Techno India NJR Institute of Technology

Course File

Power System - I (5EE4-02)

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Department of Electrical Engineering

Syllabus:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

3rd Year - V Semester: B.Tech. (Electrical Engineering)

5EE4-02: POWER SYSTEM - I

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	HOURS
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Basic Concepts** 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
3	**Power System Components:** 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, autotransformers, 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.	15
4	**Over-voltages and Insulation Requirements** Generation of Over-voltages: Lightning and Switching Surges. Protection against Overvoltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.	04

5	**Fault Analysis and Protection Systems** 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.	**09**
6	**Introduction to DC Transmission & Renewable Energy Systems** 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	**09**
	TOTAL	**42**

Course Overview:

This course familiarizes students with standards and policies of the electric utility industry, and provides them with basic vocabulary used in the business from this 42-hour course. It introduces the electric power system, from generation of the electricity all the way to the wall plug. Students will learn about the segments of the system, and common components like power cables and transformers.

After going through this course student will gain basic concepts power system components, over voltage and insulation requirements, fault analysis and protection systems, introduction to DC transmission and renewable energy systems. With this course experience, students will be prepared to develop solutions to some of the toughest challenges their organizations are facing. This course will helps student to get place in power industry.

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	The students will be able to analyze the performance of transmission lines, efficiency in transmission lines.
2	Synthesis	The students will be able to understand the basics of corona, sag and other problems that arise in transmission lines.
3	Analysis	The students will be able to analyze and identify the power factor improvement, capacitor bank installation in distribution systems, and metering systems in industrial and residential areas.
4	Application	Students will be able to prepare different tariff structures and relate Indian electricity rules under a deregulated environment.
5	Analysis	Students will be able to explain DC Transmission and Renewable systems.

Prerequisites:

1. The prerequisites for this course are fundamentals of basic electrical engineering and circuit analysis.
2. Students should be efficient in algebraic equation solving.
3. Students should be familiar with conventional and non conventional energy .
4. Three phase networks, machine models.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	2	2	-	-	-	-	-	-	-
CO2	2	2	1	2	1	-	-	-	-	-	-	-
CO3	2	1	2	2	1	-	-	-	-	-	-	-
CO4	2	1	2	1	1	-	-	-	-	-	-	-
CO5	1	2	2	1	1	-	-	-	-	-	-	-
1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	**1**	**INTRODUCTION: OBJECTIVE**
2	1	Scope and outcome of the course
3	**2**	**BASIC CONCEPTS** overview
4	2	Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids.
5	2	Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage
6	2	Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems)
7	2	Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems
8	2	Analysis of simple three-phase circuits
9	**3**	**POWER SYSTEM COMPONENTS** overview
10	3	Overhead Transmission Lines and Cables, Electrical and Magnetic Fields around conductors
11	3	Corona Losses
12	3	Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations Travelling-wave Equations
13	3	Sinusoidal Steady state representation of Lines: Short, medium and long lines
14	3	Power Transfer, Voltage profile and Reactive Power
15	3	Characteristics of transmission lines. Surge Impedance Loading

16	3	Series and Shunt Compensation of transmission lines.
17	3	Transformers: Three-phase connections and Phase-shifts.
18	3	Three winding transformers, autotransformers, Neutral Grounding transformers. Tap-Changing in transformers.
19	3	Transformer Parameters. Single phase equivalent of three-phase transformers.
20	3	Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus.
21	3	Real and Reactive Power Capability Curve of generators.
22	3	Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits.
23	3	Loads: Types, Voltage and Frequency Dependence of Loads.
24	3	Per-unit System and per-unit calculations.
25	**4**	**OVER-VOLTAGES AND INSULATION REQUIREMENTS** overview
26	4	Generation of Over-voltages: Lightning and Switching Surges
27	4	Protection against over-voltages, Insulation Coordination
28	4	Propagation of Surges
29	4	Voltages produced by traveling surges. Bewley Diagrams
30	**5**	**FAULT ANALYSIS AND PROTECTION SYSTEMS** Method of Symmetrical Components
31	5	positive, negative and zero sequences
32	5	Balanced and Unbalanced Faults
33	5	Representation of generators, lines and transformers in sequence networks.
34	5	Computation of Fault Currents. Neutral Grounding.
35	5	Switchgear: Types of Circuit Breakers
36	5	Attributes of Protection schemes. Back-up Protection
37	5	Protection schemes: Over-current, directional and their application.
38	5	Protection schemes: distance protection, differential protection) and their application.
39	**6**	**INTRODUCTION TO DC TRANSMISSION &** Renewable Energy Systems
40	6	DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC).
41	6	LCC and VSC based dc link, Real Power Flow control in a dc link.
42	6	Comparison of ac and dc transmission.
43	6	Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid.

