JEPPIAAR ENGINEERING COLLEGE
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF INSTITUTION

To build Jeppiaar Engineering College as an institution of academic excellence in technology and management education, leading to become a world class University.

MISSION OF INSTITUTION

- To excel in teaching and **learning, research and innovation** by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, **development, dissemination of knowledge** and interact with **national and international communities.**
- To equip students with ethical **values, and life skills** that would enrich their lives and enable them to meaningfully contribute to the **progress of the society.**
- To prepare students for **higher studies and lifelong learning,** enrich them with the **practical and entrepreneurial skills** necessary to excel as future professionals and contribute to **Nation's economy.**

PROGRAM OUTCOMES (POs)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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
4. **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.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **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.
7. **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.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **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.

11 **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.

12 **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.

VISION OF THE DEPARTMENT

The Department of Electrical and Electronics Engineering strives to be a Centre of Excellence in education and technical research, in the endeavour of which the Department will continually update the teaching methodologies, progress in the emerging technologies and continue to play a vital role in the development of the society.

MISSION OF THE DEPARTMENT

M1	To develop the ability to **learn** and work creatively that would enhance the ability of both students and faculty to do **innovative research**.
M2	To **create** and maintain state-of-the art facilities which provide students and faculty with opportunities to analyse, apply and **disseminate knowledge globally**.
M3	To impart the knowledge in essential interdisciplinary fields which will enhance the **interpersonal skills**, team work, professional **ethics** and make them work effectively for their own benefit and the **betterment of the society**.
M4	Prepare students for **lifelong learning** of theoretical and **practical concepts** to face intellectual, **economical** and career challenges.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 01	Strengthen the knowledge in Electrical and Electronics Engineering to enable them **work** for modern industries by promoting energy conservation and sustainability.
PEO 02	Enrich analytical, creative and critical **logical reasoning** skills to solve problems faced by emerging domains of electrical and electronics engineering industries worldwide.
PEO 03	Develop effective communication and inter-personal skills to work with enhanced team spirit in multidisciplinary projects with a broader **ethical**, professional, economical and **social** perspective.
PEO 04	Prepare the students either to establish **start ups** or to pursue **higher education** at reputed institutions.

PROGRAM SPECIFIC OUTCOME (PSOs)

PSO 1	**Professional Skills:** Apply the knowledge of Mathematics, Science and Engineering to solve real time problems in the field of **Power Electronics, Electrical Drives, Power Systems, Control Systems and Instrumentation**.
PSO 2	**Research and Innovation:** Analyze and synthesize circuits by solving complex engineering problems to obtain the **optimal solution** using effective software tools and hardware prototypes in the field of robotics and renewable energy systems.
PSO 3	**Product development:** Develop concepts and **products** by applying ideas of electrical domain into other diversified engineering domains.

BLOOM'S TAXONOMY

Definitions of the different levels of thinking skills in Bloom's taxonomy

1. **Remember** – recalling relevant terminology, specific facts, or different procedures related to information and/or course topics. At this level, a student can remember something, but may not really understand it.

2. **Understand** – the ability to grasp the meaning of information (facts, definitions, concepts,etc.) that has been presented.

3. **Apply** – being able to use previously learned information in different situations or in problem Solving.

4. **Analyze** – the ability to break information down into its component parts. Analysis also refers to the process of examining information in order to make conclusions regarding cause and effect, interpreting motives, making inferences, or finding evidence to support statements/arguments.

5. **Evaluate** – being able to judge the value of information and/or sources of information based on personal values or opinions.

6. Create – the ability to creatively or uniquely apply prior knowledge and/or skills to produce new and original thoughts, ideas, processes, etc. At this level, students are involved in creating their own thoughts ideas.

List of Action Words Related to Critical Thinking Skills

REMEMBER	UNDERSTAND	APPLY	ANALYZE	EVALUATE	CREATE
Count	Associate	Add	Analyze	Appraise	Categorize
Define	Compute	Apply	Arrange	Assess	Combine
Describe	Convert	Calculate	Breakdown	Compare	Compile
Draw	Defend	Change	Combine	Conclude	Compose
Identify	Discuss	Classify	Design	Contrast	Create
Label	Distinguish	Complete	Detect	Criticize	Drive
List	Estimate	Compute	Develop	Critique	Design
Match	Explain	Demonstrate	Diagram	Determine	Devise
Name	Extend	Discover	Differentiate	Grade	Explain
Outline	Extrapolate	Divide	Discriminate	Interpret	Generate
Point	Generalize	Examine	Illustrate	Judge	Group
Quote	Give	Graph	Infer	Justify	Integrate
Read	examples	Interpolate	Outline	Measure	Modify
Recall	Infer	Manipulate	Point out	Rank	Order
Recite	Paraphrase	Modify	Relate	Rate	Organize
Recognize	Predict	Operate	Select	Support	Plan
Record	Rewrite	Prepare	Separate	Test	Prescribe
Repeat	Summarize	Produce	Subdivide		Propose
Reproduce		Show	Utilize		Rearrange
Select		Solve			Reconstruct
State Write		Subtract			Related
		Translate			Reorganize
		Use			Revise
					Rewrite
					Summarize
					Transform
					Specify

Course/Branch : B.E/EEE Subject : Power System Analysis

Duration : June2018 - Oct2018 Subject Code : EE6501

Semester : V Section: A& B Staff Handling: P.Rajarajeswari and S.Sakthi

Regulation :2013 `

AIM:

To understand the necessity and to become familiar with the modeling of power system and components and to apply different methods to analyze power system for the purpose of system planning and operation.

OBJECTIVES:

- To model the power system under steady state operating condition.
- To apply numerical methods to solve the power flow problem.
- To model and analyze the system under faulted conditions.
- To model and analyze the transient behaviour of power system when it is subjected to a fault.

UNIT I INTRODUCTION 9

Need for system planning and operational studies – basic components of a power system.-Introduction to restructuring - Single line diagram – per phase and per unit analysis – Generator - transformer – transmission line and load representation for different power system studies.- Primitive network - construction of Y-bus using inspection and singular transformation methods – z-bus.

UNIT II POWER FLOW ANALYSIS N 9

Importance of power flow analysis in planning and operation of power systems - statement of power flow problem - classification of buses - development of power flow model in complex variables form -iterative solution using Gauss-Seidel method - Q-limit check for voltage controlled buses – power flow model in polar form - iterative solution using Newton-Raphson method .

UNIT III FAULT ANALYSIS – BALANCED FAULTS **9**

Importance of short circuit analysis - assumptions in fault analysis - analysis using Thevenin's theorem - Z-bus building algorithm - fault analysis using Z-bus – computations of short circuit capacity, post fault voltage and currents.

UNIT IV FAULT ANALYSIS – UNBALANCED FAULTS **9**

Introduction to symmetrical components – sequence impedances – sequence circuits of synchronous machine, transformer and transmission lines - sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix.

UNIT V STABILITY ANALYSIS **9**

Importance of stability analysis in power system planning and operation - classification of power System stability - angle and voltage stability – Single Machine Infinite Bus (SMIB) system: Development of swing equation - equal area criterion - determination of critical clearing angle and time – solution of swing equation by modified Euler method and Runge-Kutta fourth order method.

TOTAL: 45 PERIODS

OUTCOMES :

Ability to understand and analyze power system operation, stability, control and protection.

COURSE OUTCOMES: After the course, the student should be able to:

CO	Course Outcomes	Pos	Psos
C3 1.1	Describe the importance of single line diagram, Impedance diagram and form the Y-bus matrix for the power system.	1,2,4,5,7,12	1
C3 1.2	Develop the power flow equation for power system problems and Determine the line flows using various algorithm	1,2,3,4,5,6,7,12	1,2
C3 1.3	Illustrate the importance of short circuit studies; Calculate the fault currents for symmetrical fault condition.	1,2,3,4,5,6,7,12	1,2
C3 1.4	Introduction to symmetrical fault analysis and Draw the sequence network for L-G, L-L and L-L-G fault of the power system and Explain the concept of power system stability, Analyze the stability of single machine infinite bus system	1,2,3,4,5,6,7,12	1,2
C3 1.5	Explain the concept of power system stability, Analyze the stability of single machine infinite bus system	1,2,4,5,6,7,12	1

Mapping of Course Outcomes(COs), Course(C),ProgramSpecificOutcomes (PSOs)with Program Outcomes. (POs)– [Levels of correlation:3 (High),2 (Medium), 1(Low)]

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C3 1.1	3	3	-	2	1	-	1	-	-	-	2	2	3	-	-
C3 1.2	3	3	2	2	1	1	1	-	-	-	2	2	3	2	-
C3 1.3	3	3	2	2	1	1	1	-	-	-	2	2	3	2	-
C3 1.4	3	3	2	2	1	1	1	-	-	-	2	2	3	2	-
C3 1.5	3	3	-	2	1	1	1	-	-	-	2	2	3	-	-
C3 1.1	3	3	-	2	1	-	1	-	-	-	2	2	3	-	-

UNIT - I	**INTRODUCTION**					**Target Periods: 9**
Sl N o	**Contents**	**CO Statement**	**Book Reference & Page No**	**Delivery method**	**Delivery Periods**	**Knowledge Level**
1	Introduction - Modern power system (or) electric energy system - Analysis for system planning and operational studies	C3 1.1	T1 [4], R2[5-11], T2[7]	Chalk & board	**1**	R & U
2	Basic components of a power system	C3 1.1	T1 [4]	Chalk & board	**1**	R & U
3	Modelling of Generator	C3 1.1	T1 [4], R2[76- 80]	Chalk & board	**1**	R, U, An
4	Modelling of Transformer with off-nominal tap ratio	C3 1.1	T1[5,6],R2[195-204]	Chalk & board	**1**	R, U, An
5	Modeling of Transmission line and load	C3 1.1	T1[6-8], T2[9-12], R2[36-37]	Chalk & board	**1**	R, U, An
6	Per unit system, Single line diagram representation	C3 1.1	T1[36-42], T1[88-90]	Chalk & board	**1**	R,U, A
7	Impedance and reactance diagrams, Change of base	C3 1.1	T1[90-101]	Chalk & board	**1**	An, E
8	Primitive network and network matrices. Formation of Y-bus	C3 1.1	Material	Chalk & board	**1**	R, U, An
9	Simple building algorithm for the formation of Z-Bus matrix	C3 1.1	T1[190-195]	Chalk & board	**1**	R, U, An

	Tutorial					
	Tutorial					
	Tutorial					
UNIT II	POWER FLOW ANALYSIS			**Target Periods:9**		
Sl No	**Contents**	**CO Statement**	**Book Reference & Page No**	**Delivery method**	**Delivery Hrs**	**Knowledge Level**
1	Importance of power flow analysis in planning and operation of power systems.	C3 1.2	T1[189]	Chalk & board	**1**	R, A, An
2	Statement of power flow problem - classification of buses into P-Q buses, P-V (voltage controlled) buses and slack bus.	C3 1.2	T1[208]	Chalk & board	**1**	R, U, A, An
3	Development of Power flow model in complex variables form and polar variables form.	C3 1.2	T1[26-30]	Chalk & board	**1**	R, U, A, An
4	Iterative solution using Gauss-Seidel method including Q-limit check for voltage controlled buses - algorithm and flow chart	C3 1.2	T1[209-220] T2[247-254] R2[335-342]	Chalk & board	**3**	R, U, A, An
5	Iterative solution using Newton-Raphson (N-R) method (polar form) including Q-limit check and bus switching for voltage-controlled buses - Jacobian matrix elements – algorithm and flow chart.	C3 1.2	T1[232-240] T2[257-262] R2[342-356] T1[240-245] R2[368-373]	Chalk & board	**3**	R, U, A, An
6	Tutorial					
7	Tutorial					
8	Tutorial					
UNIT III	**FAULT ANALYSIS – BALANCED FAULTS**			**Target Periods: 9**		

Sl No	Contents	CO Statement	Book Reference & Page No	Delivery method	Delivery Hrs	Knowledge Level
1	Introduction to fault analysis. Importance short circuit (or) for fault analysis - basic assumptions in fault analysis of power systems.	C3 1.3	T1[353], R2[308]	Chalk & board	**3**	R, U, An
2	Symmetrical (or) balanced three phase faults – problem formulation Internal voltages of loaded machines under fault conditions.	C3 1.3	T1[354-361], R2[383-390]	Chalk & board	**3**	R, U, A, An
3	Fault analysis using Z-bus matrix – algorithm and flow chart	C3 1.3	T1[363-368]	Chalk & board	**3**	R, U, A, An
4	Tutorial					
8	Tutorial					

UNIT- IV FAULT ANALYSIS – UNBALANCED **Target Periods: 9**

Sl No	Contents	CO Statement	Book Reference & Page No	Delivery method	Delivery Hrs	Knowledge Level
1	Introduction to symmetrical components – sequence impedances – sequence networks	C3 1.4	T1[399, 407-420], T2[400-406]R2[417-418]	Chalk & board	**1**	R, U
2	Single Line-Ground fault analysis – Derivation Solution of problems	C3 1.4	T1[421-422], R2[482-488]	Chalk & board	**2**	R, U, A, An
3	Line-Line fault analysis – Derivation and solution of problems	C3 1.4	T1[423-425], R2[494-512]	Chalk & board	**2**	R, U, A, An
4	Double Line-Ground fault analysis Derivation	C3 1.4	T1[425-431]	Chalk & board	**1**	R, U, A, An
5	Tutorial					
6	Tutorial					
7	Tutorial					

UNIT- V : STABILITY ANALYSIS Target Periods: 9

Sl No	Contents	CO Statement	Book Reference & Page No	Delivery method	Delivery Hrs	Knowledge Level

1	Importance of stability analysis in power system planning and operation	C3 1.5	T1[460]	Chalk & board	**2**	R, U, A, An
2	classification of power system stability - angle and voltage stability	C3 1.5	R1[17-37]	Chalk & board	**1**	R, U, A, An
3	Simple treatment of angle stability into small-signal and large- signal (transient) stability Single Machine Infinite Bus (SMIB) system	C3 1.5	R1[17-37]	Chalk & board	**1**	R, U, A, An
4	Development of swing equation	C3 1.5	T1[461-464], R2[698-702]	Chalk & board	**1**	R, U, A, An
5	Equal area criterion and solution of SMIB system problems	C3 1.5	T1[486-488], R2[717-726]	Chalk & board	**1**	R, U, A, An
6	Solution of swing equation by numerical integration techniques	C3 1.5	R1[836-837]	Chalk & board	**1**	R, U, A, An
7	Determination of critical clearing angle and time by using Runge - Kutta method	C3 1.5	R1[838-841]	Chalk & board	**1**	R, U, A, An
8	Determination of critical clearing angle and time by using Modified Euler method	C3 1.5	R1[836-838]	Chalk & board	**1**	R, U, A, An

UNIT – I INTRODUCTION
PART – A

1. **What are the main divisions of power system**? **(Nov-Dec 2014)**
    - Generation
    - Transmission
    - Distribution

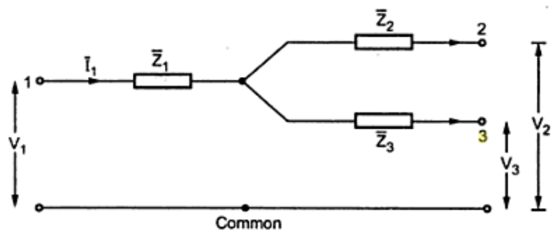
    Components are
    - Generators
    - Transformers
    - Transmission line
    - Loads
2. **The Star connected generator rated at 300 MVA , 33 KV has a reactance of 1.24 P.U Find the ohmic value of the reactance April-May 2017)**

    Base reactance are= $(KVb)^2/MVA_b$= $(33)^2/300$=3.63 ohm

    ohmic value of the reactance= 1.24*3.63= 4.50 ohm
3. **What is the need for per unit value**? **(Nov-Dec 2014)**
    - Manual calculations are simplified using p.u value
    - Computational effort in power system is very much reduced with the use of per unit quantities

- The chance of confusion between line and phase quantities is a 3Φ balanced system
- The per unit impedance referred to either side of a single phase transformer is the same
- Per unit impedance referred to either side of 3Φ transformer is the same regardless of the 3Φ connections.

4. **What are the types of load modeling**? **(May-June 2014)**
   a) Constant power representation
   b) Constant current representation
   c) Constant impedance representation
5. **What is the role of swing bus in power flow study**? **(May-June 2014)**
   The swing bus is assumed to generate the power for line losses which are estimated through the solution of load flow equations.
6. **At what condition generator bus is treated as load bus**? **(May-June 2014)**
   When the generator bus iterated value of reactive power exceeds the specified reactive power limits, the reactive power is set as Q_i = violated power limits (either Q_{min} or Q_{max} as the case may be) and the generator bus is treated as load bus.
7. **What are the advantages of per unit system (April-May 2011) ,(April-May 2017),(Nov-Dec-2016)**
   a) P.u unit data representation yields valuable relative magnitude information.
   b) Circuit analysis of system containing transformers of various transformation ratios is greatly simplified.
   c) Circuit parameters are tend to fall in relatively narrow numerical ranges making erroneous data easy to spot.
   d) P,u systems are ideal for the computerized analysis and simulation of complex power system problem.
8. **What is slack bus? (April-May 2011)**
   In slack bus voltage magnitude and phase angle of voltages are specified, pertaining to a generator bus usually a large capacity generation bus in chosen.
   This bus makes up the difference between the scheduled loads and generated power that are caused by the losses in the network.
9. **What is meant by percentage reactance? (May-June 2013)**
   It is the voltage drop across the reactance expressed as % of normal voltage when carrying Ife pertaining to normal voltage.
10. **Draw the equivalent circuit of a 3 winding transformer**. **(May-June 2013)**



11. **What are the functions of modern power systems? (Nov-Dec2013)**
    To monitor voltage at various buses and components
    To design modern protection system
    To plan the future expansion of loads and present existing system.
12. **Name the diagonal and off diagonal elements of bus impedance matrix? (Nov-Dec2013)**
    The diagonal elements of bus impedance matrix- driving point impedances of the buses (self)
    The off diagonal elements of bus impedances matrix- transfer impedances of the buses (mutual)

13. What is the need of base values?

The components or various sections of power system may operate of different voltage and power levels. It will be convenient for analysis of power system if the voltage, power, current and impedance ratings of components of power system are expressed with reference to a common value called base value. Hence for analysis purpose, a base value is chosen for voltage, power, current and impedance ratings of the components are expressed as a percent of per unit of the base value.

14. Why the value of voltage and 3-phase KVA are directly used for per unit calculation in 3-phase system? (May/June 2016)

The per-unit value of a line-to-neutral (V_{LN}) voltage on the line-to-neutral voltage base value ($V_{b,L-N}$) is equal to the per unit value of the line-to-line voltage(V_{LL}) at the same point on the line-to-line voltage (V_{bLL}) if the system is (V_{LL}) at the same point on the line-to-line voltage base(V_{bLL})if the system is balanced. $\frac{V_{LN}}{V_{bL-N}} = \frac{V_{LL}}{V_{bL-L}}$.Theper unit value of a 3-phase KVA on the 3-phase (KVA) base is identical to the per unit value of KVA per phase on the KVA per phase base.i.e., $\frac{\text{3phaseKVA}}{\text{3 phase base KVA}} = \frac{\text{KVA per phase}}{\text{Base KVA per phase}}$.Therefore in 3-phase systems the line value of voltage and 3-phase KVA are directly used for unit calculations.

15. What is single line diagram? (Nov/Dec 2015)

A single line diagram is diagrammatic representation of power system in which the components are represented by their symbols and the inter connection between them are shown by a single straight line (even though the system is 3-phase system). The ratings and the impedances of the components are also marked on the single line diagram.

16. Define per unit value.(Nov/Dec 2015)

The per unit value of any quantity is defined as the ratio of the actual value of the quantity to the base value expressed as a decimal. The base value is an arbitrary chosen value of the quantity.

$$\text{Per unit value} = \frac{\text{Actual value}}{\text{Base value}}$$

17. Write the equation for converting the p.u. impedance expressed in one base to another?

$$Z_{pu,New} = Z_{pu,old} X \left[\frac{KV_{b,old}}{KV_{b,new}}\right]^2 X \left[\frac{MVA_{b,new}}{MVA_{b,old}}\right]$$

18. How the loads are represented in reactance or impedance diagram? (Nov/Dec 2016)

The resistive and reactive loads can be represented by any one of the following representation.

i) Constant power representation, Load power $S = P + jQ$

ii) Constant current representation, Load Current $I = \sqrt{\frac{P^2+Q^2}{|V|}} \angle\delta - \theta$

iii) Constant impedance representation. Load impedance $Z = \frac{V^2}{P-jQ}$

19. A generator rated at 30MVA, 11KV has a reactance of 20% calculate its p.u reactance for a base of 50 MVA and 10KV.

$$X_{pu,New} = X_{pu,old} X \left[\frac{KV_{b,old}}{KV_{b,new}}\right]^2 X \left[\frac{MVA_{b,new}}{MVA_{b,old}}\right] = 0.2 \text{ x } (11/10)^2 \text{x } (50/30) = 0.403pu$$

20. The base KV and base MVA of a 3-phase transmission line is 33KV and 10 MVA respectively calculate the base current and base impedance?

Base current, $I_b = \frac{(KVA)_b}{\sqrt{3}KV_b} = \frac{(MVA)_b \times 1000}{\sqrt{3}KV_b} = \frac{10 \times 1000}{\sqrt{3} \times 33} = 175A$

Base impedance, $Z_b = \frac{(KV_b)^2}{MVA_b} = \frac{33^2}{10} = 108.9\Omega$

21. What is impedance diagram?

The impedance diagram is the equivalent circuit of power system in which the various components of power system are represented by their approximate or simplified equivalent circuits. The impedance diagram is used for load flow studies.

22. What is reactance diagram?

The reactance diagram is the simplified equivalent circuit of power system in which the various components are represented by their reactance. The reactance diagram can be obtained from impedance diagram if all the resistive components are neglected. The reactance diagram is used for fault calculations.

23. What are the approximations made in reactance diagram?

i)The neutral reactance are neglected ii) Shunt branches in the equivalent circuits of transformers are neglected iii) The resistance are neglected.iv) All static loads and induction motors are neglected.v)the capacitance of the transmission lines are neglected

24. Give equations for transforming base KV on LV side to HV side of transformer.

$$\text{Base KV on HT side} = \text{Base KV on LT side X} \frac{\text{HT voltage rating}}{\text{LT voltage rating}}$$

$$\text{Base KV on LT side} = \text{Base KV on HT side X} \frac{\text{LT voltage rating}}{\text{HT voltage rating}}$$

25. What is bus?

The meeting point of various components in a power system is called as bus.The bus is a conductor made of copper or aluminum having negligible resistance. The buses are considered as points of constant voltage in a power system.

26. What are the disadvantages of per unit system?

The disadvantages of per unit system are some equations that hold in the unscaled case are modified when scaled into per unit factors such as$\sqrt{3}$ and 3 are removed or added in this method. Equivalent circuits of the components are modified making them somewhat more abstract. Sometimes these shifts that are clearly present in the unscaled circuit vanish in per unit circuit.

27. What is "Tap changing" transformer? State its types.

The transformer is wounded with tapping on either primary or secondary winding to adjust the voltage. The device used to give the constant output voltage is called tap changing transformer. The types arei)ON load automatic tap changer ii)OFF load tap changer.

