CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET464	COMPUTER AIDED POWER SYSTEM ANALYSIS	PEC	2	1	0	3

Preamble: The basic objective of this course is to familiarize the efficient computational techniques applied in analyzing the power system.

Prerequisite: Circuits and Networks, Power Systems I, Power Systems II

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

CO1	Develop the model of power system networks
CO2	Solve linear systems using computationally efficient methods
CO3	Solve load flow problem to analyse the state of power systems
CO4	Formulate optimal power flow problem in power system networks
CO5	Analyse power system under short circuit conditions and infer the results to design a protective system

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
CO1	3	1	1	-	1	-	-	-	-	-	-	-
CO2	3	2	1	-	1	-	-	-	-	-	-	-
CO3	3	2	2	-	2	-	-	-	-	-	-	-
CO4	3	2	2	-	2	-	-	-	-	-	-	-
CO5	3	3	3	-	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)	20	20	40
Analyse (K4)	10	10	20
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

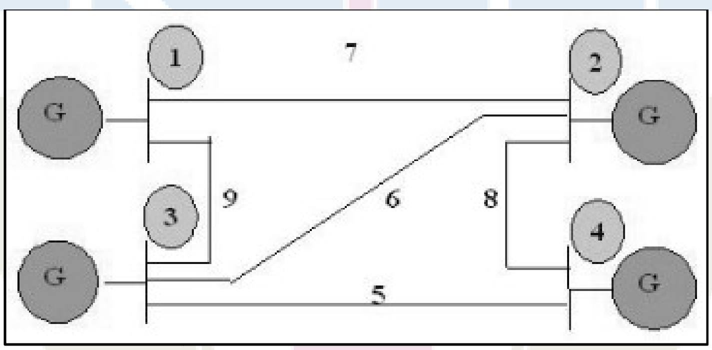
End Semester Examination Pattern:

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 a maximum 2 sub-divisions and carry 14 marks.

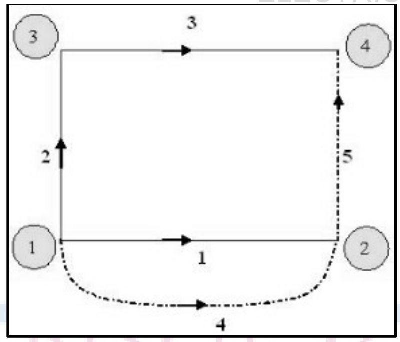
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. For the network shown in Fig. obtain the bus incidence matrix A. (K3)(PO1,PO2,PO3,PO5)



2. For the network in Fig, form the primitive matrices [z] & [y] and obtain the bus admittance matrix by singular transformation. (K2, K3)(PO1,PO2,PO3,PO5)



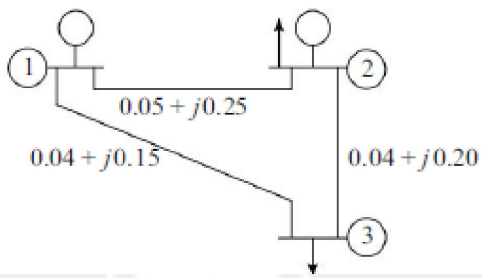
Course Outcome 2 (CO2):

1. Solve Ax=b using Gaussian elimination, given $A = \begin{bmatrix} 5 & -2 & -3 \\ -3 & 7 & -2 \\ -3 & -3 & 8 \end{bmatrix}$ $b = \begin{bmatrix} 4 \\ -10 \\ 6 \end{bmatrix}$ (K2)(PO1,PO2,PO3,PO5)

2. Enumerate Tinney's optimal ordering schemes. (K2)(PO1,PO2,PO3,PO5)

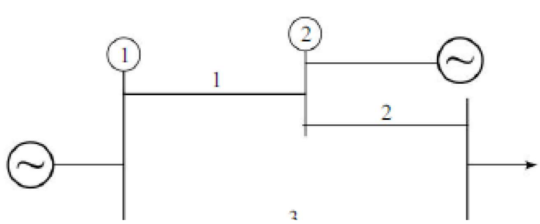
Course Outcome 3 (CO3):

