INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION FORMS

Course Title	**:**	**Computer Methods in Power Systems**			
Course Code	**:**	**A60222**			
Regulation	**:**	**R15**			
Course Structure	**:**	**Lectures**	**Tutorials**	**Practicals**	**Credits**
		04	**01**	**-**	**4**
Course Coordinator	**:**	**Dr. P Sridhar, Professor**			
Team of Instructors	**:**	**Mr. S Srikanth, Assistant Professor**			

I. COURSE OVERVIEW:

Computer methods in power systems deals with power system network matrices through graph theory, power flow studies through the computer control, of power systems, short circuit studies, per unit system representation, concept of sequence impedance, symmetrical and unsymmetrical faults and steady state and transient stability studies.

II. PREREQUISITES:

Level	Credits	Periods / Week	Prerequisites
UG	4	4	Knowledge of electrical circuits and power systems.

III. COURSE ASSESSMENT METHODS:

a) Marks Distribution:

Session Marks	University End Exam Marks	Total Marks
There shall be two mid tem examinations. Each midterm exam consists of subjective type and objective type test. The subjective test is for 10 marks, with duration of 1 hour. Subjective test of each semester shall contain four questions; the student has to answer two out of them. Each carrying 5 marks The objective test paper Is prepared by JNTUH, which consists of 20 questions each carrying 0.5 marks and total of 10 marks. The student is assessed by giving two assignments, one, after completion of 1 to 2 1/2 units and the second, after the completion of 2 1/2 to 5 units each carrying 5 marks. On the total the internal marks are 25. The average of two internal tests is the final internal marks. The external question paper is set by JNTUH consisting of part –A and part-B. Where part consists of short answer questions carrying total marks of 25 and	75	100

part part-B consists of 5 essay type questions consists of internal choice each carrying 10 marks and the total of 50. The total external marks are 75.		

IV. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1	I Mid Examination	80 minutes	20
2	I Assignment	-	05
3	II Mid Examination	80 minutes	20
4	II Assignment	-	05
5	External Examination	3 hours	75

V. COURSE OBJECTIVES:

The course should enable the students to:

I. **Understand** the concept of graph theory and formation of network matrices.
II. **Analyze** the load flow studies using different load flow study methods.
III. **Demonstrate** symmetrical and unsymmetrical faults in power systems.
IV. **Explain** the PU (per-Unit) system, concept of sequence impedance and its significance.
V. **Illustrate** the steady state and transient state stability analysis in power systems.

VI. COURSE OUTCOMES:

Students, who complete the course, will have demonstrated the ability to do the following:

1. Understand power system network matrices through graph theory and formulate Y bus matrix by different methods for a given power system.
2. Formulate Z bus matrix for a given power system.
3. Able to solve problems for modification of Z bus with the changes in the network.
4. Illustrate real and reactive power problems of an existing power system using the computer methods.
5. Understand and compare different load flow techniques including DC load flow.
6. Identify the most appropriate algorithm for load flow and short circuit studies.
7. Analyze the given power system network under normal and fault conditions.
8. Discuss short circuit analysis in power systems.
9. Able to investigate the state of a power system of any size and be in a position to analyze a practical system under steady state and fault conditions.
10. Understand symmetrical components and sequence networks.
11. Determine steady state stability in power systems and formulate methods to improve the same.
12. Develop proper mathematical models, related to rotor angle stability and voltage stability of in power system.
13. Explain transient stability analysis in power systems and methods to improve transient stability.
14. Analyze the performance of single and multi-machine systems under transient, steady state and dynamic conditions
15. Formulate algebraic equations pertaining to power systems to assess the stability and performance using various computer based algorithms.
16. Summarize the electromagnetic and electromechanical phenomena taking place in synchronous machines.
17. Generalize performance of power system networks referred to stability point of view under various abnormal conditions.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Level	Proficiency assessed by
PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	S	Assignments
PO 2	**Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	N	Exercise
PO 3	**Design / Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	H	Assignments, Discussion
PO 4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	H	Exercise
PO 5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	N	------
PO 6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	S	Exercise
PO 7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	S	Discussion, Seminars
PO 8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	N	Discussion, Seminars
PO 9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	S	Discussions
PO 10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	S	Discussion,Seminars
PO 11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	N	-----
PO 12	**Life-Long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	S	Prototype, Discussions

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency Assessed by
PSO1	**Professional Skills:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	H	Lectures, Assignments
PSO2	**Problem-Solving Skills:** Can explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	S	Lectures
PSO3	**Successful Career and Entrepreneurship:** The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test , maintain power system and applications.	S	Projects

N - None **S - Supportive** **H- Highly Related**

IX. SYLLABUS:

UNIT I

Power System Network Matrices-1:

Graph Theory: Definitions, Bus Incidence Matrix, Y bus formation by Direct and Singular Transformation Methods, Numerical Problems.