28. What is off nominal transformation ratio?

When the voltage (or) turns ration of a transformer is not used to decide the ratio of base kV, its voltage (or) turns ration is called off-nominal ratio. Usually the voltage ratio of regulation transformer will be off-nominal ratio.

29. Write the four ways of adding an impedance to an existing system so as to modify Z_{Bus} matrix.

1. Adding a branch of impedance Z_b from a new bus p to the reference bus. 2. Adding a branch of impedance Z_b from a new bus p to an existing bus. 3. Adding a branch of impedance Z_b from an existing bus q to the reference bus. 4. Adding a branch of impedance Z_b between two existing buses p and q.

30. What are the methods available for forming bus impedance matrix?

(i)Form the bus impedance matrix and then take its inverse to get bus impedance matrix.

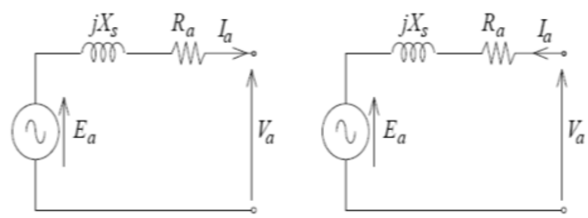
(ii)Directlyform the bus impedance matrix from the reactance diagram. This method utilizes the techniques of modifications of existing bus impedance matrix due to addition of new bus.

31. What is the purpose of providing third winding (tertiary) in a transformer?

i) Third winding may be used for interconnecting three transmission line at different voltages.

ii) It is sometimes used for other purposes such as connecting shunt capacitors (or) suppression of third harmonics voltages.iii)To get supply power for substation internal purposes.iv)Tertiary winding can serve the purpose of measuring voltage of an HV testing transformer.

32. Draw a simple per-phase model for a cylindrical rotor synchronous machine. (May 2011)

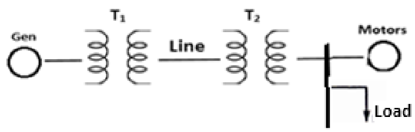


Synchronous Machine per phase equivalent circuits in (a) Generator and (b) Motor reference directions.

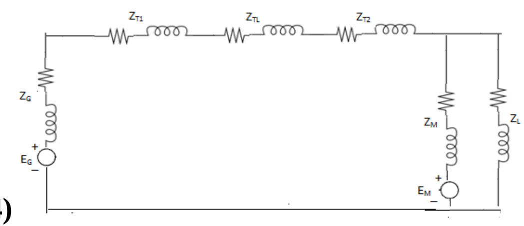
If the reactance in ohms is 15, find the p.u value for a base of 15KVA and 10KV? (May 2012)

$$Z(pu) = \frac{Z \times MVA_b}{KV_b^2} = \frac{15 \times 15}{10^2} = 2.25$$

33. Draw the impedance diagram for the given single line representation of the power system.

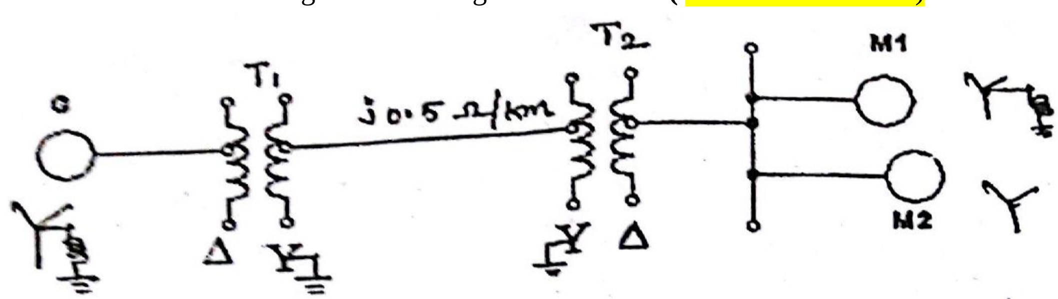


(May 2014)



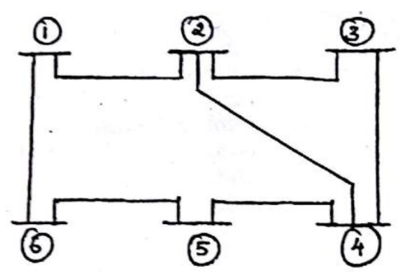
Part B

1. 300 MVA, 20 KV 3 ph generators has sub transient reactance of 20 %. The generator supplies 2 synchronous motors through a 64 Km transmission line having transformers at both ends as shown in fig .1 In this , T_1 is 3 ph transformer 350 MVA , 20 / 230 KV, 10 % reactance & T_2 is made of 3 single phase transformer of rating 100 MVA , 127/13.2 KV, 10 % reactance. Series reactance of the transmission line is 0.5 ohm/km. The rating of 2 motors are : M_1=200 MVA 13.2 KV, 20 % & M_2=100MVA ,13.2 KV ,20 % Draw the reactance diagram with all the reactance marked in P.U Select the generator rating as base values.**(** APRIL/MAY-2017)



2. Form the bus admittance matrix for the data given below using singular transformation method Take node '6' as reference node. **(APRIL/MAY-2017)**

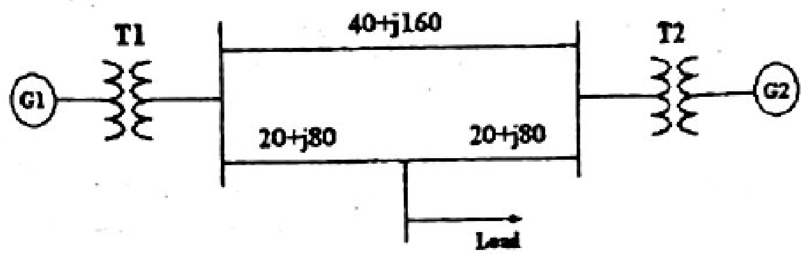
Elements	Bus code	X(P.U)
1	1-2	0.04



2	1-6	0.06
3	2-4	0.03
4	2-3	0.02
5	3-4	0.08
6	4-5	0.06
7	5-6	0.05

3. Prepare a per phase schematic of the system shown in fig. and show all the impedance in per unit on a 100 MVA, 132 KV base in the transmission line circuit. The necessary data are given as follows **:(NOV-DEC 2016)**

G1: 50 MVA, 12.2 KV, X=0.15 p.u
G2: 20 MVA, 13.8 KV, X=0.15 p.u
T1: 80 MVA, 12.2/161 KV, X=0.1 p.u
T2: 40 MVA, 13.8/161 KV, X=0.1 p.u
Load: 50 MVA, 0.8 pf lag operating at 154 KV
Determine the p.u impedance of the load.

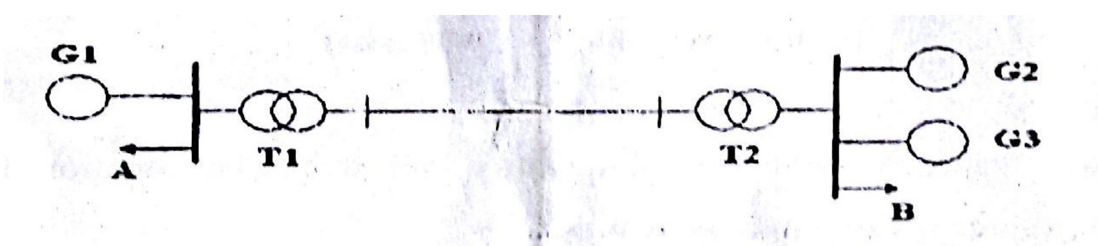


4. The parameters of a 4- bus system are as under: **(NOV-DEC 2016)**

Line starting bus	Line ending bus	Line impedance	Line charging admittance
1	2	0.2+j0.8	j0.02
2	3	0.3+j0.9	j0.03
2	4	0.25+j1.0	j0.04
3	4	0.2+j0.8	j0.02
1	3	0.1+j0.4	j0.01

Draw the network and find bus admittance matrix

5. The data for the system whose single line diagram as shown in fig. is as follows **:(APRIL-MAY 2016)**
G1: 30 MVA, 10.5 KV, X"=1.6 Ω
G2: 15 MVA, 6.6 KV, X"=1.2 Ω
G3: 25 MVA, 6.6 KV, X"=0.56 Ω
T1: 15 MVA, 33/11 KV, X=15.2 Ω/ph on H.T side
T2: 15 MVA, 33/6.2 KV, X=16.0 Ω/ph on L.T side
Transmission Line: X=20.5 Ω/ph
Loads A: 40 MW, 11 KV, 0.9 pf lagging
Loads B: 40 MW, 6.6 KV, 0.85 pf lagging
Choose the base power as 30 MVA, and approximate base voltage for different parts. Draw the reactance diagram. Indicate p.u reactance's on the diagram.



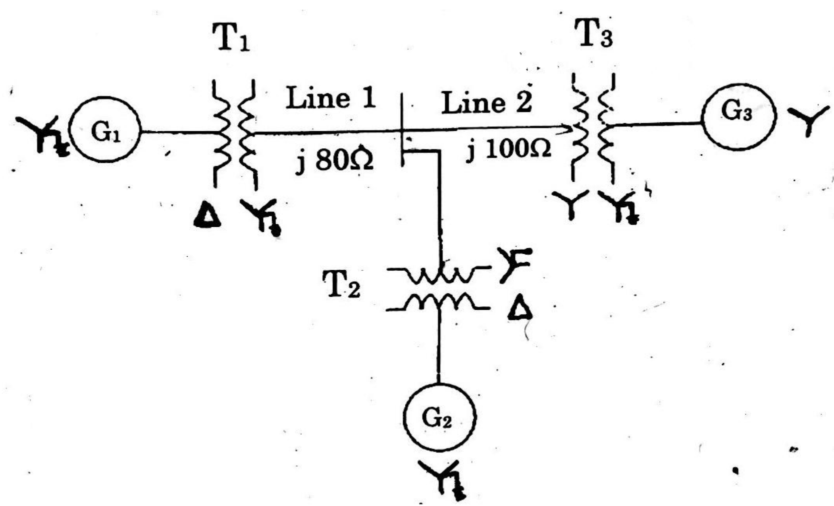
6. Determine the Y bus by inspection method for the line specification as mentioned below
(APRIL-MAY 2016)

Line p-q	Impedance in p.u	Half line charging admittances in p.u
1-2	0.04+j0.02	j0.05
1-4	0.05+j0.03	j0.07
1-3	0.025+j0.06	j0.08
2-4	0.08+j0.015	j0.05
3-4	0.035+j0.045	j0.02

7. Draw the PI model representation of transformer with off nominal tap ratio alpha **(APRIL-MAY 2016)**

8. Draw the reactance diagram for the power system shown in fig. Neglect resistance and use a base of 50 MVA and 13.8 KV on generator G1. **(NOV-DEC 2015)**

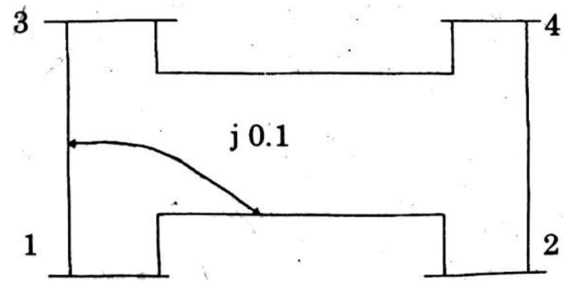
G1: 20 MVA, 13.8 KV, X"=20%
G2: 30 MVA, 18 KV, X"=20%
G3: 30 MVA, 20 KV, X"=20%
T1: 25 MVA, 220/13.8 KV, X"=10%
T2: 3 single phase unit each rated 10 MVA, 127/18 KV, X=10%
T3: 35 MVA, 220/22 KV, X=10%



9. Form Y_{bus} of the test system shown in figure. Using singular transformation method. The impedance data is given in Table. Take (1) as reference. **(NOV-DEC 2015)**

Element	Self		Mutual	
No.	Bus code	Impedance	Bus code	Impedance

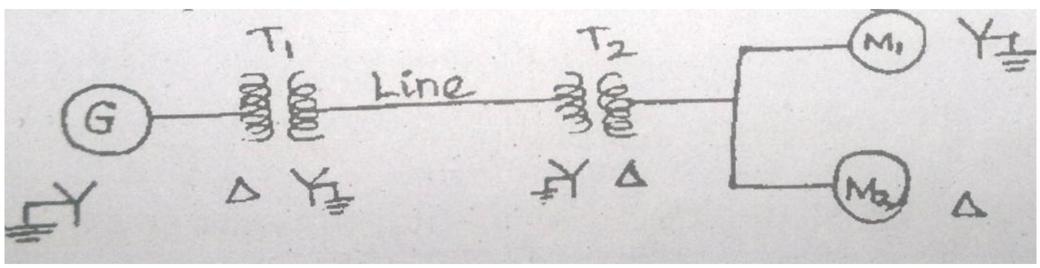
Table 1



1	1-2	0.5	1-2	0.1
2	1-3	0.6		
3	3-4	0.4		
4	2-4	0.3		

10. A 90 MVA, 11 KV 3 phase generator has a reactance of 25%. The generator supplies two motors through transformer and transmission line as shown in figure. The transformer T_1 is a 3-phase transformer, 100MVA, 10/132 KV, 6% reactance. The transformer T_2 is composed of 3 single phase units each rated, 300 MVA, 66/10 KV, with 5% reactance. The connection of T_1 & T_2 is shown. The motors are rated at 50 MVA and 400 MVA both 10 KV and 20% reactance. Taking the generator rating as base, draw reactance diagram and indicate the reactance in per unit. The reactance of line is 100 ohms.

(NOV-DEC 2013)



11. Obtain the per unit impedance diagram of the power system of fig. shown below.

Fig. one line diagram representation of a simple power system

Generator No 1: 30 MVA, 10.5 Kv, X"=1.6 ohms

Generator No 2: 15 MVA, 6.6 Kv, X"=1.2 ohms

Generator No 3: 25 MVA, 6.6 Kv, X"=0.56 ohms

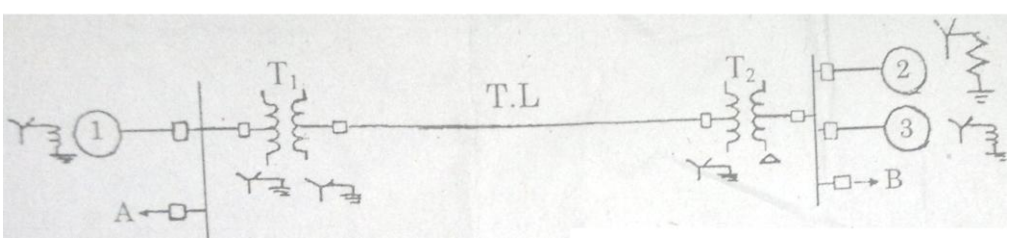
Transformer T_1 (3 phase): 15 MVA, 33/11 Kv, X=15.2 ohms per phase on high tension side.

Transformer T_2 (3 phase): 15 MVA, 33/6.2 Kv, X=16 ohms per phase on high tension side.

Transmission line: 20.5 ohms/phase.

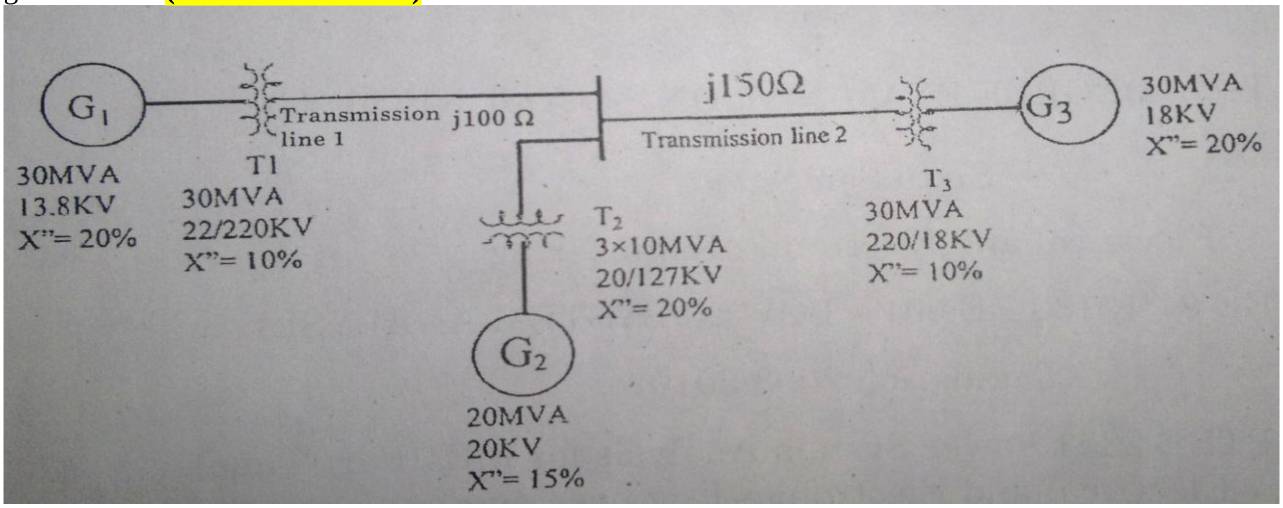
Load A: 15 MW, 11 Kv, 0.9 lagging power factor.

Load B: 40 MW, 6.6 Kv, 0.85 lagging power factor. **(NOV-DEC-14,NOV-DEC 10,NOV-DEC 05)**

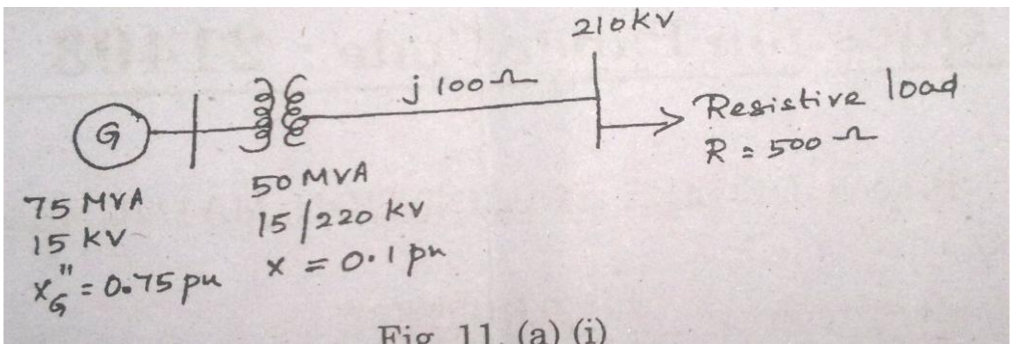


(ii) Draw the per unit equivalent circuit of single – phase transformer?

12. The single line diagram of a power system is shown in figure along with components data. Determine the new per unit values and draw the reactance diagram. Assume 25 MVA, and 20 Kv as new base on generator G1 **(APRIL-MAY 2014)**



13. For the system shown in figure. Determine the generator voltage. Take a base of 100 MVA and 210 KV in the transmission line**.(APRIL-MAY 2013)**



14. The one line diagram of a power system is shown in fig. The 3 phase power and line-line ratings are as given below.**(NOV-DEC 2012)**

G1: 80 MVA, 22 KV, X"=9%

T1: 50 MVA, 22/220 KV, X"=10%

T2: 40 MVA, 220/22 KV, X"=6%

T3 & T4: 40 MVA, 22/110 KV, X"=6.4%

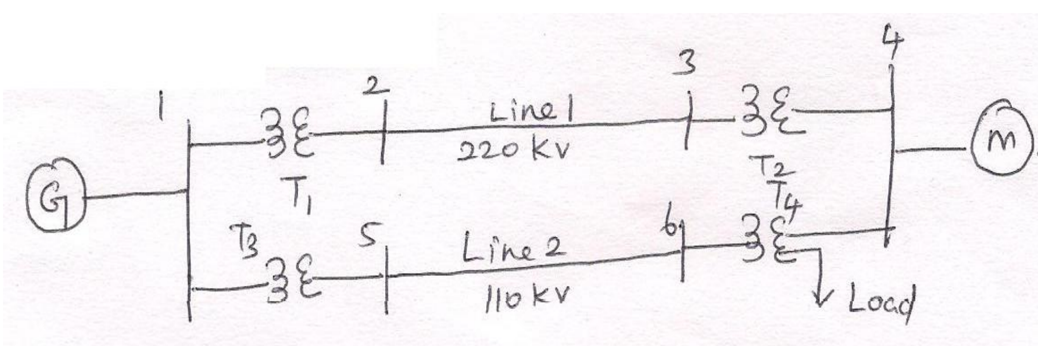
Line 1: 200 KV, X=121Ω

Line 2: 110KV, X=42.35 Ω

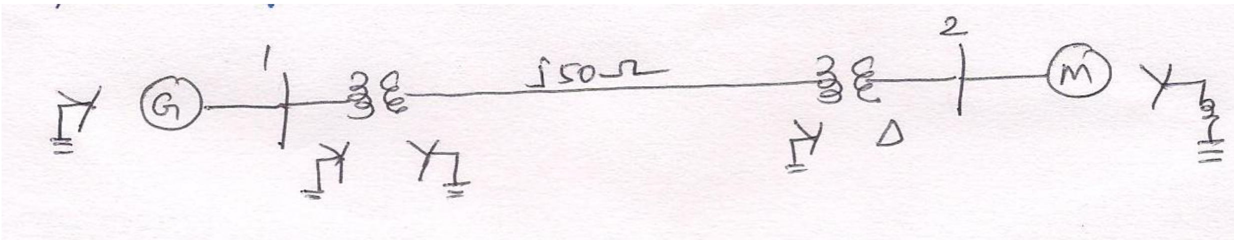
M: 68.85 MVA, 20 KV, X=22.5%

Load: 10 MVAR, 4 KV, Δ connected capacitors.

