CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET304	POWER SYSTEMS II	PCC	3	1	0	4

Preamble: The basic objective of this course is to deliver fundamental concepts in power system analysis. The steady state and transient analysis of electrical power system is comprehensively covered in this course ranging extensively using the conventional methods as well as advanced mathematics.

Prerequisite: EET 301 Power Systems I

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

CO 1	Apply the per unit scheme for any power system network and compute the fault levels.
CO 2	Analyse the voltage profile of any given power system network using iterative methods.
CO 3	Analysethe steady state and transient stability of power system networks.
CO 4	Model the control scheme of power systems.
CO 5	Schedule optimal generation scheme.

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	3										2
CO 2	3	3	2									2
CO 3	3	3	2									1
CO 4	3	2										
CO 5	3	3	1								3	1

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. Why do we adopt per unit scheme of representation? (K2)
2. Which is the most frequent fault and which is the most severe fault? Substantiate with equation. (K2, K3)

Course Outcome 2 (CO2):

1. How is consistency followed in load flow studies? (K4)
2. How does acceleration factor improve convergence in Gauss Siedel Load flow? (K4)

Course Outcome 3 (CO3):

1. Differentiate between steady state and transient stability? (K1, K2)
2. Derive a swing equation. (K3)

Course Outcome 4 (CO4):

1. What is the significance of Inertia constant? (K3)
2. Draw the schematic representation of AGC. Show the frequency deviation pattern. (K1, K2, K3)

Course Outcome 5 (CO5):

1. What are penalty factors? Explain the significance. (K2, K3)
2. Why do we need Unit commitment? Explain with an example. (K3)

Model Question paper

QP CODE: PAGES:5

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET 304

Course Name: POWER SYSTEMS II

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. The generator neutral grounding impedance appears as 3Zn in the zero-sequence net work. Why?
2. A single-phase transformer is rated at 110/440 V, 3 KVA. Its leakage reactance measured on 110 V side is 0.05 ohm. Determine the leakage impedance referred to 440 V side.
3. What is the need of slack bus in load flow analysis?
4. A power system consists of 300 buses out of which 20 buses are generator buses and 25 buses are provided with reactive power support. All other buses are load buses. Determine the size of the Newton Raphson load flow Jacobian matrix.
5. Explain critical clearing angle and its significance with respect to the stability of a power system.
6. Explain Equal Area criterion and state the assumptions made.
7. Draw the basic block diagram of Automatic Voltage Regulator.
8. Discuss the application of SCADA in power system monitoring
9. Explain unit commitment? List out the constraints on unit commitment.
10. Write the conditions for the optimal power dispatch in a lossless system.

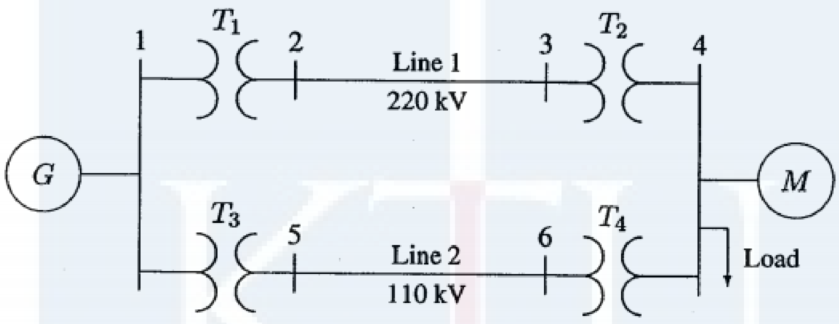
PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module I

1. a)The one-line diagram of a three phase power system is shown in figure below. Select the common base of 100 MVA and 22 kV on the generator side. Draw an impedance diagram with all impedances including the load impedance marked in per unit. The

manufacturer's data for each device is given as follows. The three phase load at bus 4 absorbs 57 MVA, .6 power factor lagging at 10.45 kV. Line1 and Line 2 have reactances of 48.4Ω and 65.43Ω, respectively.

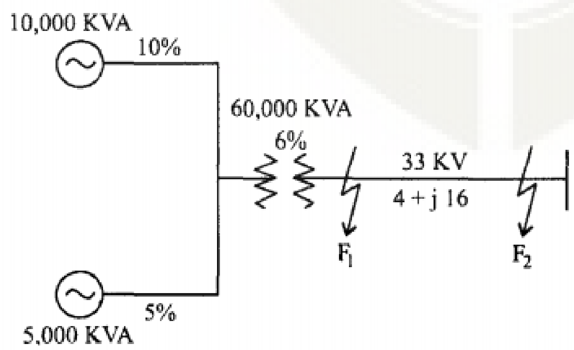
G	90 MVA	22 kV	X=18%
T_1	50 MVA	22/220 kV	X=10%
T_2	40 MVA	220/11 kV	X=6%
T_3	40 MVA	22/110 kV	X=6.4%
T_4	40 MVA	110/11 kV	X=8%
M	66.5 MVA	10.45 kV	X=18.5%



(10)

b) What are the advantages of pu system? Obtain the expression for converting the per unit impedance expressed on one base to another. **(4)**

2. a) A 33 KV line has a resistance of 4 ohm and reactance of 16 ohm respectively. The line is connected to a generating station bus bars through a 6000 KVA step up transformer which has a reactance of 6%. The station has two generators rated 10,000 KVA with 10% reactance and 5000 KVA with 5% reactance. Calculate the fault current and short circuit KVA when a 3-phase fault occurs at the HV terminals of the transformers and at the load end of the line.

