DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

COURSE FILE

OF

POWER SYSTEM-I

TABISH SHANU

ASSISTANT PROFESSOR, DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

विज्ञान एवं प्रावैधिकी विभाग
Department of Science and Technology
Government of Bihar

Department of Electrical Engineering

Vision of EEE: - To bring forth engineers with an emphasis on higher studies and a fervor to serve national and multinational organisations and, the society.

Mission of EEE: -

M1: - To provide domain knowledge with advanced pedagogical tools and applications.

M2: - To acquaint graduates to the latest technology and research through collaboration with industry and research institutes.

M3: - To instil skills related to professional growth and development.

M4: - To inculcate ethical valued in graduates through various social-cultural activities.

PEO of EEE

PEO 01 – The graduate will be able to apply the Electrical and Electrical Engineering concepts to excel in higher education and research and development.

PEO 02 – The graduate will be able to demonstrate the knowledge and skills to solve real life engineering problems and design electrical systems that are technically sound, economical and socially acceptable.

PEO 03 – The graduates will be able to showcase professional skills encapsulating team spirit, societal and ethical values.

Program Outcomes (POs) based on Program Educational Objectives (PEOs) of Electrical Engineering Department:

PO 1. Students will be able to apply knowledge of applied mathematics & science in electrical engineering problems.

PO 2. Students will be able to identify, formulate and solve society and industries related problems.

PO 3. Students will be able to apply knowledge to design a system, component or process to meet desired needs within realistic constraints.

PO 4. Students will be able to conduct laboratory experiments and to critically analyze and interpret experimental data.

PO 5. Students will be able to use the recent techniques, skills, and modern tools necessary for engineering practices.

PO 6. Students will be able to understand the impact of engineering problems, solutions in a global and societal context.

PO 7. Students will be able to demonstrate professional and ethical responsibilities.

PO 8. Students will be able to apply leadership quality to work with team in the area of electrical engineering towards the solution of multi-disciplinary tasks.

PO 9. Students will be able to communicate effectively through verbally, technical writing, reports and presentation.

PO 10. Students will be able to develop confidence for self-education and ability to engage in life-long learning.

Course Description

This course is designed to introduce the concepts and phenomenon electrical power transmission and distribution, both AC & DC. It also imparts knowledge of electrical and mechanical aspects of design of transmission line. It will give clear understanding of underground cables to the student. The Power System-I curriculum is designed to prepare interested students to make their career in transmission line conductor design, tower design, generating stations and substations.

Course Objectives

- This course is the fundamentals of Power System.
- Power system is basically divided into 3 parts i.e. generation, transmission & distribution. In this course, we will deal with distribution & transmission.
- Also, this course gives emphasis on the use of Underground cables.

After the completion of this course the students will be able to:

- Understand the concepts of power systems.
- Understand the various power system components.
- Evaluate fault currents for different types of faults.
- Understand the generation of over-voltages and insulation coordination.
- Understand basic protection schemes.
- Understand concepts of HVDC power transmission and renewable energy generation.

Mapping of CO's with PO's

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	2	1	1	-	2	-	-	-	1	2	3	1
CO2	3	3	3	2	3	-	-	-	-	-	1	1	2	3
CO3	3	2	3	1	3	-	-	-	-	-	1	1	1	3
CO4	2	2	1	3	3	1	1	1	-	-	2	2	2	3

B. Tech. V Semester (EEE)

EEE13 Power System -I

L T P/D Total	Max Marks:	100	
3-0-2 4		Final Exam:	70 Marks
		Sessional:	20 Marks
		Internals:	10 Marks.

Module 1: Basic Concepts (4 hours)

Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids.

Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (15 hours)

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power.

Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.

Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, auto-transformers, Neutral Grounding transformers. Tap-Changing in transformers.

Transformer Parameters. Single phase equivalent of three-phase transformers.

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Module 3: Over-voltages and Insulation Requirements (4 hours)

Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley

Diagrams.

Module 4: Fault Analysis and Protection Systems (10 hours)

Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)

DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

Text/References:

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education, 1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Education, 2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, “Electric Power Systems”, Wiley, 2012.

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA w.e.f. –

EEE Semester – 5th, Session (2018-22)

Day	Branch	1 (10am-10.50am)	2 (10.50am-11.40am)	3(11.40am-12.30pm)	4(12.30pm-1.20pm)	Lunch (1.20pm – 1.50pm)	5(1.50pm – 2.40pm)	6(2.40pm-3.30pm)	7(3.30pm-4.20pm)
Monday	E.E.E.								
Tuesday	E.E.E.								
Wednesday	E.E.E.						PS-I		
Thursday	E.E.E.			PS-I		LUNCH	PS-I		
Friday	E.E.E.	PS-I					PS-I		
Saturday	E.E.E.			PS-I					

<u>Mechanical</u> – M1 - 1 to 30   <u>E.E.E.</u> - E1 - 1 to 30   <u>C. Sc.</u> - CS1 – 1 to30   <u>Civil</u> - C1 – 1 to 30

S-1 M2 –31 to All   S-2 E2 – 31 to All   S-3 CS2 – 31 to All   B.C.R. C2 – 31 to All

Prof . Incharge Routine   Principal

D.C.E. Darbhanga   D.C.E., Darbhanga

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

5th Sem. Branch:- Electrical & Electronics Engineering Batch (2018-22)

Subject :- Power System-I

S.No.	Name of Student	Roll No.	Registration No.
1	Dipu Kumar	18-EE-34	18110111001
2	Aditya Anand	18-EE-58	18110111002
3	Subham Kumar	18-EE-01	18110111003
4	Ankit Kumar	18-EE-08	18110111004
5	Kajal Kumari	18-EE-06	18110111006
6	Juhi Kumari	18-EE-09	18110111007
7	Vishal Kumar	18-EE-04	18110111008
8	Nikhil Kumar	18-EE-41	18110111009
9	Subham Kumar	18-EE-10	18110111010
10	Ajanoy Yadav	18-EE-12	18110111011
11	Harsh Kumar	18-EE-13	18110111012
12	Amit Kumar Sharma	18-EE-19	18110111015
13	Sanjeev Anand	18-EE-28	18110111016
14	Anand Kumar	18-EE-39	18110111017
15	Avinash Chauhan	18-EE-44	18110111018
16	Samiksha Deep	18-EE-32	18110111019
17	Kanchan Kumari	18-EE-26	18110111021
18	Sonu Sangam	18-EE-46	18110111022
19	Rupesh Kumar	18-EE-48	18110111023
20	Chitragupt Kumar	18-EE-53	18110111024
21	Sugam Odambo	18-EE-50	18110111025

22	Rachana Kumari	18-EE-57	18110111026
23	Jay Kumar Vishwas	18-EE-52	18110111027
24	Arti Kumari	18-EE-60	18110111028
25	Anamika Kumari	18-EE-55	18110111029
26	Mahanand	18-EE-54	18110111030
27	Deepshikha	18-EE-49	18110111031
28	Akanksha	18-EE-69	18110111033
29	Prince Kumar	18-EE-68	18110111034
30	Harendra Kumar Kamat	18-EE-61	18110111035
31	Laxman Kumar	18-EE-63	18110111036
32	Suman Kumar	18-EE-67	18110111037
33	Rimi Kumari	18-EE-70	18110111040
34	Saurabh Kumar Jha	18-EE-76	18110111041
35	Rani Kumari	18-EE-81	18110111044
36	Mrinalini	18-EE-74	18110111045
37	Sourav Raj	18-EE-75	18110111046
38	Ayazur Rahman	18-EE-71	18110111048
39	Dhiraj Kumar	18-EE-82	18110111049
40	Shubham Raj	18-EE-20	18110111050
41	Prateesh Kumar	18-EE-22	18110111051
42	Sushma Kumari	19LE-EE06	19110111036
43	Kajal Kumari	19LE-EE08	19110111901
44	Anushka Kumari	19LE-EE07	19110111902
45	Abhishek Kumar	19LE-EE04	19110111903
46	Chandradeepa Kumari	19LE-EE05	19110111904
47	Prity Kumari	19LE-EE01	19110111905
48	Rishu Roushan	19LE-EE02	19110111906
49	Shubham Alok	19LE-EE09	19110111907

50	Nitish Kumar	19LE-EE03	19110111908

Institute/College Name:	Darbhanga College of Engineering
Program Name:	B.Tech (EEE, 5th semester)
Course Code:	
Course Name:	Power System-I
Lecture/Tutorial(per week):	3/1
Course Credits:	4
Course Co-coordinator Name:	Mr. Tabish Shanu

1. Scope and Objective of Course

This course is designed to introduce the concepts and phenomenon of different sources of Power Generation and to give an idea about the fundamental concepts of electrical power transmission and distribution, both AC & DC. It also imparts knowledge of electrical and mechanical aspects of design of transmission line. It will give clear understanding of underground cables to the student.

The course outcomes are

1. Articulate power system concepts required in engineering problems.
2. Design power system components for a specified system and its applications.
3. Ability to discuss various power sources for generation of power and their Merit/Demerits.
4. Formulate A.C and D.C distribution networks for necessary variable calculation.
5. Ability to calculate usage of electrical power.
6. Ability to discuss functions of Substation.

2. Textbooks

TB1: Elements of Power System Analysis by Stevenson (McGraw Hill)
TB2: Modern Power System by N J Nagrath & Kothari (TMH)
TB3: Elective Power System by Soni, Bhatnagar & Gupta
TB4: Electrical Power system by C. L. Wadhwa

3. Reference Books

RB1: Principles of Power Systems by V.K Mehta
RB2: Extra High Voltage AC transmission by Rakosh Das Begamudre

Other readings and relevant websites

S. No.	Link of journals, Magazines, websites and Research papers
1.	https://www.youtube.com/watch?v=uy9lZCdkQIM&list=PLD4ED2FAF3C155625
2.	http://nptel.ac.in/courses/108105067/#
3.	https://www.youtube.com/watch?v=fBm1dr_gRBk
4.	http://nptel.ac.in/courses/117105140/
5	http://www.sakshieducation.com/Engineering/listS.aspx?cid=12&sid=666&chid=1112&tid=548
6	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-061-introduction-to-electric-power-systems-spring-2011/#

Course plan

Lecture No.	Date of Lecture	Topics	Web Links for Videos Lecture	Text Books/Reference books/Reading Materials	Page No. of Text Books
1-3		**Introduction** Effect of system voltage on transmission efficiency, Single phase AC, 3 phase AC System, Choice of Conductor's Size	http://nptel.ac.in/courses/108105104/	TB4	1-13
		Tutorial-1			
4-6		**Distribution** Choice of voltage, Radial and ring Feeders: Calculation of voltage drop in AC, Radial and ring system	http://nptel.ac.in/courses/108105104/	TB4	1-13
		Tutorial-2			
7-12		**Electrical Design- Part I** Calculation of inductance of conductor due to internal and external flux, Inductance of Single Phase System; Kin and proximity effects/ GMR of solid conductor, GMR of standard conductor, Mutual GMD Inductance of opposite conductor lines, Inductance of 3-phase lines single circuit and double circuit	http://nptel.ac.in/courses/117105140/4	TB1	141-167

		Tutorial-3			
13-18		**Electrical Design- Part II** Symmetrical spacing and unsymmetrical spacing, Inductance of bundled conductor system, Calculation of capacitance of single phase and 3-phase system, symmetrical and unsymmetrical spacing, single circuit and double circuit bundled conductor system, effect of earth on capacitance of line.	http://nptel.ac.in/courses/117105140/4	TB1	170-191
		Tutorial-4, Assinment-1			
19-24		**Mechanical Design** Types of supports cross arms and conductors, Calculation of sag and tension, cases of unequal height of supports, Stringing chart, earth clearance of live conductors, vibration, dampers.		TB4	153-171
		Tutorial-5			
25-29		**Performance of Lines- Part I** Short, medium and long lines, A.B.C.D, constants: regulations nominal and T equivalent pie and T representation	http://nptel.ac.in/courses/117105140/21	TB4	59-97
		Tutorial-6			
		Performance of Lines- Part II			
30-34		Surge impedance, surge impedance loading of line, universal power circle diagram, Lossless line	http://nptel.ac.in/courses/117105140/21	TB4	59-97
		Tutorial-7			

		Underground Cables- Part I			
35-39		Types, insulating materials, sed. Stress in isolation and capacitance inter sheath and capacitance grading, PF in cables capacitance of 3-core cables.	http://nptel.ac.in/courses/108105104/6	TB4	189-223
		Tutorial-8			
		Underground Cables- Part II			
40-44		Instantaneous and long time breakdown strength, dielectric losses, lionization, deterioration, Heat production, Sheath current, Thermal characteristics.	http://nptel.ac.in/courses/108105104/6	TB4	189-223
		Tutorial-9, Assinment-2			

Syllabus

Topics	No. of Lectures	Weightages
Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids. Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.	**4**	10%
Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines. **Transformers**: Three-phase connections and Phase-shifts. Three-winding transformers, auto- transformers, Neutral Grounding transformers. Tap-Changing in transformers. Transformer Parameters. Single phase equivalent of three-phase transformers.	**15**	36%

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.		
Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.	**4**	10%
Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding. Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.	**10**	24%
DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.	**9**	20%

This document is approved by

Designation	**Name**	**Signature**
Course Coordinator	Mr. Tabish Shanu	
H.O.D	Mr. Prabhat Kumar	
Principal	Dr. Achintya	
Date		

Evaluation and Examination Blue Prints:

Internal assessment is done through quiz tests, presentations, assignments and project work. Two sets of question papers are asked from each faculty and out of these two, without the knowledge of faculty, one question paper is chosen for the concerned examination. The components of evaluations along with their weightage followed by the University is given below

Sessional Test 20%

Internals	10%
End term examination	70%

Institute / School Name :	DARBHANGA COLLEGE OF ENGINEEERING		
Program Name	**B.E, EEE**		
Course Code	EEE13		
Course Name	POWER SYSTEM- I		
Lecture / Tutorial (per week):	3/0	**Course Credits**	4
Course Coordinator Name	Mr. TABISH SHANU		

LECTURE PLAN

Basic Concepts **(4 hours)**

Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power

Grids and Micro-grids.

Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy

Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.

Power System Components **(15 hours)**

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple

configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power.

Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.

Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, auto-transformers, Neutral Grounding transformers. Tap-Changing in transformers.

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Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Over-voltages and Insulation Requirements **(4 hours)**

Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley

Diagrams.

Fault Analysis and Protection Systems **(10 hours)**

Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

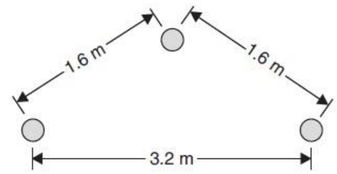
Introduction to DC Transmission & Renewable Energy Systems **(9 hours)**

DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc

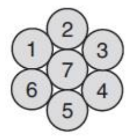
transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

Assignment-I

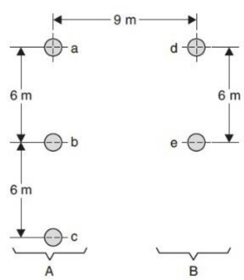
1. Determine the inductance of a 3-phase line operating at 50 Hz and conductors arranged as follows. The conductor diameter is 0.8 cm.