Draw an impedance diagram showing all impedances in p.u on a 100 MVA base. Choose 22 KV as the voltage base for generator

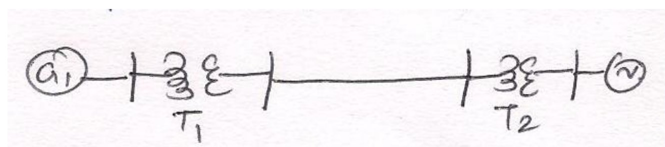


15. Draw the per unit impedance for the power system in fig. Neglect resistance and use a base of 100 MVA, 220 KV, in 50 ohm line. The rating of the generator, motor and transformer's are:
Generator: 40 MVA, 25 KV, X"=20%
Motor: 50 MVA, 11 KV, X"=30%
Y-Y Transformer: 40 MVA, 33Y-220Y KV, X=15%
Y-Δ Transformer: 30 MVA, 11Δ-220Y KV, X=15% **(NOV-DEC 2012)**



16. A 3 phase Δ-Y transformer with rating 100 MVA, 11 KV/400V has its primary and secondary leakage reactance as 12 Ω/ph and 0.05 Ω/ph, respectively. Calculate the p.u reactance of transformer
(NOV-DEC 2011)

17. Choosing a common base of 20 MVA, Compute the per unit impedance (reactance) of the components of the power system in fig. and draw the positive sequence impedance diagram.
G1: 20 MVA, 10.5 KV, X"=1.4 Ω
G2: 10 MVA, 6.6 KV, X"=1.2 Ω
T1: 10 MVA, 33/11 KV, X=15.2 Ω/ph on H.T side.
T2: 10 MVA, 33/6.2 KV, X=16 Ω/ph on H.T side.
Transmission line: 22.5 Ω /ph **(NOV-DEC 2008)**

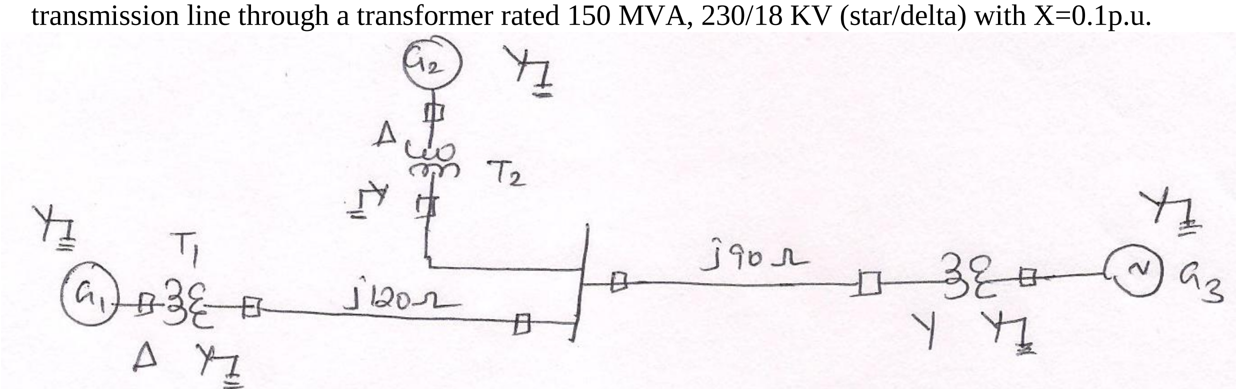


18. Show a single line diagram of unloaded 3 generator power system with interconnection between the generator by means of 3 transformers and a transmission line with two sections with their impedance marked on the diagram. The rating of generators and transformers are given below**.** **(APRIL-MAY 2008)**

Generator	MVA	KV	Reactance in p.u
1	25	6.6	0.2
2	15	6.6	0.15
3	30	13.2	0.15
Transformer	MVA	KV	X
1	30	6.9Δ-115Y	10%
2	15	6.9Δ-115Y	10%
3 single Ph units each rated 10 MVA		6.9/69 KV	10%

Draw a reactance diagram and mark all values in p.u choosing a base of 30 MVA, 6.6KV in generator circuit.

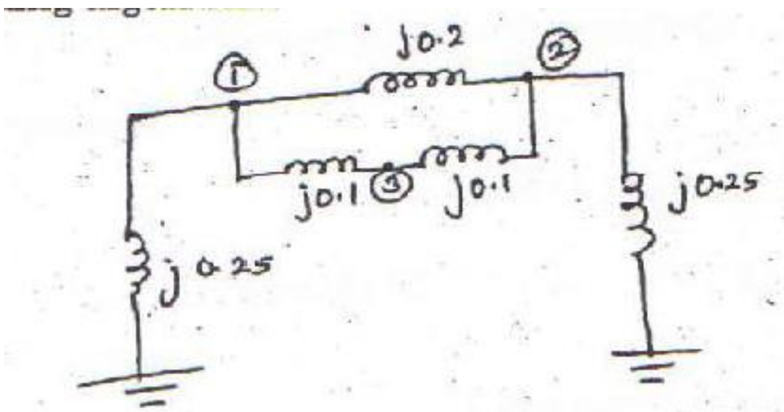
19. A 120 MVA, 19.5 KV, generator has a synchronous reactance of 0.15 p.u and it is connected to a transmission line through a transformer rated 150 MVA, 230/18 KV (star/delta) with X=0.1p.u.



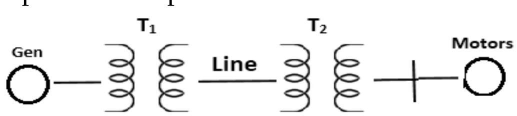
(i) Calculate the p.u reactance by taking generator rating as base value.
(ii) Calculate the p.u reactance by taking transformer as base value.
(iii) Calculate the p.u reactance for a base of 100 MVA, and 220 KV on H.T side of a transformer.

20. A Three phase Delta- Star transformer with rating 100KVA, 11KV/400V has its primary and secondary leakage reactance as 12 ohm/ph and 0.05 ohm/ph respectively. Calculate the p.u reactance of transformer.

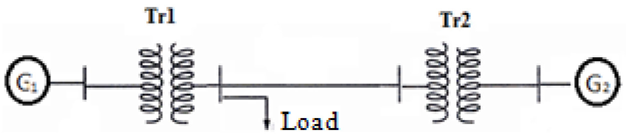
21. Form Z bus using bus building algorithm



22. Explain modern power system in detail and draw basic components of power system.
(Nov 2014)
23. The three phase power and line-line ratings of the electric power system are given below:G1:60MVA,20KV,X=9%;T1:50MVA,20/200KV,X=10%;T2:50MVA,200/20KV,X=10%;M: 43.2MVA, 18KV, X=8%; Line: 200KV, Z=120+j200 ohm. Draw an impedance diagram showing all impedances in per-unit on a 100-MVA base. Choose 20KV as the voltage base for generator.



24. A 20MVA, 11KV three phase synchronous generator has a sub transient reactance of 10%. It is connected through three identical single phase Δ-Y connected transformer 5000KVA 11/127.02KV with a reactance of 15% to a high voltage transmission line having a total series reactance of 80ohm. At the end of HT transmission line, three identical single phase star/star connected transformer of 5000KVA, 127.02/12.702KV with a reactance of 20%. The load is drawing 15MVA, at 12.5 KV and 0.9p.f lagging. Draw single line diagrams of the network choose a common base of 15MVA and 12.5KV and determine the reactance diagram.
25. Write short notes on the following: i)per-phase analysis of a generator ii)per-phase analysis of 3-windig transformer
26. With the help of single line diagram, explain the basic components of a power system
27. i)Write detailed notes about the per phase model of a three phase transformer.(May 2011)
ii) Draw an impedance diagram for the electric power system shown in figure, showing all the impedances in per unit on a 100 MVA base .Choose 20 KV as the voltage base for generator. The 3ϕ power and line rating are given below. G1:90MVA,20KV,X=9%.;Tr1:80MVA,20/200KV,X=16% Tr2: 80MVA, 200/20KV,X=20%;G2:90MVA,18KV,X=9%;Line:200KV,X=120Ω,Load:200 KV, S=48MW+j64MVAR.



28. What are the advantages of per unit computations?
29. Form the bus impedance matrix for the network shown by building algorithms.
30 Why is per unit system used in power system analysis? And list its advantages
31. Describe the Z Bus building algorithms in detailed by using a three bus system. (May, 2014)

UNIT – II POWER FLOW ANALYSIS
PART – A

1. What is load flow (or) Power flow study (Nov-Dec 2014)

The load flow problem consists of calculation of voltage magnitude and its phase angle at the buses. And also the active and reactive line flows for the specified terminal or bus conditions. The bus quantities to be determined are:

a) Magnitude of Voltage(V), b) Phase angle of voltage ‘δ’, c) Real power (P),
d) Reactive power (Q)

2. Define voltage controlled bus? (Nov-Dec 2014)

For this bus, voltage magnitude corresponding to the generation voltage and real power generation corresponding to the generator ratings are specified, through load flow solution. It is required to find the reactive power generation and the phase angle of bus voltage.

3. What is the role of swing bus in power flow study? (May-June 2014)

The swing bus is assumed to generate the power for line losses which are estimated through the solution of load flow equations.

4. At what condition generator bus is treated as load bus? (May-June 2014)

When the generator bus iterated value of reactive power exceeds the specified reactive power limits, the reactive power is set as Q_i = violated power limits (either Q_{min} or Q_{max} as the case may be) and the generator bus is treated as load bus.

5. What are the advantages of per unit system (April-May 2011)

e) P.u unit data representation yields valuable relative magnitude information.
f) Circuit analysis of system containing transformers of various transformation ratios is greatly simplified.
g) Circuit parameters are tend to fall in relatively narrow numerical ranges making erroneous data easy to spot.
h) P,u systems are ideal for the computerized analysis and simulation of complex power system problem.

6. What is slack bus? (April-May 2011)

In slack bus voltage magnitude and phase angle of voltages are specified, pertaining to a generator bus usually a large capacity generation bus in chosen. This bus makes up the difference between the scheduled loads and generated power that are caused by the losses in the network.

7. What is the necessity for slack bus? (May-June 2013)

The swing bus or slack bus is assumed to generate the power for line losses which are estimated through the solution of load flow equations.

8. What is meant by acceleration factor? (May-June 2013)

Acceleration factor (a) = convergence characteristics.

Convergence is gauss seidal method can be speeded by acceleration factor for (en) a=1.6.

9. When will the generator bus treated as load bus ? (Nov-Dec2013)

When the generator bus iterated value of reactive power exceeds the specified reactive power limits, the reactive power is set as Qi =violated reactive power limit (either Qmin or Qmax) and the generator bus is treated as load bus

10. Why do Y bus used in load flow study instead of Zbus? (Nov-Dec2013)

Data preparation is simple

Bus admittance matrix can be easily formed and modified for network changes such as addition of lines, regulating transformers

Sparsity of the bus admittance matrix is the greater advantage as H reduces computer memory and time requirement largely also bus impedance matrix is a full-matrix.

11. What are the different types of buses in a power system? (May/June 2016)

The buses of a power system can be classified into three types based on the quantities being specified for the buses. The different types of buses are,(i) Load bus or PQ bus (ii)Generator bus or voltage controlled bus or PV bus(iii)Slack bus (or) swing bus (or) reference bus

12. What will be the reactive power and bus voltage when the generator bus is treated as load bus?(Nov/Dec 2015)

When the generator bus is treated as load bus, the reactive power of the bus is equated to the limit it has violated, and the previous iteration value of bus voltage is used for calculating current iteration value.

13. What are the advantages of G-S method?

i) Calculations are simple so the programming task is lessii) the memory requirement is lessiii) Useful for small systems

14. What are the disadvantages of G-S method?

i) Requires large number of iterations to reach convergence. ii) Not suitable for large systems iii) Convergence time increases with size of the system

15. What are the advantages of N-R method?

i) The N-R method is faster, more reliable and the results are accurate ii)Requires less number of iterations for convergence. iii) The number of iterations is independent of the size of the system.vi) Suitable for large size system.

16. What are the disadvantages of N-R method?

i) Programming is more complex ii) The memory requirement is more iii) Computational time per Iteration is higher due to large number of calculations per iteration.

17. How the disadvantages of N-R method are overcome?

The disadvantages of large memory requirement can be overcome by decoupling the weak coupling between P- δ and Q-V (i.e using de coupled load flow algorithm). The disadvantage of large computational time per iteration can be reduced by simplifying the decoupled load flow equations. The simplifications are made based on the practical operating conditions of a power system.

18. How are the diagonal elements of Y_{bus} known as?
The diagonal elements of $Y_{bus}$are known as the short circuited driving point admittance or self-admittance of the buses.

19. State the major steps involved in load flow studies?
The major steps involved in load flow studies are i) Mathematical modeling of the power system; this would be a set of non-linear algebraic equations. ii) Solution of the non-linear equations through an iterative technique.

20. Why acceleration factor is used in the G-S method?
To increase the rate of convergence of the iterative process, acceleration factor is used.

21. What is the need of load flow solution?
The load flow solution is essential for designing a new power system and for planning extension as well as operation of the existing one for increased power demand.

22. What is load bus?
A load bus is one at which the active power and reactive power are specified. In this bus its voltage can be allowed to vary within permissible values. i.e ±5%. Also bus voltages phase angle is not very important for the load.

23. How the convergence of N-R method is speeded up?
The convergence of N-R method is speeded up using fast decoupled load flow (FDLF) method. In FDLF, the weak coupling between P-V and Q- δ are decoupled and the equations are further simplified equations are further simplified using the practical operating conditions of the power system.

24. What is the need for voltage control in a power system?
The various components of a power system (or equipments connected to power system) are designed to work satisfactorily at rated voltages. If the equipments are not operated at rated voltages then the performance of the equipments will be poor and the life of the equipments will reduce. Hence the voltages at various points in a power system should be maintained at rated value (specified value)

25. How the reactive power of a generator is controlled?
The reactive power of a generator is controlled by varying the magnitude and phase of induced emf, which in turn varied by varying excitation. For an increase in reactive power the magnitude of induced emf is increased and its phase angle is decreased. For a reduction in reactive power the magnitude of induced emf is decreased and its phase angle is increased.

26. What is Jacobian matrix? How the elements of Jacobian matrix are determined?(May 2011)(Nov/Dec 2016)
The matrix formed the first order derivatives of load flow equations is called Jacobian matrix (J).The elements of Jacobian matrix will change in every iteration. In each iteration the elements of this matrix are obtained by partial differentiating the load flow equations with respect to an unknown variable and then calculating the first derivatives using the solution of previous iteration.

27. Whatare the information that are obtained from a power flow study? (May 2012)

Bus voltages, Line / transformer power flows, and transmission power losses.

28. Compare Gauss-seidal and Newton Raphson methods of load flow solutions. (May 2012)(apr/may 2015)

S. N	Gauss seidal	Newton Raphson
1.	Reliable	More reliable
2.	Require large number of iterations to reach convergence. It has linear convergence characteristics	Faster. Require less number if iteration to reach convergence It has quadratic convergence characteristics.
3.	Programming task is less	Programming is more complex.
4.	Suitable for small size system and not suitable for large system. Number iterations increases with increase in size.	Suitable for large size system. Number of iterations does not depend on size of the system.
5.	Memory required is less	Memory required is more.

29. Why power flow analysis is made?(Nov2012)

Power flow analysis is performed to calculate the magnitude and phase angle of voltage at the buses and also the active power and reactive volt amperes flow for the given terminal or bus conditions. The variables associated with each bus or node arei) magnitude of voltage (v) ii) phase angle of voltage (δ) iii) active power (P) iv) reactive volt amperes (Q).

30. What is acceleration factor?(Nov2012) (May 2013)

The acceleration factor is a numerical multiplier which is used to increase which is used to increase the rate of convergence in an iterative process. The previous value at the bus is multiplied by the acceleration factor to obtain a correction to be added to previous values.

31. What is the need of slack bus? (May 2013) (May 2014)(nov/dec 2016)

The slack bus is needed to account for transmission line losses.In a power system the total power generated will be equal to sum of power consumed by loads and losses.In a power system only the generated power and load power are specified for buses.The slack bus is assumed to generate the power required for losses.Since the losses are unknown the real and reactive power are not specified for slack bus .They are estimated through the solution of load flow equations.

32. Why do Y_{Bus} used in load flow study instead of Z_{Bus}? (Nov 2013)

Y_{bus} is sparsity matrix ie. Number of non-zero elements is less compared to zero elements. Henceformation of Y_{bus}needs less memory.

33. When will the generator bus be treated as load bus? (Nov 2013) (May 2014)

If the reactive power of a generator bus violates the specified limits then the generator bus is treated as load bus.

34. Define voltage controlled bus (November 2014)

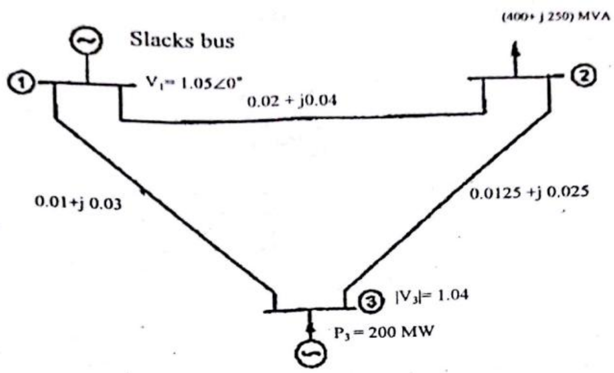
These are the buses where generators are connected. Therefore the power generation in such buses is controlled through a prime mover while the terminal voltage is controlled through the generator excitation. Keeping the input power constant through turbine-governor control and keeping the bus voltage constant using automatic voltage regulator, we can specify constant P_{Gi} and $|V_i|$ for these buses. This is why such buses are also referred to as P-V buses. It is to be noted that the reactive power supplied by the generator Q_{Gi} depends on the system configuration and cannot be specified in advance. Furthermore we have to find the unknown angle δ_i of the bus voltage.

35. In which method for solving load flow problem acceleration factor is used.

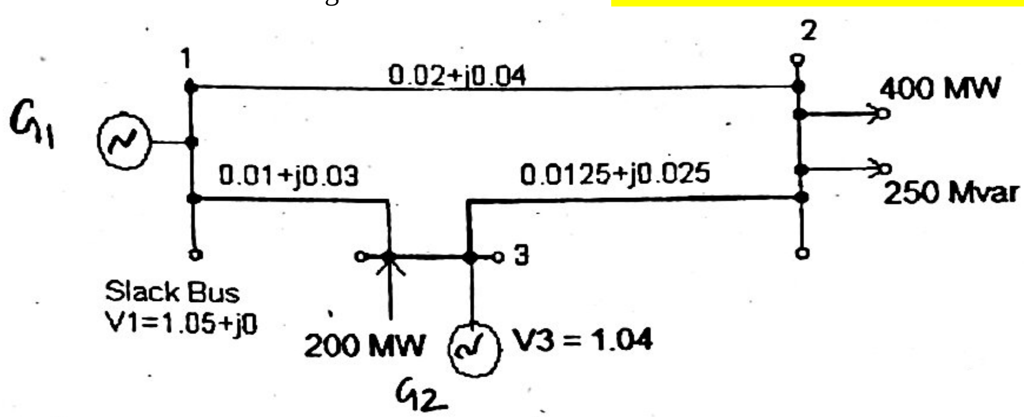
Gauss seidal method

Part B

1. Single line diagram of a simple power system, with generators at busses 1 and 3 is shown in Fig. The magnitude of voltages at bus 1 is 1.05 p.u. Voltage magnitude at bus 3 is fixed at 1.04 p.u. with active power generation of 200 MW. A load consisting of 400 MW and 250 MVAR is taken from bus 2. Line impedances are marked in p.u. on a 100 MVA base and the line charging susceptances are neglected. Determine the voltage at buses 2 and 3 using Gauss-Seidal method at the end of first iteration. Also calculate slack bus power. **APRIL-MAY 2017**



2. The Fig shows the one line diagram of a simple 3 bus power system with generators at buses 1 and 3. Line impedances are marked in p.u. on a 100 MVA base. Determine the bus voltages at the end of second iteration using Gauss-Seidel method. **NOV-DEC 2016 MAY-JUNE 2009**



3. The system data for load flow solution are given in tables 2 and 3. Determine the voltages at the end of the first iteration using the Gauss-Seidal method. Take α = 1.6 **NOV-DEC 2015**

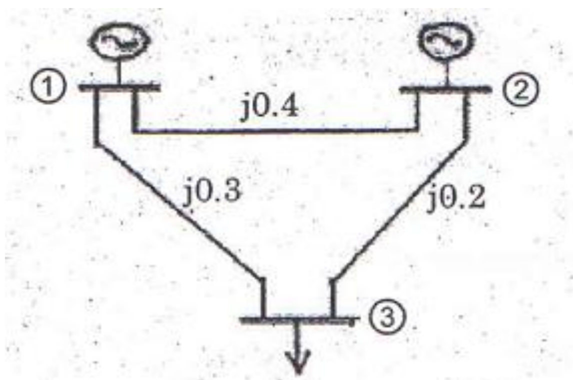
Line admittances

Bus code	**Admittances**
1-2	2-j8.0
1-3	1-j4.0
2-3	0.666-j2.664
2-4	1-j4.0
3-4	2-j8.0

Schedule of active and reactive powers

Bus code	**P in p.u**	**Q in p.u**	**V in p.u**	**Remarks**
1	-	-	1.06	Slack
2	0.5	0.2	1+j0.0	PQ
3	0.4	0.3	1+j0.0	PQ
4	0.3	0.1	1+j0.0	PQ

4. Fig shown below a three bus power system Bus.1: slack bus V= 1.05 p.u, Bus 2: PV Bus $|V|$ = 1.0 p.u , P_g= 3 p.u. Bus 3: PQ Bus P_L=4 p.u, Q_L = 2 p.u. carry out one iteration of load flow solution by Guss Seidal method. Neglect limits on reactive power generation? **NOV-DEC 2014**



5. A three bus power system is shown in figure. The relevant per unit line admittance on 100 MVA base are indicated on the diagram and bus data are given in table. From Y_{bus} and determine the voltages at bus 2 and bus 3 after first iteration using Gauss seidal method. Take the acceleration factor α = 1.6 **NOV-DEC 2013**

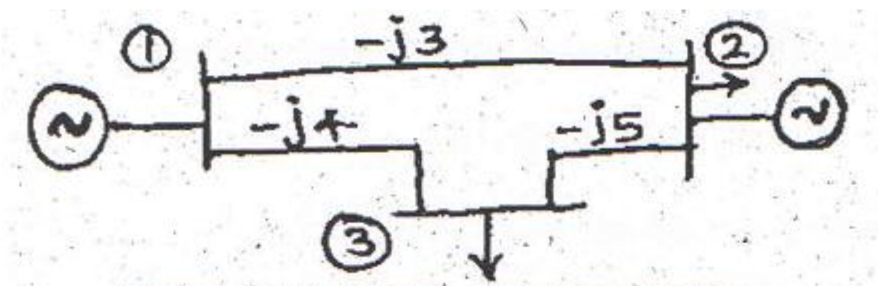


Figure. 12(a) A three – bus power system

Bus No	Type	Generation		Load		Bus Voltage	
		P_G	Q_G(MVAr)	P_L	Q_L	V(pu)	δ deg
1	Slack	?	?	0	0	1:02	0°
2	PQ	25	15	50	25	?	?
3	PQ	0	0	60	30	?	?

6. Consider the power system with the following data:

$$Y_{bus}=\begin{vmatrix} -j12 & j8 & j4 \\ j8 & -j12 & j4 \\ j4 & j4 & -j8 \end{vmatrix}$$

Bus No	Type	Generation		Load		Bus Voltage	
		P	Q	P	Q	V(pu)	δ deg
1	Slack	-	-	-	-	1.0	0°
2	PV	5.0	-	0	-	1.05	-
3	PQ	0	0	3.0	0.5	-	-

Assume that the bus 2 can supply any amount of reactive power. With a flat start, perform the first iteration of power flow analysis using Newton-Raphson method. **MAY-JUNE 2013**

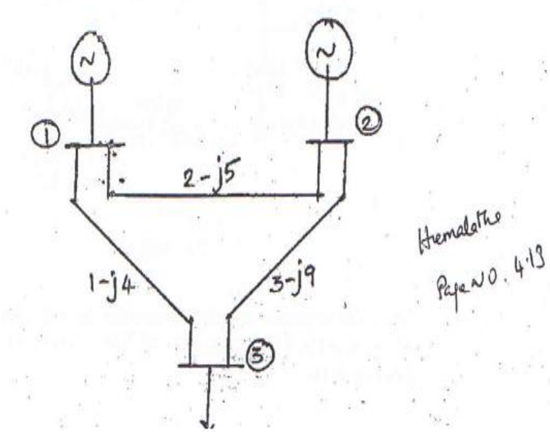
7. The figure given below shows a power system. **NOV-DEC 2012,NOV-DEC 2011**

Bus 1: Slack bus $E_{specfied}$ =1.05 0°

Bus 2: PV bus $E_{specfied}$ =1.2 p.u P_G = 3 p.u

Bus 3: PQ bus P_L = 4 p.u Q_L = 2 p.u

Carry out one iteration of load flow solution by Gauss-Seidal method. Take Q limits of generation 2 as $0 \leq Q < 4$. Take α=1.

