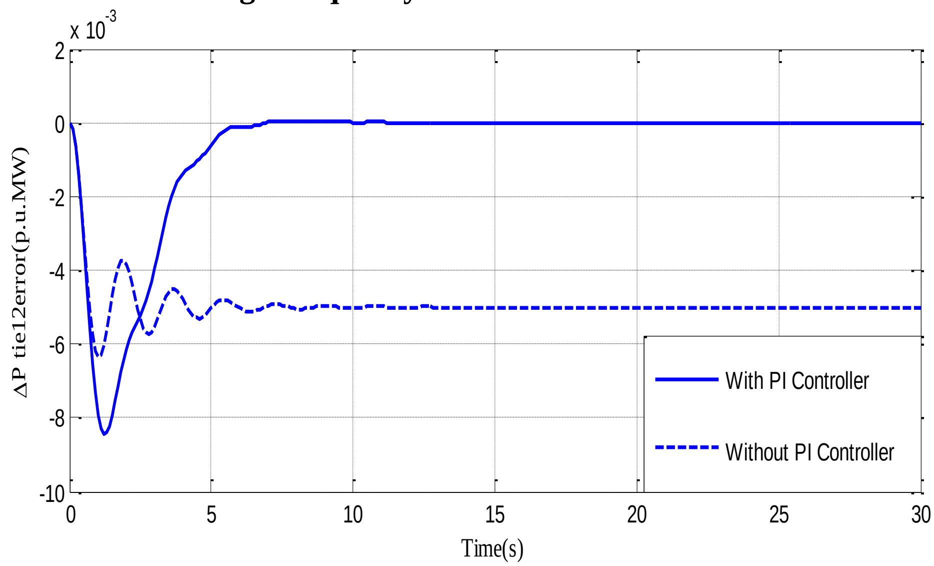


Fig: Tie line power deviation of area-1&2 vs time

RESULT:

OUTCOME:

APPLICATIONS:
Application of load frequency are Maintaining frequency and power interchanges with neighboring control areas at the scheduled values are the two primary objectives of a power system LFC

VIVA QUESTIONS:

1. What is meant by two area control?
2. What is the basic role area control?
3. How frequency and power deviations are controlled in two area control?
4. What is tie line?
5. Why load frequency control is important in operation of two area control

9. SIMULATION OF TRANSIENT RESPONSE OF RLC CIRCUITS TO PULSE INPUT, STEP AND SINUSOIDAL INPUT

AIM: To study the responses of series RLC circuits for a given step, pulse & sinusoidal inputs.

SIMULATION TOOLS REQUIRED:

- **PC with PSPICE Software**

THEORY:

The series RLC circuit above has a single loop with the instantaneous current flowing through the loop being the same for each circuit element. Since the inductive and capacitive reactance's XL and XC are a function of the supply frequency, the sinusoidal response of a series RLC circuit will therefore vary with frequency, f. Then the individual voltage drops across each circuit element of R, L and C element will be "out-of-phase" with each other as defined by:

I(t) = Imax sin(ωt)

- The instantaneous voltage across a pure resistor, VR is "in-phase" with current
- The instantaneous voltage across a pure inductor, VL "leads" the current by 90^o
- The instantaneous voltage across a pure capacitor, VC "lags" the current by 90^o
- Therefore, VL and VC are 180o "out-of-phase" and in opposition to each other.

The fundamental integral differential equation of a series RLC circuit is given by

$$V_S(t) = i(t)R + L[\frac{di(t)}{dt}] + (\frac{1}{C})\int i(t)dt$$

ApplyingLaplacetransformationtoaboveequation,

- **For Step Input:**

  V(t)=0 when t <0

  =1 when t>0

ApplyingLaplacetransforms $V_S(S)=(1 / S)$

- **For Sinusoidal Input:**

- **ForPulseInput:**

SPECIFICATIONS:

Step input: V1 = 0, T1 =0, V2 = 1V, T2 = 1ns, V3 = 1V, T3 = 1ms.

Pulse input: V1 = -10V, V2 = 10V, TD = TR = TF = 1ns, PW = 40us, PER = 80us.

Sinusoidal input: VOFF = 0V, VAMPL = 169.7V, FREQ = 50 Hz.

PROGRAMS:

PROGRAM FOR TRANSIENT RESPONSE OF RLC CIRCUITS TO STEP INPUT:

SIMPLE RLC CIRCUIT FOR STEP INPUT V1 1 0 PWL(0 0 1 NS 1V 1MS 1 V)

V2 4 0 PWL(0 0 1 NS 1V 1MS 1V)

V3 7 0 PWL(0 0 1 NS 1V 1MS 1V)
R1 1 2 1 OHM
L1 2 3 50 UH
C1 3 0 10UF
R2 4 5 2 OHMS
L2 5 6 50 UH
C2 6 0 10UF
R3 7 8 8 OHMS
L3 8 9 50 UH
C3 9 0 10UF
.TRAN 1US 800 US
.PROBE
.END

PROGRAM FOR TRANSIENT RESPONSE OF RLC CIRCUITS TO PULSE INPUT:
SIMPLE RLC CIRCUIT FOR PULSE INPUT
V1 1 0 PULSE(-10 10 1 NS 1 NS1NS 40US 80US)
V2 4 0 PULSE(-10 10 1 NS 1 NS1NS 40US 80US)
V3 7 0 PULSE(-10 10 1 NS 1 NS1NS 40US 80US)
R1 1 2 1 OHM

CIRCUIT DIAGRAM:

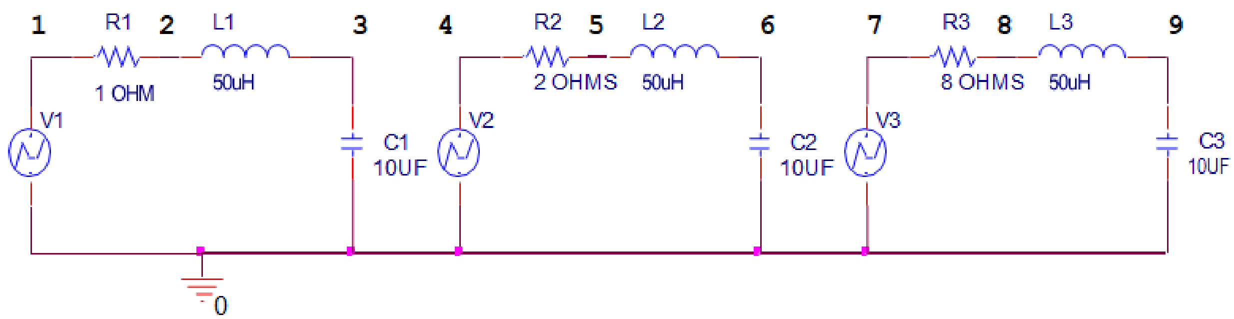


Fig: Series RLC circuit for step input

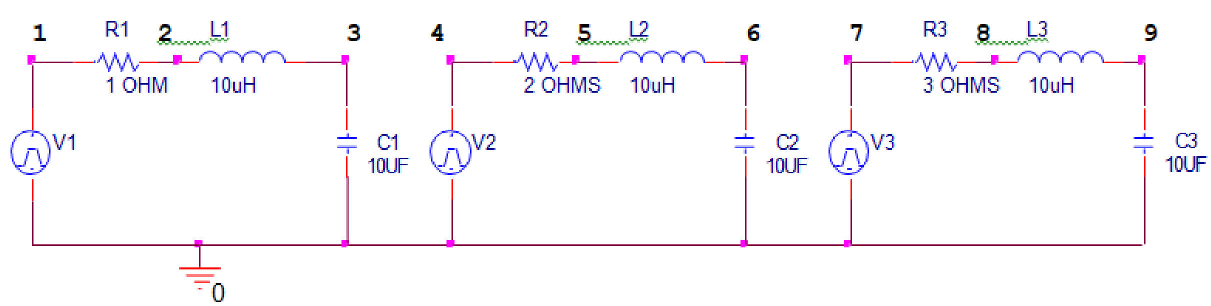


Fig: Series RLC circuit for square input

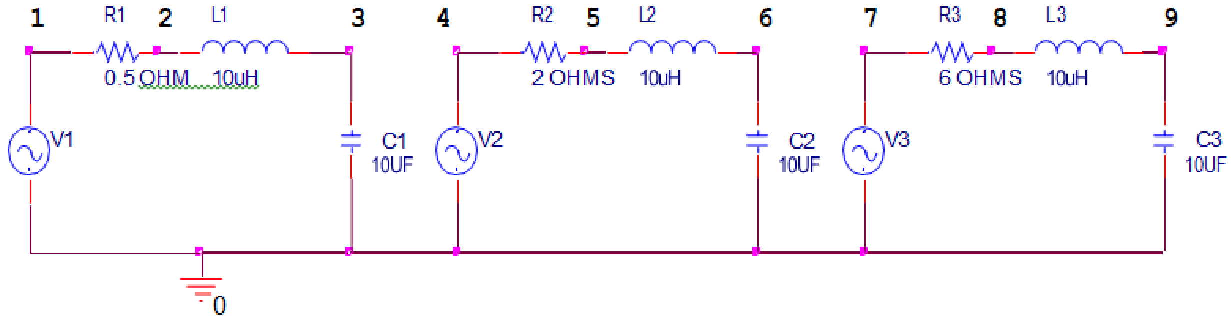


Fig: SERIES RLC CIRCUIT FOR SINUSOIDAL INPUT

RESULT:

OUTCOME:

10(A). SIMULATION OF SINGLE PHASE FULL CONVERTER WITH RL & RLE LOADS

AIM: To analyze the single-phase full converter with RL and RLE Loads.