44	6	Wind Energy Systems: Power curve of wind turbine
45	6	Fixed and variable speed turbines.
46	6	Permanent Magnetic Synchronous Generators and Induction Generators.
47		Power Electronics interfaces of wind generators to the grid
48		Revision of course work
49		Revision of course work
50		Revision of course work

Text/Reference Books:

1. Kankar Bhattacharya, Math H.J. Boller, JaapE. Daalder, 'Operation of Restructured Power System' Klumer Academic Publisher – 2001.
2. Mohammad Shahidehpour, and Muwaffaqalomoush, - "Restructured electrical Power systems" Marcel Dekker, Inc. 2001.
3. Loi Lei Lai; "Power system Restructuring and Deregulation", John Wiley & Sons Ltd., England.

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/108/105/108105104/
Quiz	https://quizizz.com/admin/quiz/60dd69a02d4626001d77f3f8/power-system-quiz
Notes	https://sites.google.com/site/eeenotes2u/courses/power-system-generation-transmission-and-distribution

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous Year Question Paper

5E1362

5E1362

B.Tech. V- Semester (Main) Examination, Nov. - 2019
PCC/PEC Electrical Engg.
5EE4-02 Power System - I
(Common for EE,EX)

Time : 3 Hours **Maximum Marks : 120**
Min. Passing Marks : 42

Instructions to Candidates:

*Attempt **all ten** questions from **Part A**, **five** questions out of **Seven** from **Part B** and **Four** questions out of **Five** from **Part C**. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly). Units of quantities used/calculated must be stated clearly.*

PART - A

(Answer should be given up to **25** words only)

All questions are **compulsory** **(10×2=20)**

1. Why transmission lines are 3 phase 3 wire circuits while distribution lines are 3 phase 4 wire circuits?
2. What are standard Transmission and Distribution voltages in India?
3. Why skin effect is absent in DC system?
4. What is difference between feeder and distributor?
5. What is meant by symmetrical fault?
6. What is Ferranti effect?
7. What is the reason for transients during short circuits?
8. What is meant by transposition of line conductors?
9. Define per unit value.
10. What is the drawback in series connected capacitor?

PART - B

(Analytical Problem solving questions)

Attempt any five questions (5×8=40)

1. a) Describe the various methods for reducing corona effect in an overhead transmission line.

   b) A 3 - phase, 220kV, 50 Hz transmission line consists of 1.5 cm radius conductor spaced 2 meters apart in equilateral triangular formation. If the temperature is 40°C and atmospheric pressure is 76 cm, calculate the corona loss per km of the line. Take $m_0 = 0.85$.

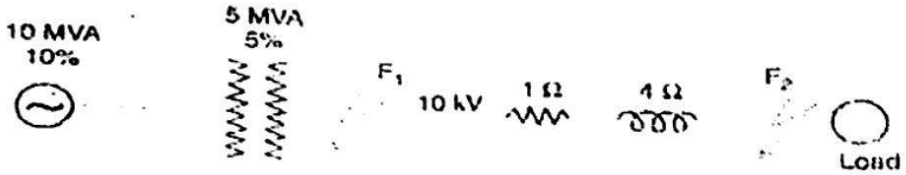
2. Explain different types of distribution systems.

3. Derive an expression for inductance of three phase transmission line.

4. A 3 - phase transmission line operating at 10 kV and having a resistance of 1Ω and reactance of 4Ω is connected to the generating station bus - bars through 5 MVA step - up transformers having a reactance of 5%. The bus - bars are supplied by a 10 MVA alternator having 10% reactance. Calculate the short - circuit kVA fed to symmetrical fault between phases if it occurs

   i) at the load end of transmission line

   ii) at the high voltage terminals of the transformer



5. With the help of block diagrams explain the operations of standalone and grid interactive Solar PV systems.

6. What is a nominal $\pi(\rho i)$ circuit? Find the ABCD constants for nominal π circuit.

7. What is meant by insulation coordination? How are the protective devices chosen for optimal insulation level in power system?