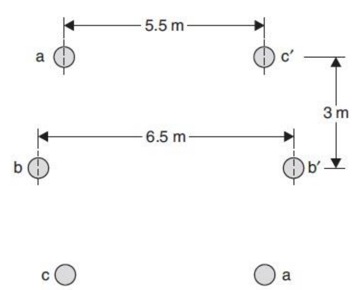
2. A conductor consists of seven identical strands each having a radius of r. Determine the factor by which r should be multiplied to find the self GMD of the conductor.



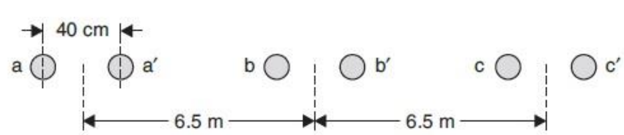
3. Determine the inductance of a single phase transmission line consisting of three conductors of 2.5 mm radii in the 'go' conductor and two conductors of 5 mm radii in the, return, conductor. The configuration of the line is as shown in figure below.



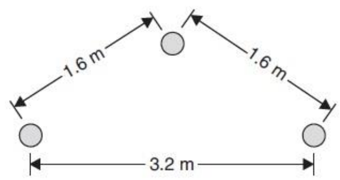
4. Determine the inductance of the double circuit line shown in figure. The self GMD of the conductor is 0.0069 metre.



5. Determine the capacitance and charging current per km of the line, if the line operates at 220 kV, diameter = 4.5 cm.



6. Determine the capacitance and the charging current per km when the transmission line operating at 132 kV. The conductor diameter is 0.8 cm.



Assignment-II

1. A single phase overhead transmission line delivers 1.1 MW at 33 kV at 0.8 p.f. lagging. The total resistance and inductive reactance of the line are 10 Ω and 15 Ω respectively. Determine: (i) sending end voltage (ii) sending end power factor and (iii) transmission efficiency.
2. What is the maximum length in km for a 1-phase transmission line having copper conductor of 0.775 cm^2 cross-section over which 200 kW at unity power factor and at 3.3kV are to be delivered? The efficiency of transmission is 90%. Take specific resistance as 1.725 μΩcm.
3. A 3-phase line delivers 3600 kW at a p.f. 0·8 lagging to a load. If the sending end voltage is 33 kV, determine (i) the receiving end voltage (ii) line current (iii) transmission efficiency. The resistance and reactance of each conductor are 5.31 Ω and 5.54 Ω respectively.
4. An 11 kV, 3-phase transmission line has a resistance of 1·5 Ω and reactance of 4 Ω per phase. Calculate the percentage regulation and efficiency of the line when a total load of 5000 kVA at 0.8 lagging power factor is supplied at 11 kV at the distant end.
5. A 3-phase, 50 Hz, 16 km long overhead line supplies 1000 kW at 11kV, 0.8 p.f. lagging. The line resistance is 0.03 Ω per phase per km and line inductance is 0.7 mH per phase per km. Calculate the sending end voltage, voltage regulation and efficiency of transmission.
6. A 3-phase, 50 Hz transmission line 100 km long delivers 20 MW at 0·9 p.f. lagging and at 110 kV. The resistance and reactance of the line per phase per km are 0.2 Ω and 0.4 Ω respectively, while capacitance admittance is 2.5×10^{-6} siemen/km/phase. Calculate (i) the current and voltage at the sending end (ii) efficiency of transmission. Use nominal T method.
7. A 100-km long, 3-phase, 50-Hz transmission line has following line constants:
   Resistance/phase/km = 0.1 Ω
   Reactance/phase/km = 0.5 Ω
   Susceptance/phase/km = 10×10^{-6} S
   If the line supplies load of 20 MW at 0.9 p.f. lagging at 66 kV at the receiving end, calculate by nominal π method:
      (i) Sending end power factor (ii) regulation (iii) transmission efficiency
8. A balanced 3-phase load of 30 MW is supplied at 132 kV, 50 Hz and 0.85 p.f. lagging by means of a transmission line. The series impedance of a single conductor is (20 + j52) ohms and the total phase-neutral admittance is 315×10^{-6} siemen. Using nominal T method, determine: (i) the A, B, C and D constants of the line (ii) sending end voltage (iii) regulation of the line.
9. A 132 kV, 50 Hz, 3-phase transmission line delivers a load of 50 MW at 0.8 p.f. lagging at the receiving end. The generalised constants of the transmission line are: A = D = 0.95 ∠1.4º ; B = 96 ∠78º ; C = 0.0015 ∠90º. Find the regulation of the line and charging current. Use Nominal-T method.
10. Find the following for a single circuit transmission line delivering a load of 50 MVA at 110 kV and p.f. 0.8 lagging: (i) sending end voltage (ii) sending end current (iii) sending end power (iv) efficiency of transmission. Given A = D = 0.98 ∠3º; B = 110 ∠75º ohm; C = 0.0005 ∠80º siemen.

Power System-I
Assignment III

1. With equation find out the volume of conductor in case of 3-phase 3-wire system and 3-phase 4-wire system in overhead power transmission.
2. Explain connection schemes of Distribution System.
3. Derive equation of capacitance of three phase line with unsymmetrical spacing. Assume transposition.
4. Derive the equation for inductance of single phase two wire line.
5. What is string efficiency? Derive its equation in case of 3 disc string. Explain methods of improving string efficiency.
6. Determine generalized constant for medium transmission line by nominal T method.
7. Define grading of cable. Explain inter sheath grading with diagram and equation.
8. Derive an expression for the inductance per phase for a 3-phase overhead transmission line when conductors are unsymmetrically placed but the line is completely transposed.
9. What is skin effect? On which factors it depends? Why it is absent in d.c. system?
10. A d.c. distributor AB is fed at both ends. At feeding point A, the voltage is maintained at 235 V and at B, it is 236 V. The total length of the distributor is 200 meters and loads are tapped off as under:
    20 A at 50 m from A
    40 A at 75 m from A
    25 A at 100 m from A
    30 at 150 m from A
    The resistance per kilometer of one conductor is 0.4 ohm. Calculate the minimum voltage and the point at which it occurs.
11. A single phase distributor 2 kilometers long supplies a load of 120 A at 0.8 p.f. lagging at its far end and a load of 80 A at 0.9 p.f. lagging at its mid-point. Both power factors are referred to the voltage at the far end. The resistance and reactance per km (go and return) are 0.05 ohm and 0.1 ohm respectively. If the voltage at the far end is maintained at 230V, calculate: (i) voltage at the sending end and (ii) phase angle between voltages at the two ends.

Power System-I
Assignment IV

1. Define the sag in overhead line. Derive the equation of sag in case of when supports are at equal and unequal level. Also find the sag during effect of wind and ice loading.
2. Name the different types of insulators used in transmission system. Explain suspension type insulator.
3. An insulator string consists of three units, each having a safe working voltage of 15kV. The ratio of self- capacitance shunt capacitance of each unit is 8:1. Find the maximum safe working voltage of the string. Also find the string efficiency.
4. Explain function of insulators and Discuss
   Pin Insulator and Suspension Insulator.
5. With diagram explain construction of Screened cables.
6. Define grading of cable. Explain inter sheath grading with diagram and equation.
7. Compare the merits and demerits of underground versus overhead system.
8. Calculate the capacitance of a 100 km long 3-phase, 50 Hz overhead transmission line consisting of 3 conductors, each of diameter 2 cm and spaced 2·5 m at the corners of an equilateral triangle.
9. Derive the expression for the capacitance between conductors of single phase line.
10. Calculate the inductance of each conductor in a 3-phase, 3-wire system when the conductors are arranged in a horizontal plane with spacing such that D31 = 4 m; D12= D23 = 2m. The conductors are transposed and have a diameter of 2·5 cm.
11. What is skin effect? On which factors it depends? Why it is absent in d.c. system?
12. Write a short note on thermal resistance of cable.
13. Explain briefly the following methods of grading of cable
    (a) Intersheath grading
    (b) Capacitance grading

TUTORIAL-I

1. Each line of a 3-phase system is suspended by a string of 3 identical insulators of self capacitance C farad. The shunt capacitance of connecting metal work of each insulator is 0.2C to earth and 0.1C to line. Calculate string efficiency of the system if a guard ring increases the capacitance to the line of metal work of the lowest insulator to 0.3C.

2. A 2-wire dc street mains AB, 600 m long is fed from both ends at 220 V. Loads of 20A, 40A, 50A and 30A are tapped at distances of 100m, 250m, 400m and 500m from the end A respectively. If the area of X-section of distributor conductor is 1 cm2 find the minimum consumer voltage. Take ρ = 1.7 × 10-6 Ω cm.

3. The capacitance per kilometer of a 3-phase belted cable is 0·18 μF between two cores with the third core connected to sheath. Calculate the kVA taken by 20 km long cable when connected to 3-phase, 50 Hz, 3300 V supply.

Tutorial-II

1. A single phase distributor 2 kilometers long supplied of 120 A at 0.8 p.f. lagging at its far end and a load of 80 A at 0.9 p.f. lagging at its mid-point. Both p.f are referred to the voltage at the far end. The resistance and reactance per km (go and return) are 0.05 Ω and 0.1 Ω respectively. If voltage at the far end is maintained at 230 V, calculate: (i) voltage at the sending end (ii) phase angle between voltages at the two ends.

2. Calculate the capacitance of a 100 km long 3-phase, 50 Hz overhead transmission line consisting of 3 conductors, each of diameter 2 cm and spaced 2·5 m at the corners of an equilateral triangle.

3. Calculate the inductance of each conductor in a 3-phase, 3- wire system when the conductors are arranged in a horizontal plane with spacing such that D31 = 4 m; D12= D23 = 2m. The conductors are transposed and have a diameter of 2·5 cm.

Tutorial-III

1. Each line of a 3-phase system is suspended by a string of 3 similar insulators. If the voltage across the line unit is 17.5 kV, calculate the line to neutral voltage. Assume that the shunt capacitance between each insulator and earth is 1/8th of the capacitance of the insulator itself. Also find the string efficiency.

2. Calculate the inductance of each conductor in a 3-phase, 3-wire system when the conductors are arranged in a horizontal plane with spacing such that D31 = 4 m, D12 = D23 = 2 m. The conductors are transposed and have a diameter of 2.5 cm.

Tutorial-III

Darbhanga College of Engineering
Department of Electrical and Electronics Engineering

ROLL No.										

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

MID-SEM EXAMINATION

Subject Name	Power System-I	**Subject Code**	
Branch & Sem.	EEE, 5^{th}	**Date**	
Max Marks	20	**Max Time**	2 Hr.

Q1: A medium line with parameters A, B, C, D is extended by connecting a short line of impedance Z in series. Find out the overall ABCD parameters of the series combination. [1]

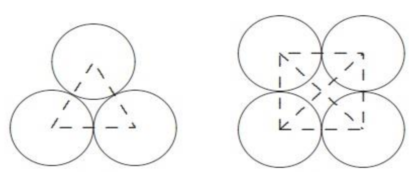
Q2: A single-phase transmission line 35 Km long consists of two solid round conductors, each having a diameter of 0.9 cm. The conductor spacing is 2.5m. Calculate the equivalent diameter of a fictitious hollow, thin-walled conductor having the same equivalent inductance as the original line. What is the value of the inductance per conductor? [2]

OR

Q3: Find the geometric mean radius of a conductor in terms of the radius *r* of an individual strand for

(a) Three equal strands as shown in Figure (a)

(b) Four equal strands as shown in Figure (b) [2]



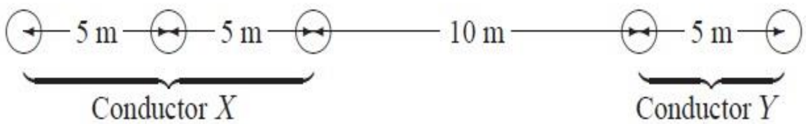
(a) (b)

Q4: Derive Kelvin's law for most economical size of conductor. What are its limitations? [3]

Q5: An overhead line has a span of 150 m between level supports. The conductor has a cross-sectional area of 2 cm^2. The ultimate strength is 5000 kg/cm^2 and safety factor is 5. The specific gravity of the material is 8·9 gm/cc. The wind pressure is 1·5 kg/m. Calculate the height of the conductor above the ground level at which it should be supported if a minimum clearance of 7 is to be left between the ground and the conductor. [3]

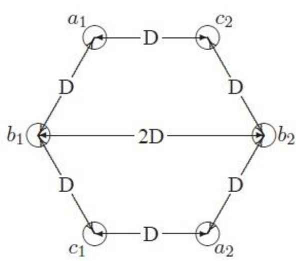
Q6: One circuit of a single-phase transmission line is composed of three solid 0.5- cm radius wires. The return circuit is composed of two solid 2.5-cm radius wires. The arrangement of conductors is as shown in figure below. Applying the concept of the *GMD* and *GMR*, find the inductance of the complete line in milli-henry per kilometer.

[3]



Q7: The conductors of a double-circuit three-phase transmission line are placed on the corner of a hexagon as shown in figure. The two circuits are in parallel and are sharing the balanced load equally. The conductors of the circuits are identical, each having a radius *r*. Assume that the line is symmetrically transposed. Using the method of *GMR*, determine an expression for the capacitance per phase per meter of the line.

