CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET301	POWER SYSTEMS I	PCC	3	1	0	4

Preamble: The basic objective of this course is to deliver fundamental concepts in power system components. The basic principle of generation, transmission and distribution of electrical power is comprehensively covered in this course ranging extensively from the conventional ones to the modern discoveries. Deregulated systems in the smart grid and micro-grid with details of grid connected energy storages are also introduced to the students through this course.

Prerequisite : EET 201 Circuits and Networks

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Identify the power generating system appropriate for a given area.
CO 2	Evaluate the electrical performance of any transmission line.
CO 3	Compute various physical characteristics of underground and overhead transmission systems.
CO 4	Select appropriate switchgear for protection schemes.
CO 5	Design a simple electrical distribution system as per the standards.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3					2		2			1	2
CO 2	3	3										
CO 3	3	2				2	2	2				
CO 4	3	1				2		2				1
CO 5	3	1				2	2	2			1	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the methods employed for improving the efficiency of thermal power plant? (K1, K2)
2. How does diversity factor decide the capacity of a power station? (K2)
3. What are the limiting factors in tapping the wind and solar potential?(K2)
4. Problem to calculate the specification of ground mounted or rooftop solar plants. (K3)

Course Outcome 2 (CO2):

1. Explain the principle and causes of proximity effect and Ferranti effect using appropriate figures (K2)
2. What is transposition of lines? Comment on its necessity in the system. (K2)
3. Problems in Transmission line modelling and analysis.(K3)

Course Outcome 3 (CO3):

1. What are the critical voltages in the formation of Corona? What is the effect of Corona? (K1, K2).
2. With a neat cross sectional view show the constructional features of an EHT Cable. (K2).
3. Problems due to sag/ corona/insulators. (K3)

Course Outcome 4 (CO4):

1. What are the essential qualities required by any insulating medium used for arc quenching? What are the usual insulating media used? (K2)
2. What is current chopping? What is its effect on the system? (K1,K2).
3. What makes the differential protection very significant in the protection schemes of electrical machines and transformers?(K2)
4. Problems in Arc interruption (K3).

Course Outcome 5 (CO5):

1. Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages. (K3).
2. How does power factor affect an HT consumer's electricity bill? (K2).
3. Problems in power factor improvement (K3).

Model Question paper

QP CODE:

PAGES:4

Reg.No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET 301

Course Name: POWER SYSTEMS I

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Draw the block diagram of wind power generation and label each part clearly.
2. Discuss the difference between conventional electric power grid and smart grid
3. Draw the possible configurations for a three phase double circuit transposed line system.
4. Derive the deviation in sag due to ice in a winter climate.
5. What is meant by the term grading associated with insulators? Why is it very significant?
6. Discuss the classification of series and shunt FACTS devices.
7. Derive the peak value of current due to capacitive current chopping.
8. With the help of a schematic, explain the architecture of an IEC61850 enabled substation architecture
9. Write notes on energy markets.
10. Calculate the voltage drop and power loss for a radial load of 120A, 0.8 pf lag supplied by a 6.6kV three phase system with a branch impedance of 2 +j2 ohms.

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) A proposed station has the following load cycle:
Time in hours: 6-8 8-11 11-16 16-19 19-22 22-24 24-6
Load in MW: 20 40 50 35 70 40 20
Draw the load curve and select suitable generator units from 10,000, 20,000, 25,000, 30,000 kVA. Prepare the operation schedule for the selected machines and determine the load factor from the curve. **(5)**

b) State Skin Effect and Ferranti Effect and elucidate them with necessary diagrams. **(5)**

c) Enlighten upon the various components and their operation in a hydroelectric power plant for energy production. **(4)**

12. a)A generating station has the following maximum loads: 16000kW, 12000kW, 10000kW, 7000kW and 800kW. The annual load factor is 50%. Calculate the diversity factor and annual energy consumption if the maximum demand on the station is noted as 24000. **(5)**

b)With a neat sketch explain the principle of working of a Thermal Power Station. **(5)**

c)What are the limiting factors in tapping the wind and solar potential? **(4)**

Module 2

13. a)Derive the expression for capacitance in a single phase overhead line under the influence of earth effect. **(5)**

b)Classify transmission lines according to their length and enlist the line models. Derive the ABCD constants for medium lines using nominal π method. **(5)**

c) Following results are obtained by making experiments on three phase, three core metal sheathed cable. (i) Capacitance between all the three bunched conductors and sheath is 1.2 micro Farad. (ii) Capacitance between any one conductor and sheath and the other two being insulated is 0.8 micro Farad. (iii) Calculate the capacitance between any two conductors when the third conductor is connected to the sheath. **(4)**