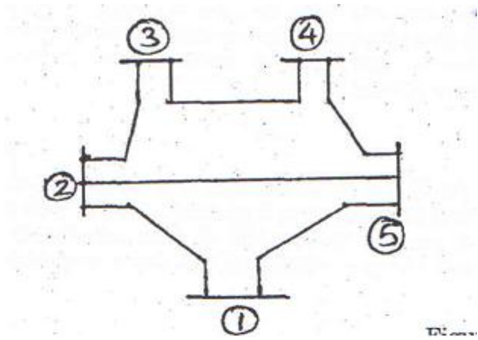


8. Figure shows a five bus power system. Each line has an impedance of (0.05+j 0.15) p.u. The line shunt admittances may be neglected. The bus power and voltage specifications are given in table.

(i) Form Y_{bus}

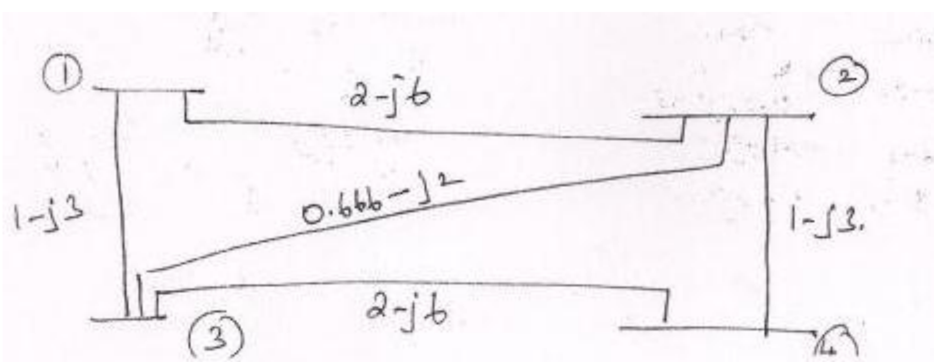
(ii) Find Q_2, δ_2, V_3, V_4 and V_5 after the first iteration using Gauss seidal method. Assume Q_2, min = 0.2 p.u and Q_2, max =0.6 p.u **MAY –JUNE 2012- B.R.GUPTA**

Fig



Bus No	P_L	Q_L	P_G	Q_G	V	Bus Type
1	1.0	0.5	not specified	Not specified	1.02	Slack bus
2	0	0	2	not specified	1.02	PV bus
3	0.5	0.2	0	0	not specified	PQ bus
4	0.5	0.2	0	0	not specified	PQ bus
5	0.5	0.2	0	0	not specified	PQ bus

9. For the sample system shown in Fig the generators are connected at all the four bases. While the loads are at buses 2 and 3. Values of real and reactive powers are listed in table. Bus 2 be a PV bus with V_2 = 1.04 p.u and bus 3 and 4 are PQ bus. Assuming a flat voltage start, find bus voltages and bus angles the end of first G-S iterations and consider the reactive power limit as 0.2≤ Q_2 ≤1. **MAY –JUNE 2008 –NAGRATH AND KOTHARI**



Bus	P_P(p.u)	Q_P(p.u)	V_P(p.u)	Remarks
1	-	-	1.04	Slack bus

2	0.5	-	1.04	PV bus
3	-1.0	0.5	-	PQ bus
4	0.3	-0.1	-	PQ bus

10. The system data for a load flow problem are given in table

(i) Compute Y –bus

(ii) Determine bus voltages at the end of 1st iteration by G-S method by taking acceleration factor as 1.6

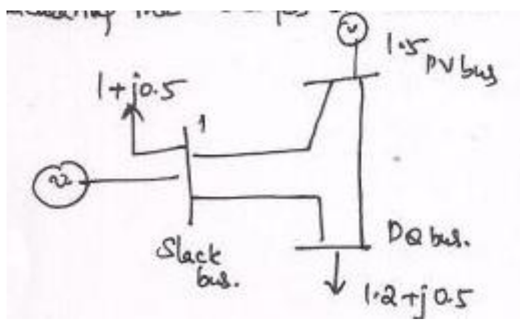
Bus data

Bus code	P_{demand}(p.u)	Q_{demand}(p.u)	V (p.u)	Remarks
1	-	-	1.06	Slack
2	0.5	0.2	-	PQ
3	0.4	0.3	-	PQ

Line data

Line No	Bus code	Admittance (p.u)
1	1-2	2-j8
2	1-3	1-j4
3	2-3	0.6-j2.6

11. Fig shows a 3 bus system. The series impedance and shunt admittance of each line 0.026+j0.11 p.u and j0.04 p.u respectively.



Bus	P_G	Q_G	P_L	Q_G	Bus voltages
1	Unspecified	Unspecified	1.0	0.5	1.03+j0 (slack)
2	1.5	Unspecified	0	0	V=1.03 (PV)
3	0	0	1.2	0.5	Unspecified (PQ bus)

For bus 2 the min and max reactive power limits are 0 and 0.8 p.u

(i) Form Y bus

(ii) Find $P_2^0, Q_2^0, P_3^0, Q_3^0$

(iii) Find $[T^0]$

(iv) Form the general eqn for calculating the changes in variables by NR method

12. Formulate the power flow equation for n bus system?

13. State the element of Jacobian Matrix for a system with PQ buses alone?

14. Compare Gauss seidal and N R method in detail?

15. State the load flow problem and derive load flow equation.

16. (a) What are the practical application of the power flow analysis ?

(b) Derive the mathematical model of phase shifting transformer to be used in a power flow analysis.

17. What is Jacobian Matrix?How the elements of Jacobian matrix are computed?(May 2012) (Nov2012)

18. Write the step by step procedure for load flow analysis by Newton Raphson method. **(May 2012)(nov 2014) (may 2014) .(may/june 2016)(nov/dec 2016)**

19. (i) Give the classification of various types of buses in a power system for load flow studies**.(Nov 2014) (Nov 2014)**

(ii) Give the advantages and limitations of Newton Raphson method.

20**.** Describe the step by step procedure for load flow solution from Gauss siedal method, if PV and PQ buses are present along with slack bus**. (May 2011)(May 2013), (May 2014) .(may/june 2016)(nov/dec 2015)**

UNIT – III FAULT ANALYSIS - BALANCED FAULT

PART – A

1. **What is the need for short circuit study? (Nov-Dec 2014)**

   To determine the magnitude of currents flowing throughout the power system at various time intervals after a fault occurs. To select the rating of fuses, breakers and switchgear in addition to setting up of protective relays.

2. **Give the frequency of various fault occurrence in ascending order (May-June 2014)**

   a) Three phase fault 5%
   b) Double line-ground fault 10%
   c) Line to line fault 15%
   d) Single line to ground fault 70%

3. **Define bolted fault(May-June 2014)**

   All the three phases are shorted and are connected to the ground, the fault current is three times the each phase shorted currents $I_f = 3I_{phase}$. This fault is called as bolted fault.

4. **Mention the objectives of short circuit analysis (April-May 2011)**

   - To protect against heavy flow of short circuit currents by disconnecting the faulty section from the healthy section by means of circuit breakers.
   - To estimate the magnitude of fault current for proper choice of circuit breaker and protective relays.
   - To develop protective schemes for various part of the system.

5. **What is meant by fault level? (MAY-JUNE 2013)**

When a fault occurs at a point in a power system the corresponding MVA is the fault level at that point.

6. **Define negative sequence impedance? (MAY-JUNE 2013)**

The impedance of network offered to the flow of negative sequence current is called negative sequence impedance

7. **What are the characteristics of shunt and series faults? (NOV-DEC2013)**

Shunt – shunt fault will decrease the voltage and frequency but increases the current flow

Series – series fault will increase the voltage and frequency but decrease the current flow.

8. **What are the observations made from the analysis of various faults? (NOV-DEC2013)**

To design the protective schemes for various parts of the system

To select the appropriate devices (relays circuit breakers)

To protective schemes consists of current and voltage sensing devices, protective relays and circuit breakers.

The selection of these mainly depends on various currents that may flow in the fault conditions.

What is Short Circuit MVA and how it is calculated?(nov/dec 2016)

The short circuit capacity or the short circuit MVA at a bus is defined as the product of the magnitudes of the rated bus voltage and the fault current. S.C MVA capacity of the circuit breaker = √ 3 x pre fault voltage in KV x S.C current in KA.

2. What are the types of faults?(nov/dec 2016)

SERIES FAULT: a) One open conductor fault b) Two open conductor fault

SHUNT FAULT: (a) Symmetrical or balanced fault (i) Three phase Fault(LLLG)(b) Unsymmetrical or unbalanced fault (i) Line to line fault(LL)(ii) Line to ground fault (LG)(iii) Double line to ground fault.(LLG).

3. What are the factors to be considered for selecting the C.B.?

The factors to be considered in selecting a circuit breaker for a protection scheme are: Normal operating voltage, Momentary, interrupting current. Speed of the breaker and S.C interrupting MVA.

4. What you mean by symmetrical faults?(November 2014)(may/june 2016)

The fault is called symmetrical fault if the fault current is equal in all the phases and the phase difference between any two phases is equal.

5. What you mean by doubling effect?

The first peak of the resultant current will become twice the peak value of the final steady current. This effect is called as doubling effect.

6. What you mean by transient and sub transient reactance?

X_d' (transient reactance) is the ratio of no load e.m.f and the transient symmetrical r.m.s current.

X_d'' (sub transient reactance) is the ratio of no load e.m.f and the sub transientsymmetricalr.m.s current.

7. What is the application of transient reactance?

The transient and sub transient reactance helps in calculating the interrupting and maximum momentary s.c currents.

8. Give the various assumptions made for fault analysis.

The assumptions made in analysis of faults are:i) Each synchronous machine model is represented by an e.m.f behind a series reactance ii) In the transformer models the shunt that account for core loss and magnetizing components are neglected.iii) In the transmission line models the shunt capacitances are neglected.iv)All series resistances in generators, transformers, lines are neglected.v) In the normal operating conditions the pre fault voltage may be considered as 1.0 p.u.vi) Load impedances are neglected; hence the pre fault system may be treated as unloaded. vii) As the pre fault currents are much smaller than the post fault currents the pre fault currents can be neglected.

9. Name any methods of reducing short circuit current.

By providing neutral reactances and by introducing a large value of shunt reactances between buses.

10.What are the reactances used in the analysis of symmetrical faults on the synchronous machines as its equivalaentreactances.

i) Subtransient reactance X_d'' ii) Transient Reactance X_d' iii) Synchronous reactance X_d

11. What is synchronous reactance?

It is the ratio of induced emf and the steady state r.m.scurrent. $X_d = E_g / I$

It is the sum of leakage reactance and the armature reaction reactances. It is given by$X_d = X_l + Xa$,Xd = Synchronous reactance. X_l= Leakage reactance Xa = Armature reaction reactance.

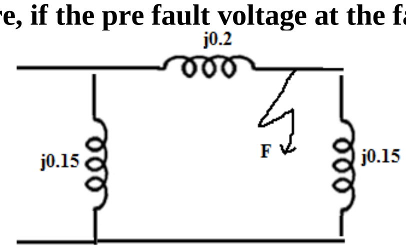
12.What are the causes of fault in power system.(nov/dec 2015)

A fault may occur on a power system due to a number of reasons. Some of the causes are(i)Insulation failure of the system(ii)Falling of a tree along a line(iii)Wind and ice loading on the transmission lines(iv)Vehicles colliding with supporting structures(v)Overloading of underground cables(vi)Birds shorting the lines.

13. Name the main differences in representation of power system for load flow and short circuits studies

S.N	Load flow studies	Short circuit studies
1	The resistances and reactances are considered	The resistances are neglected
2	To solve load flow analysis, the bus admittance matrix is used	To solve load flow analysis, the bus impedance matrix is used
3	It is used to determine the exact voltages and currents	Prefault voltages are assumed to be 1 p.u and the prefault current can be neglected

14. Find the fault current in figure, if the pre fault voltage at the fault point is 0.97p.u?



$$Z_{th} = j\frac{(0.15 + 0.2)X0.15}{(0.15 + 0.2) + 0.15} = j0.105 \text{ pu}$$

Fault Current $I_f = \frac{V_{pf}}{Z_{th}} = \frac{0.97}{j0.105} = j9.238 \text{ p. u.}$

15. What is the reason for transients during short circuits?

The fault or short circuits are associated with sudden change in currents. Most of the components of the power system have inductive property which opposes any sudden change in currents and so the faults (short circuit) are associated with transients.

16. What is the significance of transient reactance in short circuit studies?

The transient reactance is used to estimate the transient value of fault current. Most of the circuit breakers open their contacts only during this period. Therefore, for a circuit breaker used for fault clearing, its interrupting short – circuit rating should be less than the transient fault current.

17. What is the significance of sub - transient reactance in short circuit studies?

The sub - transient reactance is used to estimate the initial value of fault current immediately on the occurrence of the fault. The maximum momentary short circuit current rating of the circuit breaker used for protection or fault clearing should be less than this fault clearing value.

18. How to conduct fault analysis of a power system network?

By using equivalent circuit representation and by using bus impedance matrix

19. What is meant by fault calculations?

The fault condition of a power system can be dived into sub transient, transient and steadystate periods. The currents in the various parts of the system and in the fault are different in these periods. The estimation of these currents for various types of faults at variouslocations in the system are commonly referred as fault calculations.

20. Mention the objectives of short circuit studies or fault analysis. (May 2011)(Nov 2012), (Nov2014)

The short circuit studies are essential in order to design or develop the protective schemes for various parts of the system. The protective scheme consists of current and voltage sensing devices, protective relays and circuit breakers. The selection or proper choice of these mainly depends on various currents that may flow in the fault conditions.

21. Write down the balanced and unbalanced faults occurring in a power system. (May 2011)

BALANCED FAULT:3 phase short circuit fault

UNBALANCED FAULT:Single line to ground fault,line to line fault and double- line to ground fault.

22. Distinguish symmetrical and unsymmetrical fault. (Nov 2012)(May 2013)

The fault is called Symmetrical fault if the fault current is equal in all the phases.eg. 3ϕ short circuit fault. The fault is called unsymmetrical fault if the fault current is not equal in all the threephases.eg.i) single line to ground fault ii) line to line fault iii) double line to ground fault iv) open conductor fault

23. What is meant by fault level? (May 2013)

It relates to the amount of current that can be expected to flow out of a bus in to a 3 phase fault.

Fault level in MVA at bus $i = V_{i\,pu\,nominal} * I_{i\,pu\,fault} * S_{3\phi\,base}$.

25. Define bolted fault.(May 2014)(may/june 2016)

A fault represents a structural network change equivalent with that caused by the addition of impedance at the place of the fault. If the fault impedance is zero, then the fault is referred as bolted or solid fault.

26.what are the uses of short circuit capacity.

It is used for determining the dimension of a busbar and the interrupting capacity of a circuit breaker.

27. Name the method of reducing short circuit capacity.

The short circuit capacity is reduced by introducing artificial series reactors.

29. Which type of fully is more severe.

Three phase to ground fault.

30. Why symmetrical fault occurs in a power system.

The short circuit fault occurs in a power system due to insulation failure of equipments ,flash over of lines initiated by a lightning stroke or through accidental faulty operation.

31.state the application of short circuit analysis.

(i).for proper relay setting and coordination

(ii).to obtain the rating of protection and switch gear

(iii).to select the circuit breaker

(iv).to perform whenever system expansion is planned.

32.what are the methods to find fault current in fault calculation.

By applying kirchoff's law ,thevenin's theorem ,bus building algorithm.

33.what are application of thevenin's theorem method

(i).the fault current can be evaluated

(ii). The bus voltages and line current during the fault can be determined.

(iii).post fault voltages and currents can be obtained by using prefault voltage and current

1. A 3 phase, 5 MVA, 6.6 kV alternators with a reactance of 8% is connected to a feeder series impedance (0.12+j0.48) ohm/phase/km through a step up transformer. The transformer is rated at 3 MVA, 6.6 kV/33 kV and has a reactance of 5%. Determine the fault current applied by the generator operating under no load with a voltage of 6.9 kV, when a 3 phase symmetrical fault occurs at a point 15 km along the feeder. (8) **APRIL-MAY 2017, NOV-DEC 2016**

   (ii) Draw the detailed flowchart, which explains how a symmetrical fault can be analyzed using Zbus. (8) **APRIL-MAY 2017, APRIL-MAY 2014, APRIL-MAY 2013, NOV-DEC 2012-JERALDIN**

2. A 100 MVA, 11kV generator with X''= 0.20 p.u is connected through a transformer and each motor has X''=0.20 p.u and X'= 0.25 p.u on a base of 20 MVA, 33kV the bus voltage at the motors is 33kV when three phase balanced fault occurs at the point F. Calculate (i) Sub transient current in the fault (ii) Sub transient current in the circuit breaker B. (iii) Momentary current in the circuit breaker B. (iv) The current to be interrupted by C.B B in 5 cycles. (16) **APRIL-MAY 2017**

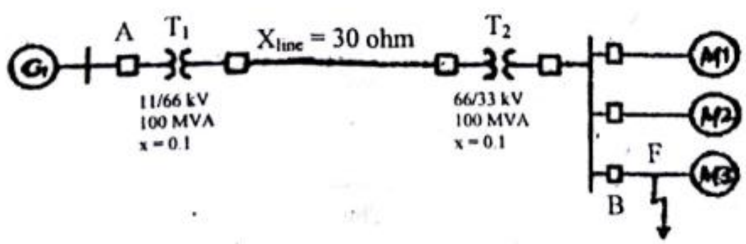


Fig. 1

3. A) For the radial network shown in Fig.2 phase fault occurs at point F. Determine the fault current and the line voltage at 11.8 kV bus under fault condition. **NOV-DEC 2016**

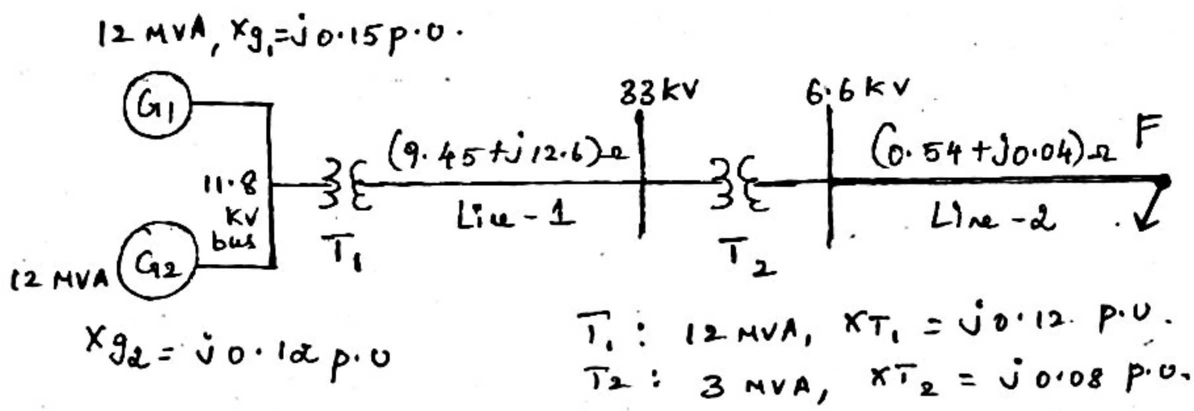
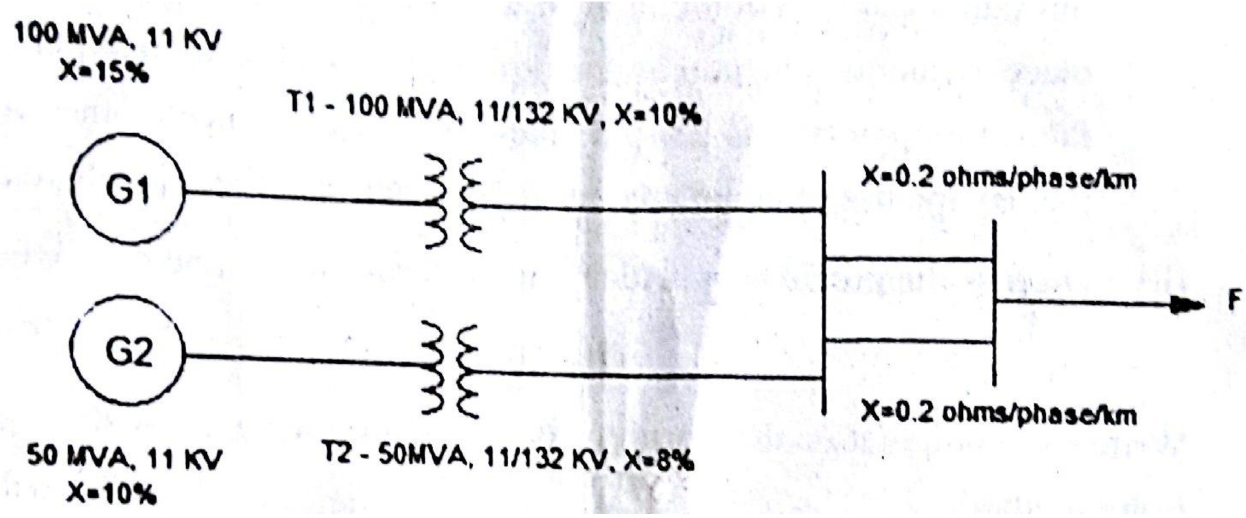


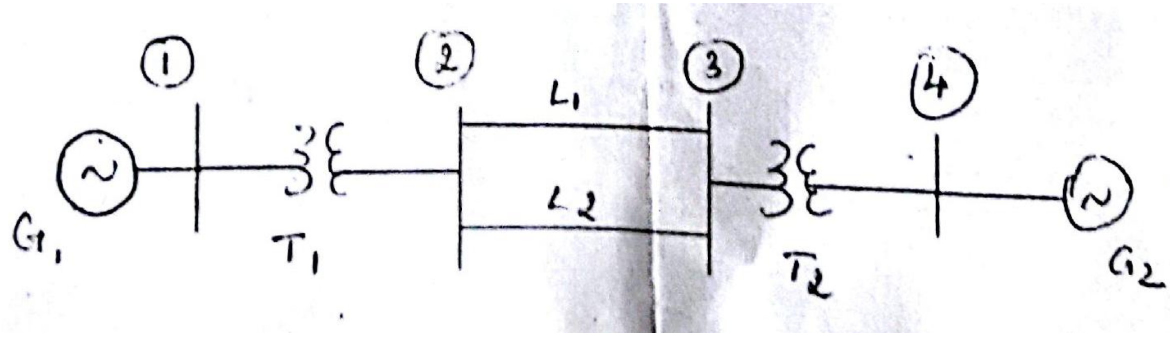
Fig. 2

4. A) A generating station is feeding a 132 kV system is shown in fig. Determine the total fault current, fault level and fault current supplied by each alternator for a 3 phase fault at the receiving end bus. The line is 200 km long. **MAY-JUNE 2016,NOV-DEC 2013**