[3]



Q8: A 230-kV, three-phase transmission line has a per phase series impedance of $z = 0{:}05+j0{:}45$ - per Km and a per phase shunt admittance of $y = j.0000034$ siemens per km. The line is 80 km long. Using the nominal π model, determine (a)The transmission line ABCD constants. Find the sending end voltage and current, voltage regulation, the sending end power and the transmission efficiency when the line delivers (b) 200 MVA, 0.8 lagging power factor at 220 kV. (c) 306 MW, unity power factor at 220 kV. [5]

Code : 031404

B.Tech 4th Semester Exam., 2016

POWER SYSTEM—I

Time : 3 hours *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are **NINE** questions in this paper.*

(iii) *Attempt **FIVE** questions in all.*

(iv) *Question No. **1** is compulsory.*

1. Choose and write the correct option (any *seven*) : 2×7=14

   (a) The angle of *A*, constant of the transmission line normally lies between

   (i) 90°–70°

   (ii) 70°–40°

   (iii) 40°–10°

   (iv) 10°–0°

   (b) By increasing the transmission voltage to double of its original value, the same power can be despatched keeping the line loss

   (i) equal to original value

   (ii) half the original value

   (iii) double the original value

   (iv) one-fourth of original value

   (c) Power transmission by cable is generally adopted for line lengths

   (i) above 100 km

   (ii) up to 200 km

   (iii) less than 50 km

   (iv) less than 10 km

   (d) Reactive power is

   (i) rate of energy transfer

   (ii) the product of r.m.s. volt and quadrature component of r.m.s. current

   (iii) the product of r.m.s. volt and r.m.s. current

   (iv) the product of r.m.s. volt and in phase component of r.m.s. current

   (v) None of the above

(e) In a long transmission line under no-load condition

(i) the receiving end voltage is less than the sending end voltage

(ii) the sending end voltage is less than the receiving end voltage

(iii) the sending end voltage is equal to the receiving end voltage

(iv) None of the above

(f) The presence of earth in case of overhead lines

(i) increases the capacitance

(ii) increases the inductance

(iii) decreases the capacitance

(iv) decreases the inductance

(g) The effect of bonding the cable is

(i) to increase the effective resistance and resistance

(ii) to increase the effective resistance but reduce inductance

(iii) to reduce the effective resistance and inductance

(iv) to reduce the effective resistance but increase the inductance

(h) Effect of increase in temperature in overhead line is to

(i) increase the stress and the length

(ii) decrease the stress but increase in length

(iii) decrease the stress and length

(iv) Any of the above

(i) The capacitance between any two conductors of a 3-core cable with sheath earthed is 3 μF. The capacitance per phase will be

(i) 1·5 μF

(ii) 6 μF

(iii) 1 μF

(iv) None of the above

(j) To obtain the minimum value of stress in cable R/r ratio should be

(i) 2·13

(ii) 3·14

(iii) 2·718

(iv) 1·96

2. Compare the volume of copper required for the distributor cable in a low-voltage distribution network in a DC 3-wire system, with a 3-ϕ, 4-wire system. Assume the same consumer voltage, same percentage loss, unity power factor and balanced load. The neutrals of half the X-section of corresponding outer. 14

3. (a) Write a short note on 'choice of transmission voltage'. 5

(b) A 2-core, 11 kV cable is to supply 1 MW at 0·8 p.f. lag for 3000 hours in a year. Capital cost of the cable is ₹ (20+400a) per meter, where a is the X-sectional area of core in cm^2. Interest and depreciation total 10% and cost per unit of energy is 15 P. If the length of cable is 1 km, calculate the most economical X-section of the conductor. The specific resistance of copper is 1·75 $\mu\Omega$-cm. 9

4. A 1-ϕ distributor, one km long has resistance and reactance 0·4 Ω and 0·6 Ω (go and return) respectively. At the far end, the voltage $V_B = 240$ V and the current is 100 A at a p.f. of 0·8 lag. At the mid-point B of the distributor current of 100 A is tapped at a power factor of 0·6 lag with reference to the voltage V_B at the mid-point. Calculate the supply voltage V_S for the distributor and the phase angle between supply end and receiving end. 14

(Turn Over)

5. Derive from first principles the capacitance per km to neutral of a 3-ϕ overhead transmission line with unsymmetrical spacing of conductors assuming transposition. 14

6. (a) Discuss the effect of wind and ice on sag. 7

(b) What is a stringing chart? What is its utility? 7

7. Explain the physical significance of the generalized ABCD constants of a transmission line. State the units of these constants. Determine these constants for a medium transmission line with nominal-T configuration. Draw neatly corresponding vector diagram. 14

8. Explain in detail how the receiving end power circle diagram can be drawn. Obtain the condition for maximum power. 14

9. (a) Find expression for the capacitance of a cable per km length. 7

(b) Write a short note on 'Thermal resistance of cables'. 7

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Code : 031404

B.Tech. 4th Semester Exam., 2015

POWER SYSTEM—I

Time : 3 hours *Full Marks* : 70

Instructions :

(i) All questions carry equal marks.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct answer (any *seven*) :

(a) For a medium length transmission line, A is

(i) equal to B

(ii) equal to C

(iii) equal to D

(iv) not equal to any of the above

(b) To increase the transmission capability of a high-voltage longline

(i) the resistance can be increased

(ii) the resistance can be decreased

(iii) the series reactance can be reduced

(iv) the shunt admittance can be reduced

(Turn Over)

(c) The surge impedance of 50-mile long underground cable is 50 ohms. For a length of 25 miles the impedance will be

(i) 26 ohms

(ii) 50 ohms

(iii) 100 ohms

(iv) 12·5 ohms

(v) None of the above

(d) In a transmission system, the weight of copper used is proportional to

(i) E^2

(ii) E

(iii) $1/E^2$

(iv) $1/E$

(v) None of the above

(e) Stringing chart is useful for

(i) finding the sag in the conductor

(ii) the design of tower

(iii) the design of insulator string

(iv) finding the distance between towers

(Continued)

(f) The regulation of a line at full-load 0·8 of lagging is 12%. The regulation at full-load 0·8 p.f. leading can be

(i) 24%

(ii) 18%

(iii) 12%

(iv) 4%

(g) The inductance of a line is minimum when

(i) GMD is high

(ii) GMR is high

(iii) Both GMD and GMR are high

(iv) GMD is low and GMR is high

(h) Which distribution system is more reliable?

(i) Ring main system

(ii) Tree system

(iii) Radial system

(iv) All are equally reliable

(i) In a 3-core cable, the capacitance between 2 conductors (with sheath earthed) is 3 μF. The capacitance/phase is

(i) 1·5 μF

(ii) 3 μF

(iii) 6 μF

(iv) 12 μF

(j) For a transmission line with resistance $R\ \Omega$, reactance $X\ \Omega$ and negligible capacitance, the parameter A is

(i) 0

(ii) 1

(iii) $R + jX$

(iv) $(R^2 + X^2)^{1/2}$

2. Describe the various systems of power transmission and compare the following as regard to the amount of copper used for the same distance, the same power transfer, the same maximum voltage to ground and the same power loss :

(a) 3-phase, 3-wire AC

(b) 3-wire DC

(c) 1-phase, 2-wire AC

3. (a) State Kelvin's law and explain why in practice the law is usually not strictly observed.

(b) The following data relate to a 2-wire feeder :

Current carried through out the year = 220 A

The portion of the capital cost which is proportional to X-sectional area = ₹ 6 per kg of Cu conductor

Cost of energy = 6 P per kWh

Interest and depreciation charges = 10% PA

Density of copper = 8·93 g/cm^3

Specific resistance of copper = 1·8 μΩ-cm

Find the most economical X-section of the conductor.

4. A 1·5 km long single-phase 2-wire feeder supplies the loads as under :

60 A at 0·8 p.f. (lagging), 600 m from the fed point

40 A at 0·85 p.f. (lagging), 1200 m from the fed point

50 A at 0·88 p.f. (lagging), 1500 m from the fed point

The resistance and reactance of the feeder per km length (go and return) are 0·12 Ω and 0·2 Ω respectively. If the voltage at the far end is to be maintained at 220 V, calculate the voltage of the sending end, and its phase angle with respect to the receiving end voltage.

5. (a) Find the inductance per phase of 3-ϕ overhead transmission line using 2 cm diameter conductors when these are placed at the corners of equilateral triangle of sides 4 meters. Also do the derivation needful.

(b) The three conductors of a 3-ϕ transmission line are arranged in a horizontal plane and are 4 meters apart. The diameter of each conductor is 2·5 cm. Determine the inductance per km of the each conductor (line to neutral). Assume balanced load and *R, Y, B* phase sequence. Determine the average inductance per phase for regularly transposed line.

6. (a) Discuss the effect of wind and ice on sag.

(b) The following data refers to a transmission line supported on level supports :

Span length = 220 meters

Hard drawn copper conductor :

X-sectional area = 120 mm^2;

37/2·11 mm; W_c = 1·2 kg/m

Ultimate tensile stress = 42·2 kg/mm^2

Factor of safety = 4

Wind pressure = 55 kg/m^2

Thickness of ice coating = 12 mm

Density of ice = 913 kg/m^3

Find the vertical sag.

7. A 50 Hz, 3-ϕ, 100 km long transmission line has a total resistance of 35 Ω, series reactance of 140 Ω and shunt admittance (line to neutral) 930×10^{-6} mho. It delivers 40 MW at 220 kV at 0·9 p.f. lagging. Using nominal π method determine the following :

   (a) A, B, C, D constants

   (b) Sending end voltage

   (c) Sending end current

   (d) Sending end power factor

   (e) Voltage regulation

   (f) Transmission efficiency

8. Derive the expressions for voltage and current distributions over a longline. Explain the significance of characteristic impedance loading in connection with the longlines. Deduce the above voltage and current relations in the hyperbolic form and obtain the element values of an equivalent to represent the longlines.

9. Explain briefly the following methods of grading of cables :

   (a) Capacitance grading

   (b) Intersheath grading.

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Code : 031404

B.Tech. 4th Semester Exam., 2014

POWER SYSTEM—I

Time : 3 hours *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are* ***NINE*** *questions in this paper.*

(iii) *Attempt* ***FIVE*** *questions in all.*

(iv) *Question No.* **1** *is compulsory.*

1. Choose the correct answer on any *seven* from the following : 2×7=14

(a) The electric power can be transmitted by

(i) overhead system

(ii) underground system

(iii) either *(i)* or *(ii)*

(iv) None of the above

(b) In a transmission system, the weight of copper used is proportional to

(i) E^2

(ii) E

(iii) $\frac{1}{E^2}$

(iv) $\frac{1}{E}$

  (Turn Over)

(c) ACSR conductors have

(i) all conductors made of aluminium

(ii) outer conductors made of aluminium

(iii) inner conductors made of aluminium

(iv) no conductors made of aluminium

(d) Stranded conductors usually have a central wire around which there are successive layers of 6, 12, 18, 24 wires. For *n*-layers, the total number of individual wires is

(i) $3n(n+1)$

(ii) $2n(n+1)$

(iii) $3n(n+1)+1$

(iv) $2n(n+1)+1$

(e) The inductance of 1 - ϕ two-wire power transmission line per km gets doubled when the

(i) distance between the wires is doubled

(ii) distance between the wires is increased four-fold

(iii) distance between the wires is increased as square of the original distance

(iv) radius of the wire is doubled

  (Continued)

(f) 120 km long transmission line is considered as a

(i) short line

(ii) median line

(iii) long line

(iv) either (i) or (ii)

(g) Percentage regulation of a transmission line is given by the expression

(i) $\frac{V_R - V_S}{V_R} \times 100$

(ii) $\frac{V_R - V_S}{V_S} \times 100$

(iii) $\frac{V_S - V_R}{V_R} \times 100$

(iv) $\frac{V_S - V_R}{V_S} \times 100$

(h) Sheaths are used in cables to

(i) provide proper insulation

(ii) provide mechanical strength

(iii) prevent ingress of moisture

(iv) None of the above

(i) The charging current drawn by the cable

(i) lags behind the voltage by 90°

(ii) leads the voltage by 90°

(iii) leads the voltage by 180°

(iv) None of the above

(j) Transmission line constants are

(i) resistance

(ii) inductance

(iii) capacitance

(iv) All of the above

2. (a) Derive the Kelvin's law for most economical size of conductor. 6

(b) The cost per km for each of the copper conductor of a section a sq. cm for a transmission line is ₹ $(2{,}800a + 1{,}300)$. The load factor of the load current is 80% and the load factor for the losses is 65%. The rate of interest and depreciation is 10% and the cost of energy is 5 paisa per kW-h. Find the most economical current density for the transmission line by the use of Kelvin's law. Given $\rho = 1 \cdot 78 \times 10^{-8}\ \Omega - m$.

3. The following data refers to a 50 Hz, 1-ϕ transmission line :

Length = 20 km

Load delivered at receiving end = 5 MW at 0·8 Pf (lag)

Resistance of each conductor = 0·02 Ω/km

Inductance of conductor = 0·65 mH/km

The voltage at the receiving end is required to be kept at 10 kV.

Find—

(a) sending end voltage and voltage regulation of the line;

(b) the value of capacitors to be placed in parallel with the load such that regulation is reduced to 50% of that obtained in (a).

Compare the transmission efficiencies in parts (a) and (b). 14

4. (a) Prove that the vol. gradient at surface of conductor in the cable will be minimum when $\frac{R}{r} = e$, where r is the radius of conductor and R is the inner radius of sheath. 7

(b) Enumerate the different types of losses in a cable. Also, derive the expression for dielectric loss.

5. A single-core lead covered cable is to be designed for 66 kV to earth. Its conductor radius is 0·5 cm and its three insulating materials A, B and C have relative permittivities 4, 2·5 and 4 with maximum permissible stresses of 50, 30 and 40 kV/cm respectively. Determine the minimum internal diameter of lead sheath. Discuss the arrangement of insulating materials. 14

6. Derive the expression for tension and sag in conductors if supports of equal height are used. 14

7. A transmission line conductor consists of hard drawn copper conductor 120 mm^2 cross-section, the conductor used is 37/2·11 mm having weight of 1118 kg/km and has a span of 200 meters. The supporting structures being level. The conductor has an ultimate tensile stress of 42·2 kg/mm^2 and allowable tension is not to exceed 1/4th of ultimate strength. Find—

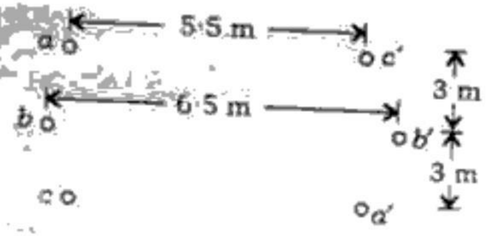
(a) sag in still air;

(b) sag with wind pressure of 60 kg/m^2;

(c) sag with the wind pressure in part b and an ice coating of 10 mm.

Also, find the vertical sag under this condition. Assume density of ice as 0·915 gm/cc. 14

8. Determine the inductance of the double circuit line shown in figure below. The self GMD of the conductor is 0·0069 meter : 14



9. Prove that the capacitance of a 3-ϕ unsymmetrically spaced transposed transmission line is given by

$$C = \frac{2\pi\varepsilon_0}{\ln \frac{\sqrt[3]{abc}}{r}} \text{ F / meter}$$

where a, b, c are the spacing between the conductors of different phases and r is radius of conductor. 14

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Question Bank

1. Discuss the effect of wind and ice on sag.
2. What is stringing chart? What is its utility?
3. Explain the physical significance of the generalized ABCD constants of a transmission line. Determine these constants for medium transmission line for nominal-T configuration. Draw neatly corresponding vector diagram.
4. Explain in detail how the receiving end power circle diagram can be drawn. Obtain the condition for maximum power.
5. Find the expression for capacitance of a cable per km length.
6. Write a short note on thermal resistance of cables.
7. Find the inductance of a 3-phase overhead transmission line using 2cm diameter conductors when these are placed at the corners of a equilateral triangle of sides 4m. Also do the derivation.
8. Derive the voltage and current distribution over a long transmission line. Explain the significance of characteristic impedance loading in connection with the long transmission line.
9. Explain briefly the methods of grading of cables.
10. Explain different types of conductors used in overhead transmission line.