14. a) An 80 km long transmission line has a series impedance of (0.15+j0.75) ohm per km and a shunt admittance of j5.1 x 10^{-6} ohm per km. Find the A, B, C, D parameters by Nominal π method. **(7)**

b) Derive the inductance of a single phase transmission line with three conductors arranged vertically in Side A and two conductors in Side B. The distance between adjacent conductors in each Side is 6m and that between the sides are 8m. Each conductor is of radius 0.3cm. **(7)**

Module 3

15. a)A transmission line conductor at a river crossing is supported from two towers at a height of 45m and 75m above the water level. The span length is 300m. Weight of the conductor is 0.85kg/mm. Determine the clearance between the conductor and water at a point midway between towers if the tension in the conductor is 2050kg. **(5)**

b) Illustrate the methods used for improving string efficiency of overhead line insulators using appropriate figures and equations. **(5)**

c) Surge impedance loading is a key parameter of any power system. Why? **(4)**

16. a) Explain the advantages and disadvantages of corona. **(4)**

b) (i) A single core, lead sheathed cable is graded by using three dielectrics of permittivity 6, 5 and 4 respectively. The conductor diameter is 2.5cm and overall diameter is 7cm. If the dielectrics are worked at the maximum stress of 38kV/cm, find the safe working voltage of the cable. **(5)**

(ii) What will be the value of safe working voltage for the same core and outside diameter assuming the same maximum stress? (ii) What should be the intersheath voltage, if the taps are provided at the same diameters as in Case (i) with a dielectric of permittivity 5, for the same maximum working stress? **(5)**

Module 4

17. a) With a neat sketch explain the principle of operation of an Vacuum Circuit Breaker **(4)**

b)What are the primary causes of overvoltages? How are the equipments protected from overvoltages? **(5)**

c)Explain the principle of operation of a static overcurrent relay. **(5)**

18. a)In a short circuit test on a 132kV three phase system, the breaker gave the following result: power factor of the fault =0.6, recovery voltage 0.97of full line value; the breaking current is symmetrical and the re-striking transient had a natural frequency of 16kHz. Determine the rate of rise of re-striking voltage. Assume that the fault is grounded. **(5)**

b)Explain the significant features of a Microprocessor based relay. **(5)**

c) What makes the differential protection very significant in the protection schemes of electrical machines and transformers? **(4)**

Module 5

19. a) Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages. **(5)**

b)What are the modern practices in distribution system? **(4)**

c)How do you justify the connection of capacitors for the improvement of power factor economically? Explain with a real life example. **(5)**

20. a) State the main types of distribution systems and compare their applications. **(3)**

b) Derivemost economical power factor for constant kW load & constant kVA type loads? **(7)**

c) A 3-phase, 5 kW induction motor has a power factor of 0.85 lagging. A bank of capacitor is connected in delta across the supply terminal and power factor raised to 0.95 lagging. Determine the kVAR rating of the capacitor in each phase? **(4)**

Syllabus

Module I (9 Hours)

Power System evolution–Load curve -Load factor, diversity factor, Load curve (brief description only) - Numerical Problems.
Generation-conventional (block schematic details, special features, environmental and ethical factors, advantages, disadvantages) -hydro, thermal, nuclear –renewable energy(block schematic details, special features, environmental factors, regulations, advantages, disadvantages) –solar and wind –Design of a rooftop/ground mounted solar farm (concepts only) – Energy storage systems as alternative energy sources- grid storage systems- bulk power grids –smart grids – micro grids.

Module II (10 hours)

Power Transmission System(Electrical Model)-Line parameters -resistance- inductanceand capacitance (Derivation of three phase double circuit) - Transmission line modelling-classifications -short line, medium line, long line- transmission line as two port network-parameters- derivation and calculations

Module III (10 hours)

Power Transmission System Calculation of Sag and tension-Insulators –string efficiency-grading–corona-Characteristics of transmission lines-Surge Impedance Loading- Series and shunt compensation.
Underground cables-ratings- classification- Capacitance –grading-testing
Introduction to EHVAC, HVDC and FACTS: Principle, classification and advantages/disadvantages

Module IV (12 hours)

Switchgear: Need for protection-circuit breakers-rating- SF6,VCB – Principle of GIS-protective relays – Demonstration of a typical electromechanical relay - Static, Microprocessor and Numeric types –Principles of overcurrent, directional, distance and differential- Types of protection schemes (Numeric relays) - causes of over voltages– Insulation co-ordination- Communication:PLCC - Fibre Optic-Introduction to IEC61850.