Fig

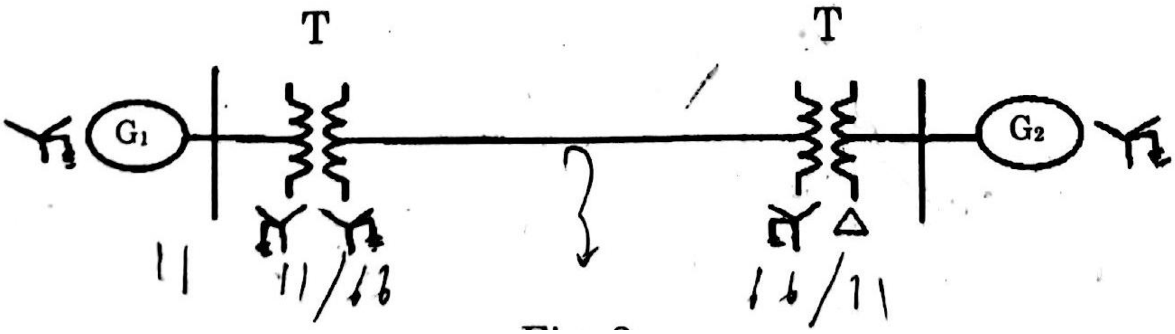
5. A symmetrical fault occurs at bus 4 for the system shown in Fig. Determine the fault current using Zbus Building algorithm. **MAY-JUNE 2016**



Fig

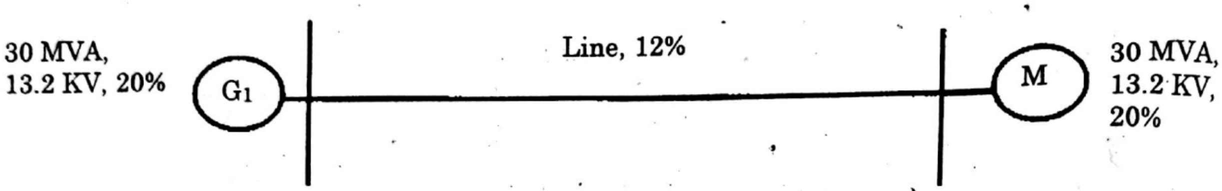
G1, G2 : 100 MVA, 20 kV, X'= 15%
Transformer : X leakage = 9%
L1, L2 : X' =10 %

6. A) Generator G1 and G2 are identical and rated 11 kV , 20 MVA and have a transient reactance of 0.25 p.u at own MVA base. The transformers T1 and T2 are also identical and are rated 11/66 KV, 5 MVA and have a reactance of 0.06 p.u to their own MVA base. A 50 km long transmission line is connected between the two generators. Calculate three phase fault current, when fault occurs at middle of the line as shown in fig. **NOV-DEC 2015**



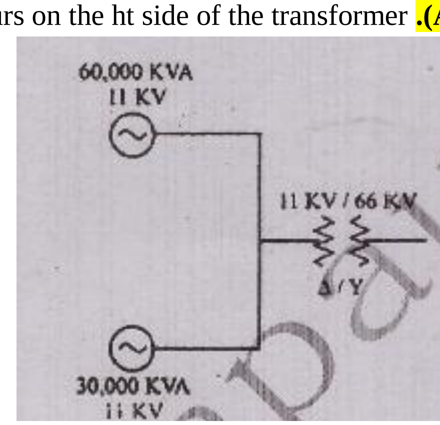
Fig

7. A synchronous generator and synchronous motor each rated 30 MVA, 13.2 kV and both have subtransient reactance of 20% and the line reactance of 12% on a base of machine ratings. The motor is drawing 25 MW at 0.85 p.f leading. The terminal voltage is 12 KV when a three phase short circuit fault occurs at motor terminals. Find the subtransient current in generator, motor and at the fault point. **NOV-DEC 2015**



Fig

8. Two generators are connected in parallel to the low voltage side of a 3 phase delta star transformer as shown in the figure.generator 1 is rated 60,000 kva,11 kv.generator 2 is rated 30,000 kva,11 kv.each generator has a sub-transient reactance of X_d"=25%.the transformer is rated 90,000 kva at 11 kv-delta /66 kv star with a reactance of 10%.before a fault occurred, the voltage on the high tension side of the transformer is 63kv.the transformer is unloaded and there is no circulating current between the generators. find the sub-transient current in each generator when a three phase fault occurs on the ht side of the transformer **.(APRIL-MAY 2015)**

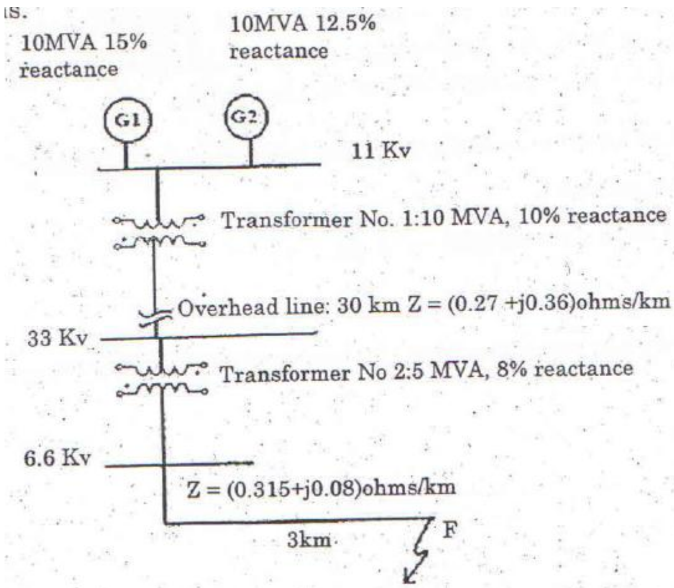


9. A generator transformer unit is connected to a line through a circuit breaker. The unit ratings are:

Generator: 10 MVA,6.6 KV, X_d''=0.1 pu, X_d'=0.2 pu and X_d=0.8 pu
Transformer: 10MVA,6.9/33 kv reactance0.08 pu
The system is operating on no load at a line voltage of 30 kv, when a three phase fault occurs on the line just beyond the circuit breaker. Find
(i).The initial symmetrical rms current in the breaker.
(ii).The maximum possible dc offset current in the breaker
(iii).The momentary current rating of the breaker
(iv).The current to be interrupted by the breaker and the interrupting KVA,and
(v).The sustained short circuit current in the breaker. **.(APRIL-MAY 2015)**

10. **(Nov-Dec 2014 –Nagoor kani)** For the radial network shown below a three-phase fault occurs at F. Determine the fault current and the line voltage at 11 KV bus under fault conditions.

Fig



11. **(April-May 2014 – Nagoor kani)** A generator is connected through a five cycle circuit breaker to a transformer is rated 100 MVA, 18 KV with reactances X_d "= 20%, X_d'=25% and X_d= 110%. It is operated on no-load and at rated voltage. When a 3 phase fault occurs between the breaker and the transformer, find,

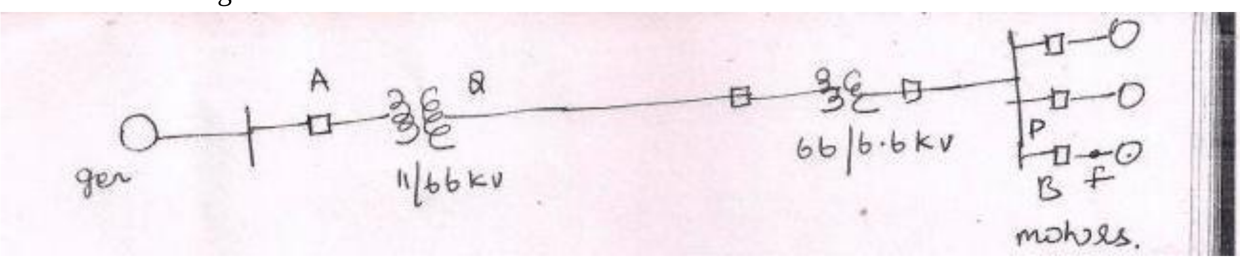
(i) Short circuit current in circuit breaker
(ii) The initial symmetrical rms current in the circuit breaker
(iii) The maximum possible dc component of the short circuit current in the breaker
(iv) The current to be interrupted by the breaker
(v) The interrupting MVA

12. **(NOV-DEC 2013 – B.R Gupta)** A 11 KV, 100 MVA alternator having a sub- transient reactance of 0.25 p.u is supplying a 50 MVA motor having a sub –transient reactance of 0.2 pu through a transmission line. The line reactance is 0.05 pu on a base of 100 MVA. The motor is drawing 40 MW at 0.8 power factor leading with a terminal voltage of 10.95 kv when a 3-phase fault occurs at the generator terminals. Calculate the total current in the generator and motor under fault conditions.

13. **(MAY-JUNE 2013- Nagoor kani)** A synchronous generator and motor are rated 30 MVA, 13.2 KV and both have subtransient reactance of 20%. The line connecting them has reactance of 10% on base of machine ratings. The motor is drawing 20000 kW at 0.8 pf leadind and terminal voltage of 12.8 kv when a symmetrical 3-phase fault occurs at the motor terminals. Find the sub-transient current in the generator, motor and fault by using interval voltages of the machines.
14. **(MAY-JUNE 2012)-Nagoor Kani** A 3 ph , 5 MVA, 6.6 KV alternator with a reactance of 8% is connected to a feeder of series impedance of (0.12+j0.48) ohm/phase per km.The transformer is rated at 3 MVA ,6.6 KV/33 KV and has a reactance of 5 % .Determine the fault current supplied by the generator operating under no lo9ad with a voltage of 6.9 KV, When a 3 Ph symmetrical fault occurs at a point 15 Km along the feeder
15. **(NOV-DEC 2011)**What are the basic assumptions made in fault calculations?
16. A 25 MVA , 11 KV generator with xd''=0.2 p.u is connected through a transformer ,line and a transformer to a bus that supplies three identical motors, as shown in fig Each motor has xd''=0.3 p.u on a base of 5 MVA, 6.6 K.V.The 3ph rating of step up transformer is 25 MVA 11/66 KV with a leakage reactance of 0.1 p.u and that of step down transformer is 25 MVA, 66/6.6 KV with a leakage reactance of 0.1 P.u .The bus voltage at the motor is 6.6 KV whan a 3 ph fault occurs at the point F.For a specied fault calculate**(NAGRATH & KOTHARI P.NO 337)**

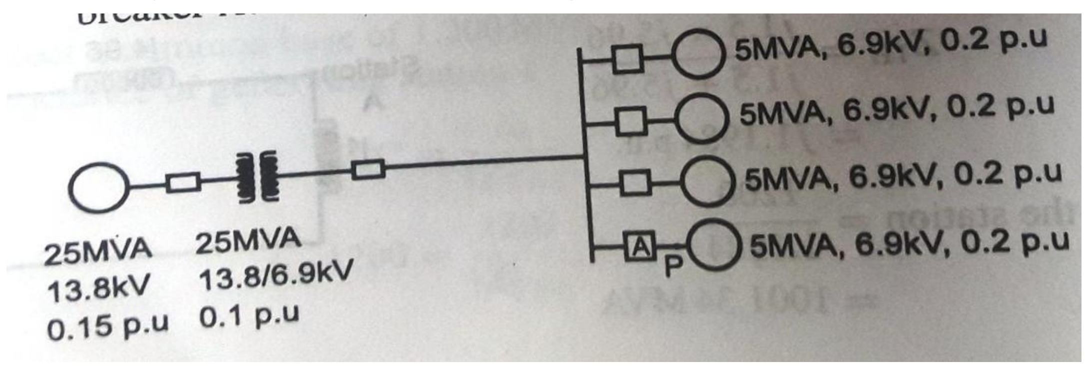
    i) The sub transient current in the fault
    ii) Sub Transient current in the breaker B
    iii) The momentary current in breaker B

    Fig



17. A 25000 KVA , 13.8 KV generator with Xd''= 15 % is connected through a transformer to a bus which supplies four identical motors as shown in fig. The sub transient reactance Xd'' of each motor is 20% on a base of 5000 KVA, 6.9 KV .The three phase rating of the transformer is 25000 KVA ,13.8/6.9 KV with a leakage reactance of 10% The bus voltage at the motor is 6.9 KV when a 3 ph fault occurs at point P for the specied fault determine **(Hemalatha p.no 3.30)**

    (i) The sub transient fault in the fault
    (ii) The sub transient current in breaker A
    (iii) The symmetrical short circuit interrupting current



18.A Synchronous generator rated 500 KVA, 400V, 0.1 p.u, sub transient reactance is supplying a passive load of 400KW at 0.8 lag p.f. Calculate the initial symmetrical RMS current for a 3ϕ fault at the generator terminals.

19. Two generating stations having S.C capacities of 1500MVA & 1000MVA respectively and operating at 11 KV are linked by a interconnected cable having s reactance of 0.6Ω/phase. Determine S.C capacity of each station.

20. Two synchronous motors are connected to the bus of a large system through a short transmission line as shown. The ratings of the various components are:Motor each: 1MVA, 440V, 0.1p.u reactance. Line:0.05Ω reactance. Large system S.C MVA at 440V bus is 8.0. When two motors are in operation at 440V, calculate the S.C current (symmetrical) fed into a 3 phase fault at the motors.

21. A small generating station has a bus bar divided into three sections. Each section is connected to a tie-bar with reactors each rated at 5MVA, 0.1p.u reactance. A generator of 8 MVA rating and 0.15 p.u reactance is connected to each section of the bus bar. Determine the S.C capacity of the breaker if a 3 phase fault takes place on one of the sections of the bus bar.

22. A Station operating at 33 KV is divided into sections A & B. Section A consists of three generators 15 MVA each having a reactance of 15% and section B is fed from the grid through a 75 MVA transformer of 8% reactance. The ckt breakers have each a rupturing capacity of 750 MVA. Determine the reactance of the reactor to prevent the breakers being over loaded if a symmetrical S.C occurs on an outgoing feeder connected to A

23. The per unit impedance matrix of a four bus power system shown in figure below,

$$Z_{Bus}=\begin{bmatrix} j0.15 & j0.075 & j0.14 & j0.135 \\ j0.075 & j0.1875 & j0.09 & j0.0975 \\ j0.14 & j0.09 & j0.2533 & j0.21 \\ j0.135 & j0.0975 & j0.21 & j0.2475 \end{bmatrix}$$

Calculate the fault current for a solid three symmetrical fault at bus 4. Also calculate the post fault bus voltages and line currents.

24. Explain symmetrical fault analysis using Z-bus matrix with neat flow chart.**(May 2011)(Nov 2012)(May 2013)**

25. The bus impedance matrix of 4-bus system with values in p.u is given by,

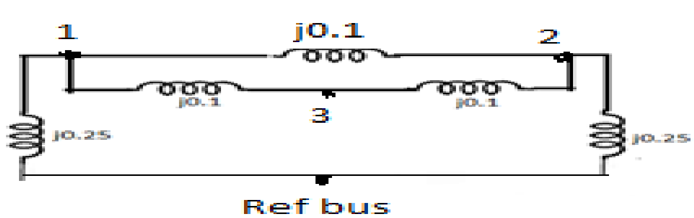
$$Z_{Bus}= j\begin{bmatrix} 0.15 & 0.08 & 0.04 & 0.07 \\ 0.08 & 0.15 & 0.06 & 0.09 \\ 0.04 & 0.06 & 0.13 & 0.05 \\ 0.07 & 0.09 & 0.05 & 0.12 \end{bmatrix}$$

In this system generator are connected to buses 1 and 2 and their sub transient reactances included when finding Z_{Bus}. If pre-fault current is neglected, find sub transient current in p.u in the fault for a 3-ph fault on bus-4.Assume prefault voltage as 1 p.u. If the sub transient reactance of generator in Bus 2 is 0.2p.u., find the sub transient fault current supplied by generator. **(May 2012)**

26. A generator is connected through afive cycle circuit breaker to a transformer is rated 100 MVA,18 KV with reactancesX_d''=20%,X_d'=25% and X_d= 110%. It is operated on no-load and at rated voltage.When a 3-phase fault occurs between the breaker and the transformer, find,

(i) Short circuit current in circuit breaker; (ii) The initial symmetrical rms current in the circuit breaker (iii) The maximum possible dc component of the short circuit current in the breaker;(iv)The current to be interrupted by the breaker;(v)The interrupting MVA**(May 2014)(apr/may 2015)**

27. For the three bus network Fig. shown below, obtain Z bus by building algorithm **(Nov 2014)**



UNIT – IV FAULT ANALYSIS –UNBALANCED FAULT

PART – A

1. **Name the fault in which all the three sequence components currents are equals and in which positive and negative sequence currents together is equal to zero sequence current.**

   Ans:- Double line to ground fault.

2. **Define negative sequence impedance? (MAY-JUNE 2013)**

   The impedance of network offered to the flow of negative sequence current is called negative sequence impedance

3. **What is the observation made from the analysis of various faults? (NOV-DEC2013)**

   To design the protective schemes for various parts of the system

   To select the appropriate devices (relays ,circuit breakers)

   To protective schemes consists of current and voltage sensing devices, protective relays and circuit breakers.

   The selection of these mainly depends on various currents that may flow in the fault conditions.

4. **Write the boundary conditions for single line to ground fault? (NOV-DEC2013)**

   Boundary conditions are ,

   $I_f=I_a$

   $V_a=Z_fI_a$

   $I_b=I_c=0$

5. **What is sequence network (April-May 2011)**

   In a three phase system, the phase currents are resolved into three symmetrical components they are positive, negative and zero sequence. They are mentioned by Ia+, Ia-, Ia0 respectively. When all the sequence representations are connected together in a phase is called sequence network.

6. **Write the symmetrical components of a three phase system? (April-May 2011)**

   a) Positive sequence component

   b) Negative sequence component

   c) Zero sequence components

7. **Name the faults involving ground**.

   The faults involving ground are: single line to ground fault ii)double line to ground fault iii)Three phase fault

8. **Define positive sequence impedance.**

   The negative sequence impedance of equipment is the impedance offered by the equipment to the flow of positive sequence currents.

9. **In what type of fault the +ve sequence component of current is equal in magnitude but opposite in phase to negative sequence components of current?**

   Line to line fault.

10. **In which fault the negative and zero sequence currents are absent?**

    In three phase fault the negative and zero sequence currents are absent.

11. **What are the boundary condition in line-to-line fault?**

    $I_a=0$; $I_a+I_c=0$; $V_b=V_c$

12. **Write down the boundary condition in double line to ground fault?**

    $I_a=0$; $V_b=0$; $V_c=0$

13. **Give the boundary condition for the 3-phase fault.**

    $I_a + I_b = I_c=0$; $V_a=V_b=V_c=0$

14. **Name the fault in which positive, -ve and zero sequence component currents are equal.**

(May 2012)

In single line to ground fault the +ve, -ve and zero sequence component currents are equal

15.Name the various unsymmetrical faults in a power system.

i) single line to ground fault ii) line to line fault iii) double line to ground fault iv) open conductor fault

16.Write a short notes on Zero sequence network.

While drawing the zero sequence network of a given power system, the following points may be kept in view.The zero sequence currents will flow only if there is a return path i.e.path from neutral to ground or to another point in the circuit.In the case of a system with no return path for zero sequence currents, these currents cannot exist.

17.Write a short notes on negative sequence network.

The negative sequence network can be readiley obtained from positive sequence network with the following modifications:i)Omit the emfs of 3 – phase generators and motors in the positive sequence network. It is because these devices have only positive sequence generated voltages.ii)Change, if neccesary, the impedances between the generators neutral and ground pass no negative sequence current and hence are not included in the negative seqeunce network.iii)For static devices such as transmission lines and transformers, the negative sequence impedances have the same value as the corresponding positive sequence impedances.

18.Write a short notes on positive sequence network.

While drawing the positive sequence network of a given power system, the following points may be kept in view:Each generator in the system is represented by the generated voltage in series with appropriate reactance and resistance.Current limiting impedances between the generators neutral and ground pass no positive sequence current and hence are not included in the positive sequence network.All resistance and magnetizing currents for each transformer are neglected as a matter of simplicity.For transmission lines, the shunt capacitances and resistances are generally neglected.

19.How will you express positive, negative and zero – sequence impedances of Y – connected loads?(may/june 2016)(nov/dec 2016)

Positive seqence impedance $Z^1 = Z_s + 3Z_n + 2Z_m$ .Negative sequence impedance $Z^2 = Z_s - Z_m$

Zero sequence impedance $Z^0 = Z_s - Z_m$ Where, Z_s = self impedance of Y – connected load, Z_n= load neutral impedance Z_m = Mutual impedance.

22. Which is the most frequently occurring fault?

Single line to ground fault is the most frequently occurring fault

23. Define unsymmetrical fault.

The fault is called unsymmetrical fault if the fault current isnot same in all the three phases.

24. Which is the most severe fault in power system?

Three phase fault is the most severe and rarely occurring fault in the power system.

25. What is sequence network?(May 2011)(nov/dec 2015)

The network which is used to represent the positive, negative and zero sequence components of unbalanced system is called as sequence network

26**. What are the symmetrical components of a three phase system? (May 2011)(Nov 2012) & (Nov 2014)(may/june 2016)(nov/dec 2015)**

1) Positive sequence 2) negative sequence 3) Zero sequence

27. What is meant by a Fault?(May 2012)

A fault in acircuit is any failure which interferes with the normal flow of current .The faults are associated with abnormal change in current, voltage and frequency of the power system. The faults may cause damage to the equipment if it is allowed to persist for a long time.

28. List the various symmetricaland unsymmetrical faults in a power system.(May 2012)

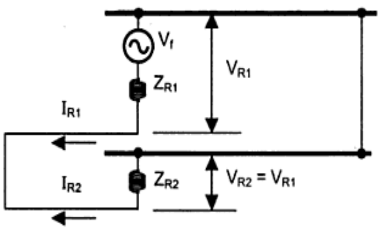
Symmetricalfault:3 phase short circuit fault.

Unsymmetrical fault: i) single line to ground fault ii) line to line fault iii) double line to ground fault iv)open conductor fault

29. Define negative sequence impedance?(May 2013)

The negative sequence impedance of an equipment is the impedance offered by the equipment to the flow of negative sequence current.

30. Draw the sequence network connections corresponding to L-L fault at bus. (May 2013)



31. What are the observations made from the analysis of various faults?(Nov 2013)

i) To check the MVA ratings of the existing circuit breakers, when new generation are added into a system; ii) To select the rating for fuses, circuit breaker and switch gear in addition to setting up of protective relays; iii) To determine the magnitudes of currents flowing throughout the power system at various time intervals after a fault occurs.

32. Write the boundary conditions for single line to ground fault.(Nov 2013)

The boundary conditions are Va = 0; I_b=I_c=0

33.What are the features of zero sequence current?(May 2014)

As zero sequence currents in three phases are equal and of same phase, three systems operate like single phase as regards zero sequence currents.Zero sequence currents flow only if return path is available through which circuit is completed.

34.Write **the symmetrical component current of phase 'a' in terms of currents.(May 2014).** $I_{a0} = \frac{1}{3}[I_a + I_b + I_c]$ $I_{a1} = \frac{1}{3}[I_a + aI_b + a^2I_c]$ $I_{a2} = \frac{1}{3}[I_a + a^2I_b + aI_c]$

35.What is sequence network? (Nov 2014) (nov/dec 2016)

In the method of symmetrical components, to calculate the effect of a fault on a power system, the sequence networks are developed corresponding to the fault condition. These networks are then interconnected depending on the type of fault. The resulting network is then analyzed to find the fault current and other parameters.

36. Write the relative frequency of occurrence of various types of fault

Type of fault	Relative frequency of occurrence of fault
Three phase fault	5%
LLG fault	10%
LL fault	15%
LG fault	70%

37.Name the fault which does not have zero sequence fault component.