Question bank with solutions

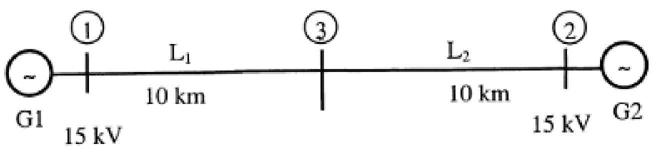
1. In an unbalanced three phase system, phase current $I_a = 1\angle(-90^o)$ pu, negative sequence current $I_{b2} = 4\angle(150^o)$ pu, zero sequence current I_{c0} $3\angle 90^o$ pu. The magnitude of phase current I_b in pu is

a) 1.00 b) 7.81 c) 11.53 d) 13

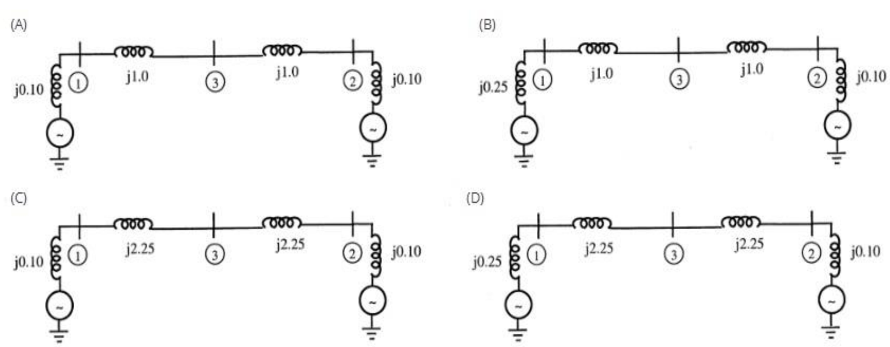
2. The sequence components of the fault current are as follows: $I_{positive}$ = j1.5 pu, $I_{negative}$ = –j0.5 pu, I_{zero} = –j1 pu. The type of fault in the system is

a) LG b) LL c) LLG d) LLLG

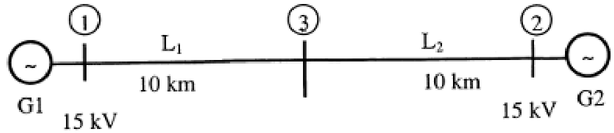
3. Two generator units G1 and G2 are connected by 15 kV line with a bus at the midpoint as shown below



G1 = 250MVA, 15 kV, positive sequence reactance X=25% on its own base ,G_2 = 100MVA, 15 kV, positive sequence reactance X=10% on its own base L_1 and L_2 = 10 km, positive sequence reactance X = 0.225 Ω/km. For the above system, positive sequence diagram with p.u values on the 100 MVA common base is



4. Two generator units G1 and G2 are connected by 15 kV line with a bus at the midpoint as shown below



G1 = 250MVA, 15 kV, positive sequence reactance X=25% on its own base, G_2 = 100MVA, 15 kV, positive sequence reactance X=10% on its own base L_1 and L_2 = 10 km, positive sequence reactance X = 0.225 Ω/km. In the above system, the three-phase fault MVA at the bus 3 is

a) 82.55 MVA b) 85.11MVA c) 170.91MVA d) 181.82 MVA

5. What is the need for short circuit studies or fault analysis?

Answer: 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 of these devices mainly depends on various currents that may flow in the fault conditions.

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

Answer: The faults 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, so the faults are associated with transients.

7. What is meant by a fault?

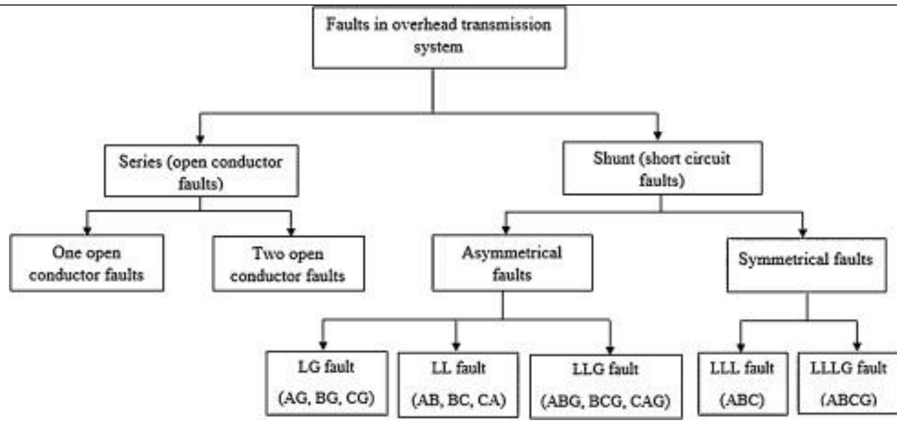
Answer: A fault in a circuit is any failure which interrupts with the normal flow of current. The faults are associated with abnormal change in current, voltage and frequency of the power system. The faults may cause damage to the equipments, if it is allowed to persist for a long time. Hence every part of a system has been protected by means of relays and circuit breakers to sense the faults and to isolate the faulty part from the healthy part of the network in the event of fault.

8. Why faults occur in a power system?

Answer: Faults occur in a power system due to insulation failure of equipment, flashover of lines initiated by a lightening stroke, permanent damage to conductors and towers or accidental faulty operations.

9. Write down the classification of faults occurring in power system.

Answer:



10. What are the assumptions made in short circuit studies of a large power system network?
Answer:
a) The phase to neutral emfs of all generators remain constant, balanced and unaffected by the faults.
b) Each generator is represented by an emf behind either the subtransient or transient reactance depending upon whether the short circuit current is to be found immediately after the short circuit or after about 3 – 4 cycles.
c) Load currents may often be neglected in comparison with fault currents.
d) All network impedances are purely reactive. Thus the series resistances of lines and transformers are neglected in comparison with their resistances.
e) Shunt capacitances and shunt branches of transformers are neglected. Hence, transformer reactances are taken as their leakage reactances.

11. For a fault at the terminals of a synchronous generator, the fault current is maximum for a
a) Three phase b) LG c) LL d) LLG

12. The rating of circuit breakers are generally decided on the basis of
a) unsymmetrical fault current b) symmetrical fault currents c) normal circuit currents d) none

13. The most common fault in a overhead transmission line is
a) LG b) LL c) LLGd) Three phase

14. Reactors are used in various locations in power system to
a) Increase short circuit current
b) Avoid short circuit current
c) Limit short circuit current
d) None

15. The most severe fault on the power system is
a) Three phase b) LL c) LLGd)LG

16. Reactors are connected in
a) Series b) Parallel c) Series-parallel d) None of these

17. In a balanced three phase system
a) Only negative sequence current is zero

b) Only positive sequence current is zero
c) Only zero sequence current is zero
d) Both a & c

18. The vector sum of positive sequence current is
a) Infinite b) low c) Zero d) None of these

19. The use of reactors permits the installation of circuit breakers of
a) Lower rating b) higher rating c) same rating d) None of these

20. If the percentage reactance of a system upto the fault point is 20% and base kVA is 10000, then short circuit kVA is
a) 10000 b) 50000 c) 2000 d) 500

21. The short circuit in a system may lead to
a) Fire and explosion b) voltage dip c)excessive current d) all of these

22. The positive and negative sequence impedance of a transmission line are
a) Equal b) Zeroc) Different d) infinite

23. Unsymmetrical faults
a) Introduce unbalance in the system
b) are more frequent than symmetrical faults
c) both a & b
d) None of these

Three-Phase AC Circuits

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Significant Features of Three-Phase AC Circuits

- Almost all ac power generation and transmission is in the form of three-phase ac circuits
- AC power systems have a great advantage over DC systems in that their voltage levels can be changed with transformers to reduce transmission losses.
- Three-phase (3f) ac power system consists of
  - 3f ac generators

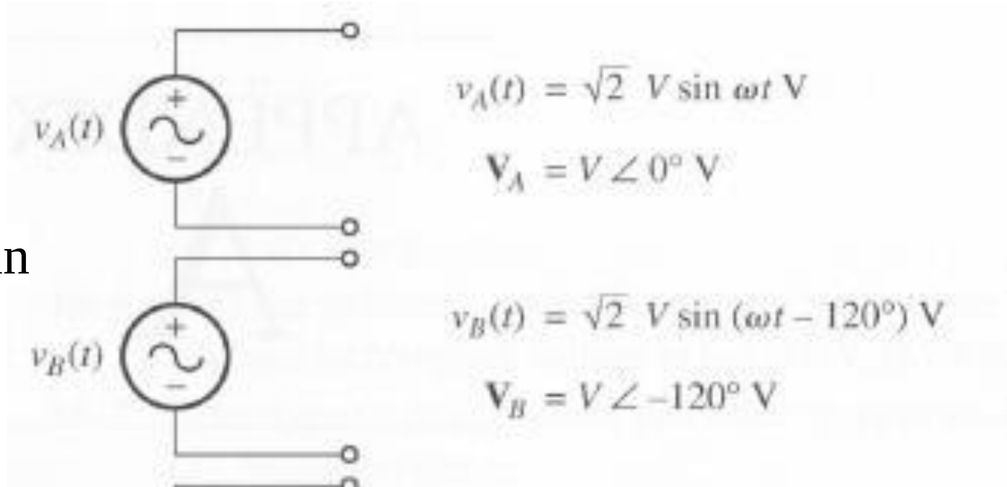
- 3f transmission lines
- 3f loads

- Advantages of having 3f power systems over 1f ones:
  - More power per pound of metal of electrical machines of 3f.
  - Power delivered to a 3f load is constant, instead of pulsating as it does in a 1f system.

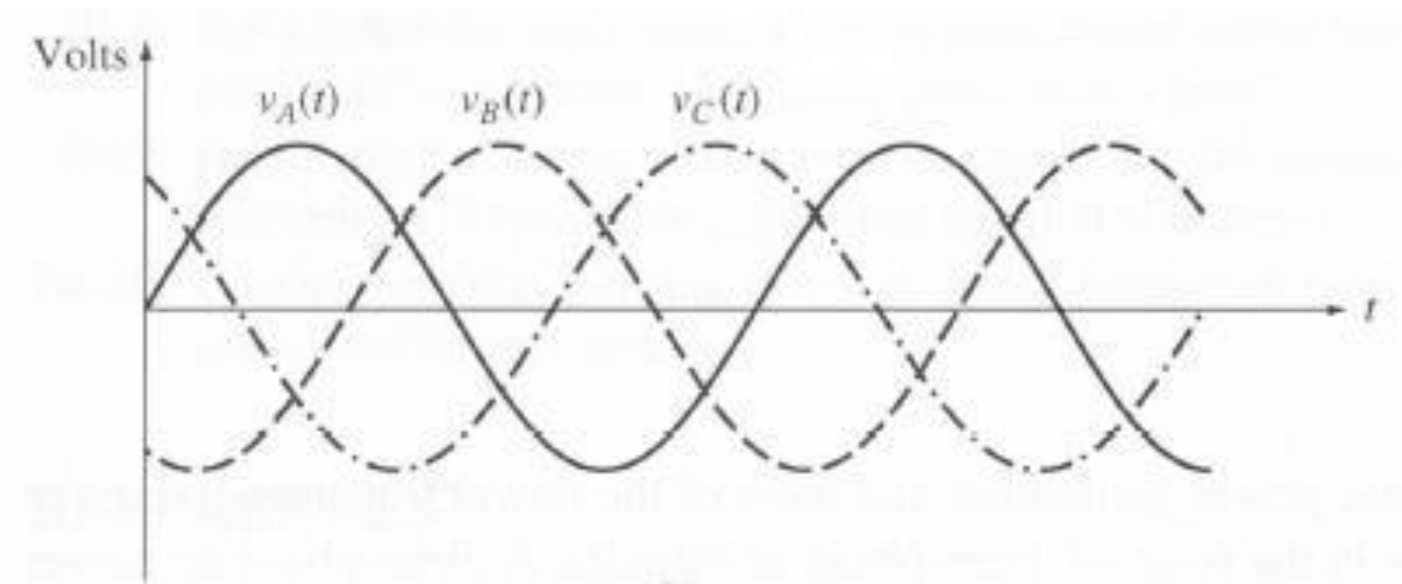
Generation of 3f Voltages and Currents

A 3f generator consists of three 1f generators:

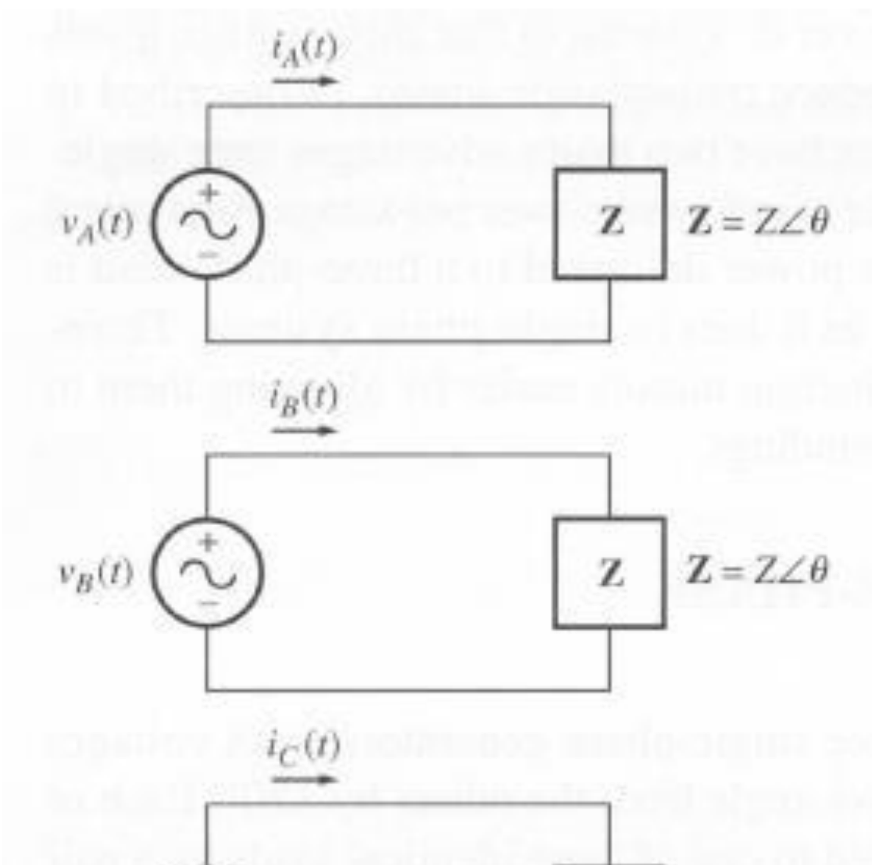
- voltage of all phases are equal in magnitude

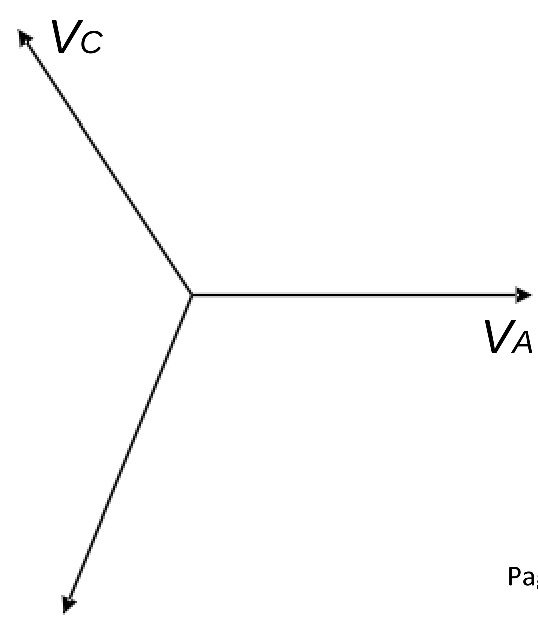


- differing in phase angle from each other by 120o.