SIMULATION TOOLS REQUIRED:

- PCwithPSPICESoftware

THEORY:

Full wave converters are thyristors based devices which convert fixed alternating voltage directly to DC voltage. The circuit consists to four thyristors connected which forms a bridge.

The KVL for the circuit gives

$$V_S = V_m \sin \omega t = Ri_0 + \frac{Ldi_0}{dt} (\alpha < \omega t < \beta)$$

The solution of this equation is of the form

$$i_0 = \frac{V_m}{Z} \sin(\omega t - \phi) + Ae^{-(R/L)t}$$

$$Z = [R^2 + (\omega L)^2]^{\frac{1}{2}}$$

$$\phi = \tan^{-1}(\omega L/R)$$

At $\omega t = \alpha \ t = \alpha/\omega \ i_0 = 0$

We know $\omega t = \alpha \Rightarrow V_m \sin(\theta) = E$

Min value of firing angle $\theta = \sin^{-1}(\frac{E}{V_m})\vartheta$

Max value of firing angle $\theta_2 = \prod - \theta_1$

CIRCUIT DIAGRAMS:

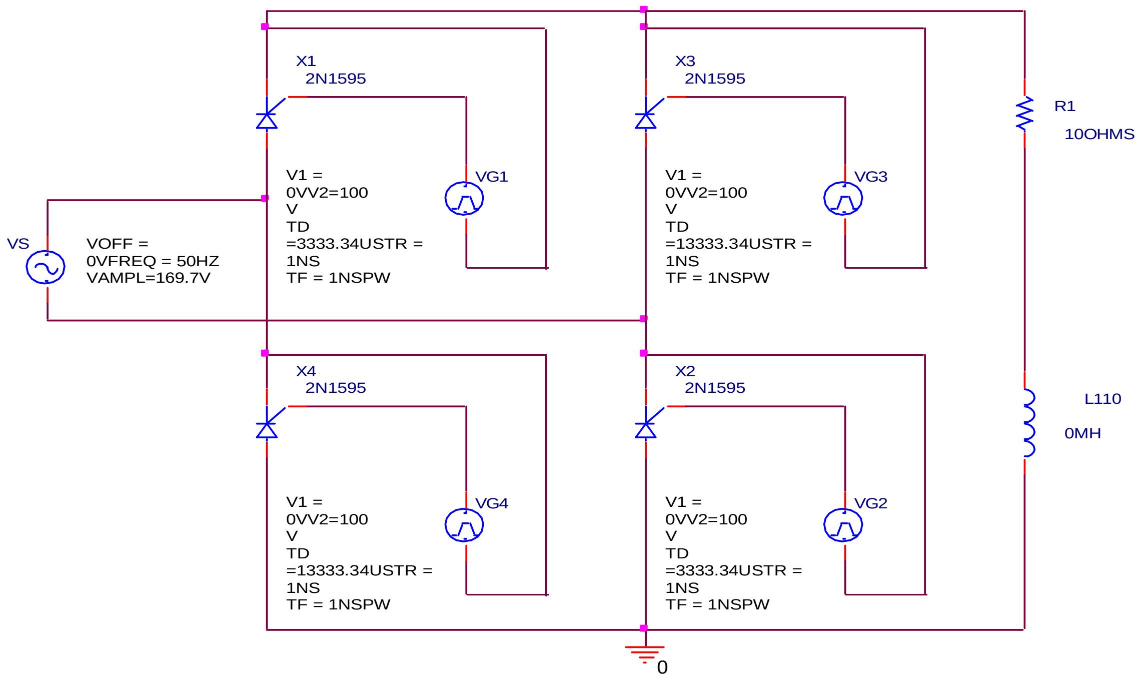


Fig: Single phase full converter with RL load

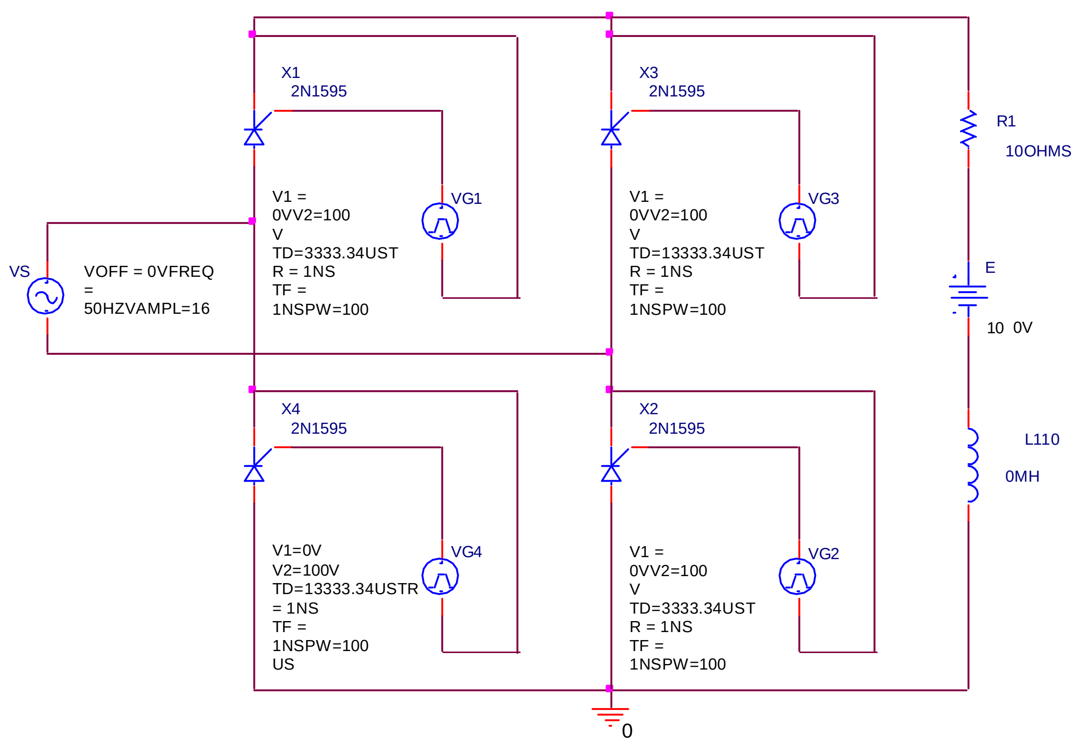


Fig: Single phase full converter with RLE load

SPECIFICATIONS:

Sinusoidal input: V_{OFF}=0V,V_{AMPL}= 169.7V,FREQ=50 Hz.

Gate signal G_1 and G_2: V_1=0V,V_2=100V,T_D=3333.34us,T_R=T_F=1ns,PW= 100us, PER = 20ms.

Gate signal G_3 and G_4: V_1=0V,V_2=100V,T_D=13333.34us,T_R=T_F=1ns,PW= 100us, PER = 20ms.

Firing circuit: R_G=50Ώ,V_X,V_Y=0V,R_T=1Ώ,C_T=10uf,R_{ON}=0.0125,R_{OFF}= 10E+5,V_{ON}= 0.5V, V_{OFF}= 0V, I_S= 2.2E-15, BV = 1800V, TT = 0 sec.

PROGRAMS:

PROGRAM FOR SINGLE PHASE FULL CONVERTER WITH RL LOAD

```
SIGLE-PHASE FULL CONVERTER CIRCUIT WITH RL LOAD
VS1 12SIN(0 169.7V 50HZ)
R17810OHM
L180100MH
VG137PULSE(0100V3333.34US1NS1NS100US20000US)
VG347PULSE(0100V13333.34US1NS1NS100US20000US)
VG252PULSE(0100V3333.34US1NS1NS100US20000US)
VG461PULSE(0100V13333.34US1NS1NS100US20000US)
XT11737SCR
XT20252SCR
XT32747SCR
XT40161SCR
.SUBCKT SCR 1232 S1
1562 SMOD
RG3450OHMS
VX42DC0V
VY 5 7 DC 0V
DT 7 2 DMOD
RT 621OHM
CT6210UF
F126POLY(2)VXVY05011
.MODELSMODVSWITCH(RON=0.0125ROFF=10E+5VON=0.5VVOFF=0V)
.MODELDMODD(IS=2.2E-15BV=1800TT=0)
.ENDSSCR
.TRAN1US60MS
.PROBE
.END
```

PROGRAM FOR SINGLE PHASE FULL CONVERTER WITH RLE LOAD

```
SIGLE-PHASE FULL CONVERTER CIRCUIT WITH RLE LOAD
VS1 12SIN(0 169.7V 50HZ)
R17810OHM
L189100MH
VDC90DC100V
VG137PULSE(0100V3333.34US1NS1NS100US20000US)
VG347PULSE(0100V13333.34US1NS1NS100US20000US)
VG252PULSE(0100V3333.34US1NS1NS100US20000US)
VG461PULSE(0100V13333.34US1NS1NS100US20000US)
XT11737SCR
XT20252SCR
XT32747SCR
XT40161SCR
.SUBCKT SCR 1232 S1
1562 SMOD
RG3450OHMS
VX42DC0V
VY 5 7 DC 0V
DT 7 2 DMOD
RT 621OHM
CT6210UF
F126POLY(2)VXVY05011
.MODELSMODVSWITCH(RON=0.0125ROFF=10E+5VON=0.5VVOFF=0V)
.MODELDMODD(IS=2.2E-15BV=1800TT=0)
.ENDSSCR
.TRAN1US60MS
.PROBE
.END
```

PROCEDURE:

1. Write the program in a new text file in PSPICE AD.
2. Save the file using the notation filename.cir.
3. Activate the file by opening it.
4. Run the simulation process using blue button.
5. By clicking Add Trace icon, get the required waveform.