(i)Three phase fault

(ii).line to line fault

38.which type of fault occurs between phases b and c, voltage across b and c are equal.

Line to Line bolted fault.

PART B

1. A generator of negligible resistance having 1.0 per voltage behind transient reactance is subjected to different types of faults

Type of fault	Resulting fault current in p.u
3-phase	3.33
L-L	2.23
L-G	3.01

Calculate the per unit value of 3 sequence reactance's.

2. A 50Hz 80MVA, 11kV generator has positive, negative and zero sequence impedances of j0.4, j0.3 and j0.1p.u respectively. The generator is connected to a busbar A through a transformer X_1=X_2=X_0=j0.4p.u.on 100MVA base and rated voltage. Determine the ohmic resistance and rating of earthing resistor such that for LG fault on busbar B, the fault current of the generator does not exceed full load current. A reactor of reactance 0.08p.u on 100 MVA base is connected between bus bars A and B.
3. Develop the expressions for analyzing double line to ground fault in a large power system using Z_{bus} matrix.2.Develop the expressions for analyzing double line to ground fault in a large power system using Z_{bus} matrix.
4. A 50Hz, 13.2 KV, 15MVA alternator has X1=X2=20% and X0=8% and the neutral is grounded through a reactor of 0.5ohm. Determine the initial symmetrical rms current in the ground reactor when a double line to ground fault occurs at the generator terminals at a time when the generator voltage was 12KV.
5. Derive the necessary equations for calculating the fault current and bus voltages for a single line to ground fault.(may/june 2016)
6. A salient pole generator is rated 20 MVA, 13.8 kV and has X1=0.25p.u X2=0.35p.u and X0=0.1p.u. The neutral of the generator is solidly grounded. Compute fault current in the generator and line to line to ground fault at its terminals. Neglect initial load on the generator.
7. Two 25 MVA, 11KV synchronous generators are connected to a common bus bar which supplies a feeder. The star point one of the generators is grounded through a resistance of 1 ohm and that of the other generator is isolate. A line to ground fault occurs at the far end of the feeder. Determine the fault current. The impedance to sequence currents of each generator and feeder are given below.

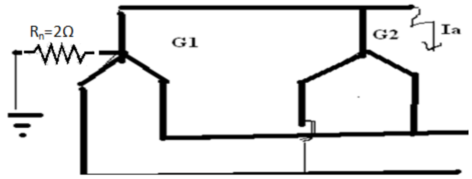
Generator	Feeder
(a) +ve sequence	j0.2
j0.4	
(b)-ve sequence	j0.15
j0.4	
(c) zero sequence	j0.08
j0.8	

8. Develop the expressions for analyzing single line to ground fault in a large power system using Z_{bus}matrix. .(may/june 2016)

9. Develop the expressions for analyzing line to line fault in a large power system using Z_{bus} matrix. .(may/june 2016)
10. What are the assumptions made in short circuit studies? Deduce and show the sequence network for a line to line fault at the terminals of a unloaded generator.(May 2011)(apr/may 2016)

11. Two 11KV, 20MVA .Three phase star connected generators operate in parallel as shown in figure. The positive ,negative and zero sequence reactance are j0.18,j0.15,j0.10 pu. The star point of one of the generator is isolated and that of the other is earthed through 2.0 ohms resistor. A single line to

ground fault occurs at the terminals of one of the generators. Estimate i)Fault current ii)current in the grounding resistor and iii)the voltage across the grounding resistor.(May 2011)

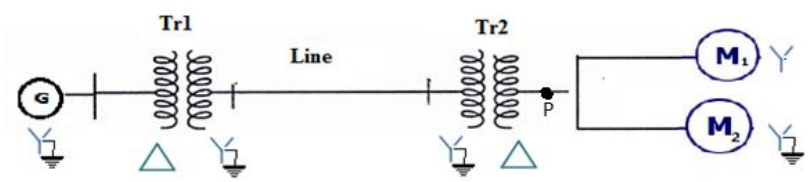


12. Derive the necessary equation to determine the fault current for a single line to ground fault. Draw a diagram showing the interconnections of sequence networks.(May 2012)

13. A11 kV, 30MVA alternator has Z1=Z2=-j0.2 pu and Z0=-j0.05 pu.A line to ground fault occurs on the generator terminals. Determine the fault current and line to line voltages during faulted conditions. Assume that the generator neutral is solidly grounded and the generator is operating at no load and at the rated voltage during the occurrence of the fault.(May 2012)(nov/dec 2015)(nov/dec 2016)
14. A 50 MVA 11 KV alternator was subjected to different types of faults. The faults are 3ϕ fault1870 A ,Line to Line Fault 2590 A, Single line to ground fault 4130 A.The alternator neutral is solidly grounded. Find the per unit values of the three sequence reactances of an alternator.(May 2012).
15.Draw the sequence network connection for a double line to ground fault at any point in a power system and from that obtain an expression for the fault current.(Nov 2012)

16. (i) Derive an expression for the total power in a three phase system interms of sequence components of voltages and currents. (ii) Discuss in detail about the sequence impedances of transmission lines.(Nov 2012)

17.Discuss in detail about the sequence impedances and networks of synchronous machines, transmission lines, transformers and load. (May 2013)
18. A single line diagram of a power network is shown in the figure. (May 2013)



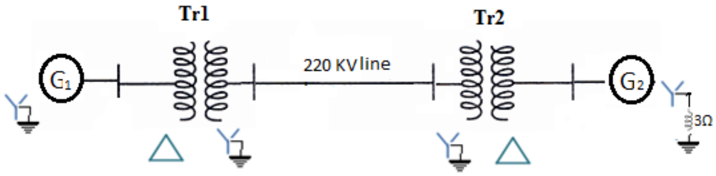
The system data is given in the tableas below:

Element	Positive sequence reactance	Negative sequence reactance	Zero sequence reactance
Generator G	0.1	0.12	0.05
Motor M_1	0.05	0.06	0.025
Motor M_2	0.05	0.06	0.025
Transformer T_{r1}	0.07	0.07	0.07
Transformer T_{r2}	0.08	0.08	0.08
Line	0.10	0.10	0.10

Generator grounding reactance is 0.5 pu. Draw sequence networks and calculate the fault for a line to line fault on phase b andc at point P. Assume 1.0 pu pre fault voltage throughout.

19. The figure shows the power system network .Draw zero sequence network for this system. The system data is as under.

Generator G_1:50 MVA ,11 KV, X_0= 0.08 pu   Transformer T_1 :50 MVA,11/220 KV, X_0= 0.1pu
Generator G_2 :30 MVA ,11
4* KV, X_0= 0.07pu   Transformer T_2 ;30 MVA ,11/220 KV ,X_0= 0.09 pu
Zero sequene reactance of line is 555.6 Ω. Choose base MVA 50 and base voltage 11 KV for LT side and 220 KV for HT side.(Nov 2013)



20.A 25 MVA , 13.2 KV alternator with solidly grounded neutral has a sub transient reactance of 0.25 p.u. The negative and zero sequence reactance are 0.35 and 0.01 p.u. respectively. If a double line-to-ground fault occurs at the terminals of the alternator, determine the fault current and line to line voltage at the fault.(May 2014)

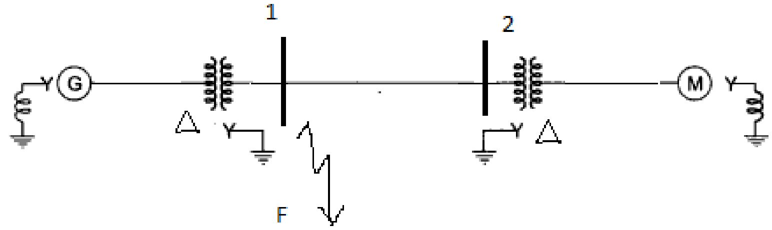
21.Obtain the expression for fault current for a line to line fault taken place through an impedance Z_b in a power system.(Nov 2013)(May 2014)

22. Obtain the expression for fault current for a line to line fault taken place through an impedance Z_b in apower system.(Nov 2013)(May 2014)(nov/dec 2016)

12. Explain about the concepts of symmetrical component. (Nov 2014)
Set of n unbalanced vector can be converted to set of n balanced vector using symmetrical component Transformation.

$Ia=Ia_0+Ia_1+Ia_2$
$I_b=I_{b0}+I_{b1}+I_{b2}$
$Ic=Ic_0+Ic_1+Ic_2$

24.A single line to ground fault occurs on Bus 1 of the system of the fig. shown below.Find
i) Current in the fault
ii) SC current in phase A of generator
iii) Voltage of the healthy phases of the bus1 using Z bus method



Given: Rating of the each machine 1200KVA, 600V,with X=X2=10%,Xo=5% each three phase transformer is rated 1200 KVA , 600V-Δ/3000V-Y with leakage reactance of 5% the reactance of the transmission line are X1 = X2 =20% and Xo=40% on the base of 1200 KVA ,3300V,the reactance of the neutral reactors are 5% on the KVA and voltage base of the machine. (Nov 2014)

UNIT–V STABILITYANALYSIS
PART – A

1. Define Dynamic stability of a power system.

Dynamic stability is the stability given to an inherently unstable system by automatic control devices and this dynamic stability is concerned with small disturbances lasting for times of the order of 10 to 30 seconds.

2. Define the inertia constants M & H.

Angular momentum (M) about a fixed axis is defined as the product of moment of inertia about that axis and the associated angular velocity. $M = I. \omega$ watt/rad/Sec^2.Inertia constant (H) is the K.E in Mega joules to the three phase MVA rating of the machine.

3. Define load angle of a generator.

Load angle:- This is the angle between the generated e.m.f or the supply voltage (E) and the terminal voltage. This angle is also called as torque or power angle of the machine.

4. State equal area criterion of stability.(may/june 2016)

The system is stable if the area under accelerating power (Pa) - δ curve reduces to zero at some value ofδ. In other words positive area under Pa -δ curve must be equal to the negative area and hence the name equal area criterion of stability.

5. What are limitations of equal area criterion?

The limitations of equal area criterion are: i) one drawback of equal area criterion approach is that critical clearing time cannot be calculated even though the critical clearing angle is known. Hence numerical methods such as Runge-kutta method, point by point or Euler’s method are employed.

ii) It’s a more simplified approach.

6. If two machines with inertia’s H_1, H_2 are swinging together, what will be the inertia of the equivalent machine?

$$H_s = \frac{H_1 G_1 + H_2 G_2}{G_s}$$

H_1 and H_2 is the Inertia constant of M_1 and M_2; G_1 and G_2 is the capacity of M_1 and M_2.

H_s is the equivalent inertia of M_1 and M_2 ; G_s is the equivalent capacity of M_1 and M_2.

7. On what basis do you conclude that the given synchronous machine has lost stability?

Following a sudden disturbance on a power system rotor speeds, rotor angular differences and power transfer undergo fast changes whose magnitude is dependent on the severity of the disturbance. If these disturbances leads to growing oscillations in the power system even after some period of time say more than 30 seconds then system said are in asynchronous state and it has lost synchronism.

8. On what a factor does the critical clearing angle depends.

The critical clearing angle depends upon the clearing time, which depends upon auto closing/reclosing and opening of circuit breakers.

9. Define steady state stability limit.(Nov 2014)

It is the maximum power that can be transferred without the system becoming unstable when the system is subjected to small disturbances.

10. Mention methods of improving the steady state stability limit.(nov/dec2016)

Pmax= (E.V / X). The steady state stability limit can be increased by i) Reducing the X, in case of transmission lines by using double circuit lines. ii) Use of series capacitors to get better voltage. iii) Higher excitation systems and quick excitation system are employed.

11. A 50Hz, 4 pole turbo alternator rated at 20 MVA, 13.2 KV has as inertia constant H = 4 KW – sec/ KVA. Find the K.E stored in the rotor at synchronous speed.

F = 50Hz. P = 4, G = 20 MVA, H = 4 KW – Sec/ KVA. Stored K.E = 4 x 20 = 80MJ.

12. Mention the methods used for the solution of swing equation.

Methods used for solution of swing equation are: Point by point method, Modified Euler's method andRunge-kutta method.

13. Give methods used for improving the transient stability.(may/june 2016)

The following methods are employed to increase the transient stability limit of the power system-
(i)Increase of system voltages,(ii) use of AVR.(iii)Use of High speed excitation systems.(iv)Reduction in transfer reactance.(v)Useof high speed reclosing breakers.

14. Define the term synchronizing power coefficient of a synchronous machine?

The rate($dp/d\delta$), ie, the differential power increase obtained per differential load angle increase is called the synchronizing power coefficient or electrical stiffness of a synchronous machine.

15. What are the applications of equal area criterion?

(i)Switching operation. (ii)Fault and subsequent circuit isolation. (iii) Fault, circuit isolation and reclosing

16. What are the classifications of angle stability?(nov/dec 2015)

Small signal stability (steady state) and transient stability (large signal).Small signal is further classified as Oscillatory and Non oscillatory stability.Oscillatory includes Inter area mode, control mode and Torsional mode

17. Define critical clearing angle and time? (May 2011)(May 2012)(Nov 2012) (Nov 2014)

Critical clearing angle 'δ_c'corresponds to critical clearing timet_c,in which the fault in the line is cleared by the circuit breaker above which the system goes out of synchronism.

18. Write swing equation (May 2011)

$P_m - P_e = M d^2\delta/dt^2$. P_{m-} Input Mechanical power: P_{e-} outputelectricalpower;M- Angular momentum

19. Define transient stability and stability limit.(May 2012)

The maximum power that can be transferred through the system during a very large disturbance without loss of synchronism is called transient stability limit.

20. Distinguish between steady state and transient state stability.(Nov 2012)

Steady state stability is basically concerned with the ability of the system to restore back to its stable state upon a small disturbance whereas the transient stability is concerned with large disturbances.

21. What is meant by power angle curve?(May 2013)(nov/dec 2015)

The graphical plot of real power versus power/torque angle is called as power angle curve.

$P_e = P_m \sin\delta$. $P_m = E_1E_2 / X$.

22. Define Infinite bus in power system. (Nov 2012)(May 2013)

The capacity of a system comprising of many machines is so large, that its voltage & frequency may be taken as constant. The connection or disconnection of a single machine does not change the |V| and frequency. Such a constant voltage and frequency system is called as Infinite bus.

23. Differentiate between voltage stability and rotor angle stability.(Nov 2013)(nov/dec 2016)

Voltage stability is the ability of a power system to maintain steady acceptable voltage at all buses in the system under normal operating conditions and after being subjected to a disturbance.
Rotor angle stability is the ability of interconnected synchronous machines of a power system to remain in synchronism.

24. Define swing curve? What is the use of this curve?(Nov 2013)

A graph of δ versus time in seconds is called swing curve. The stability of the machine is calculated by using swing curve. This curve is obtained by solving the swing equation of the machine. The critical angle and critical clearing time is calculated by using swing curve.

25. Define dynamic stability(May 2014)

The dynamic stability study is concerned with the study of nature of oscillations and its decay for small disturbances.

26. Find the frequency of oscillation for a synchronizing co-efficient of 0.6, inertia constant H= 4 and system frequency of 50 Hz.(May 2014)

Frequency of oscillation = $\sqrt{\frac{C}{M}}$; $M = \frac{H}{\pi f} = \frac{4}{\pi X 50} = 0.0255$ p.u

Frequency of oscillation = $\sqrt{\frac{0.6}{0.0255}} = 4.85\frac{rad}{sec} = \frac{4.85}{2\pi} = 0.7719\ Hz$

27.How to reduce the reactances of transmission line.

Reactance can be decreased by reducing conductor spacing. Series reactance may be reduced by using bundled conductors.

28what arte the application of under frequency load shedding scheme

Underfrequency load shedding is applicable for frequency decline much beyond the capability of governors

29.what are the effects of load rejection.

When there is a load rejection in the system, the speed of the generators and hence the system frequency will rise. The speed governing system will respond by reducing the mechanical power generated by the turbines.

30.what are the factors affecting transient stability.

Type of fault- three phase fault,LLG fault,LL fault,LG fault.

Location of fault.

PART B

1. A 50Hz generator is supplying 60% of P_{max} to an infinite bus through a reactive network. A fault occurs which increases the reactance's of the network between the generator internal voltage and infinite bus by 400%. When the fault is cleared, compute the max value of critical clearing angle by applying equal area criteria.
2. State the bad effects of instability. Distinguish between steady state and transient state stabilities.
3. Two power stations A & B are located close together. Station A has 4 identical generator sets each rated 100MVA and having an inertia constant of 9 MJ / MVA, whereas station B has three sets each rated 200MVA , 4 MJ/ MVA. Calculate the inertia constant of single equivalent machines on a base of 100 MVA.
4. Explain the Euler's method of solving the stability problem.
5. A motor is receiving 25% of the power that it is capable of receiving from an infinite bus. Ifthe load on the motor is doubled. Calculate the max value of δ during the swinging of the rotor around its new equilibrium position.

6.Describe the Runge-Kutta method of solution of swing equation for multi machine systems.

(May 2011)

7. A 3 phase generator delivers1.0 pu power to an infinite bus through a transmission network when fault occurs. The maximum power which can be transferred during pre-fault, during fault and post fault condition are 1.75pu, 0.4pu and 1.25 pu.Find the critical clearing angle**.(May 2012) (May 2011)**

8. (a) State and explain the equal area criterion. (b) Indicate how you will apply equal area criterion.(i) To find the max additional load that can be suddenly added. (ii) In a two circuit transmission system sudden loss of one circuit**.(Nov 2012) (May 2013)(May 2012)**

9. Derive the swing equation of a synchronous machine swinging against an infinite bus. Clearly state the assumptions made in deducing the swing equation. State the usefulness of this equation. State the reasons for its nonlinearity **(May 2013).(May 2014)(nov/dec 2015)(may/june 2016)(nov/dec 2016)**

10. (i)Distinguish between steady state, transient and dynamic stability. **(Nov 2013)**

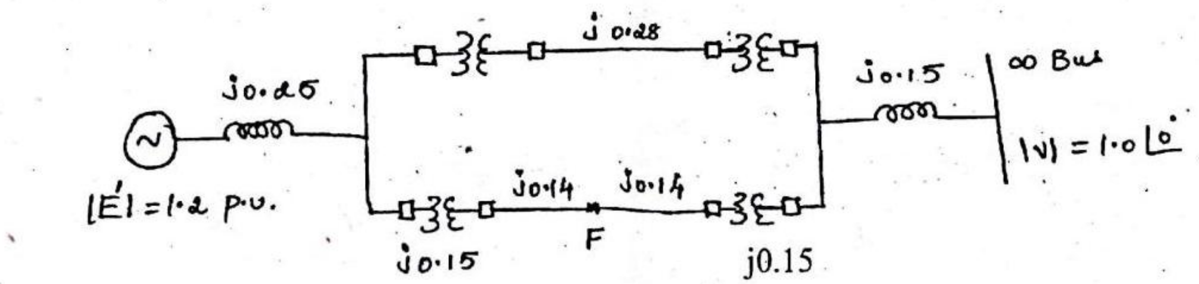
11. (i) Explain the methods of improving power system stability. **(Nov 2013)**

(ii) Explain the terms critical clearing angle and critical clearing time in connection with the transient stability of a power system..**(May 2012)(May 2011)**

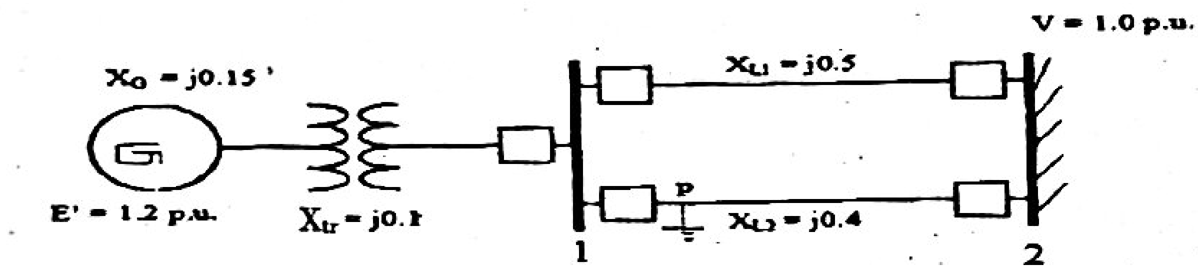
12. Describe the algorithm for modified Euler method of finding solution for power system stability problem studies**.(Nov 2012)(May 2014)**
13. A generator is operating at 50Hz,delivers 1.0 p.u power to an infinite bus through a transmission circuit in which resistance is ignored. A fault takes place reducing the maximum power transferable to 0.5 p.u.before the fault this power was 2.0 p.u and after the clearance of the fault it is 1.5 p.u.by the use of equal area criterion, determine the critical clearing angle. **(apr/may 2016)**

14.Discuss the methods by which transient stability can be improved **APRIL-MAY 2017**

15.Find the critical clearing angle of the system shown in fig for a 3 ph fault at the point F The generator is delivering 1. P.u power under pre fault conditions **APRIL-MAY 2017**



16.Find the critical clearing angle and time for the clearing the fault with simultaneous opening of the breakers when a three phase fault occurs at point P close to the bus 1 as shown in fig The generator is delivering 1 P.U power at the instant preceding the fault **NOV_DEC 2016**



17.A generator is operating at 50 Hz delivers 1.0 p.u power to an infinite bus through a transmission circuit in which resistance is ignored. A fault takes place reducing the maximum power transferable to 0.5 p.u whereas before the fault, this power was 2.0 p.u and after the clearance of the fault, it is 1.5 p.u. By the use of equal area criterion, determine the critical clearing angle. (10) **MAY_JUNE 2016,NOV DEC 2011**

18.The moment of inertia of a 4 pole ,100 MVA ,11 KV, 3 Ph 0.8 Pf ,50 Hz turbo alternator is 10000 Kg-m^2 Calculate H and M **NOV-DEC 2015**

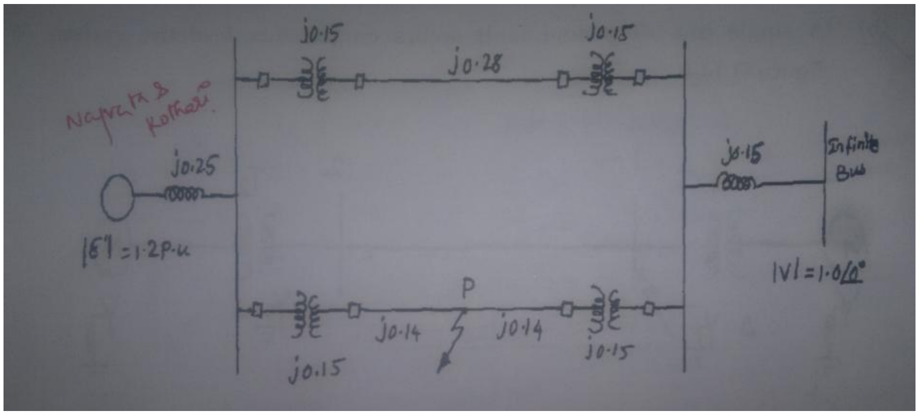
19.A synchronous motor is receiving 30 % of the power that is capable of receiving from an infinite bus.If the load on the motor is doubled ,Calculate the maximum value of delta during the swinging of the motor around its new equilibrium position **NOV-DEC 2015**

20. (ii) A three phase generator delivers 1.0 p.u, power to an infinite bus through a transmission network when a fault occurs. The maximum power which can be transferred during prefault, during fault and post fault conditions is 1.75 p.u, 0.4 p.u, 1.25 p.u. Find critical clearing angle. **Book: B.R Gupta April May 2012**

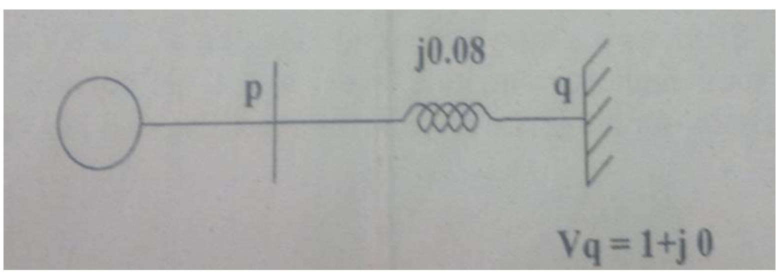
21.Shows the transmission network The P.U reactances of the equipment are as shown. the voltage behind transient reactance of the generator is 1.2 p.u. The generator is delivering 1.0 p.u power under pre fault condition Determine conditions and

i) Transfer reactance for pre fault , during fault, and post fault
ii) Critical clearing angle **April –May 2010**

Book: Nagrath & Kothari



22. The synchronous machine shown in fig is generating 100 MW and 75 MVAR . The voltage of the infinite bus q is 1+j0 pu. The generator is connected to the infinite bus throunh a line reactance 0.06 pu. On a 100 MVA base . The machine transient reactance is 0.2 pu. And the inertia constant is 6 pu on a 100 MVA base . A 3 ph fault at Bus P for a duration of 0.1 sec .Compute the rotor angle at t= 0.03 sec (Δt=0.03 sec) using Modified Eular Method . Frequency of the supply is 60 HZ. **April –May 2010**



23 .Derive the swing equation of a single machine connected to an infinite bus system and explain the steps of solution by runge kutta method **APRIL-MAY 2017**

24. Derive the swing equation and discuss the importance of stability studies in power system planning and operation **NOV_DEC 2016**

25.Write the computational algorithm for obtaining swing curve using Modified euler method **APRIL MAY 2016**

Reg. No. : | | | | | | | | | | | |

Question Paper Code : 71509

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Sixth Semester

Electrical and Electronics Engineering

EE 2351/EE 61/10133 EE 601 – POWER SYSTEM ANALYSIS

(Regulation 2008/2010)

(Common to PTEE 2351/10133 EE 601 Power System Analysis for B.E. (Part–Time) Fourth Semester Electrical and Electronics Engineering Regulation 2009/2010)

Time : Three hours   Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. A 400 kV transmission line has a surge impedance of 400 Ω. What would be its surge impedance loading?