Three-Phases of the Generator Connected to Three identical Loads





V_B

Phasor diagram showing the voltages in each phase

Currents in the Three Phases and the Neutral

Currents flowing in the three phases

0

V□0

I a Z□□

- □I□□□

V□□120 0 0

I b Z□□

- □I□□120 □□ V□□240 0

I_c Z□□ 0

- □I□□240 □□

It is possible to connect the negative ends of these three single phase generators and the loads together, so that they share a common return line, called neutral.

$\boldsymbol{I_N}$ □$\boldsymbol{I_a}$ □$\boldsymbol{I_b}$ □$\boldsymbol{I_c}$

□$\boldsymbol{I}$□□□□$\boldsymbol{I}$□ □ □120^0 □□ □ □$\boldsymbol{I}$□ □ □240^0 □□ □

□ □***cos***□□□□□***jsin***□□□□□□***cos***□ □120^0 □□□ □***jsin***□ □120^0

□□□□□

□$\boldsymbol{I}$□□ □□***cos***□ □240^0 □□□ □***jsin***□ □240^0 □□□□□□□

□

□0

As long as the three loads are equal, the return current in the neutral is zero.

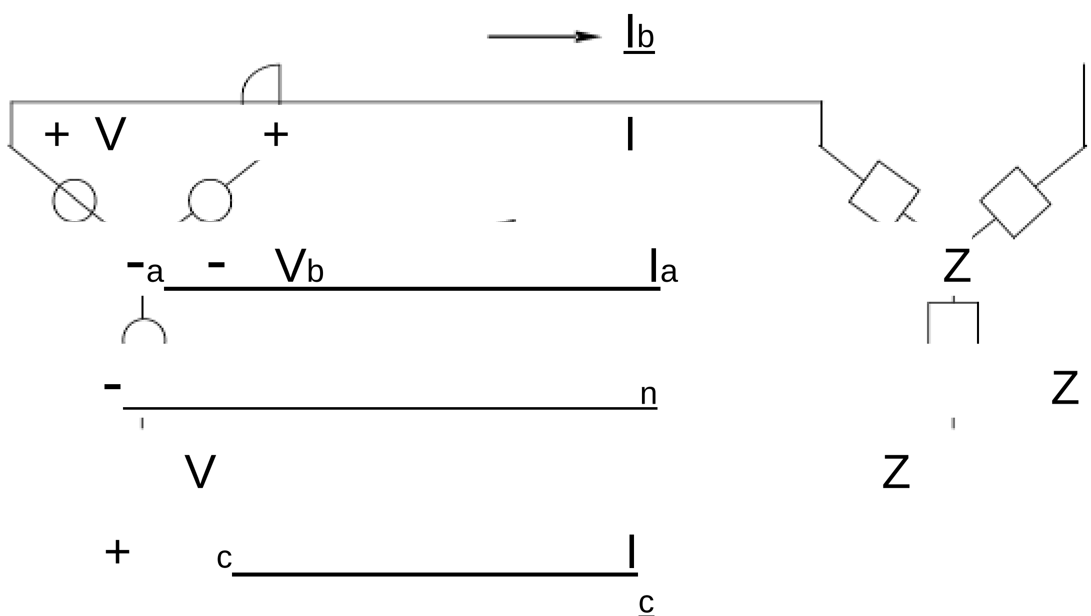
Balanced Power Systems

- In a balanced power system:
  - Three generators have same voltage magnitude and phase difference is 120^o.
  - Three loads are equal and magnitude and angle.

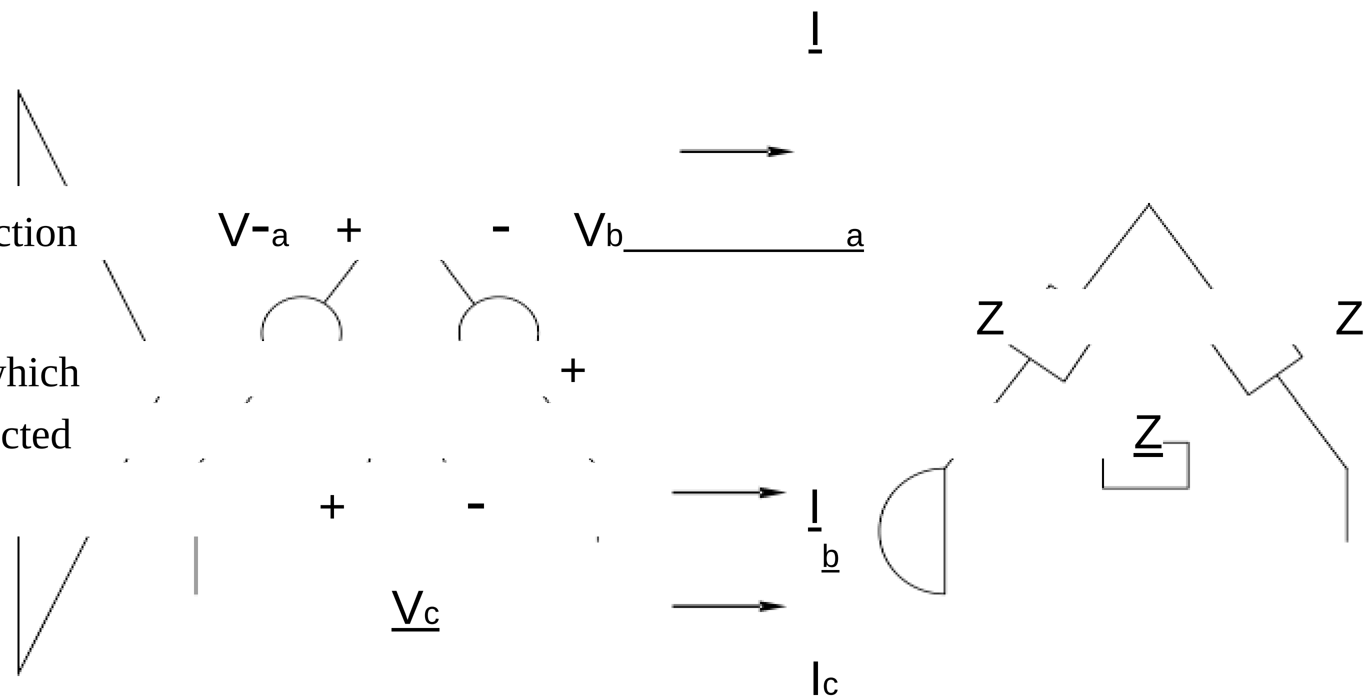
- *abc* phase sequence: the voltages in the three phases peak in the order *a*, *b* and *c*. It is possible to have *acb* phase sequence.

Y and ∆ Connections

A connection of this sort is called Wye-connection.



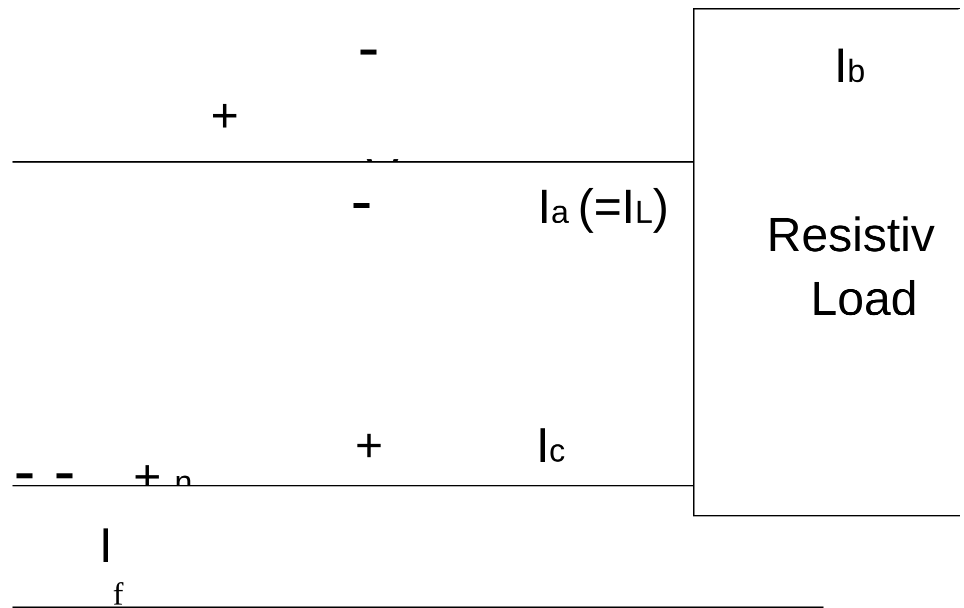
Another possible connection is delta-connection, in which the generators are connected head to tail.



Voltages and Currents in a Y-Connected 3f Circuit

Phase quantities: voltages and currents in a given phase

Line quantities: voltages between lines and current in the lines



+ V_a

-

+

e

V_{an} □ V_f □ 0_0 I_a □ I_f □ 0_0

$$V_{bn} = V_\phi \angle -120^0 \qquad I_b = I_\phi \angle -120^0$$

$$V_{cn} = V_\phi \angle -120^0 \qquad I_c = I_\phi \angle -240^0$$

$$\boldsymbol{V_{ab}} = \boldsymbol{V_{an}} - \boldsymbol{V_{bn}} = \boldsymbol{V}_\phi \angle 0^0 - \boldsymbol{V}_\phi \angle -120^0 = \sqrt{3}\boldsymbol{V}_\phi \angle 30^0$$

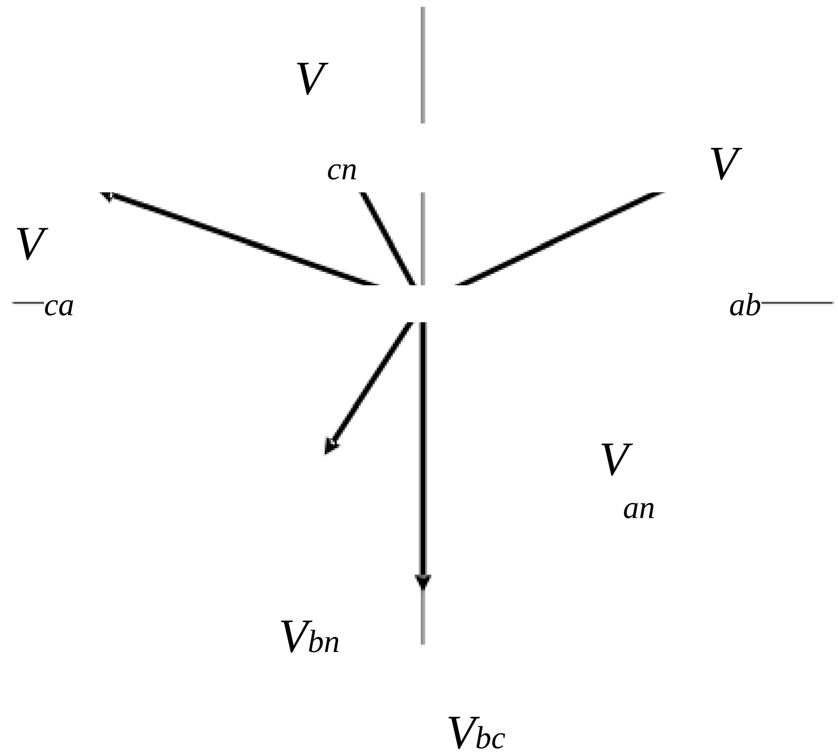
Voltages and Currents in a Y-Connected 3ϕ Circuit (cont’d)

The relationship between the magnitude of the line-to-line voltage and the line-to-neutral (phase) voltage in a Y-connected generator or load

$$\boldsymbol{V_{LL}} = \sqrt{3}\boldsymbol{V}_\phi$$

In a Y-connected generator or load, the current in any line is the same as the current in the corresponding phase.

$$I_L = I_f$$



Voltages and Currents in a Δ-Connected 3f Circuit

I

In a delta-connected generator or load, the line-to-line voltage between any two lines will be the same as the voltage in the corresponding phase.

ab

- I

-

I

I

V +

A

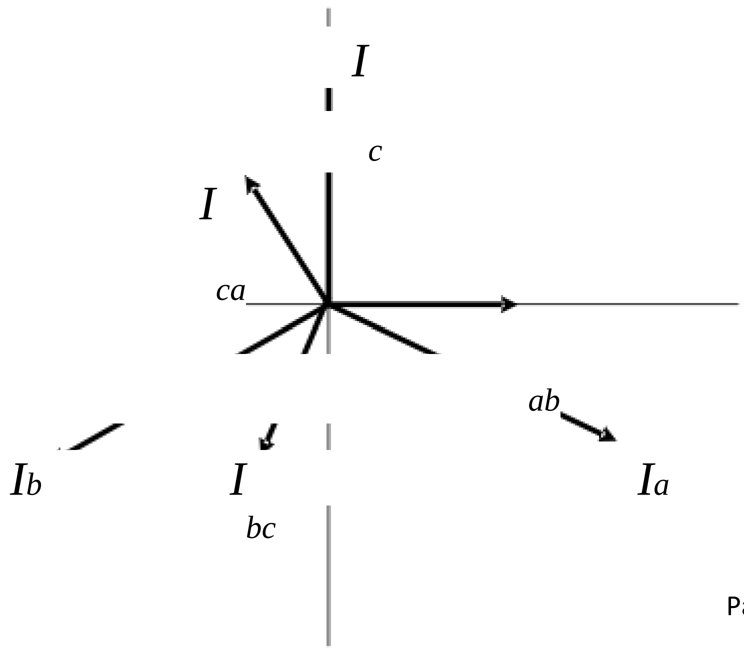
-
I
c
+

V_{LL} □ V_f

In a delta-connected generator or load, the relationship between the magnitudes

of the line and phase currents:

I_L □ f



Power Relationship in 3f Circuits

The 3f voltages applied to this load:

$$v_{an}(t) = \sqrt{2}V \sin(\omega t)$$

$$v_{bn}(t) = \sqrt{2}V \sin(\omega t - 120^0)$$

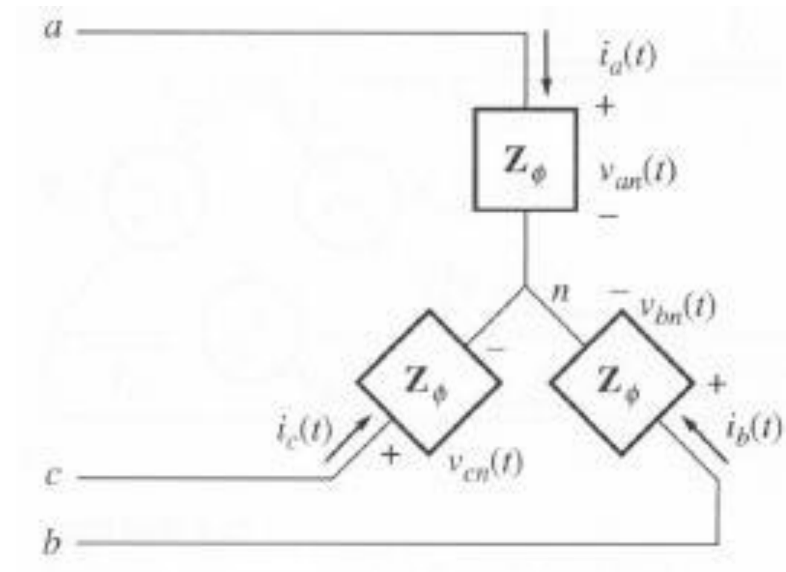
$$v_{cn}(t) = \sqrt{2}V \sin(\omega t - 240^0)$$

The 3f currents flowing in this load:

$$i_a(t) = \sqrt{2}I \sin(\omega t - \theta)$$

$$i_b(t) = \sqrt{2}I \sin(\omega t - 120^0 - \theta)$$

$$i_c(t) = \sqrt{2}I \sin(\omega t - 240^0 - \theta)$$



A balanced Y-connected load.