1. Exhibit the structure of fast decoupled load flow equations and DC load flow equations with numerical values for the 3 bus power system shown in the figure. (K3)(PO1,PO2,PO3,PO5)



Bus	Load/Gen. Data			
	Gen.		Load	
	MW	MVAR	MW	MVAR
1	0	0	0	0
2	100	50	50	25
3	0	0	75	30
4	0	0	100	50

2. Considering Bus 1 as slack bus, use DC load flow to obtain one iteration of load flow solution for the system shown below. (K2, K3)(PO1,PO2,PO3,PO5)



Line data (all are in p.u)

Line number	***Between buses***	***Line impedance***
1	1-2	0 + j0.1
2	2-3	0 + j0.2
3	1-3	0 + j0.3

Bus data (all are in p.u)

Bus no.	***Type***	***Generator***		***Load***		***Voltage magnitude***	***Reactive power limits***	
		P	***Q***	***P***	***Q***	***|V|***	Q_{min}	Q_{max}
1	Slack	-	-	-	-	1.0	-	-8
2	P-V	5.3217	-	-	-	1.0	0	5.3217
3	P-Q	-	-	3.6392	0.5339	-	-	-

Course Outcome 4 (CO4):

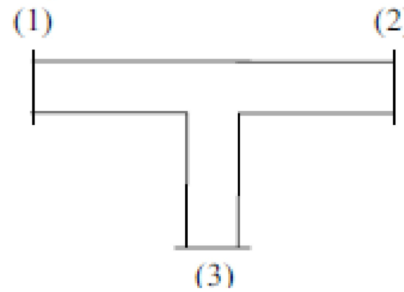
1. Formulate the optimal power flow problem with equality constraints. (K2,K3)(PO1,PO2,PO3,PO5)
2. Discuss the equality and inequality constraints in optimal power flow. (K1)(PO1,PO2,PO3,PO5)
3. Incremental fuel costs in Rs/ mega watthour for a plant consisting of two units are given by

$$\square_1 = \frac{df_1}{dP_1} = 0.008P_1 + 8\lambda_2 = \frac{df_2}{dP_2} = 0.0096P_2 + 6.4$$

   Assume that both units are operating at all times, determine the saving in fuel cost in Rs/hr for the economic distribution of total load of 900 MW between the two units of the plant compared with equal distribution of the same total load. (K3)(PO1,PO2,PO3,PO5)

Course Outcome 5 (CO5):

1. All lines in the network shown in figure have a positive sequence impedance of j0.2 p.u. Generators with transient reactances j0.05 p.u. are connected at buses 1 and 2. Assuming prefault voltage as 1< 0°, for a three-phase to ground fault bus 3, find fault current, fault voltages at buses and currents in all the lines. Determine the fault level at bus 3. (K3, K4)(PO1,PO2,PO3,PO5)



2. A 50-Hz turbo generator is rated 500 MVA, 22 kV. It is Y- connected and solidly grounded and is operating at rated voltage at no load. It is disconnected from the rest of the system. Its reactances are X_d''= X_1= X_2 = 0.15 and X_0 = 0.05 per unit. Determine the ratio of the subtransient line current for a single line to ground fault to the subtransient line current for a symmetrical fault. (K3)(PO1,PO2,PO3,PO5)

Model Question Paper

QP CODE:

PAGES:4

Reg.No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHT SEMESTER
B. TECH. DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET464
Course Name: COMPUTER AIDED POWER SYSTEM ANALYSIS

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all Questions. Each question carry 3 marks

1. Define tree, co-tree, link and branch of a graph.
2. How will the ZBUS matrix be modified, if any line is removed from the previous existing network, or the impedance value of the existing line gets modified.
3. Write short notes on Tinney's optimal ordering.
4. Discuss about triangular factorization of system matrices.
5. Compare NR load flow, decoupled load flow and fast decoupled load flow.
6. What is the principle underlying the decoupled approach in load flow solutions? Narrate its typical solution strategy.
7. Explain the constraints considered in formulating Optimal Power Flow.
8. Explain the concept of economic dispatch problem in the power system.
9. What is the need of performing short circuit analysis in a power system?