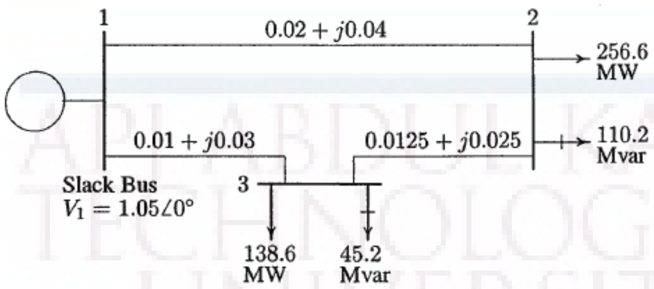


3. **(10)**

b) Explain the different types of current limiting reactors. **(4)**

Module II

4. a)For the system shown in figure obtain the load flow solution at the end of 2 iterations by Gauss Seidel method . The line impedances are marked in per unit on a 100 MVA base.



(10)

b) Explain DC load flow. **(4)**

5. Consider the three bus system shown below. Each of the three lines have aseries impedance of 0.02+j0.08 pu and a total shunt admittance of j0.02 pu. The specified quantities at the buses are tabulated below.

Bus	Real load Demand, P_D	Reactive load demand, Q_D	Real power Generation, P_G	Reactive power Generation, Q_G	Voltage specification
1	2.0	1.0	Unspecified	Unspecified	$V_1 = 1.04 + j0$
2	0.0	0.0	0.5	1.0	Unspecified
3	1.5	0.6	0.0	$Q_{G3} = ?$	$\lvert V_3 \rvert = 1.04$

Controllable reactive power source is available at bus 3 with the constraint $0 \leq Q_{G3} \leq 1.5$pu. Find the load flow solution using FDLF method (one iteration).

(14)

Module III

6. a) Starting from first principles, derive swing equation of a synchronous machine. **(6)**

b) Two generators rated at 4-pole, 50 Hz, 50 MW 0.85 p.f (lag) with moment of inertia28,000 kg-m^2 and 2-pole, 50Hz, 75 MW 0.82 p.f (lag) with moment of inertia 5,000 kg-m^2 are connected by a transmission line. Find the inertia constant of each machine and the inertia constant of single equivalent machine connected to infinite bus. Take 100 MVA base. **(8)**

7. a) A 50 Hz generator is delivering 50% of the power that it is capable of delivering through a transmission line to an infinite bus. A fault occurs that increases the reactance between the generator and the infinite bus to 500% of the value before the

fault. When the fault is isolated, the maximum power that can be delivered is 75% of the original maximum value. Determine the critical clearing angle for the condition described. **(10)**

b) Explain Equal Area criterion and state the assumptions made. **(4)**

Module IV

8. a)Two turboalternators rated for 110 MW and 210 MW have governor drop characteristics of 5 per cent from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action. **(10)**

b) Enumerate the reasons for keeping strict limits on the system frequency variations. **(4)**

9. a) Develop and explain the block diagram of automatic load frequency control of anisolated power system. **(10)**

b) A 100 MVA synchronous generator operates on full load at a frequency of 50 Hz. Inertia constant is 8 MJ/MVA. The load is suddenly reduced 100 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 seconds. Determine the change in frequency that occurs in this time. **(4)**

Module V

10. a)The fuel inputs per hour of plants 1 and 2 are given as

$F_1 = 0.2\ P_1^{\ 2} + 40\ P_1 + 120$ Rs. per hr

$F_2 = 0.25\ P_2^2 + 30\ P_2 + 150$Rs. per hr

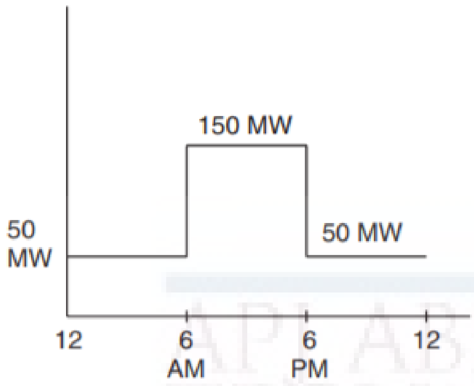
Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100 MW and 25 MW, the demand is 180 MW, and transmission losses are neglected. If the load is equally shared by both the units, determine the saving obtained by loading the units as per equal incremental productioncost. **(6)**

b) Assume that the fuel input in Btu per hour for units 1 and 2 are given by

$F_1 = (8P_1 + 0.024\ P_1^2 + 80)10^6$

$F2 = (6P_2 + 0.04\ P_2^2 + 120)10^6$

The maximum and minimum loads on the units are 100 MW and 10 MW respectively. Determine the minimum cost of generation when the following load (as per Figure given below) is supplied. The cost of fuel is Rs. 2 per million Btu.