Instantaneous power supplied to each of the three phases:

$$P_a(t) = v_{an}(t)\, i_a(t) = 2VI \sin(\omega t) \sin(\omega t - \theta) = VI[\cos\theta - \cos(2\omega t - \theta)]$$

$$P_b(t) = v_{bn}(t)\, i_b(t) = 2VI \sin(\omega t - 120^0) \sin(\omega t - 120^0 - \theta) = VI[\cos\theta - \cos(2\omega t - 240^0 - \theta)]$$

$$P_c(t) = v_{cn}(t)\, i_c(t) = 2VI \sin(\omega t - 240^0) \sin(\omega t - 240^0 - \theta) = VI[\cos\theta - \cos(2\omega t - 480^0 - \theta)]$$

Total power supplied to the 3φ load:

$$P_{total}(t) = P_{3\phi} = P_a(t) + P_a(t) + P_a(t) = 3VI\cos\theta = 3P_{1\phi}$$

<u>3φ Power Equations Involving Phase Quantities</u>

The 1f power equations:

$\boldsymbol{S}_{1f}$ □ $\boldsymbol{V}_f \boldsymbol{I}_f$

$\boldsymbol{P}_{1f}$ □ $\boldsymbol{V}_f \boldsymbol{I}_f$ ***cos***□

S

$\boldsymbol{Q}_{1f}$ □ $\boldsymbol{V}_f \boldsymbol{I}_f$ ***sin***□

Q=Ssin□

□ 90^o

The 3f power equations:

P=Scos□

$\boldsymbol{S}_{3f}$ □ $3\boldsymbol{V}_f \boldsymbol{I}_f$

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

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

3φ Power Equations Involving Line Quantities

For a Y-connected load:

$$I_L = I_{\phi} \quad and \quad V_{LL} = \sqrt{3} V_{\phi}$$

$$P_{3\phi} = 3 V_{\phi} I_{\phi} \cos\theta = 3 \left(\frac{V_{LL}}{\sqrt{3}} \right) I_L \cos\theta = \sqrt{3} V_{LL} I_L \cos\theta$$

For a delta-connected load:

$$I_L = \sqrt{3} I_{\phi} \quad and \quad V_{LL} = V_{\phi}$$

$$P_{3f} \; \square 3 V_{f} I_{f} \cos\square \; \square 3 V_{LL} \square \; \square I_{L} \; \square \square \cos\square \square \quad 3 V_{LL} 90 L_{o}$$

$$\sqrt{} \qquad \sqrt{} \qquad I \; \cos\square$$

• $3 \; \square$

Therefore, regardless of the connection of the load:

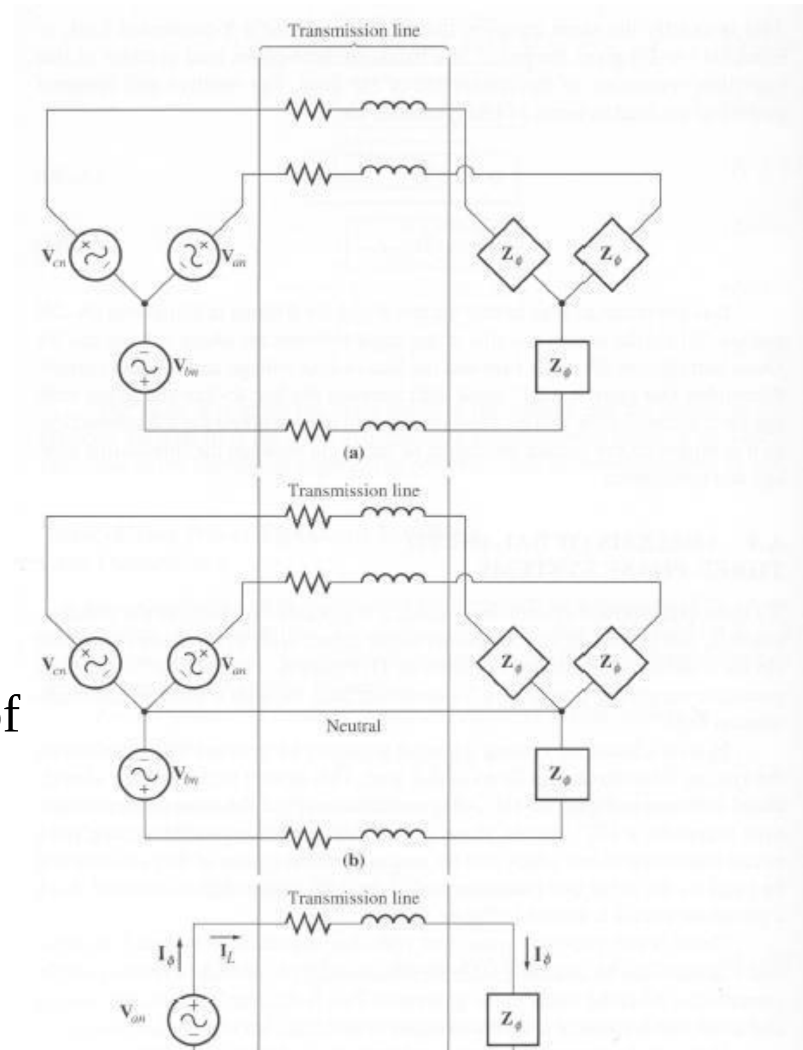
$$P_{3f} \; \square \; \sqrt{3} V_{LL} I_{L} \cos\square$$

$$Q_{3f} \; \square \; \sqrt{3} V_{LL} I_{L} \sin\square$$

$$S_{3f} \; \square \; \sqrt{3} V_{LL} I_{L}$$

Analysis of Balanced 3f Systems

If a three-phase power system is balanced, it is possible to determine voltages and currents at various points in the circuit with a per phase equivalent circuit.

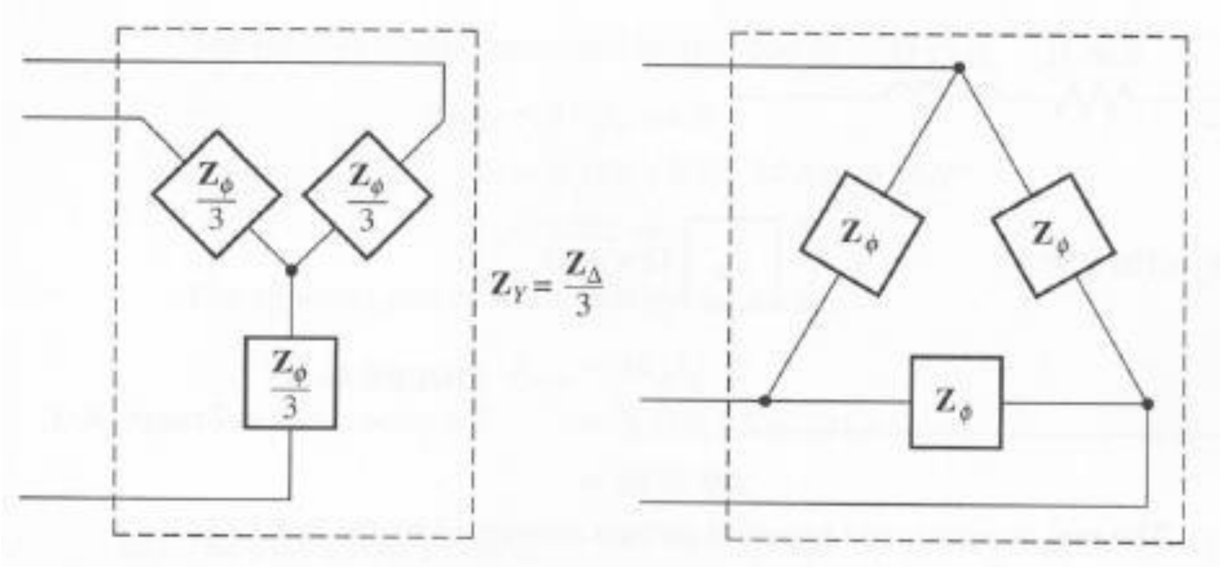


- Neutral wire can be inserted, as no current would be flowing through it, thus, system is not affected.
- Three phases are identical except for 120^{o} phase shift for each phases.
- It is thus possible to analyze circuit consists of one phase and neutral.

- Results would be valid for other two phases as well if 120^{o} phase shift is included.

Wye-Delta Transformation

- Above analysis if OK for Y-connected sources and loads, but no neutral can be connected for delta-connected sources and loads.
- As a result, the standard approach is to transform the impedances by using the delta-wye transform of elementary circuit theory.


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

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Power System-I.

Unit I :- Distribution.

→ Comparison b/w DC & AC power supply. & examples of DC system.

→ AC supply systems. (3 phase 3 wire for large blocks of power & 3-phase 4 wire system for distribution side).

→ Effect of system voltage on AC power supply system:-

In-creases η of transmission :→

$$P = VI\cos\varphi$$

$$I = \frac{P}{V\cos\varphi} \quad , \quad P_L = I^2R \;;\; I\downarrow,$$

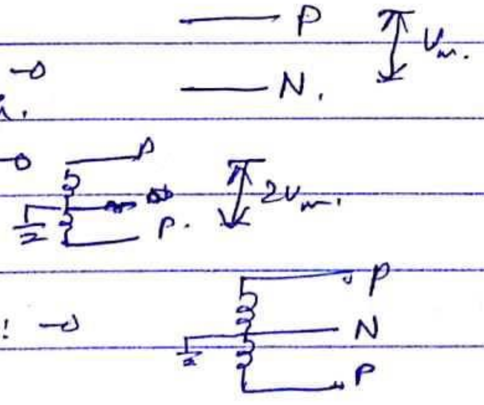
$$P_L \propto \frac{1}{V^2} \quad , \quad \eta\uparrow.$$

→ Single phase & 3 phase system.

220 Vrms. 415, 690, 11kV, 33kV, 66kV, 132kV, 220kV, 400kV 765kV

Gen → Xn. → Dn. → P.S

→ 1φ AC systems:-



(a) 2 wire sys. with one earth. →

(b) 2 wire sys. with mid point earthed. →

(c) 3 wire system! →

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$P = VI\cos\varphi.$$

→ 3φ AC system :- $P = \sqrt{3}\,V_L I_L\cos\varphi$ → This can be either. 3 wire or 4 wire system.

Advantages of Higher x^{n} voltage :-

① Power x^{r} Capacity of x^{n} line ↑es. , $P_{max} \propto V^{2}$

$$P = \frac{V_s V_R}{X} \sin\delta$$

② x^{n} line losses will be minimized :- $P = VI\cos\varphi$

$I \propto \frac{1}{V}$ (keeping P & $\cos\varphi$)

$$P_L = I^2 R = \frac{P^2 R}{V^2 \cos^2\varphi} \quad \therefore P_L \propto \frac{1}{V^2}.$$

③ Area & volume of the $cond^{r}$ is reduced :- $R = \frac{\rho l}{A}$, $A \propto \frac{1}{R}$.

$P_L = I^2 R$ $\qquad A = \frac{P^2}{P_L V^2 \cos^2\varphi}$

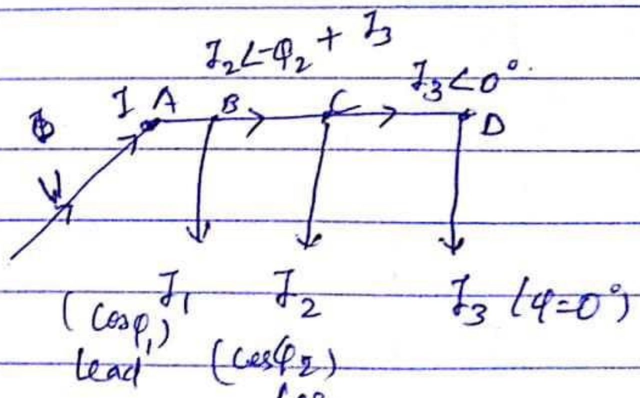
$R = \frac{P_L}{I^2}$

$$R = \frac{P_L}{\left(P/V\cos\varphi\right)^2} = \frac{P_L V^2 \cos^2\varphi}{P^2} \propto \frac{1}{A} \quad , A \propto \frac{P^2}{P_L V^2 \cos^2\varphi}$$

④ $I^2 \propto \frac{1}{V^2}$, $P_L \propto \frac{1}{V^2}$, η ↑es.

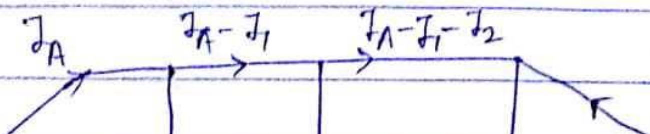
Feeders :- ① Radial :-

ⓐ Source feed at one end :-

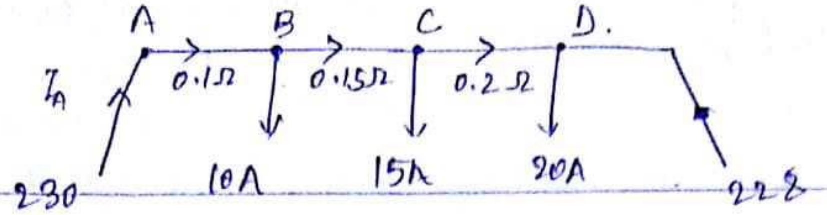


$$I = I_1 \cos\angle\varphi_1 + I_2\angle-\varphi_2 + I_3.$$

ⓑ Source is feeding from both ends. :-



Ex:-



$I_{AB} = I_A$, $I_{BC} = I_A - 10$, $I_{CD} = I_A - 10 - 15$

$V_A = 230$, $V_D = 228$

$\Rightarrow$ $230 - 0.1 I_A - 0.15(I_A - 10) - 0.2(I_A - 25) = 228$

$\Rightarrow$ $I_A = 18.91A$.

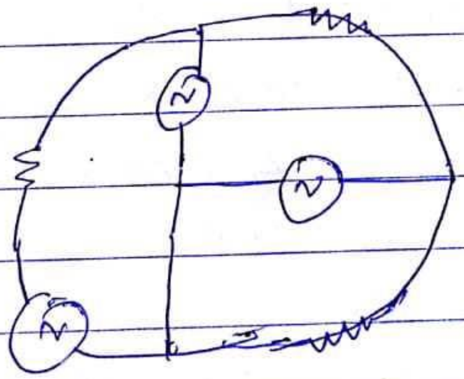
$I_{AB} = 18.91A$, $I_{BC} = 8.91A$, $I_{CD} = 18.91 - 25 = -6.09 A$.
reverse direction.