PRECAUTIONS:

1. Avoid typing, floating errors,
2. Study the all observations very carefully,
3. Save the file with extension .cir,
4. Don't tamper with settings of software.

MODELWAVEFORMS:

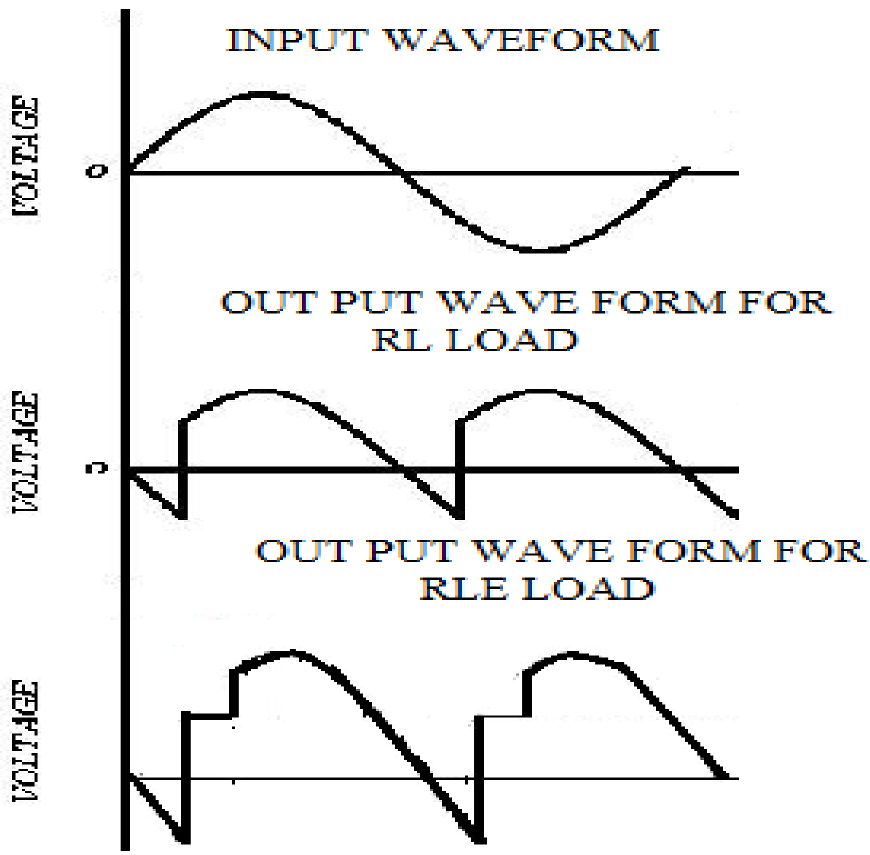


Fig: Input and output waveforms for full wave converter with RL and RLE load

THEROTICAL CALCULATIONS:

A) FOR RL LOAD

$$V_0 = \frac{2V_m}{\Pi} COS(\alpha)$$

At α=60 we get 54.02V

B) FOR RLE LOAD

At $\omega t = \alpha$ i.e $t = \alpha/\omega$ $i_0 = 0$

We know that $\omega t = \alpha = V_m \sin(\theta) = E$

Min value of firing angle $\theta = \sin^{-1}(\frac{E}{V_m}) = \sin^{-1}(\frac{100}{169.32}) = 36.1$

Max value of firing angle $\theta_2 = 180 - \theta_1 = 143.9$

SIMULATION RESULTS:

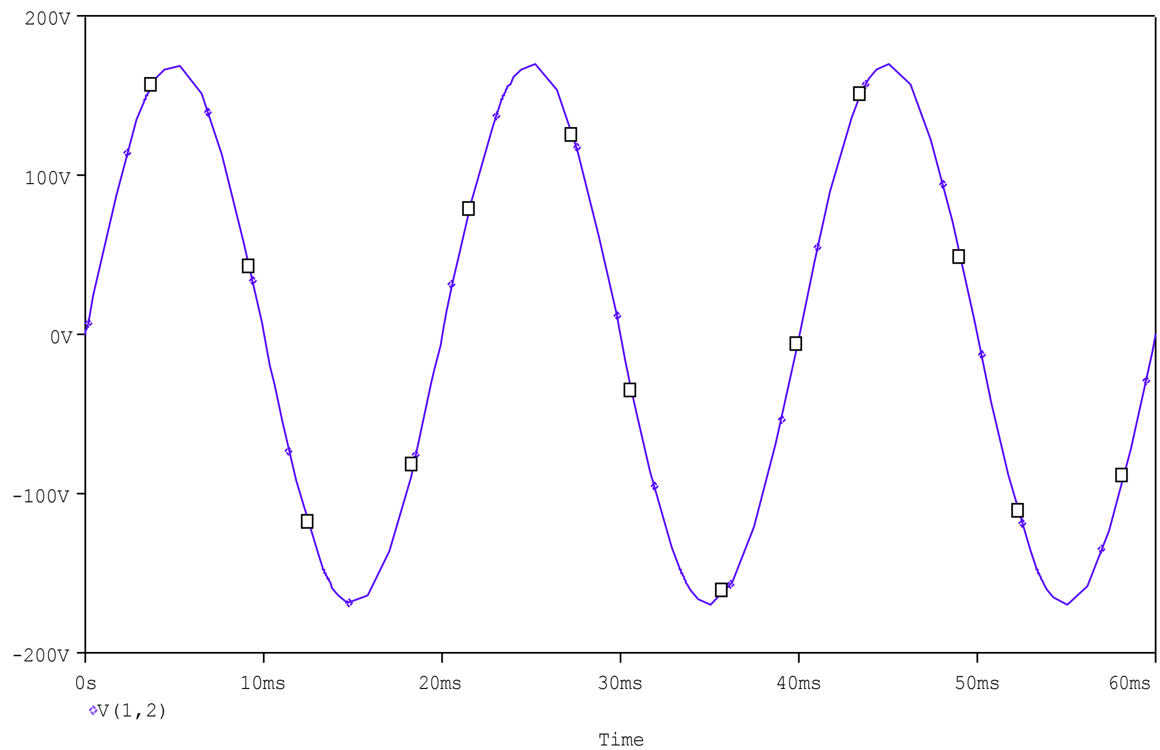


Fig: Input waveform of full-wave converter

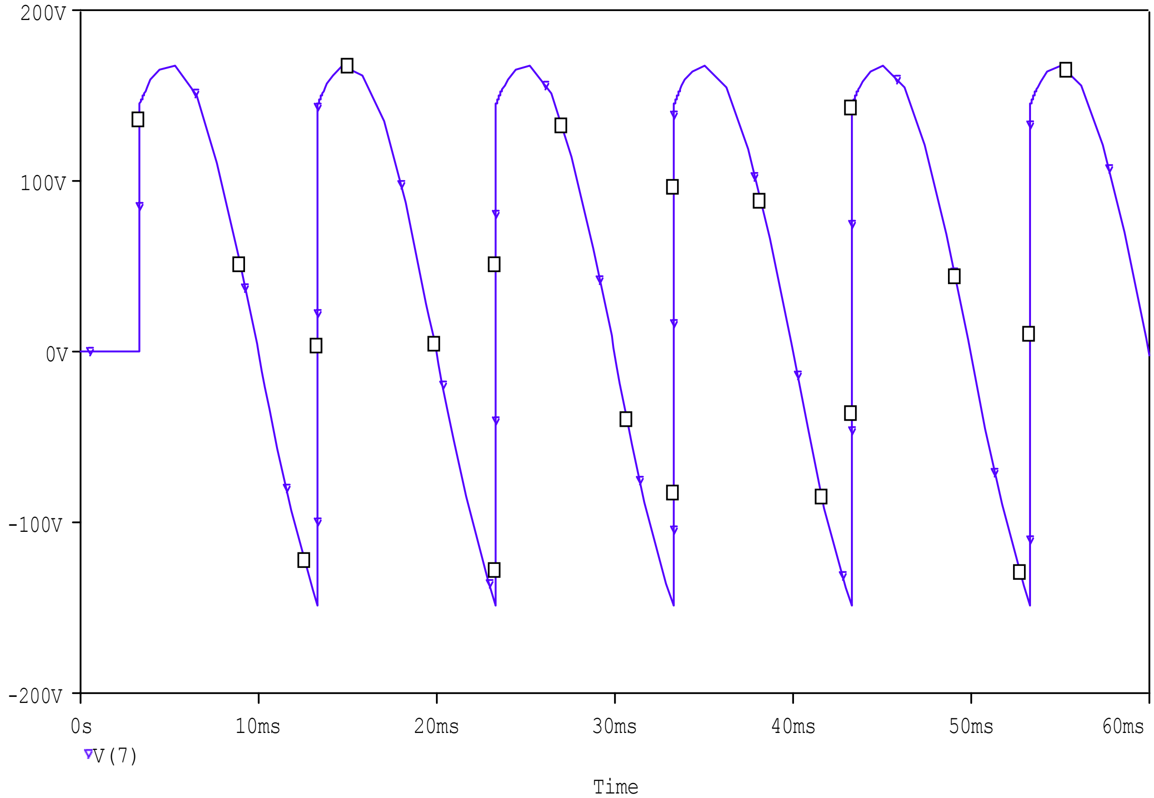


Fig: Output waveform of full-wave converter with RL load

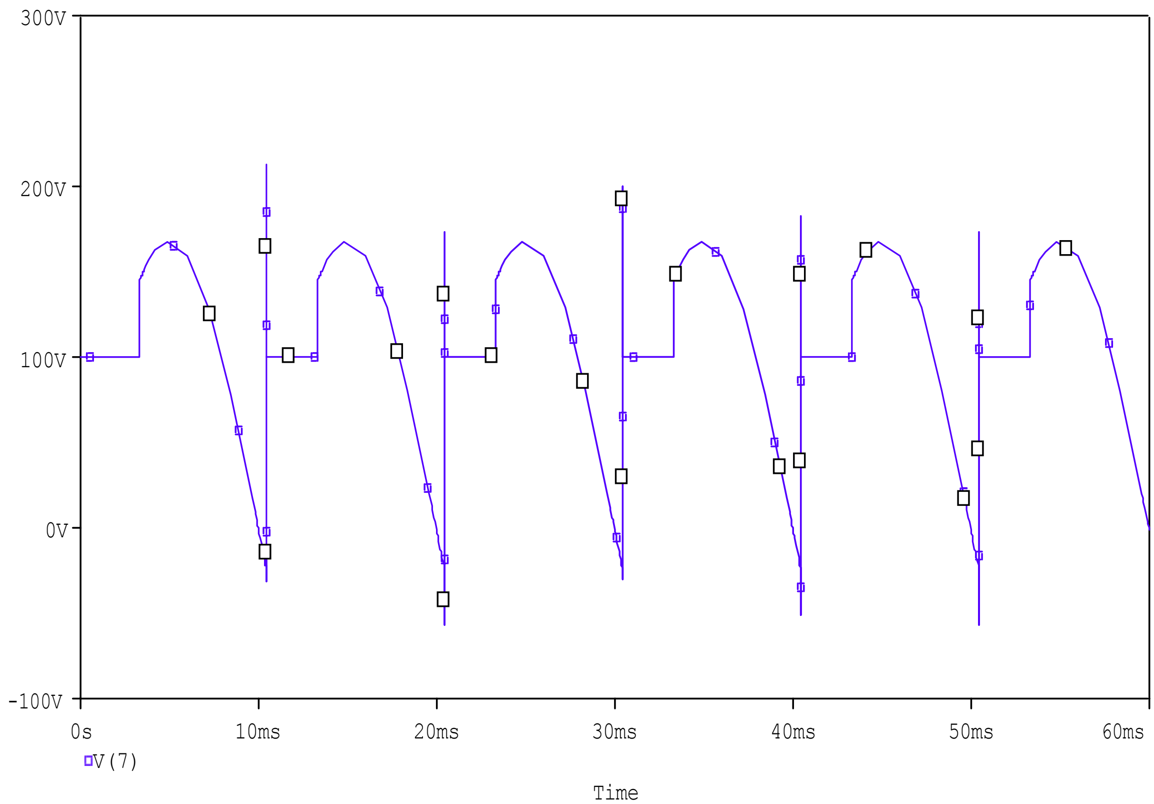


Fig: Output waveform of full-wave converter with RLE load

RESULT:

OUTCOME:

APPLICATIONS:

The single-phase full-wave controlled rectifier is used to control power flow in many Applications (e.g., power supplies, variable-speed dc motor drives, and input stages of other Converters)

VIVA QUESTIONS:

1. What are different types of power electronic converters?
2. Difference between full-wave converter and fully controlled converter?
3. Derive average output voltage equation for single phase fully controlled converter?

10(B) SIMULATION OF SINGLE PHASE AC VOLTAGE CONTROLLER WITH RL LOAD

AIM: To analyze the single-phase AC voltage controller with RL load.

SIMULATION TOOLS REQUIRED:

- PC with PSPICE Software

THEORY:

Ac voltage controllers are thyristor based devices which convert fixed alternating voltage directly to variable alternating voltage without a change in frequency. The circuit consists to two thyristors connected in anti-parallel.

The KVL for the circuit gives

$$V_S = V_m \sin \omega t = Ri_0 + \frac{Ldi_0}{dt} (\alpha < \omega t < \beta)$$

The solution of this equation is of the form

$$i_0 = \frac{V_m}{Z} \sin(\omega t - \phi) + Ae^{-(R/L)t}$$

$$Z = [R^2 + (\omega L)^2]^{\frac{1}{2}}$$

$$\phi = \tan^{-1}(\omega L / R)$$

At $\omega t = \alpha$ i.e $t = \alpha / \omega$ $i_0 = 0$

$$-^{-1}\left(\omega L / R\right)$$

CIRCUIT DIAGRAM:

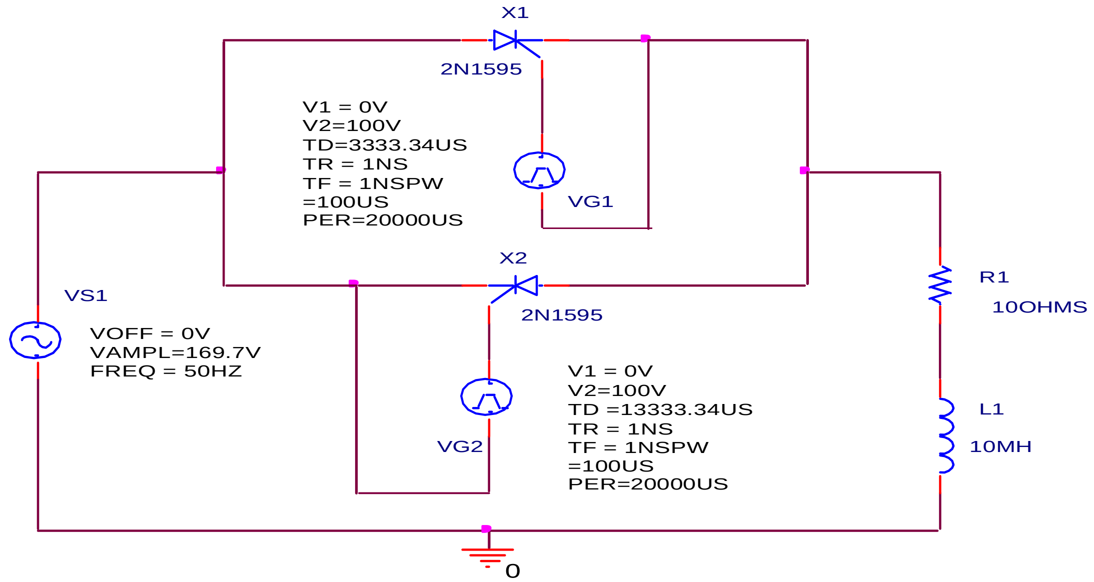


Fig: Single Phase AC voltage controller with RL load

SPECIFICATIONS:

Sinusoidal input: V_{OFF}=0V,V_{AMPL}= 169.7V,FREQ=50 Hz.

Gate signal G_1:V_1=0V,V_2=100V,T_D=3333.34us,T_R=T_F=1ns,PW=100us, PER = 20ms.
Gate signal G_2:V_1=0V,V_2=100V,T_D=13333.34us,T_R=T_F=1ns,PW=100us, PER = 20ms.

Firing circuit:R_G=50 Ω,V_X,V_Y=0V,R_T=1 Ω,C_T=10uf,R_{ON}=0.0125,R_{OFF}= 10E+5, V_{ON}= 0.5V, V_{OFF}= 0V, I_S= 2.2E-15, BV = 1800V, TT = 0 sec.

PROGRAM:

```
SINGLE-PHASE AC VOLTAGE CONTROLLER CIRCUIT WITH RL
LOAD
VS1 10SIN(0 169.7V 50HZ)
R12310OHM
L13010MH
VG142PULSE(0100V3333.34US1NS1NS100US20000US)
VG251PULSE(0100V13333.34US1NS1NS100US20000US)
XT11242SCR
XT22151SCR
.SUBCKT SCR 1232 S1
1562 SMOD
RG3450OHMS
VX42DC0V
VY 5 7 DC 0V
DT 7 2 DMOD
RT 621OHM
CT6210UF
F126POLY(2)VXVY05011
.MODELSMODVSWITCH(RON=0.0125ROFF=10E+5VON=0.5VVOFF=0V)
.MODELDMODD(IS=2.2E-15BV=1800TT=0)
.ENDSSCR
.TRAN1US60MS
.PROBE
.END
```

PROCEDURE:

1. Write the program in a new text file in PSPICE AD.
2. Save the file using the notation filename.cir.
3. Activate the file by opening it.
4. Run the simulation process using blue button.
5. By clicking Add Trace icon, get the required waveform.