2. The ABCD constants of a three 345 kV transmission line are A = D = 0.98182 + j0.0012447, B = 4.035 + j58.947, C = j0.00061137. The line delivers 400 MVA at 0.8 lagging power factor at 345 kV. Determine the sending end voltage.

3. Distinguish between the Newton-Raphson and Gauss-seidel methods of load flow analysis.

4. Why is bus impedance matrix preferred for fault analysis?

5. What for Short circuit capacity (SCC) should be known at any bus. Write down the expression for SCC.

6. For a system, the bus impedance matrix was found to be

$$Z = j\begin{bmatrix} 0.0450 & 0.0075 & 0.030 \\ 0.0075 & 0.06375 & 0.030 \\ 0.030 & 0.030 & 0.0210 \end{bmatrix}$$

The impedances are in per unit. A three phase symmetrical fault occurs at bus 3 through a fault impedance of $Z_f = j0.19$ per unit. Find out the post fault voltage at bus 2 assuming zero prefault current.

7. Derive the expression for neutral grounding reactance such that the single line to ground fault current is less than the three phase fault current.

8. State the reason why, the negative sequence impedance of a transmission line is taken as equal to positive sequence impedance of the line.

9. A four pole, 60-Hz synchronous generator has a rating of 200 MVA, 0.8 power factor lagging. The moment of inertia of the rotor is 45,100 kg-m^2. Determine M and H.

10. What is the significance of critical clearing time?

PART B — (5 × 16 = 80 marks)

11. (a) A 230 kV transmission line has a per phase series impedance of Z = 0.05 + j0.45 Ω per km and a per phase shunt admittance of Y = j3.4 × 10^{-6} siemens per km, the line is 80 km long. Using the nominal π model, determine the ABCD constants, sending end voltage and current, voltage regulation, the sending end power and the transmission efficiency when the line delivers 306 MW, unity power factor at 220 V.

Or

(b) Using the method of building algorithm find the bus impedance matrix for the network shown in figure 1.

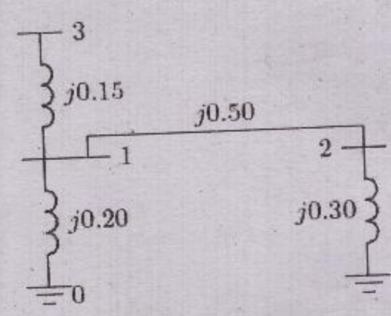


Fig. 1

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12. (a) Figure 2, shows the one line diagram of a simple three bus power system with generation at buses at 1 and 2. The voltage at bus 1 is V = 1 + j0.0 V per unit. Voltage magnitude at bus 2 is fixed at 1.05 p.u. with a real power generation of 400 MW. A load consisting of 500 MW and 400 MVAR is taken from bus 3. Line admittances are marked in per unit on a 100 MVA base. For the purpose of hand calculations, line resistances and line charging susceptances are neglected.

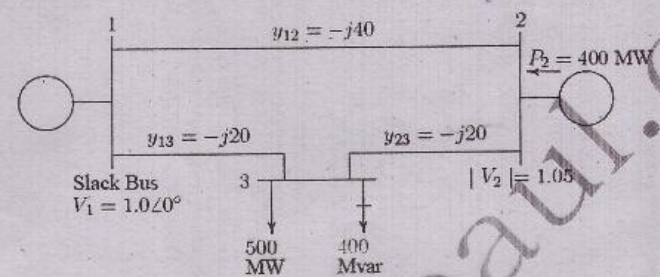

Fig. 2

Using Newton-Raphson method, start with the initial estimates of $V_2^{(0)} = 1.05 + j0.0$ and $V_3^{(0)} = 1.05 + j0.0$, and keeping $|V_2| = 1.05$ p.u., determine the phasor values V_2 and V_3. Perform two iterations.

Or

(b) In the power system network shown in figure 3, bus 1 is slack bus with $V_1 = 1.0 + j0.0$ per unit and bus 2 is a load bus with $S_2 = 280$ MW + j60 MVAr. The line impedance on a base of 100 MVA is Z = 0.02 + j0.04 per unit. Using gauss-seidel method, determine V_2. Use an initial estimate of $V_2^{(0)} = 1.0 + j0.0$ and perform four iterations. Also find S_1 and the real, reactive power loss in the line, assuming that the bus voltages have converged.

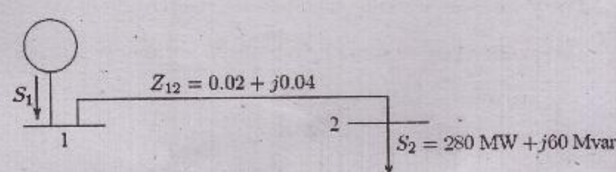

Fig. 3

13. (a) Two generators are connected in parallel to the low voltage side of a 3 phase delta star transformer as shown in figure 4. Generator 1 is rated 60,000 kVA, 11 kV. Generator 2 is rated 30,000 kVA, 11 kV. Each generator has a sub-transient reactance of $X_d'' = 25\%$. The transformer is rated 90,000 kVA at 11 kV-Δ/66 kV-Y with a reactance of 10%. Before a fault occurred, the voltage on the high tension side of the transformer is 63 kV. The transformer is unloaded and there is no circulating current between the generators. Find the sub-transient current in each generator when a three phase fault occurs on the ht side of the transformer.

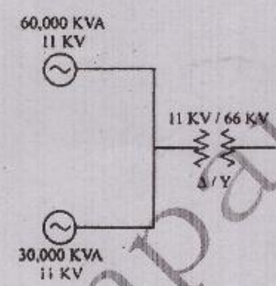

Fig. 4

Or

(b) A generator transformer unit is connected to a line through a circuit breaker. The unit ratings are :

Generator: 10 MVA, 6.6 kV: $X_d'' = 0.1$ pu, $X_d' = 0.2$ pu, and $X_d = 0.8$ pu
Transformer: 10 MVA, 6.9/33 kV, reactance 0.08 p.u

The system is operating on no load at a line voltage of 30 kV, when a three phase fault occurs on the line just beyond the circuit breaker. Find

(i) The initial symmetrical rms current in the breaker,

(ii) The maximum possible dc offset current in the breaker,

(iii) The momentary current rating of the breaker

(iv) The current to be interrupted by the breaker and the interrupting kVA, and

(y) The sustained short circuit current in the breaker

14. (a) A double line to ground fault occurs on lines b and c at point F in the system of figure 5. Find the sub transient current in phase c of the machine 1, assuming prefault currents to be zero. Both machines are rated 1200 kVA, 600 V with reactances of $X'' = X_2 = 10\%$ and $X_0 = 5\%$. Each three phase transformer is rated 1200 kVA, 600 V – Δ/300 V – Y with leakage reactance of 5%. The reactances of the transmission line are $X_1 = X_2 = 20\%$ and $X_0 = 40\%$ on a base of 1200 kVA, 3300 V. The reactances of the neutral of the grounding reactors are 5% on the kVA base of the machines.

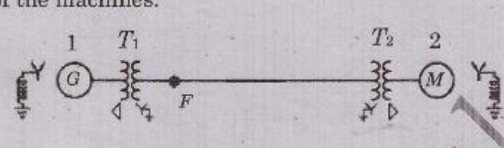

Fig. 5

Or

(b) Calculate the sub-transient current in each phase for a dead short circuit on one phase to ground at bus 'q' for the system shown in figure 6.

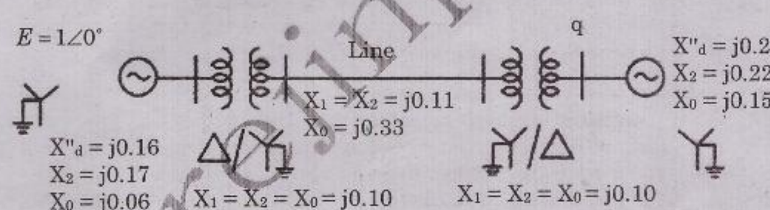

Fig. 6

15. (a) The single line diagram of a system is shown in figure 7. There are four identical generators of rating 555 MVA, 24 kV, 60 Hz supplying power infinite bus bar through two transmission circuits. The reactances shown in figure are in per unit on 2220 MVA, 24 kV base (refer to the low voltage side of the transformer). Resistances are assumed to be negligible. The initial operating conditions, with quantities expressed in per unit on 2220 MVA, 24 kV base, is as follows :

$P = 0.9$, $Q = 0.436$ (over excited), $\vec{E}_t = 1.0 < 28.34$, $\vec{E}_B = 0.90081 < 0$.

The generators are modeled as a single equivalent generator represented by the classical model with the following parameters expressed in per unit on 2220 MVA, 24 kV base.

$X'_d = 0.3,\ H = 3.5 MW.s/MVA\ \ K_D = 0$.

Circuit 2 experiences a solid three phase fault at point F, and the fault is cleared by isolating the fault circuit. Determine the critical clearing time and critical clearing angle by computing the time response of the rotor angle, using numerical integration.

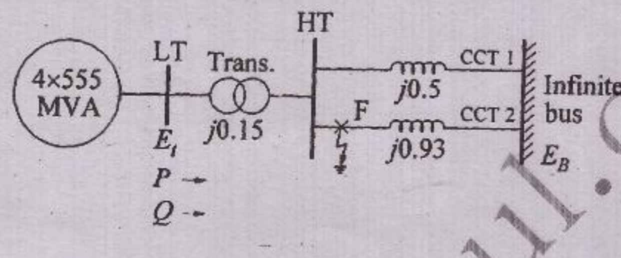

Fig. 7

Or

(b) (i) Define steady state stability and stability limit with the help of Power- Power angle curve. What are the techniques available to improve steady state stability? (6)

(ii) A 60-Hz synchronous generator has a transient reactance of 0.2 per unit and an inertia constant of 5.66 MJ/MVA. The generator is connected to an infinite bus through a transformer and a double circuit transmission line, as shown in Figure 8. Resistances are neglected and reactances are expressed on a common MVA base and are marked on the diagram. The generator is delivering a real power of 0.77 per unit to bus bar 1. Voltage magnitude at bus 1 is 1.1 p.u. The infinite bus voltage V = 1.06∠0 per unit. Determine the generator excitation voltage and obtain the swing equation.

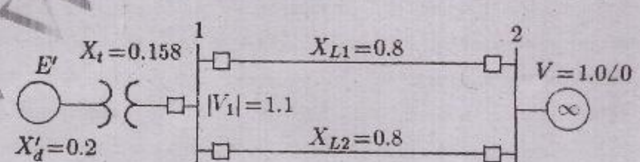

Fig. 8

Electrical and Electronics Engineering

EE 6501 – POWER SYSTEM ANALYSIS

(Regulations 2013)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is single line diagram?

2. Define per unit value.

3. What is the need for load flow study?

4. When is generator bus treated as load bus?

5. Why do faults occur in a power system?

6. What is direct axis reactance? X_d

7. What are the symmetrical components of a three phase system?

8. What is the sequence operator?

9. How is the power system stability classified?

10. Write the power angle equation?

PART B — (5 × 16 = 80 marks)

11. (a) Draw the reactance diagram for the power system shown in fig. 1. Neglect resistance and use a base of 50MVA and 13.8KV on generator G_1

G_1 : 20MVA, 13.8KV, X" = 20%
G_2 : 30MVA, 18.0KV, X" = 20%
G_3 : 30MVA, 20.0KV, X" = 20%
T_1 : 25MVA, 220/13.8 KV, X = 10%
T_2 : 3 Single phase unit each rated 10MVA, 127/18 KV, X = 10%
T_3 : 35MVA, 220/22 KV, X = 10%

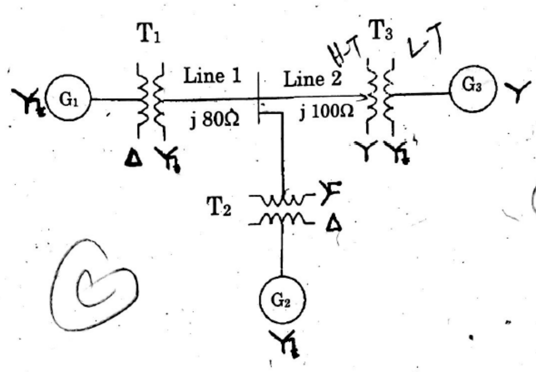

Fig. 1

Determine the new values of per unit reactance of G_1, T_1, Transmission line 1, Transmission line 2, G_2, T_2, G_3 and T_3.

Or

(b) Form Y_{bus} of the test system shown in fig.2 using singular transformation method. The impedance data is given in Table 1. Take (1) as reference node.

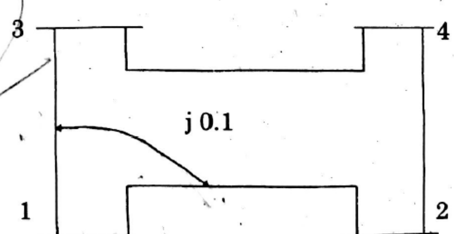

Fig. 2

Table 1

Element No	Self Bus code	Self Impedance	Mutual Bus code	Mutual Impedance
1	1 – 2	0.5	1 – 2	0.1
2	1 – 3	0.6		
3	3 – 4	0.4		
4	2 – 4	0.3		

12. (a) The system data for a load flow solution are given in Tables 2 and 3. Determine the voltages at the end of the first iteration using the Gauss-Seidel method. Take $\alpha = 1.6$.

Table 2 : Line admittances

Bus code	Admittance
1-2	2–j8.0
1-3	1–j4.0
2-3	0.666–j2.664
2-4	1–j4.0
3-4	2–j8.0

Table 3: Schedule of active and reactive powers

Bus Code	P in p.u	Q in p.u	V in p.u	Remarks
1	–	–	1.06	Slack
2	0.5	0.2	1+j0.0	PQ
3	0.4	0.3	1+j0.0	PQ
4	0.3	0.1	1+j0.0	PQ

Or

(b) Draw and explain the step by step procedure of load flow solution for the Gauss seidel method when PV buses are present.

13. (a) Generator G1 and G2 are identical and rated 11KV, 20MVA and have a transient reactance of 0.25 p.u at own MVA base. The transformers T1 and T2 are also identical and are rated 11/66KV, 5MVA and have a reactance of 0.06 p.u to their own MVA base. A 50km long transmission line is connected between the two generators. Calculate three phase fault current, when fault occurs at middle of the line as shown in fig. 3.

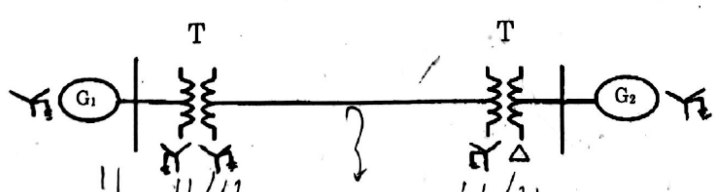

Fig. 3

Or

(b) A synchronous generator and synchronous motor each rated 30 MVA, 13.2 KV and both have subtransient reactance of 20% and the line reactance of 12% on a base of machine ratings. The motor is drawing 25 MW at 0.85 p.f leading. The terminal voltage is 12KV when a three phase short circuit fault occurs at motor terminals. Find the subtransient current in generator, motor and at the fault point.

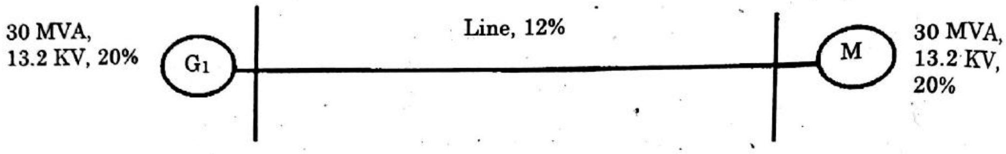

Fig.4

14. (a) Derive the expression for the three phase power in terms of symmetrical components.

Or

(b) A 30 MVA, 11 KV, 3ϕ synchronous generator has a direct subtransient reactance of 0.25 p.u. The negative and zero sequence reactance are 0.35 and 0.1 p.u respectively. The neutral of the generator is solidly grounded. Determine the subtransient current in the generator and the line to line voltages for subtransient conditions when a single line to ground fault occurs at the generator terminals with the generator operating unloaded at rated voltage.

15. (a) (i) Derive the expression for swing equation. (10)

(ii) The moment of inertia of a 4 pole, 100 MVA, 11 kV, $3-\phi$, 0.8 power factor, 50 HZ turbo alternator is 10000 kg-m^2. Calculate H and M. (6)

Or

(b) A synchronous motor is receiving 30% of the power that it is capable of receiving from an infinite bus. If the load on the motor is doubled, calculate the maximum value of δ during the swinging of the motor around its new equilibrium position.

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Question Paper Code : 57320

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2016

Fifth Semester

Electrical and Electronics Engineering

EE6501 – POWER SYSTEM ANALYSIS

(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. Define per unit value of an electrical quantity and write the equation for base impedance for a three phase power system.
2. Write the equation for per unit impedance if change of base occurs.
3. What is the need for load flow analysis ?
4. Mention the various types of buses in power system with specified quantities for each bus.
5. State and explain symmetrical fault.
6. What is bolted fault or solid fault ?
7. What are the symmetrical components of a three phase system ?
8. Write down the equation to determine symmetrical currents from unbalanced current.
9. State Equal area criterion.
10. Define transient stability of a power system.

PART – B (5 × 16 = 80 Marks)

11. (a) The data for the system whose single line diagram shown in Fig.11(a) is as follows :

G1: 30 MVA, 10.5 kV, X" = 1.6 ohms

G2 : 15 MVA, 6.6 kV, X" = 1.2 ohms

G3 : 25 MVA, 6.6 kV, X" = 0.56 ohms

T1 : 15 MVA, 33/11 kV, X = 15.2 ohms/phase on H.T side

T2 : 15 MVA, 33/6.2 kV, X=16.0 ohms/phase on L.T side

Transmission line : X = 20.5 ohms/phase

Loads : A : 40 MW, 11 kV, 0.9 p.f lagging

B : 40 MW, 6.6 kV, 0.85 p.f lagging

Choose the base power as 30 MVA and approximate base voltages for different parts. Draw the reactance diagram. Indicate pu reactance on the diagram. **(16)**

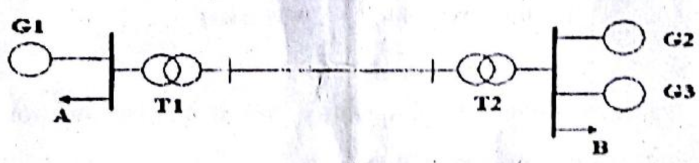


Fig. 11(a)

OR

(b) (i) Determine the Ybus matrix by inspection method for line specification as mentioned below. **(12)**

Line p-q	Impedance in p.u.	Half Line charging admittance in p.u.
1-2	0.04+j0.02	j0.05
1-4	0.05+j0.03	j0.07
1-3	0.025+j0.06	j0.08
2-4	0.08+j0.015	j0.05
3-4	0.035+j0.045	j0.02

(ii) Draw the π-model representation of a transformer with off nominal tap ratio 'α'. **(4)**

12. (a) With a neat flow chart, explain the computational procedure for load flow solution using Gauss Seidal load flow solution. (16)

OR

(b) Draw the flow chart and explain the algorithm of Newton-Raphson iterative method when the system contains all types of buses. (16)

13. (a) A generating station feeding a 132 kV system is shown in fig. 13(a). Determine the total fault current, fault level and fault current supplied by each alternator for a 3 phase fault at the receiving end bus. The line is 200 km long. (16)

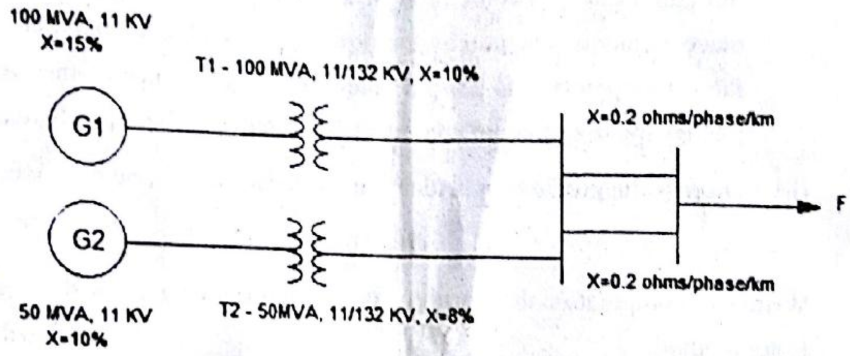


Fig.-13(a)

OR

(b) A Symmetrical fault occurs at bus 4 for the system shown in Fig 13.(b). Determine the fault current using Zbus Building algorithm. (16)

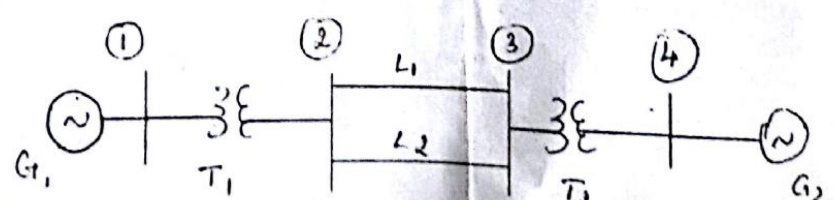


Fig.13(b)

G1, G2 : 100 MVA, 20 kV, X' = 15%

Transformer : $X_{leakage}$ = 9%

L1, L2 : X' = 10%

14. (a) (i) What are the assumptions to be made in short circuit studies ? (4)

(ii) Deduce and draw the sequence network for LLG fault at the terminals of unloaded generator. (12)

OR

(b) Derive the expression for fault current in line to line fault on unloaded generator. Draw an equivalent network showing the interconnection of networks to simulate line to ground fault. (16)

15. (a) (i) A generator is operating at 50 Hz, delivers 1.0 p.u. power to an infinite bus through a transmission circuit in which resistance is ignored. A fault takes place reducing the maximum power transferable to 0.5 p.u. Before the fault, this power was 2.0 p.u. and after the clearance of the fault it is 1.5 p.u. By the use of equal area criterion, determine the critical clearing angle. (10)

(ii) Discuss the methods by which transient stability can be improved. (6)

OR

(b) Write the computational algorithm for obtaining swing curves using Modified Euler method. (16)

Reg. No. : [ ]

Question Paper Code : 80377

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2016.