C $\Rightarrow$ min. potential point.

$V_C = 230 - 18.91 \times 0.1 - 8.9 \times 0.15 = 226.7V$ Ans.

→ Less reliability, cheap, different voltage at consumer end.

② Ring Feeder :-



Advantages :- Reliable power supply.
Uniform voltage to all consumers.

Disadvantages :- Complex, costly,

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* [Char' of cond^r].
Types of conductors:- ① AAC (All Aluminium conductor) - , Aluminium → 60% conductivity as compared to copper & density 0.303 times as that of copper

④ ACSR (Aluminium cond^r steel reinforced). → its core consists of galvanized steel in order to prevent rusting.
→ steel core takes greater percentage of mechanical stresses while the aluminium carries the bulk of current.
→ cos of the use of larger span, the no. of line supports may be reduced by about 25%. Thus the overall cost of supports, foundations, insulators & erection is considerably reduced.

② ACAR (Aluminium cond^r Aluminium reinforced).
— expensive

③ AAAC — all Aluminium alloy cond^r.
— same as AAC except the alloy.
- Strength is equivalent to ACSR but it is lighter in weight due to the absence of steel.
- Expensive (alloy composition).
- lesser sag than AAC.
- longer spans can be used as compared to AAC cond^{rs}

* Characteristics of ideal cond^r:-
① max. electrical conductivity

Economic choice of X^{n} voltage :-

- Capital choice of voltage directly influences various other factors such as supporting structures, cond^n size, insulators, transformers used in X^{n}.
- it will closely influence economics of power X^{n}. (initial investment).

Advantages :-

- Efficient transmission.
- Cost saving.
- Improved Voltage regn.

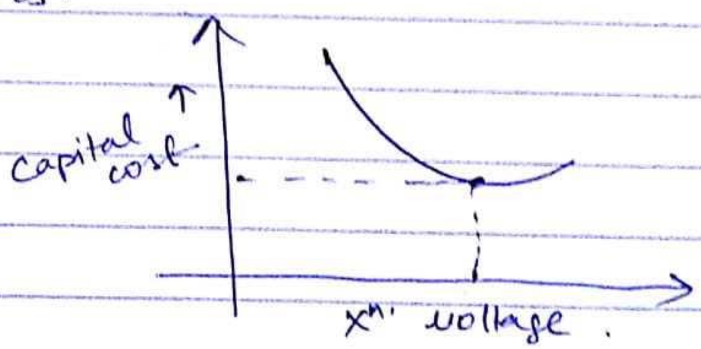
$$\frac{(V_s - V_R)}{V_s} \times 100$$

(V_s → sending end, V_R → receiving end.)

(it should be as less as possible).

Limitations :-

- cost of insulators, X^{rs}, lighting arrestors, structures, towers ↑es.
- switchgears, tow. etc ↑es.

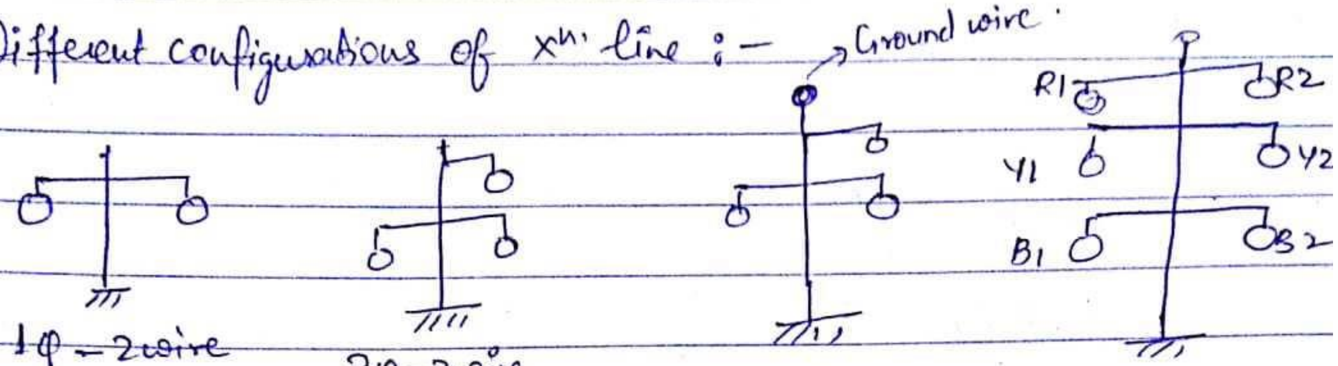


Unit II

Xn. line Parameters :-

(1) Inductance (2) Capacitance (3) Resistance.

Different configurations of xn. line :-



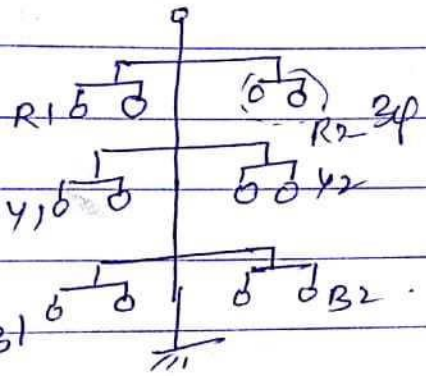
1φ - 2wire (distribution side)

3φ - 3wire (Local distribution) side.

3φ - 4wire (Xn. line)

3φ - double Circuit line

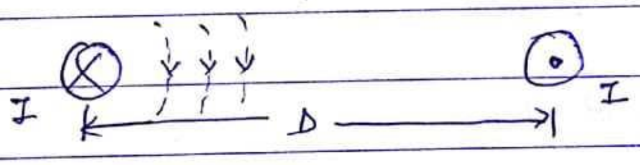
3 Line & 1 neutral



3φ - double ckt bundled condr.

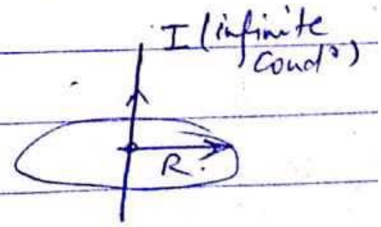
(1)

Inductance of two wire 1-φ xn. line :-



Biot Savart's law :- $dB = \frac{\mu}{4\pi} \frac{I\,dl\,\sin\theta}{r^2}$

$\mu = \mu_r \mu_0$ $B = \frac{\mu_0 I}{4\pi r^2} \int dl \sin\theta$



For ∞ length → $B = \frac{\mu I}{2\pi R}$.

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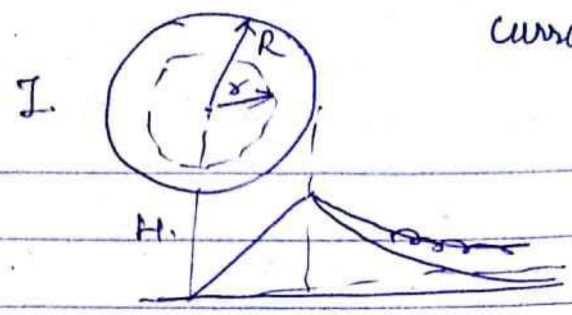

current per unit area. (Current density)

$$\frac{I}{\pi R^2} \cdot \pi r^2 = I'$$

$$\oint H' dl = I'$$

$$\Rightarrow H'(2\pi r) = I\left(\frac{r}{R}\right)^2$$

$$\Rightarrow H' = \frac{Ir}{2\pi R^2}$$

for. cond^r. ⇒ (1) Internal flux linkage.

$$H' = \frac{Ir}{2\pi R^2} \Rightarrow$$

$B' = \mu H'$ [Here, $\mu_r = 1$ so, $\mu = \mu_0$].

$$B' = \mu_0 H'$$

$$B' = \frac{\mu_0 I}{2\pi R^2} \cdot r$$

Now, $d\varphi = B' \cdot dA$

$= B' \cdot dx \cdot l$ ⇒ (Here $l = 1m$, to calculate per unit length inductance)

$$d\varphi = \frac{\mu_0 I}{2\pi R^2} x\,dx.$$

Flux linkage = Flux × No. of turns.

Only a part of cond^r. i.e $r < R$ is being enclosed by ~~cond^r~~ flux lines $d\varphi$.

Now, $\lambda = \int_0^R d\lambda = \frac{\mu_0 I}{2\pi R^2} \cdot \int_0^R r\,dr \left(\frac{r}{R}\right)^2$

$$= \frac{\mu_0 I}{2\pi R^4} \cdot \int_0^R r^3 dr = \frac{\mu_0 I}{8\pi} \quad \text{——(I)}.$$

∴ Total Internal flux linkage = $\frac{\mu_0 I}{8\pi}$

It is independent of size of cond^r.

Now: External flux linkage :— for $R \leq r < D$.

$$H = \frac{I}{2\pi r} \Rightarrow B = \frac{\mu_0 I}{2\pi r}.$$

$d\varphi = B \cdot dr \cdot 1$

$d\lambda = d\varphi \cdot 1 = \frac{\mu_0 I}{2\pi r} dr$

$$\Rightarrow \lambda = \int_R^{D-R} d\lambda = \int_R^{D-R} \frac{\mu_0 I}{2\pi} \frac{dr}{r}.$$

$$\Rightarrow \lambda = \frac{\mu_0 I}{2\pi} \ln\left(\frac{D-R}{R}\right)$$

∵ $D >> R$, $D-R \simeq D$.

$$\Rightarrow \lambda = \frac{\mu_0 I}{2\pi} \ln\left(\frac{D}{R}\right) \quad \text{——(II)}.$$

Hence :- Total flux linkage due to one cond^r $= \frac{\mu_0 I}{8\pi} + \frac{\mu_0 I}{2\pi} \ln\left(\frac{D}{R}\right)$

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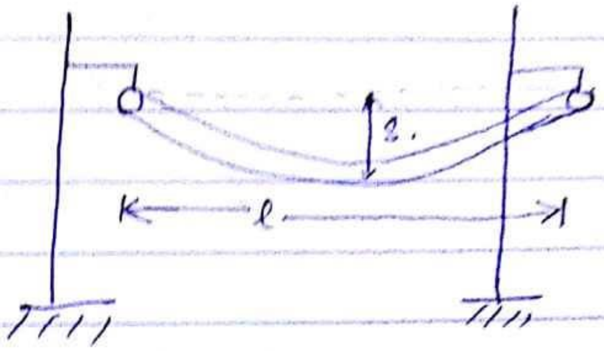
Unit 3.

Mechanical Design :-

(1) Towers at same level :-

l = span length

T = Tension

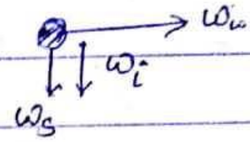


$$\text{Sag} = S = \frac{wl^2}{8T}$$

w = total weight of cond^r. kg/m.

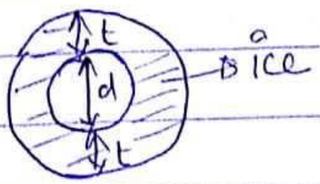
Taking wind & ice effect in consideration :-

$$w = \sqrt{(w_s + w_i)^2 + w_w^2}$$



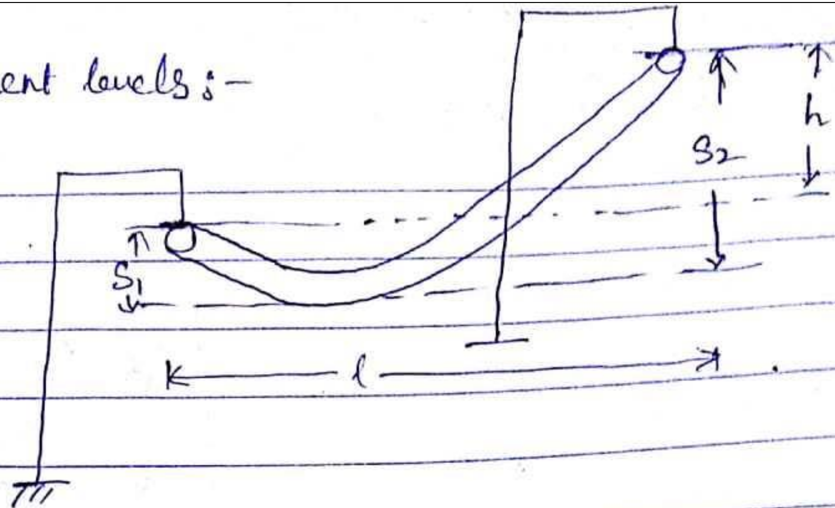
w_w = wind pressure × projected area.

= wind pr. × $(d + 2t) \times 1m$. → for per metre calculation.



$$w_i = \text{density} \times \text{volume} = \text{density} \times \underbrace{\pi\left[\left(\frac{d}{2}+t\right)^2 - \left(\frac{d}{2}\right)^2\right] \times 1}_{\text{volume}}$$

Towers at different levels :-

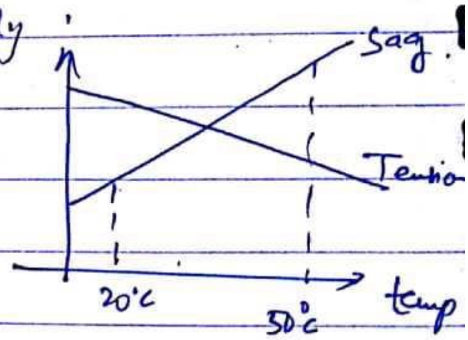


$$S_1 = \frac{w}{2T}\left(\frac{l}{2} - \frac{Th}{wl}\right)^2, \quad S_2 = \frac{w}{2T}\left(\frac{l}{2} + \frac{Th}{wl}\right)^2$$

$$h = S_2 - S_1$$

Stringing Chart :- The curves of tension & sag versus temp. are called as Stringing charts.

→ They are useful while erecting the transmission line cond^r. for adjusting the sag & tension properly :



Minimum clearance to ground :-

Voltage (AC)	Min. Height (m)
< 325V	4.6
< 66kV	6
< 110kV	6.3
< 165kV	6.6

Unit 4

Performance of Lines :- (η & V.R).