10. The Thevenin impedance and voltage at a fault point is $0.576\angle 84^{o}$ p.u. and $1\angle 0^{o}$ p.u. respectively. Determine the short circuit MVA for a base of 30MVA, 11kV.

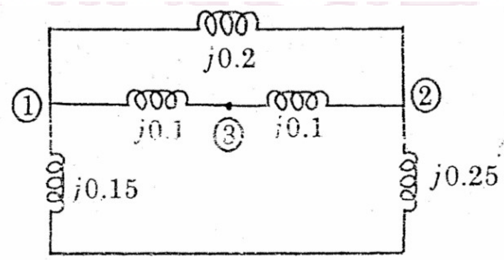
PART B

Answer any one full question from each module. Each full question carry 14 marks

Module-1

11. a) Prove $Y_{Bus}=A^{T}yA$ where A is bus incidence matrix, y is primitive admittance matrix and Y_{Bus} is bus admittance matrix. (7)

b) For the network shown in figure below, obtain Y_{Bus} by singular transformation. All line impedances are in p.u. (7)



12. For the reactance network shown in figure find Z bus by direct determination (14)

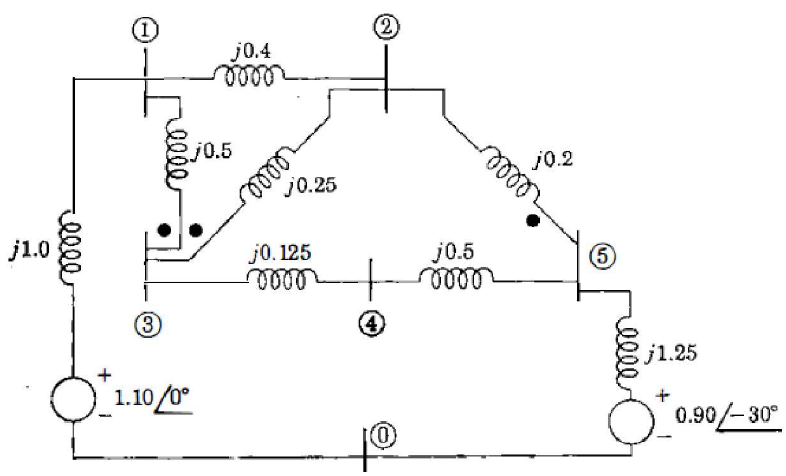
Module-2

13. Find the L and U triangular factors of the symmetric matrix. (14)

$$\mathbf{M} = \begin{bmatrix} 2 & 1 & 3 \\ 1 & 5 & 4 \\ 3 & 4 & 7 \end{bmatrix}$$

14. Using the Guassian elimination find the triangular factors of Y bus for the circuit given

(14)



Module-3

15. For the three bus power system shown in figure, carry out one iteration of load flow solution by FDLF method. Line reactances are given in pu. (14)

16. a) Discuss the Newton Raphson algorithm of Load Flow (8)
b) Stating the assumptions, discuss DC Load Flow (6)

Module-4

17. Explain the Optimal Power Flow problem and its solution by gradient method (with equality constraints only) (14)

18. a) Explain the formulation of optimal power flow problem and its solution by Newton method (8)
b) Explain security constrained optimal power flow (6)

Module-5

19. For the system shown in figure a three phase fault occurs in bus 1. Using Z_{Bus} method, find the short circuit current in the fault, currents in line 1-2 and 1-3 and bus voltages. Prefault system is on no load with 1pu voltage and prefault currents are zero. (14)

20. Obtain the sequence network for a LL fault through impedance at the terminals of an unloaded synchronous generator. (14)

Syllabus

Module I (7 hours)

Overview of graph theory - tree, co-tree and bus incidence matrix, development of network matrices Z_{bus} and Y_{bus} from graph theoretic approach (singular transformation only), building algorithm for bus impedance matrix for elements without mutual coupling.