PRECAUTIONS:

1. Avoid typing, floating errors,
2. Study the all observations very carefully,
3. Save the file with extension .cir,
4. Don't tamper with settings of software.

MODEL GRAPHS:

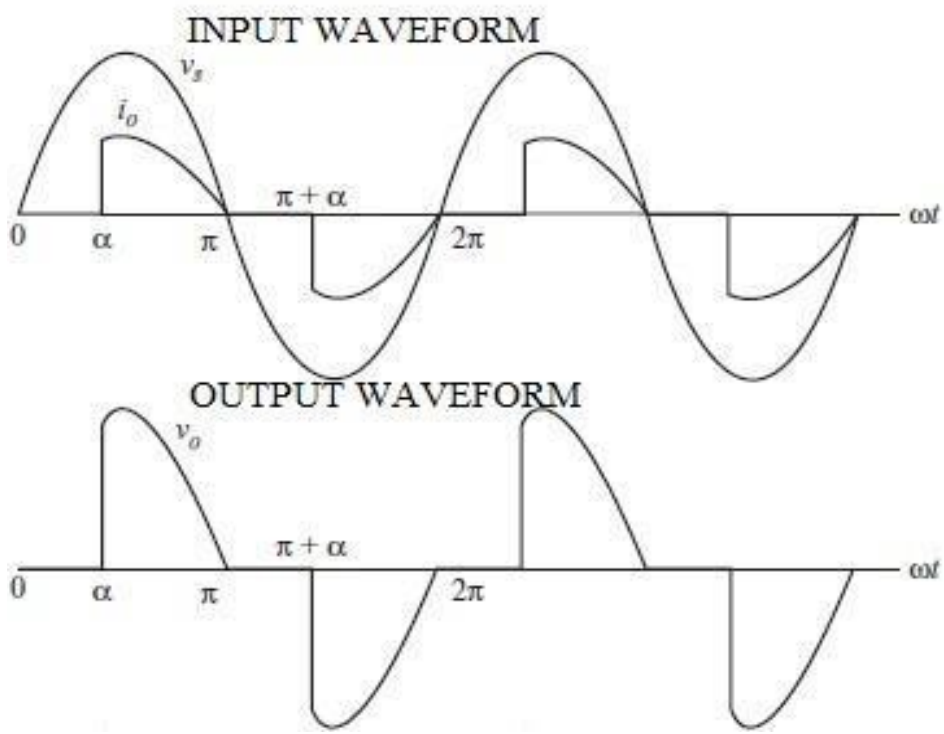


Fig: Input and output waveforms of AC voltage Controller

THEROTICAL CALCULATIONS (FOR RL LOAD):

Wt=60^0=3.33ms for50Hz

$$V_0 = \frac{V_m}{\Pi}[COS(\alpha)+1]$$

$$V_0 = \frac{V_m}{\Pi}[COS(60)+1] = 81.03V$$

SIMULATIONRESULTS:

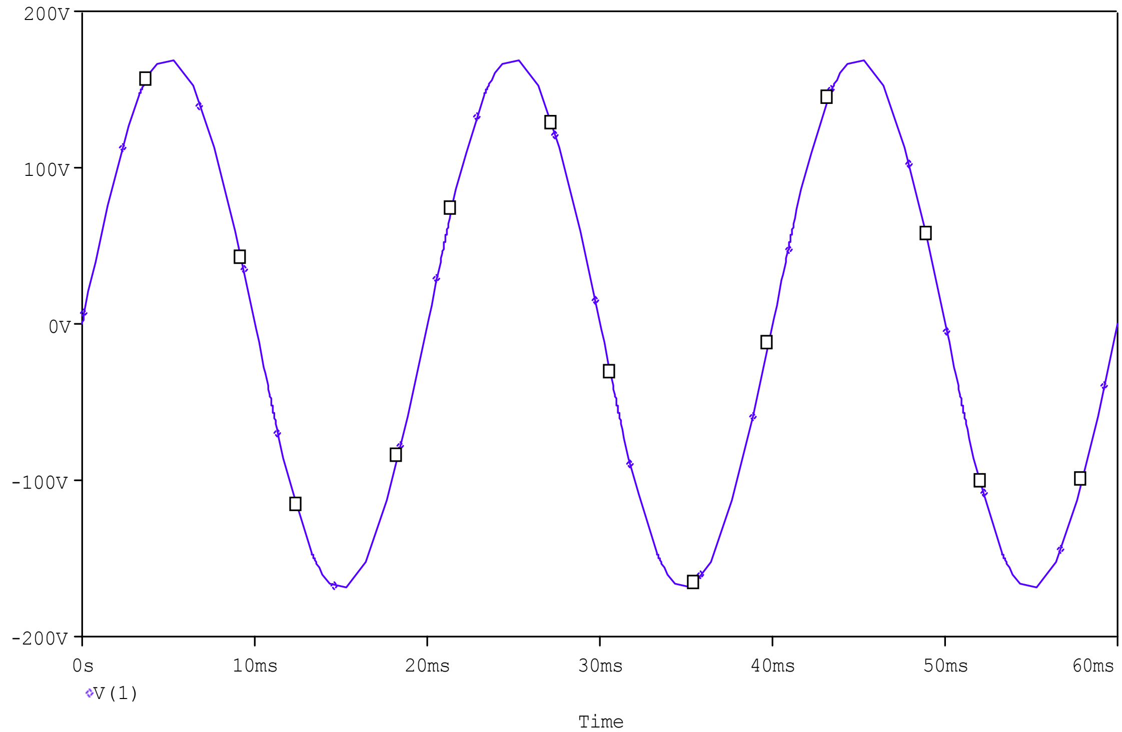


Fig: Input waveform of single phase AC voltage controller with RL load

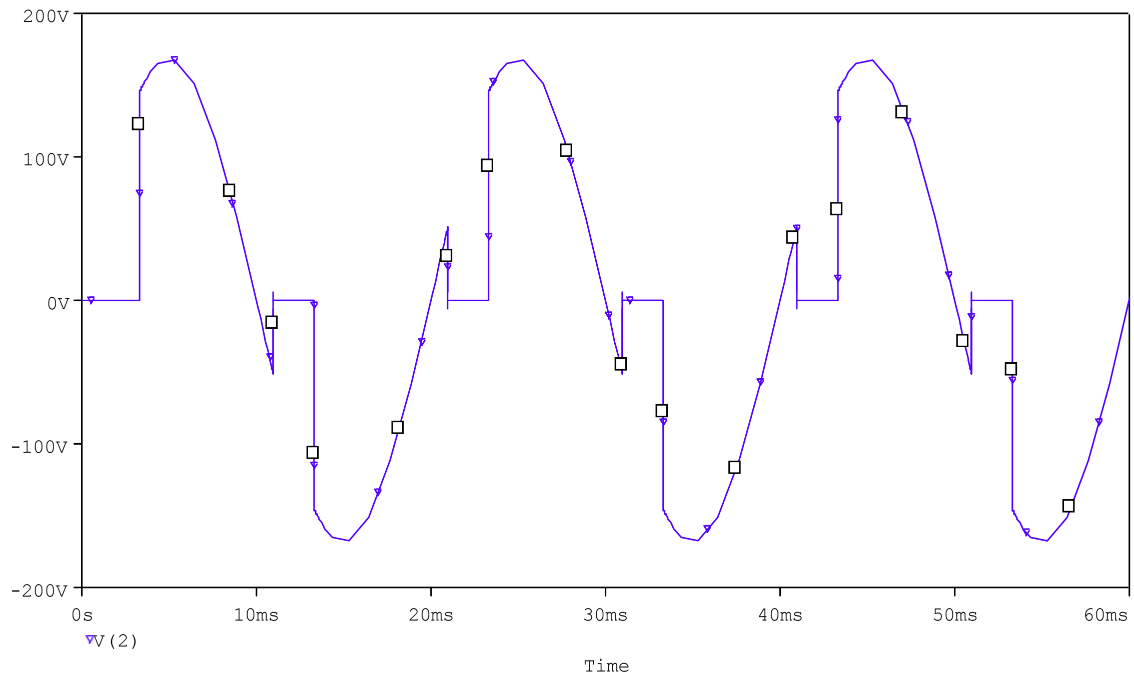


Fig: Output waveform of single phase AC voltage controller with RL load

RESULT:

OUTCOME:

APPLICATIONS:

The single-phase ac voltage controller is used to control power flow in many applications

- Induction Heating,
- Pumps,
- Speed Control of Fans,
- Light Dimmers
- Food Blenders.