PART - C

(Descriptive/Analytical/Problem Solving/Design Question)

Attempt any Four questions (4×15=60)

1. a) What is the effect of transmission voltage on line performance? Derive mathematical expressions to validate the answer. (6)

   b) A single phase AC system supplies a load of 200 kW. If this system is converted into 3 phase 3 wire AC system by running a third similar conductor then calculate the 3 phase load than can now be supplied if the voltage between the conductor is same. Assume power factor and transmission efficiency to be same in both cases. (9)

2. 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 0.2Ω and 0.4Ω 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. **(15)**

3. a) Derive an expression for fault current for single line - to - ground fault by symmertrical components method. **(7)**

   b) The per unit values of positive, negative and zero sequence reactance of a network at fault are 0.08, 0.07 and 0.05. Determine the fault current if the fault is

      i) double line - to ground

      ii) Line to line

      iii) Line to ground **(8)**

4. a) Write short notes on

      i) Distributed Generation

      ii) Surge Impedance loading. **(2×3=6)**

   b) A 50 hp induction motor has pf 0.9 & 90% efficiency at full load, at half load 0.6 pf and 70% efficiency. At no load the current is 25% of the full load current and 0.1 pf. Shunt capacitors are installed in circuit to make the line pf 0.8 at half load. Determine the line power factor at

      (i) Full load

      (ii) No load. **(9)**

5. a) Discuss merits and demerits of HVDC transmission system. **(7)**

   b) A delta connected load is supplied from a 3 - phase supply. The fuse in the B line is removed and current in the other two lines is 20 A. Find the symmetrical components of line currents. **(8)**

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY

B. TECH III – YEAR (V SEM.)

Electrical Engineering

Power System-I (5EE4-02)

Max Marks: 70 **Time: 3 Hrs**

Note:

1) The paper is divided into 2 parts: Part-A and, Part-B
2) Part-A contains 10 questions and carries 2 mark each.
3) Part-B contains 5 questions. Each question is having two options and carries 10 marks each.

PART – A

1.	What are the advantages of Per Unit system?	[CO1]
2.	Why transmission voltage is higher than generation voltage?	[CO1]
3.	What is definition of Corona?	[CO2]
4.	What is Disruptive Critical Voltage.	[CO1]
5.	Explain Reason for inter connection of power system?	[CO2]
6.	What do you mean by Distributed Energy Resources.	[CO2]
7.	Derive an expression for Per unit representation of single-phase transformer.	[CO1]
8.	What is Microgrid, Explain its types.	[CO3]
9.	Describe Autotransformer with its advantages and disadvantages.	[CO2]
10.	What is Surge Impedance loading, derive its expression.	[CO1]

PART – B

1.	Derive an expression for Inductance calculation in transmission line (single phase) consider solid cylindrical conductor: I. Magnetic field inside the conductor II. Magnetic field outside the conductor	[CO2]
	OR	
1.	A 3-phase transmission line consists of 1 cm radius conductors spaced symmetrically 4 meters apart. Dielectric Strength of air is 30 kV/cm. Determine the line voltage for commencing of corona.	[CO1]

2.	Explain meshed and radial topologies?	[CO1]
	OR	
2.	How many types of Inter-connections? Explain them in details.	[CO2]

3.	Derive an Expression for GMD and GMR for three phase symmetrical configuration.	[CO1]
	OR	
3.	What do you mean by Three phase system? Explain different types of connections in three phase system.	[CO3]

4.	Determine: I. The critical disruptive voltage II. I. The critical disruptive voltage III. Corona loss Under foul weather condition for 3-phase line 160 km long, conductor diameter 1.036 cm; 2.44-meter delta spacing. Air temp 26.6 ◦ C, corresponding to an approximate barometric pressure of 73.15 cm of mercury, operating voltage 110 kV at 50 Hz, surface irregularity factor 0.85. Assume a value of mv = 0.72. Disruptive voltage under foul weather = 0.8 X fair weather value.	[CO1]
	OR	
4.	A certain 3-phase equilateral transmission line has a total corona loss of 53 kW at 106kV and a loss of 98 kW at 110.9 kV. What is the disruptive critical voltage between lines?	[CO]

5.	Why Onload Tap Changer is necessary Explain with diagram its internal structure.	[CO]
	OR	
5.	A certain 3-phase equilateral transmission line has a total corona loss of 53 kW at 106 kV and loss of 98 kW at 110.9 kV. What is the disruptive critical voltage between lines? What is corona loss at 113kV?	[CO1]