Module II (8 hours)

Review of solution of linear system of equations by Gauss-Jordan method, Gauss elimination, and LDU factorization. Inversion of Y_{bus} for large systems using LDU factors, Tinney's Optimal ordering.

Module III (7 hours)

Review of Load Flow analysis, Newton-Raphson method(only qualitative analysis), Fast Decoupled Load Flow and DC Load Flow (numerical problems upto two iterations).

Module IV (7 hours)

Review of economic load dispatch, formulation of optimal power flow with active power cost minimization, Solution of OPF using Gradient and Newton's methods (Qualitative analysis only), Security Constrained Optimal Power Flow (concept only).

Module V (7 hours)

Network fault calculations using Z_{bus}, algorithm for calculating system conditions after fault – three phase to ground fault.

Text Books:

1. Stagg and E l Abiad, "Computer Methods in Power System Analysis", McGraw Hill, 1968.
2. G. L. Kusic, Computer Aided Power System Analysis, PHI, 1989
3. John J. Grainger, William D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill Series in Electrical and Computer Engineering.

References:

1. I. J. Nagrath and D. P. Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980.
2. J. Arriliga and N.R. Watson, Computer Modelling of Electrical Power Systems, 2/e, John Wiley, 2001.
3. L. P. Singh, "Advanced Power System Analysis and Dynamics", 3/e, New Age Intl, 1996.
4. M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis (English) 2nd Edition, Pearson Higher Education
6. Wood, Allen J., Bruce F. Wollenberg, and Gerald B. Sheblé. Power generation, operation, and control. John Wiley & Sons, 2013

Course Content and Lecture Schedule:

Sl. No.	Topic	No. of Lecture Hrs
1	**Module I (7 Hrs)**	
1.1	Introduction, Network Equation, Concept of Linear Graph – tree, cotree	1
1.2	Bus Incidence matrix, A	1
1.3	Formation of Y_{bus} and Z_{bus} by singular transformation, Numerical problem	2
1.4	Z_{bus} building algorithm without mutual coupling(derivation not required), Numerical example	3
2	**Module II (8 Hrs)**	
2.1	Solution of linear system of equations by Gauss Jordan method and Gauss elimination method, Numerical problems	3

2.2	Triangular factorization –LDU factors, Numerical problems	2
2.3	Inversion of the Y_{BUS} matrix for large systems, Numerical problems	2
2.4	Tinney's Optimally Ordering	1
3	**Module III (7 Hrs)**	
3.1	Review of Load Flow	1
3.2	Newton-Raphson method (Qualitative analysis only)	2
3.3	Fast Decoupled Load Flow (Numerical problems up to 2 iterations)	2
3.4	DC Load Flow (Numerical problems up to 2 iterations)	2
4	**Module IV (7 Hrs)**	
4.1	Review of Economic Load Dispatch - Economic dispatch of generation without and with transmission line losses	2
4.2	Concept of optimal power flow – formulation with equality and inequality constraints (with active power cost minimization)	2
4.3	Solution of OPF using Gradient and Newton method (Qualitative analysis only)	2
4.4	Security Constrained Optimal Power Flow (concept only).	1
5	**Module V (7 Hrs)**	
5.1	Symmetrical and Unsymmetrical fault calculations using Z_{BUS} – Numerical Problems (Symmetrical faults up to 3 bus systems)	4
5.2	Algorithm for SC calculations for balanced 3 phase network – three phase to ground fault only –Numerical problem	3
		36 hrs