VIVA QUESTIONS:

1. Explain about SCR.
2. Explain about differences between single phase variac and single phase ac voltage controller.

ADDITIONAL EXPERIMENTS

1. UNSYMMETRICAL FAULT ANALYSIS

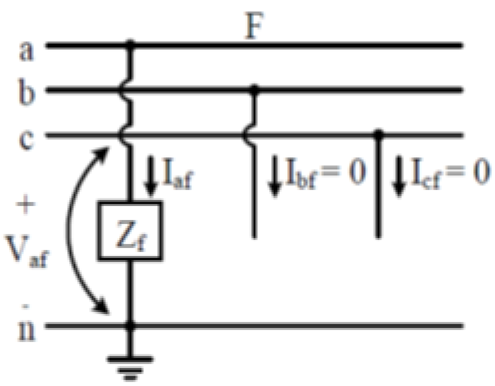
AIM: To analyze unsymmetrical faults

APPARATUS: MATLAB

THEORY:

Single Line-to-Ground Fault:

The single line-to-ground fault is usually referred as “short circuit” fault and occurs when one conductor falls to ground or makes contact with the neutral wire. The general representation of a single line-to-ground fault is shown in Figure 2.1 where F is the fault point with impedances Zf. Figure 2.2 shows the sequences network diagram. Phase ‘a’ is usually assumed to be the faulted phase, this is for simplicity in the fault analysis calculations.



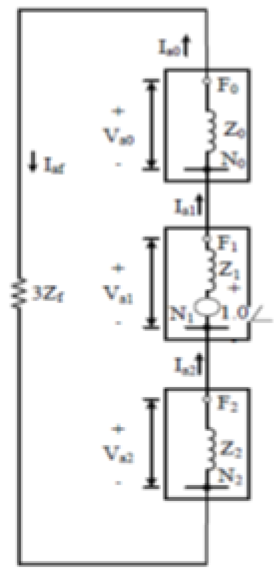


Fig: Representation of a single L-G fault Fig: Sequence network diagram of a L-G fault

Since the zero-, positive-, and negative-sequence currents are equals as it can be observed in Figure 2.2 Therefore,

$$I_{a0} = I_{a1} = I_{a2} = \frac{1.0\angle 0^\circ}{Z_0 + Z_1 + Z_2 + 3Z_f}$$

With the results obtained for sequence currents, the sequence voltages can be obtained from

$$\begin{bmatrix} V_{a0} \\ V_{b1} \\ V_{c2} \end{bmatrix} = \begin{bmatrix} 0 \\ 1.0\angle 0^\circ \\ 0 \end{bmatrix} - \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}$$

By solving Equation

$$V_{a0} = -Z_0 I_{a0}$$
$$V_{a1} = 1.0 - Z_1 I_{a1}$$
$$V_{a2} = -Z_2 I_{a2}$$

If the single line-to-ground fault occurs on phase b or c, the voltages can be found by the relation that exists to the known phase voltage components,

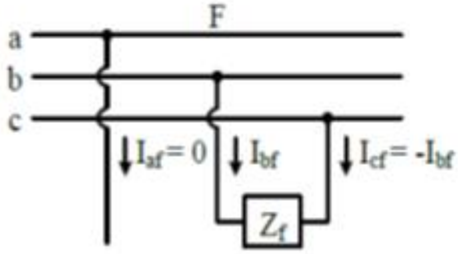
$$\begin{bmatrix} V_{af} \\ V_{bf} \\ V_{cf} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} V_{a0} \\ V_{a1} \\ V_{a2} \end{bmatrix}$$

As,

$$V_{bf} = V_{a0} + a^2 V_{a1} + a V_{a2}$$
$$V_{cf} = V_{a0} + a V_{a1} + a^2 V_{a2}$$

Line-to-Line Fault:

A line-to-line fault may take place either on an overhead and/or underground transmission system and occurs when two conductors are short-circuited. One of the characteristic of this type of fault is that its fault impedance magnitude could vary over a wide range making very hard to predict its upper and lower limits. It is when the fault impedance is zero that the highest asymmetry at the line-to-line fault occurs.



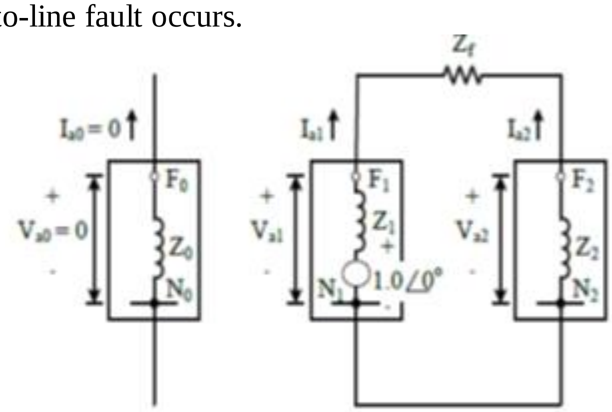


Fig: Sequence Network diagram of a L-L fault   Fig: Sequence Network diagram of a L-G fault

The general representation of a line-to-line fault is shown in Figure where F is the fault point with impedances Z_f. Phase b and 'c' are usually assumed to be the faulted phases; this is for simplicity in the fault analysis calculations.

It can be noticed that

$$I_{af} = 0$$

$$I_{bf} = -I_{cf}$$

$$V_{bc} = Z_f I_{bf}$$

And the sequence currents can be obtained as

$$I_{a0} = 0$$

$$I_{a1} = -I_{a2} = \frac{1.0\angle 0^\circ}{Z_1 + Z_2 + Z_f}$$

If $Z_f = 0$,

$$I_{a1} = -I_{a2} = \frac{1.0\angle 0^\circ}{Z_1 + Z_2}$$

The fault currents for phase b and c can be obtained as

$$I_{bf} = -I_{cf} = \sqrt{3}\, I_{a1}\angle -90^\circ$$

The sequence voltages can be found as

$$V_{a0} = 0$$
$$V_{a1} = 1.0 - Z_1 I_{a1}$$
$$V_{a2} = -Z_2 I_{a2} = Z_2 I_{a1}$$

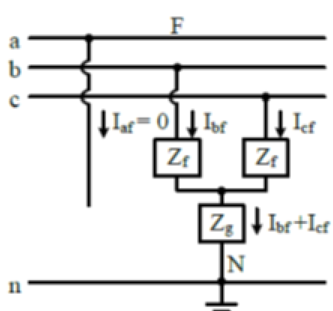
Finally, the line-to-line voltages for a line-to-line fault can be expressed as

$$V_{ab} = V_{af} - V_{bf}$$
$$V_{bc} = V_{bf} - V_{cf}$$
$$V_{ca} = V_{cf} - V_{af}$$

Double Line-to-Ground Fault:

A double line-to-ground fault represents a serious event that causes a significant asymmetry in a three-phase symmetrical system and it may spread into a three-phase fault when not clear in appropriate time. The major problem when analyzing this type of fault is the assumption of the fault impedance Z_f, and the value of the impedance towards the ground Z_g.

The general representation of a double line-to-ground fault is shown in Figure where F is the fault point with impedances Z_f and the impedance from line to ground Z_g. Phase b and c are assumed to be the faulted phases, this is for simplicity in the fault analysis calculations.



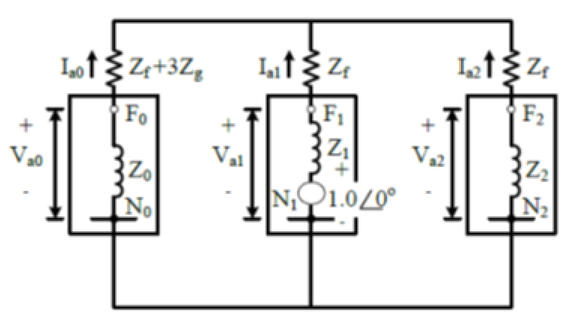


Fig: Representation of a single L-L-G fault **Fig: Sequence network diagram of a L-L-G fault**

It can be observed that

$$I_{af} = 0$$
$$V_{bf} = (Z_f + Z_g)I_{bf} + Z_g I_{cf}$$
$$V_{cf} = (Z_f + Z_g)I_{cf} + Z_g I_{bf}$$

The positive-sequence currents can be found as

$$I_{a1} = \frac{1.0\angle 0^\circ}{(Z_1 + Z_f) + \frac{(Z_2 + Z_f)(Z_0 + Z_f + 3Z_g)}{(Z_2 + Z_f) + (Z_0 + Z_f + 3Z_g)}}$$

$$I_{a2} = -[\frac{(Z_0 + Z_f + 3Z_g)}{(Z_2 + Z_f) + (Z_0 + Z_f + 3Z_g)}]I_{a1}$$

$$I_{a0} = -[\frac{(Z_2 + Z_f)}{(Z_2 + Z_f) + (Z_0 + Z_f + 3Z_g)}]I_{a1}$$

An alternative method is,

$$I_{af} = 0 = I_{a0} + I_{a1} + I_{a2}$$
$$I_{a0} = -(I_{a1} + I_{a2})$$

If $Z_f$and $Z_g$are both equal to zero, then the positive-, negative-, and zero-sequences can be obtained from

$$I_{a1} = \frac{1.0\angle 0^\circ}{(Z_1) + \frac{(Z_2)(Z_0)}{(Z_2 + Z_0)}}$$

$$I_{a2} = -[\frac{(Z_0)}{(Z_2 + Z_0)}]I_{a1}$$

$$I_{a0} = -[\frac{(Z_2)}{(Z_2 + Z_0)}]I_{a1}$$

The current for phase a is

$$I_{af} = 0$$

$$I_{bf} = I_{a0} + a^2 I_{a1} + aI_{a2}$$
$$I_{cf} = I_{a0} + aI_{a1} + a^2 I_{a2}$$