(8)

11. a) A 2 bus system consist of two power plants connected by a transmission line. The cost curve characteristics of the two plants are
$C_1= 0.01P_1^2+ 16P_1+20$ Rs/hr
$C_2= 0.02P_2^2 +20P_2 +40$ Rs/hr

When a power of 120 MW is transmitted from plant 1 to load (near to plant 2), a loss of 14 MW is occurred. Determine the optimal scheduling of plants and load demand, if cost of received power is 30 Rs./MWhr. **(10)**

b) The incremental fuel cost of two generating units G_1 and G_2 is given by $IC_1 = 25+0.2P_1$, $IC_2 = 32+0.2P_2$, where P_1 and P_2 are real powers generated by the unit. Find the economic allocation for a total load of 250 MW. Neglect the transmission losses. **(4)**

Syllabus

Module I (10 hours)

Per unit quantities-single phase and three phase- Symmetrical components- sequence networks- Fault calculations-symmetrical and unsymmetrical- Fault level of installations- Limiters - Contingency ranking.

Module II (8 hours)

Load flow studies – Introduction-types-network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson (Qualitative analysis only) and Fast Decoupled method (two iterations) - principle of DC load flow - Introduction to distribution flow.

Module III (10 hours)

Power system stability - steady state, dynamic and transient stability-power angle curve-steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Point by Point method - RK method - Equal area criterion application - methods of improving stability limits - Phasor Measurement Units- Wide Area Monitoring Systems

Module IV (10 hours)

Turbines and speed governors-Inertia-Automatic Generation Control: Load frequency control: single area and two area systems - Subsynchronous Resonance - Automatic voltage control -Exciter Control- SCADA systems

Module V (8 hours)

Economic Operation - Distribution of load between units within a plant - transmission loss as a function of plant generation - distribution of load between plants - method of computing penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.

References:

1. Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3. Kundur P., *Power system Stability and Control*, McGraw Hill, 2006
4. Cotton H. and H. Barbera, Transmission & Distribution of Electrical Energy, 3/e, Hodder and Stoughton, 1978.
5. Gupta B. R., *Power System Analysis and Design*, S. Chand, New Delhi, 2006.
6. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
7. Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai& Sons, New Delhi, 1984.
8. John J Grainger and William D Stevenson, *Power System Analysis*, 4/e, McGraw Hill, 1994.
9. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
10. Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2004.
11. Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Module I(10 hours)**	
1.1	Per unit quantities-single phase and three phase.- -Numerical Problems	2
1.2	Symmetrical components- sequence networks-Numerical Problems	3
1.3	Fault calculations-symmetrical and unsymmetrical-Numerical Problems	3
1.4	Fault level of installations- Limiters-Numerical Problems	2
2	**Module 2(8 Hours)**	

2.1	Load flow studies – Introduction-types	1
2.2	Network model formulation and admittance matrix-Numerical Problems	2
2.3	Gauss-Siedel (two iterations) -Numerical Problems not more than three buses	1
2.4	Newton-Raphson (Qualitative analysis only)	2
2.5	Fast Decoupled method (two iterations) -Numerical Problems not more than three buses	1
2.6	Principle of DC load flow. Introduction to distribution flow.	1
3	**Module 3(10 hours)**	
3.1	Power system stability steady state, dynamic and transient stability--Numerical Problems	2
3.2	power angle curve-steady state stability limit --Numerical Problems	2
3.3	Point by Point method Equal area criterion application-Numerical Problems. RK method-(Abstract idea only)	2
3.4	Methods of improving stability limits-Numerical Problems	2
3.5	Contingency ranking-SSR-(Abstract idea only) – PMUs and Wide area monitoring systems	2
4	**Module IV (10 hours)**	
4.1	Turbines and speed governors-inertia.	2
4.2	Automatic Generation Control: Load frequency control: single area and two area systems-Numerical Problems	3
4.3	Automatic voltage control -Exciter Control.	2
4.4	SCADA systems--(Abstract idea only)	1
4.5	Phasor Measurement Unit- Wide Area Monitoring Systems-(Abstract idea only)	2
5	**Module V (8 hours)**	
5.1	Economic Operation Distribution of load between units within a plant transmission loss as a function of plant generation distribution of load between plants-Numerical Problems	3
5.2	Method of computing penalty factors and loss coefficients-Numerical Problems	2

5.3	Unit commitment: Introduction — Constraints on unit commitments: Spinning reserve, Thermal unit constraints- Hydro constraints- Numerical Problems.	3