Module V (7 hours)

Power Distribution Systems– Distribution systems- Aerial Bunched Cables -Insulated conductors- Network standards-Earthing- transformer location – balancing of loads.
Methods of power factor improvement using capacitors- Tariff mechanisms– Introduction to energy markets (regulated and deregulated systems) -Distribution Automationsystems

Practical Exposure: Visit to a local Substation or a nearby power generating station, visit to a site of solar installation-Evaluation by a Viva

References:

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2. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
3. Kothari D. P. and I. J. Nagrath, *Power System Engineering*, McGraw Hill, 3rd Edition, 2019
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5. Stevenson W. D., *Elements of Power System Analysis*, 4/e, McGraw Hill, 1982.
6. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
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11. IEC 61850 Communication Protocol Manual.
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21. Badri Ram and D. N. Viswakarma, *Power System Protection and Switchgear*, 2/e, Tata McGraw Hill Publication, 2011.
22. A. S. Pabla, *Electric Power Distribution*, 6/e, Tata McGraw Hill Publication, 2011 (or 5/e 2004).

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Power System evolution and Generation (9 hours)**	
1.1	Power System evolution- Load curve- Economic factors - Numerical Problems.	2
1.2	Hydroelectric -Thermal and Nuclear power plant- (Block schematic details, special features, environmental and ethical factors, advantages, disadvantages)	2
1.3	Nonconventional energy sources-Wind farm –(Block schematic details, special features, environmental factors, regulations, advantages, disadvantages).	1
1.4	Renewable energy sources – Solar–(Block schematic details, special features, environmental factors, regulations, advantages, disadvantages) - Design of a rooftop– Design of a ground mounted solar farm	2
1.5	Energy storage systems as alternate energy sources- Grid Storage systems - Bulk power grids - micro-grids	2
2	**Power Transmission System(Electrical Model)(10 hours)**	
2.1	Line parameters -resistance- inductance and capacitance (Derivation of single phase, three phase, single circuit and double circuit) - Numerical Problems.	5
2.2	Transmission line modelling- classifications -short line, medium line, long line-models- Transmission line as two port network-ABCD parameters- derivation and calculations- Numerical Problems.	5
3	**Power Transmission (Physical Aspects)(10 Hours)**	
3.1	Calculation of Sag and tension- Numerical Problems.	2
3.2	Insulators –string efficiency- grading- Numerical Problems.	2
3.3	Corona- Numerical Problems.	1
3.4	Surge Impedance Loading- Series and shunt compensation- Principle only.	1
3.5	Underground cables-ratings- classification- Capacitance –grading-testing- Numerical Problems.	2
3.6	Introduction to EHVAC, HVDC and FACTS: Principle, classification and advantages/disadvantages	2

4	**Switchgear (12 Hours)**	
4.1	Need for protection-formation of arc-Arc quenching theory- Restriking Voltage-Recovery voltage, RRRV - Interruption of Capacitive currents and current chopping (Numerical Problems) Circuit breakers-rating- SF6,VCB- (Diagram, construction, working, advantages, disadvantages) - Principle of GIS	3
4.2	Protective relays –Demonstration of a typical electromechanical relay - Static-Comparison and duality of Amplitude and Phase comparators-(Circuit Diagram, working, advantages, disadvantages) Microprocessor -(Flow Chart, working, advantages, disadvantages) and Numeric-(Block Diagram, working, advantages, disadvantages) Overcurrent, directional, distance and differential-(Principle, circuit diagram) Types of protection schemes (Using Numeric relays)	6
4.3	Causes of over voltages–Surge Protection	1
4.4	Transmission System -Communication- Fibre Optic - Abstract ideas only)	1
4.5	Introduction to IEC 61850	1
5	**Power Distribution Systems(7 Hours)**	
5.1	Distribution systems- DC and AC distribution: Types of distributors- bus bar arrangement-Numerical problems. Aerial Bunched Cables -Insulated conductors-(Abstract ideas only)	2
5.2	Network-standards -Earthing- transformer location – balancing of loads-(Abstract ideas only)	2
5.3	Tariff – regulated and deregulated systems- Numerical Problems	1
5.4	Methods of power factor improvement using capacitors- Numerical Problems	1
5.5	Distribution Automation systems	1