The total fault current flowing into the neutral is

$$I_n = 3I_{a0} = I_{bf} + I_{cf}$$

The resultant phase voltages from the relationship can be expressed as

$$V_{af} = V_{a0} + V_{a1} + V_{a2} = 3V_{a1}$$
$$V_{bf} = V_{cf} = 0$$

And the line-to-line voltages are

$$V_{abf} = V_{af} - V_{bf} = V_{af}$$
$$V_{bcf} = V_{bf} - V_{cf} = 0$$
$$V_{caf} = V_{cf} - V_{af} = -V_{af}$$

CIRCUIT DIAGRAM:

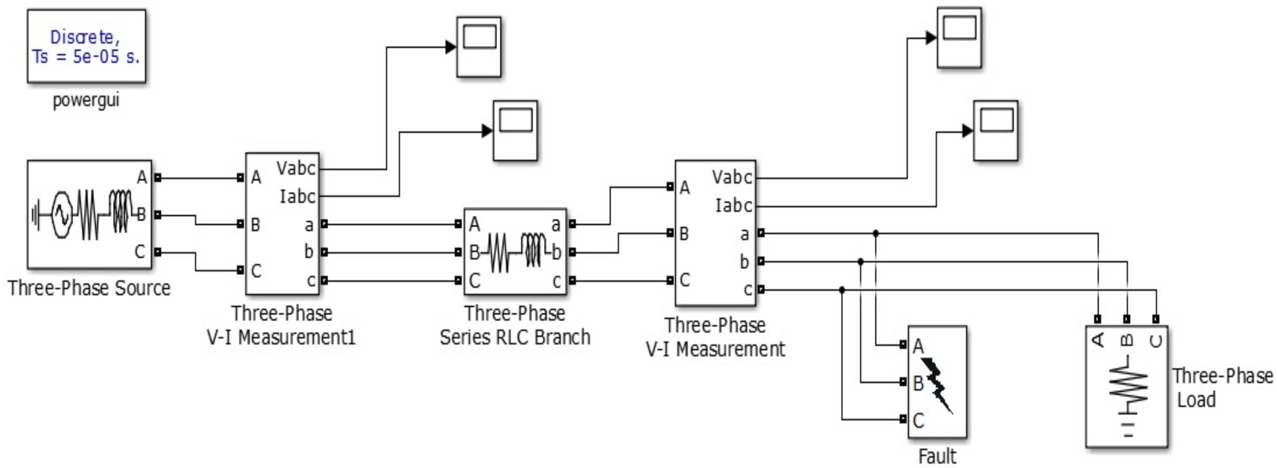


Fig. Simulink Model for unsymmetrical faults

PROCEDURE:

1. Open Matlab-->Simulink--> File ---> New---> Model.
2. Open Simulink Library and browse the components.
3. Connect the components as per circuit diagram.
4. Set the desired voltage and required frequency.
5. Simulate the circuit in different faults using MATLAB.
6. Plot the waveforms.

RESULT:

OUTCOME:

2. FERRANTI EFFECT OF TRANSMISSION LINE

AIM: To study the Ferranti Effect of Transmission line

APPARATUS:

1. ABCD Transmission line KIT
2. Ammeter
3. Voltmeter
4. Rheostat

CIRCUIT DIAGRAM:

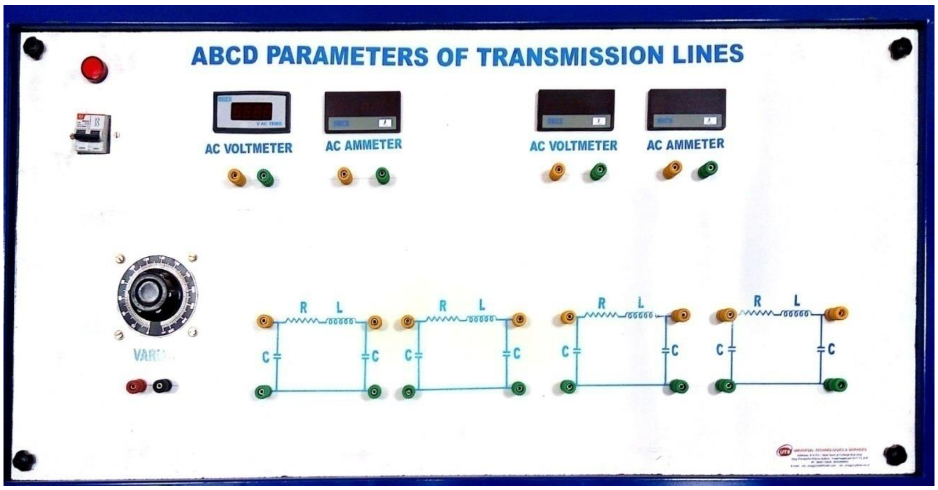


Fig.Front Panel Diagram of ABCD Transmission line KIT

THEORY:

A long transmission line/cables draws a substantial quantity of charging current. If such a line/cable is open circuited or very lightly loaded at the receiving end, the voltage at receiving end may become greater than voltage at sending end due to capacitive reactance. This is known as Ferranti Effect. Both capacitance and inductance is responsible to produce this effect. The capacitance (which is responsible for charging current) is negligible in short line but **significant** in medium line and **appreciable** in long line. Hence, this phenomenon occurs in medium and long lines. The figure shown below is representing a transmission line by an equivalent pi(π)-model. The voltage rise is proportional to the square of the line length.

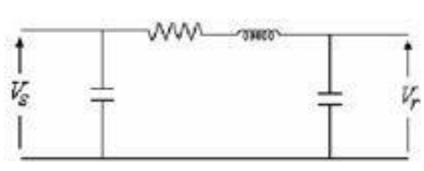


Fig: Nominal π-transmission line model

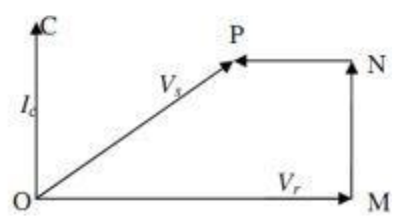


Fig: Phasor Diagram

When load current is increased of R-L loads the resultant current is not remains leading, because of the inductive drop. Hence, receiving end voltage (Vr) is lesser than sending end voltage (Vs) under full load conditions.

PROCEDURE:

1. Apply 100V AC supply to the sending end side of the first section in the after open the receiving end side.
2. Note down the corresponding values from digital meter on the kit.
3. Now cascade one more section in the kit and repeat the step-1 and 2.
4. After that cascade two more sections in the kit and repeat step-1 and 2 to find the effect in the long transmission line.
5. Switch off the supply and disconnecting the circuit.

OBSERVATION TABLE:

S. No	Length of the line(km)	Sending end voltage V_i(V)	Receiving end voltage V_O(V)	Sending end current I_i(A)	Receiving end current I_O(A)
1					
2					
3					
4					

RESULT:

OUTCOME:

APPLICATIONS:

1. Providing accurate real-time model for better monitoring and control of the trans-mission grid.
2. Assessing power system grid stability in near real-time with respect to overloads, static voltage limits and voltage collapse.
3. Enabling you to evaluate network control actions under a wide variety of hypothesized conditions.
4. Maintaining historical cases for after-the- fact analysis.
5. **Electrical transmission system** is that means of transmitting power from generating station todifferent load centers.

3. LOAD FLOW STUDIES USING N-R METHOD

AIM: To write the MATLAB coding to find the electrical parameters of various buses in a power system using Newton Raphson method.

APPARATUS: MATLAB software with PC compatibility

THEORY: The Newton Raphson method is a power full method of solving non-linear algebric equation. It work is faster and is sure to coverage in most cases. It is indeed the practical method of load flow solution of large power network. In order to solve non-linear equations through this method we need to calculate jacobian matrix. If is obtained by differentiating the function vector f with respect to x and evaluating it at x.

$$F_0+J_0\ X_0=0$$

These sets of linear algebraic equation can be solved effectively by triangularization and block substitution .Iterations are continued till Where i=1,2,3……..n

Its only drawback is large requirement of complex. Computer memory which has been over come through a compact storage scheme convergence can be speeded up by performing the first iteration through Gs method and using the value so obtained as starting Newton Raphson method.