Fifth Semester

Electrical and Electronics Engineering

EE 6501 — POWER SYSTEM ANALYSIS

(Regulations 2013)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State the advantage of per unit analysis.

2. How are the loads represented in the reactance and Impedance diagram?

3. What is Jacobian matrix?

4. Write the need for Slack bus in load flow analysis.

5. What is the need for short circuit study?

6. How the shunt and series faults are classified?

7. Define short circuit capacity.

8. Why the neutral grounding impedance Zn appears as 3Zn in zero sequence equivalent circuit?

9. Define Voltage Stability.

10. State few techniques to improve the stability of the power system.

PART B — (5 × 16 = 80 marks)

11. (a) Prepare a per phase schematic of the system shown in Fig. 11(a) and show all the impedance in per unit on a 100 MVA, 132 kV base in the transmission line circuit. The necessary data are given as follows: (16)

G1 : 50MVA, 12.2kV, X = 0.15p.u

G2 : 20MVA, 13.8kV, X = 0.15 p.u

T1 : 80MVA, 12.2/161kV, X = 0.1 p.u

T2 : 40MVA, 13.8/161kV, X = 0.1 p.u

Load : 50MVA, 0.8 pf lag operating at 154 kV

Determine the p.u impedance of the load.

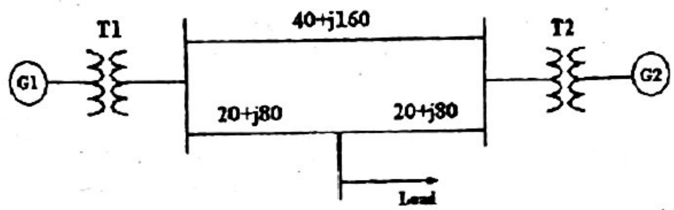


Fig. 11(a)

Or

(b) The parameters of a 4-bus system are as under :

Line starting bus	Line ending bus	Line impedance	Line charging admittance
1	2	0.2+j0.8	j0.02
2	3	0.3+j0.9	j0.03
2	4	0.25+j1.0	j0.04
3	4	0.2+j0.8	j0.02
1	3	0.1+j0.4	j0.01

Draw the network and find bus admittance matrix. (16)

12. (a) With a neat flow chart, explain the computational procedure for load flow solution using Newton Raphson iterative method when the system contains all types of buses. (16)

Or

(b) The Fig. 12(b) shows the one line diagram of a simple 3 bus power system with generators at buses 1 and 3. Line impedances are marked in p.u on a 100 MVA base. Determine the bus voltages at the end of second iteration using Gauss – Seidel method. (16)

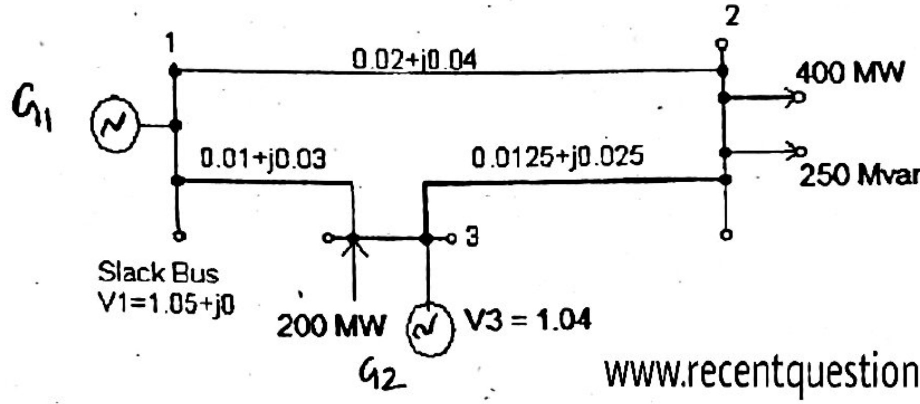


Fig. 12(b)

13. (a) For the radial network shown in Fig. 13(a) 3Φ fault occurs at point F. Determine the fault current and the line voltage at 11.8 kV bus under fault condition.

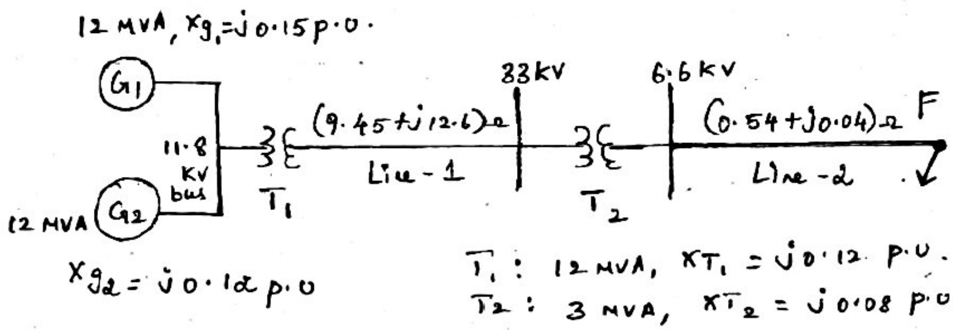


Fig. 13(a)

Or

(b) A 3 phase, 5 MVA, 6.6 kV alternator with a reactance of 8% is connected to a feeder series impedance (0.12 + j0.48) ohm/phase/km through a step up transformer. The transformer is rated at 3 MVA, 6.6 kV/33 kV and has a reactance of 5%. Determine the fault current supplied by the generator operating under no load with a voltage of 6.9 kV, when a 3 phase symmetrical fault occurs at a point 15 km along the feeder. (16)

14. (a) Derive the expression for fault current in line to line fault on unloaded generator. Draw an equivalent network showing the interconnection of networks to simulate line to line fault. (16)

Or

(b) A 30 MVA, 11 kV generator has z1 = z2 = j 0.05. A Line to ground fault occurs at generator terminals. Find the fault current and line voltages during fault conditions. Assume that the generator neutral is solidly grounded and the generator is operating at no load and at rated voltage during occurrence of fault. (16)

15. (a) Derive Swing equation and discuss the importance of stability studies in power system planning and operation. (16)

Or

(b) Find the critical clearing angle and time for clearing the fault with simultaneous opening of the breakers when a three phase fault occurs at point P close to bus 1 as shown in Fig. 15(b). The generator is delivering 1.0 pu. power at the instant preceding the fault.

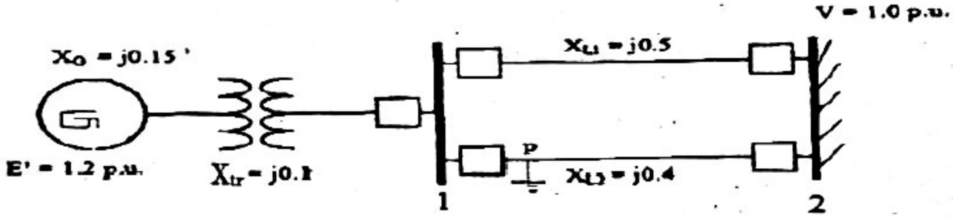


Fig. 15(b)

Reg. No. : [| | | | | | | | | | | |]

Question Paper Code : 71776

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Fifth Semester

Electrical and Electronics Engineering

EE 6501 — POWER SYSTEM ANALYSIS

(Regulations 2013)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the advantages of per unit computation.

2. A Y corrected generator rated at 300 MVA, 33kV has a reactance of 1.24 p.u. Find the ohmic value of the reactance.

3. Compare Newton Raphson and Gauss Seidal methods of load flow solutions.

4. Write the quantities that are associated with each bus in a system.

5. What is the significance of subtransient reactance and transient reactance in short circuit studies?

6. For a fault at a given location, rank the various faults in the order of severity.

7. Express the unbalanced voltages in terms of symmetrical components.

8. Draw the zero-sequence network of Y/Δ transformer with neutral ungrounded.

9. Define swing curve. What is the use of Swing curve?

10. State Equal Area Criterion.

PART B — (5 × 16 = 80 marks)

11. (a) 300 MVA, 20 kV, 3Φ generator has sub transient reactance of 20%. The generator supplies 2 synchronous motors through a 64 km transmission line having transformers at both ends as shown in Fig.11.a. In this, T1 is a 3Φ transformer 350 MVA, 20/230 kV, 10% reactance & T2 is made of 3 single phase transformer of rating 100 MVA, 127/13.2 kV, 10% reactance.

Series reactance of the transmission line is 0.5Ω/km. The ratings of 2 motors are: M1=200 MVA, 13.2 kV, 20% & M2 = 100 MVA, 13.2 kV, 20%. Draw the reactance diagram with all the reactance's marked in p.u. Select the generator rating as base values. (16)

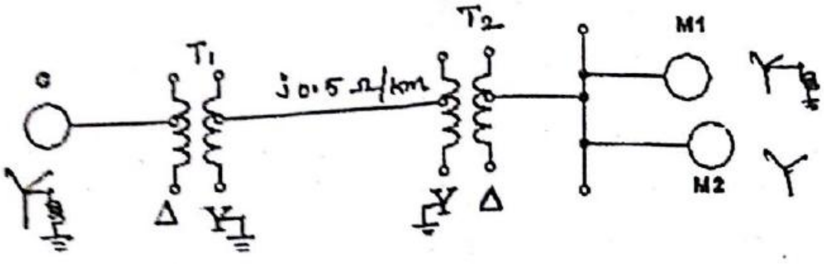
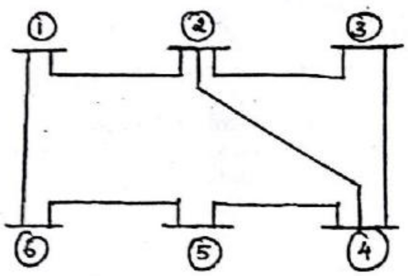


Fig.11.a.

Or

(b) Form bus admittance matrix for the data given below using Singular transformation method. Take node '6' as reference node. (16)

Elements	Bus code	X (p.u.)
1	1-2	0.04
2	1-6	0.06
3	2-4	0.03
4	2-3	0.02
5	3-4	0.08
6	4-5	0.06
7	5-6	0.05



12. (a) With a neat flow chart, explain the computational procedure for load flow solution using Newton Raphson iterative method when the system contains all types of buses. (16)

Or

(b) Single line diagram of a simple power system, with generators at busses 1 and 3 is shown in Fig. 12.b. The magnitude of voltage at bus 1 is 1.05 p.u. Voltage magnitude at bus 3 is fixed at 1.04 p.u. with active power generation of 200 MW. A load consisting of 400 MW and 250 MVAR is taken from bus 2. Line impedances are marked in p.u. on a 100 MVA base and the line charging susceptances are neglected.

Determine the voltage at buses 2 and 3 using Gauss-Seidal method at the end of first iteration. Also calculate Slack bus power.

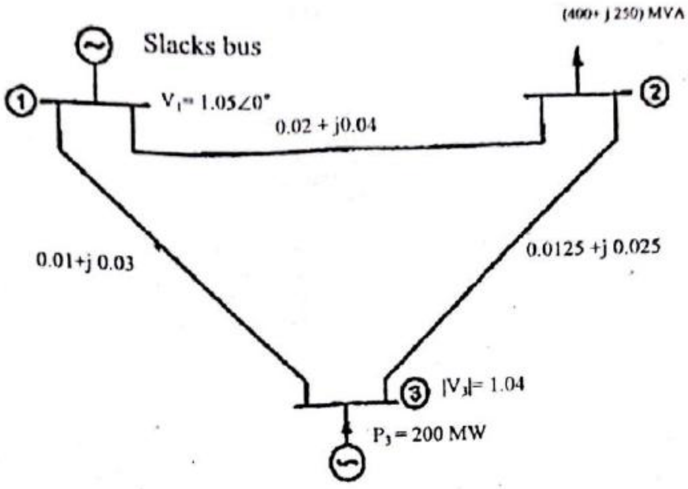


Fig.12.b.

13. (a) (i) A 3 phase. 5 MVA, 6.6 kV alternator with a reactance of 8% is connected to a feeder series impedance (0.12 + j0.48) ohm/phase/km through a step up transformer. The transformer is rated at 3 MVA, 6.6 kV/33 kV and has a reactance of 5%. Determine the fault current supplied by the generator operating under no load with a voltage of 6.9 kV, when a 3phase symmetrical fault occurs at a point 15 km along the feeder. (8)

(ii) Draw the detailed flowchart, which explains how a symmetrical fault can be analyzed using Z_{BUS}. (8)

Or

(b) A 100 MVA, 11 kV generator with X" = 0.20 p.u is connected through a transformer and line to a bus bar that supplies three identical motor as shown in Fig and each motor has X"= 0.20 p.u and X'= 0.25 p.u on a base of 20 MVA,33 kV ,the bus voltage at the motors is 33 kV when three phase balanced fault occurs at the point F. Calculate (i) Sub transient current in the fault (ii) Sub transient current in the circuit breaker B (iii) Momentary current in the circuit breaker B (iv) The current to be interrupted by C.B B in 5 cycles. (16)

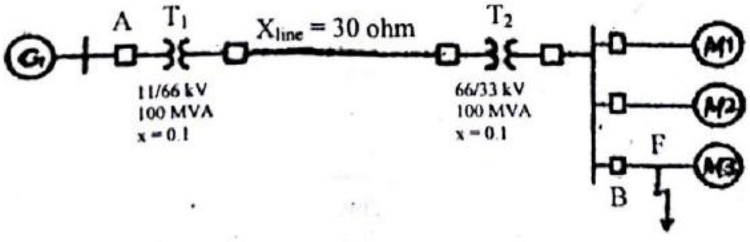


Fig.13.b.

14. (a) (i) Derive the expression for fault current in line to line fault on unloaded generator and draw an equivalent network showing the interconnection of networks. (10)

(ii) A 3 phase salient pole synchronous generator is rated 30 MVA, 11 kV and has a direct axis subtransient reactance of 0.25 p.u. The negative and zero sequence reactances are 0.35 and 0.1 p.u. respectively. The neutral of the generator is solidly grounded. Calculate the subtransient current in the generator when a line to line fault occurs at the generator terminals with generator operating unloaded at rated voltage. (6)

Or

(b) Two 11 kV, 20 MVA, three phase star connected generators operate in parallel as shown in Fig. The positive, negative and zero sequence reactance of each being respectively j 0.18, j 0.15, j 0.10 p.u. The star point of one of the generator is isolated and that of the other is earthed through a 2.0 ohm resistor. A Single line to Ground fault occurs at the terminals of one of the generators. Estimate (i) fault current (ii) current in grounded resistor and (iii) Voltage across grounding resistor. (16)

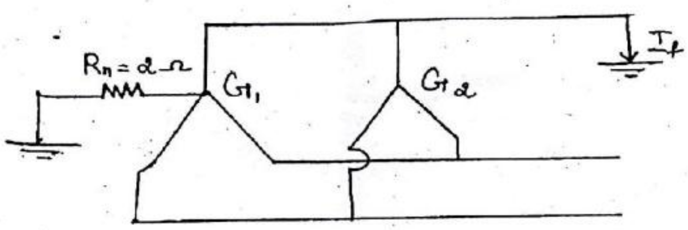


Fig.14.b.

15. (a) (i) Discuss the methods by which transient stability can be improved. (6)

(ii) Find the critical clearing angle of the system shown in Fig. 15.a., for a 3 phase fault at the point 'F'. The generator is delivering 1.0 pu. power under prefault conditions. (10)

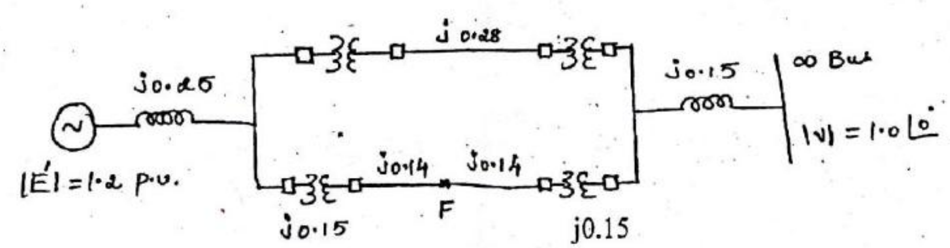


Fig.15.a.

Or

(b) Derive the swing equation of a single machine connected to an infinite bus system and explain the steps of solution by Runge -Kutta method. (16)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 50485

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Fifth Semester

Electrical and Electronics Engineering

EE 6501 – POWER SYSTEM ANALYSIS

(Regulations 2013)

ime : Three Hours

Maximum : 100 Marks

Answer ALL questions

PART – A

(10×2=20 Marks)

1. Define per unit value of an electrical quantity and write the equation for base impedance for a three phase power system.

2. Write the equation for per unit impedance if change of base occurs.

3. What is the need for load flow analysis ?

4. Mention the various types of buses in power system with specified quantities for each bus.

5. State and explain symmetrical fault.

6. What is bolted fault or solid fault ?

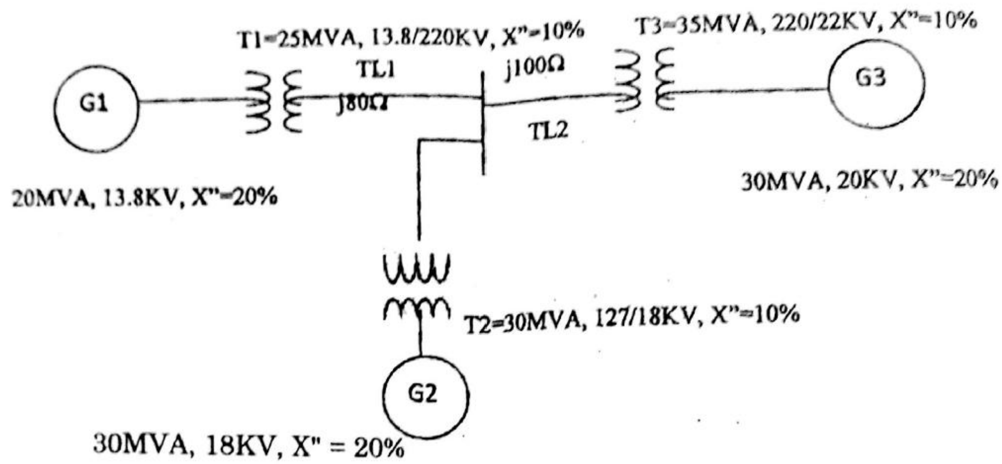
7. What are the features of zero sequence current ?

8. Write down the equation to determine symmetrical components currents from unbalanced currents.

9. State equal area criterion.

10. Define transient stability of a power system.

11. a) The single line diagram of an unloaded power system is shown in figure 11(a) along with components data determine the new per unit values and draw the reactance diagram. Assume 50 MVA and 13.8 KV as new base on generator 1. (13



(OR)

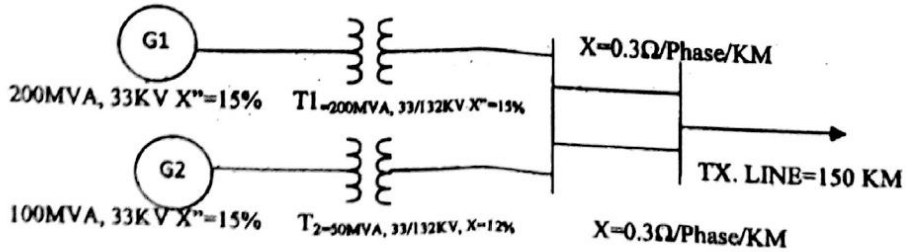
b) Describe the Z_{Bus} building algorithm in details by using a three bus system. (1

12. a) With a neat flow chart, algorithm and explain the computational procedure for load flow solution using Gauss-Seidal Methods. (1

(OR)

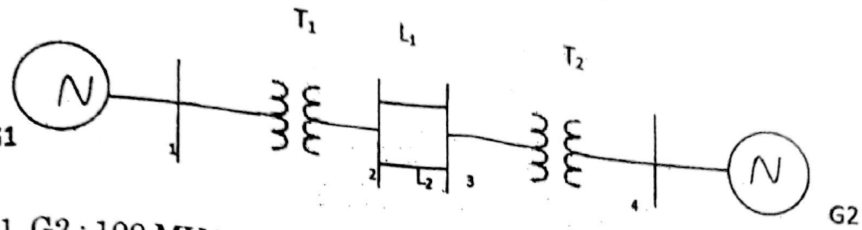
b) Draw the detailed flow chart and explain he algorithm of Newton-Raphson method when the system contains all types of buses. (1

13. a) A generating stations feeding 132 KV system is shown in Fig. 13(a). Determine the total fault current, fault level and fault current supplied by each alternator for a 3 phase solid fault at the receiving end bus. The length of the transmission line is 150 KM long. (1



(OR)

b) A symmetrical fault occurs at bus 4 for the system shown in fig. 13(b). Determine the fault current using Z_{bus} building algorithm. (13)



G1, G2 : 100 MVA, 20 KV, X" = 15% Transformers T1, T2 : $X_{Leakage}$ = 9%

L1, L2 : X" = 10%

4. a) i) What are the assumption to be made in short circuit studies ? (4)

ii) Deduce and draw the sequence network for LLG fault at the terminal of unloaded generator. (9)

(OR)

b) Derive the expression for fault current in line fault on unloaded generator. Draw an equivalent network showing the interconnection of networks to simulate line to ground fault. (13)

5. a) i) A generator is operating at 50 Hz, delivers 1.0 p.u. power to an infinite bus through a transmission circuit in which resistance is ignored. A fault takes place reducing the maximum power transferred to 0.5 p.u. Before the fault, the power was 2.0 p.u. and after the clearance of the fault it is 1.5 p.u. by the use of equal area criterion, determine the critical clearing angle. (8)

ii) Discuss the methods by which transient stability can be improved. (5)

(OR)

b) Write the computational algorithm for obtaining swing curves using modified-Euler method. (13)

PART – C (1×15=15 Marks)

6. a) i) Distinguish between steady state stability and dynamic stability. (8)

ii) Explain the importance of stability analysis in power system. (7)

(OR)

b) Explain the term critical clearing angle and critical clearing time in connection with the transient stability of a power system. (13)