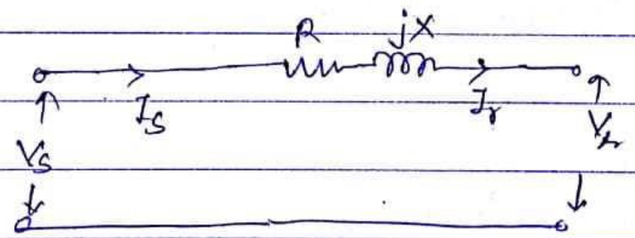
$$\% \eta = \frac{\text{Power delivered at receiving end.}}{\text{Power sent from sending end}} \times 100$$

$$\% V.R = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$ [all voltage will be taken at receiving end]

	kms
Short	upto 80
Medium	80 to 160
Long	>160

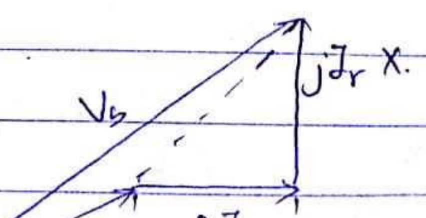
(< 80 km)

(I) Equivalent ckt. diagram of Short $X^{n'}$ line :- & its phasor



~~$V_S = V_R + I_R R \cos\phi_r$~~

Phasor :-



from phasor :-

$$V_s \cos\phi_s = V_r \cos\phi_r + I_r R \quad \text{—(1)}$$

$$V_s \sin\phi_s = V_r \sin\phi_r + I_r X \quad \text{—(2)}$$

Square & add (1) & (2).

$$V_s^2 = V_R^2 + 2 I_r R V_r \cos\phi_r + 2 I_r X V_r \sin\phi_r + I_r^2 (R^2 + X^2)$$

$$\Rightarrow V_s = V_r \left[1 + \frac{2 I_r R \cos\phi_r}{V_r} + \frac{2 I_r X V_r \sin\phi_r}{V_r} + \underbrace{\frac{I_r^2}{V_r^2}(R^2+X^2)}_{\text{negligible term}} \right]^{1/2}$$

$$\Rightarrow V_s = V_r \left[1 + \underbrace{\left\{ \frac{2 I_r R}{V_r} \cos\phi_r + \frac{2 I_r X}{V_r} \sin\phi_r \right\}}_{<<1} \right]^{1/2}$$

Applying binomial approximation.

$$V_s = V_R + I_r R \cos\phi_r + I_r X \sin\phi_r$$

Now

$$\% \text{ regulation} = \frac{V_s - V_r}{V_r} \times 100 .$$

$$\text{regulation (pu)} = \frac{I_r R \cos\phi_r + I_r X \sin\phi_r}{V_r}$$

$$= \frac{I_r R}{V_r} \cos\phi_r + \frac{I_r X}{V_r} \sin\phi_r .$$

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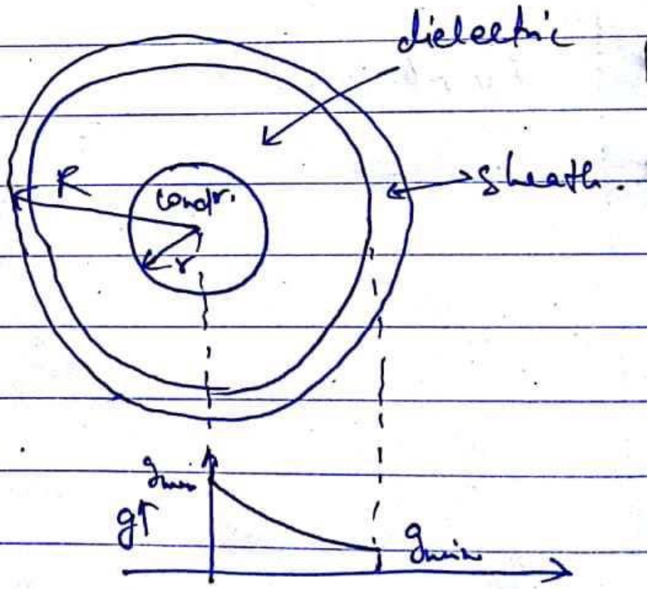
Unit IV — Underground Cables :→

Requirements :–

1. High insulation resistance.
2. High dielectric strength.
3. Good mechanical property i.e tenacity (strong, rugged) & elasticity
4. It should not be affected by chemicals around it.
5. It should be non-hygroscopic because the dielectric strength of any material goes very much down with moisture content.

Insulation material :– (1) Vulcanized Rubber (2) PVC (3) Polythene (4) Paper

Stress in Single core cable :–



$g = E$ = Electric field intensity

$= \frac{\lambda}{2\pi\epsilon x}$, $\lambda \to$ Charge per unit length

$$V = -\int_{R}^{r} E \cdot dx = \int_{r}^{R} \frac{\lambda}{2\pi\epsilon x} dx.$$

$$V = \frac{\lambda}{2\pi\epsilon} \ln\left(\frac{R}{r}\right), \quad g = \frac{\lambda}{2\pi\epsilon x} = \text{gradient}.$$

$$g_{max}\Big|_{x=r} = \frac{V}{r\ln\left(\frac{R}{r}\right)} \quad , \quad g_{min}\Big|_{x=R} = \frac{V}{R\ln\left(\frac{R}{r}\right)}$$

to find out min. value of g_{max} so as to keep overall size of ~~cable~~ a cable fixed to a particular value of radius of conductor.

$$g_{max} = \frac{V}{r\ln\left(\frac{R}{r}\right)}$$

$$f(r) = r\ln\left(\frac{R}{r}\right) \longrightarrow \text{maximize.}$$

$$f'(r) = 0 \Rightarrow r\cdot\left(\frac{r}{R}\right)\cdot\left(-\frac{1}{r^2}\right) + \ln\left(\frac{R}{r}\right) = 0.$$

$$\Rightarrow \ln\left(\frac{R}{r}\right) = 1$$

$$\Rightarrow \frac{R}{r} = e \qquad \Rightarrow \frac{R}{r} > e$$

$$\text{or. } \frac{r}{R} < \frac{1}{e}$$

There will be large difference b/w stress at the surface of condr. & stress at the inner radius of sheath.

Grading of Cables :- It is the distribution of dielectric material such that the difference b/w the max. gradient & the min. gradient is reduced, thereby a cable of same size ~~cannot~~ could be operated at higher voltages or for same operating voltage size of the cable is small.

① **Capacitance grading :-** different layers of dielectric material is used.

② **Intersheath grading :-** Same dielectric material is used but potentials at certain radii are held to certain values.

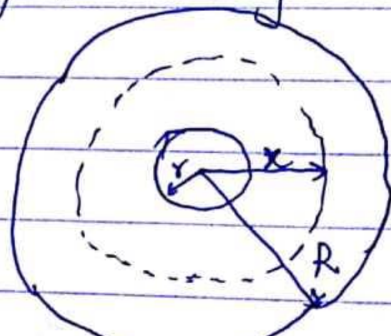
Capacitance Grading :-

$$\epsilon = \frac{K}{x}$$

ϵ ↙ varying permittivity w.r.t x.

Now, $g = \dfrac{\lambda}{2\pi\epsilon x}$

$$= \frac{\lambda}{2\pi \frac{K}{x} \cdot x} = \frac{\lambda}{2\pi K}.$$



$\Rightarrow g = \text{constant}$

→ It is like infinite number of dielectric material ~~put~~ ~~over~~ with varying permitivites are put over one

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Name of Faculty:-Mr. Tabish Shanu		**Branch:- EEE**	
Course Code:- EEE13			
Date of exam:-			
Test Abbrevation:SESSIONAL TEST			
Maximum Marks		**20**	
Test Topic:-Power System-I			
Sr.No.	Name	Registration No.	Score
1	Prity kumari	19110111905	18 / 20
2	Chitragupt Kumar	18110111024	15 / 20
3	NITISH KUMAR	19110111908	19 / 20
4	RISHU ROUSHAN	19110111906	18 / 20
5	Arti Kumari	18110111028	18 / 20
6	Prince kumar	18110111034	15 / 20
7	Rimi kumari	18110111040	16 / 20
8	RANI KUMARI	18110111044	18 / 20
9	Samiksha Deep	18110111019	14 / 20
10	Prateesh Kumar	18110111051	19 / 20
11	SHUBHAM ALOK	19110111907	18 / 20
12	Abhishek Kumar	19110111903	18 / 20
13	Upendra Kumar	16110111019	18 / 20
14	AJANOY YADAV	18110111011	16 / 20
15	Sonu sangam	18110111022	19 / 20
16	Kajal kumari	18110111006	18 / 20
17	Kajal kumari	19110111901	13 / 20
18	Shubham Kumar	18110111003	16 / 20
19	Amit Kumar Sharma	18110111015	17 / 20
20	Akanksha	18110111033	18 / 20
21	Harsh Kumar	18110111012	18 / 20
22	CHANDRADEEPA KUMARI	19110111904	16 / 20
23	Rachana Kumari	18110111026	16 / 20
24	Anushka kumari	19110111902	15 / 20
25	Ayazur Rahman	18110111048	13 / 20
26	Sushma Kumari	19110111036	13 / 20
27	ANAND KUMAR	18110111017	17 / 20
28	Dipu Kumar	18110111001	14 / 20
29	MRINALINI	18110111045	16 / 20
30	Jay Kumar Vishwas	18110111027	18 / 20
31	Ankit Kumar	18110111004	17 / 20
32	Anamika kumari	18110111029	17 / 20
33	Deepshikha	18110111031	15 / 20
34	Avinash Chauhan	18110111018	Dec-20

40	Dhiraj kumar	18110111049	16 / 20
41	sugam odambo	18110111025	18 / 20
42	Harendra Kumar Kamat	18110111035	18 / 20
43	Rupesh Kumar	18110111023	18 / 20
44	NIKHIL KUMAR	18110111009	16 / 20
45	Aditya Anand	18110111002	17 / 20
46	Juhi Kumari	18110111007	16 / 20
47	SHUBHAM RAJ	18110111050	19 / 20
48	Kanchan Kumari	18110111021	17 / 20
49	Sourav Raj	18110111046	Oct-20

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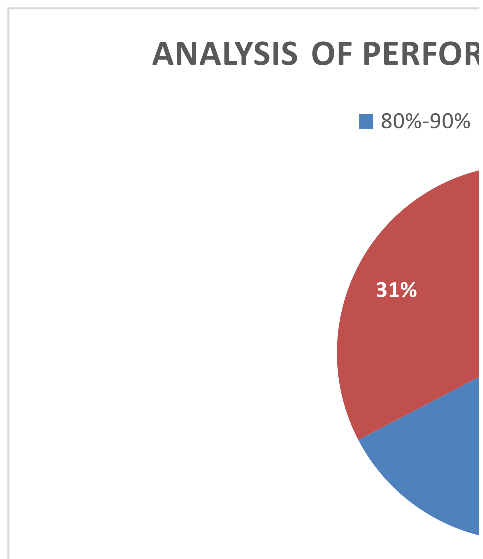
80%-90%	33
70%-80%	15
Absent	1



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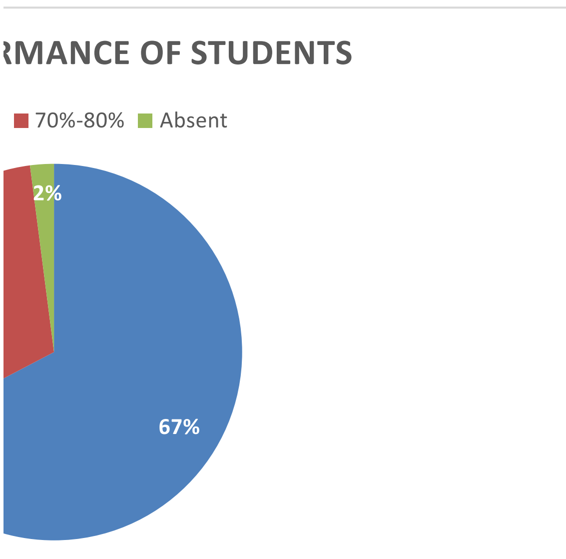

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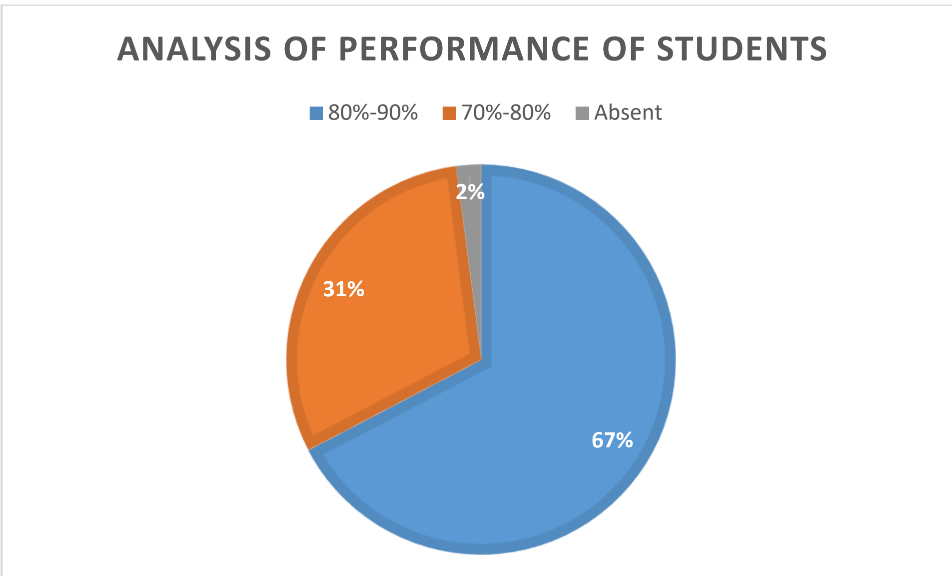
RESULT ANALYSIS



80%-90%	33
70%-80%	15
Absent	1

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Quality Measurement Sheets

a. Course End Survey

ACADEMIC YEAR: 2020-21	SEM: V	DATE:
COURSE: Power System-I	CLASS: EEE	FACULTY: Mr. Tabish Shanu

Please evaluate on the following scale:

Excellent(E)	Good(G)	Average(A)	Poor(P)	No Comment(NC)
5	4	3	2	1

SNO	QUESTIONAIRE	E 5	G 4	A 3	P 2	NC 1	Avg %
GENERAL OBJECTIVES:							
1	Did the course achieve its stated objectives?						
2	Have you acquired the stated skills?						
3	Whether the syllabus content is adequate to achieve the objectives?						
4	Whether the instructor has helped you in acquiring the stated skills?						
5	Whether the instructor has given real life applications of the course?						
6	Whether tests, assignments, projects and grading were fair?						
7	The instructional approach (es) used was (were) appropriate to the course.						
8	The instructor motivated me to do my best work.						
9	I gave my best effort in this course						
10	To what extent you feel the course outcomes have been achieved.						
Please provide written comments:							
a) What was the most effective part of this course							
b) What are your suggestions, if any, for changes that would improve this course?							
c) Given all that you learned as a result of this course, what do you consider to be most important?							

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d) Do you have any additional comments or clarifications to make regarding your responses to any particular survey item?
e) Do you have any additional comments or suggestions that go beyond issues addressed on this survey?

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TEACHING EVALUATION

Darbhanga College of Engineering, Darbhanga

Department of Electrical and Electronics Engineering

Course Assessment

ACADEMIC YEAR: 2017-18	SEM: IV	DATE:
COURSE: Power System-I	CLASS:	FACULTY: Mr. Tabish Shanu

Assessment	Criteria Used	Attainment Level			Remarks
Direct (d)	Theory				
	External Marks	___			
	Internal Marks (Theory)				
	Assignments				
	Tutorials				
Indirect (id)	Course End Survey				
Theory: Course Assessment (0.6 × d+ 0.4 × id)					