ALGORITHM:

Step 1: Assume a flat voltage profile 1+j0bfor all buses except the slack bus

Step 2: Assume a suitable value of ε called convergence criterion

Step 3: Set iteration count, k=0 and assumed voltage profile of the buses are denoted as $V_i^0, V_2^0, \ldots\ldots\ldots V_n^0$

Step 4: Set the bus count P = 1

Step 5: Check for slack bus, If it is a slack bus go to step 13 otherwise go to next step

Step 6: Calculate the real and reactive power of bus P using the equation

$$P_p^k = \sum_{q=1}^{n}\left[e_p^k\left(e_p^k G_{pq} + F_q^k B_{pq}\right) + F_q^k\left(F_q^k G_{pq} - e_q^k B_{pq}\right)\right]$$

$$Q_p^k = \sum_{q=1}^{n}\left[F_p^k\left(e_p^k G_{pq} + F_q^k B_{pq}\right) + e_p^k\left(F_q^k G_{pq} - e_q^k B_{pq}\right)\right]$$

Step 7: Calculate the change in real power

$$\Delta P^k = P_{p\,spec} - P_p^k$$

Step 8:Check the generator bus if it is a generator bus go to next step otherwise go to step 12

Step 9:Check for reactive power limit violation of generator bus.for this compare the calculated reactive power $Q_p^k$with specified limits if the limit is violated go to step 11 otherwise go to next step else go to step 13

Step 10: Check for reactive power limit violation ofgenerator buses if the limit is violated go to step 12 else go to next step

Step 11: If the calculated reactive power is within the specified limits then consider this bus as generator bus. Now calculate the voltage residue

$$\left|\Delta V_p^k\right|^2 = \left|V_p\right|^2_{spec} - \left|V_p^k\right|^2 \quad \text{then go to step 12}$$

Step 12:Is reactive power limit is violated then treat this bus as a load bus (i.e) if a $Q_p^k < Q_{p\,mn}$ then $Q_{p\,spc} = Q_{p1\,min}$

Step 13:Calculate change in reactive power for load bus

$$\Delta Q_p^k = \left|Q_{p\ spec}\right| - Q_p^k$$

Step 14: Repeat the step 6 to 13 untill all residues are calculated for this increment the bus count by 1 and go to step 6 until the Bs count is

Step15: Determine largest of the absolute value of residue let this change be ΔE

Step16: Compare ΔE & ε if ΔE < E then goto step 11 if ΔE > E go to next step

Step17: Determine the elements of jacobian matrix by partially differentiating the load flow equation and evaluates using K^{th} iteration values

Step18: Calculate the increments in real and reactive part of voltages Δe_p^k & $\Delta\delta_p^k$ by solving the matrix B=JC

Step19: Calculate new bus voltages

$$e_p^{k+1} = e_p^k + \Delta e_p^k$$

$$\delta_p^{k+1} = \delta_p^k + \Delta\delta_p^k$$

$$\left|V_p^{k+1}\right| = \sqrt{\left(e_p^{k+1}\right)^2 + \left(\delta_p^{k+1}\right)^2} \quad \& \quad \delta_p^{k+1} = \tan^{-1}\left(e_p^{k+1} / \delta_p^{k+1}\right)$$

Therefore

$$V_p^{k+1} = \left|V_p^{k+1}\right| \langle \delta_p^{k+1}$$

Step20: Advance iteration count K=K+1 & go to step 5

Step21: Calculate the line flows and stop the program

PROGRAM:

```
clear all;
clc;
n=input('Enter the number of buses');
for i=1:n
```

```
for j=1:n
fprintf('Enter the Admittance Value Between %d & %d',i,j) y(i,j)=input('');
endendyb(n,n)=0;
for i=1:n
for j=1:n if i==j
for k=1:n yb(i,j)=yb(i,j)+y(i,k);
end else
yb(i,j)=-y(i,j);
end
end
end mag(1)=1.05;
for i=2:n
mag(i)=1;
endth(1:n)=0;
for i=1:n
acp(i)=input('enter real power value:');
end
for i=1:n
acq(i)=input('enter reactive power value:');
end my=abs(yb);an=angle(yb); g=real(yb);b=imag(yb);
yb
mag
th
acp
acq
Pp(n)=0;Qq(n)=0;
for i=2:n for j=1:n
Pp(i)=Pp(i)+mag(i)*my(i,j)*mag(j)*cos(an(i,j)-th(i)+th(j));
Qq(i)=Qq(i)-mag(i)*my(i,j)*mag(j)*sin(an(i,j)-th(i)+th(j));
end
end
Pp
Qq
for i=2:n for j=2:n
if i~=j
j1(i,j)=mag(i)*mag(j)*(g(i,j)*sin(th(i)-th(j))-b(i,j)*cos(th(i)-th(j)));
j3(i,j)=-mag(i)*mag(j)*(g(i,j)*cos(th(i)-th(j))+b(i,j)*sin(th(i)-th(j)));
j2(i,j)=-j3(i,j); j4(i,j)=j1(i,j);
else
j1(i,j)=-Qq(i)-b(i,j)*(mag(i)^2);
j2(i,j)=Pp(i)+g(i,j)*(mag(i)^2);
j3(i,j)=Pp(i)-g(i,j)*(mag(i)^2);
j4(i,j)=Qq(i)-b(i,j)*(mag(i)^2);
end
end
end
ja1(1:n-1,1:n-1)=j1(2:n,2:n);
ja2(1:n-1,1:n-1)=j2(2:n,2:n);
ja3(1:n-1,1:n-1)=j3(2:n,2:n);
ja4(1:n-1,1:n-1)=j4(2:n,2:n);
jacob=[ja1 ja2;ja3 ja4] delp(1:n-1)=acp(2:n)-Pp(2:n);
delq(1:n-1)=acq(2)-Qq(2);
Char=inv(jacob)*[delpdelq]';
```

```
Chth(2:n)=Char(1:n-1);
Chmag(2:n)=Char(n:2*n-2);
mag=mag+Chmag;
th=th+Chth;
fprintf('the voltage values for buses');
mag
fprintf('The angle values for buses');
th
```

RESULT:

OUTCOME:

QUESTIONS FOR SELF ASSESSMENT:

1. What are the information's that are obtained from a load flow study?
2. What is the need for load flow study?
3. What are the different types of buses?
4. What are the iterative methods used for solution of load flow problems?
5. What are the advantages of NR method?

4(A) ECONOMIC LOAD DISPATCH WITHOUT LOSSES

AIM: To find the optimal dispatch and total cost of generator a) without line losses and generator limits

SOFTWARE:MATLAB.

PROBLEM STATEMENT:
The fuel cost function for three thermal plants in Rs/hr are given by:

$C_1 = 500 + 5.3P_1 + 0.004P_1^2$
$C_2 = 400 + 5.5P_2 + 0.006P_2^2$
$C_3 = 500 + 5.3P_3 + 0.004P_3^2$

where P1, P2, P3 are in Mega watt. The total load is 975MW.

a) Neglecting line losses and generator limits. Find optimal dispatch and the total cost in Rs/hr.

b) With the generator limits (in Megawatts) for the 3 generators $200 \leq P_1 \leq 450$ $150 \leq P_2 \leq 350$ $100 \leq P_3 \leq 225$

OPTIMAL DISPATCH OF GENERATOR PROGRAM:

```
%program to find optimal dispatch with & without generator limits and line losses%
clc;
clear all;
close all;
cost = [500 5.3 0.004
400 5.5 0.006
        200 5.8 0.009];
%Input Data of the cost functions mwlimits=[200 450
150 350
100 225];
Pdt=975;
dispatch
gencost
```

RESULT:

OUTCOMES:

QUESTIONS FOR SELF ASSESSMENT:

1. What are the information's that are obtained from a load dispatch?
2. What is the need for economic load dispatch?
3. What are the iterative methods used for economic load dispatch?
5. What are the advantages of economic load dispatch?

4(B) ECONOMIC LOAD DISPATCH WITH LOSSES

AIM: To find the optimal dispatch and total cost of generator a) with line losses and generator limits

SOFTWARE:MATLAB.

PROBLEM STATEMENT:

The fuel cost function for three thermal plants in Rs/hr. are given by:

$C_1 = 200 + 7P_1 + 0.008P_1^2$
$C_2 = 180 + 6.3P_2 + 0.009P_2^2$
$C_3 = 140 + 6.8P_3 + 0.007P_3^2$

where P1, P2, P3 are in Mega watt. The total load is 975MW.

a) Neglecting line losses and generator limits. Find optimal dispatch and the total cost in Rs/hr.

b) With the generator limits (in Megawatts) for the 3 generators $10 \leq P_1 \leq 85$ $10 \leq P_2 \leq 80$ $10 \leq P_3 \leq 70$

For this problem, assume the real power loss is given by the simplified expression:

$$P_L = 0.0218P_1^2 + 0.0228P_2^2 + 0.0179P_3^2$$

where the loss coefficients are specified in per unit on a 100 MVA base. Determine the optimal Dispatch of generation when the total system load is 150MW.

OPTIMAL DISPATCH OF GENERATOR PROGRAM:

```
%program to find optimal dispatch with & without generator limits and line losses
% clc;
clear all;
close all;
cost = [200 7 0.008
180 6.3 0.009
140 6.8 0.007];
%Input Data of the cost functions mwlimits=[10 85
10 80
10 70];
Pdt=150;
B=[ 0.02180 0
0 0.0228 0
0 0 0.0179];
basemva=100;
dispatch
gencost
```

RESULT:

OUTCOMES:

QUESTIONS FOR SELF ASSESSMENT:

1. What are the information's that are obtained from a load dispatch?
2. What is the need for economic load dispatch?
3. What are the iterative methods used for economic load dispatch?
5. What are the advantages of economic load dispatch?