Power System Network Matrices-2:

Formation of Z Bus: Partial network, Algorithm for the Modification of Z Bus Matrix for addition element for the following cases: Addition of element from a new bus to reference, Addition of element from a new bus to an old bus, Addition of element between an old bus to reference and Addition of element between two old busses (Derivations and Numerical Problems).- Modification of Z Bus for the changes in network (Problems)

UNIT II

Power flow Studies-1:

Necessity of Power Flow Studies – Data for Power Flow Studies – Derivation of Static load flow equations – Load flow solutions using Gauss Seidel Method.

Power flow Studies-2:

Acceleration Factor, Load flow solution with and without P-V buses, Algorithm and Flowchart. Numerical Load flow Solution for Simple Power Systems (Max. 3-Buses): Determination of Bus Voltages, Injected Active and Reactive Powers (Sample One Iteration only) and finding Line Flows/Losses for the given Bus Voltages.

Power flow Studies-3:

Newton Raphson Method in Rectangular and Polar Co-Ordinates Form: Load Flow Solution with or without PV Busses- Derivation of Jacobian Elements, Algorithm and Flowchart. Decoupled and Fast Decoupled Methods. - Comparison of Different Methods – DC load Flow

UNIT III

Short Circuit Analysis-:

Per-Unit System of Representation. Per-Unit equivalent reactance network of a three phase power system, Numerical problems. Symmetrical fault Analysis: Short circuit current and MVA calculations, fault levels, Application of Series Reactors, Numerical Problems.

Short Circuit Analysis-2:

Symmetrical Component Theory: Symmetrical Component Transformation, Positive, Negative and Zero equence components: Voltages, Currents and Impedances. Sequence Networks: Positive, Negative and Zero sequence Networks, Numerical Problems. Unsymmetrical Fault Analysis: LG, LL, LLG faults with and without fault impedance, Numerical Problems.

UNIT IV

Power System Steady State Stability Analysis:

Elementary concepts of Steady State, Dynamic and Transient Stabilities. Description of: Steady State Stability Power Limit, Transfer Reactance, Synchronizing Power Coefficient, Power Angle Curve and Determination of Steady State Stability and Methods to improve steady state stability.

UNIT V

Power System Transient State Stability Analysis:

Derivation of Swing Equation. Determination of Transient Stability by Equal Area Criterion, Application of Equal Area Criterion, Critical Clearing Angle Calculation.- Solution of Swing Equation: Point-by-Point Method. Methods to improve Stability - Application of Auto Reclosing and Fast Operating Circuit Breakers.

TEXT BOOKS:

1. Power system Analysis Operation and control, Abhijit Chakrabarthi, Sunita Haldar, 3 Ed, PHI, 2010.
2. Modern Power system Analysis – by I.J.Nagrath & D.P.Kothari: Tata McGraw-Hill Publishing Company, 2nd Edition.

REFERENCES

1. Computer Techniques in Power System Analysis by M. A. Pai, TMH Publications
2. Power System Analysis by Grainger and Stevenson, Tata McGraw Hill.
3. Computer techniques and models in power systems, By K. Uma rao, I. K. International
4. Power System Analysis by Hadi Saadat – TMH Edition.

X. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Learning Objectives	Topics to be Covered	Reference
1	Able to use graph theory to form Z bus and Y bus matrices.	Introduction to graph theory	R4 6.1
2	To know the Y bus formation	Numerical Problems.	R4 6.1
3	To know the Y bus formation	Bus Incidence Matrix	R4 6.1
4	To know the Y bus formation	Y bus formation by Direct Method	R4 6.2
5,6	To know the Y bus formation	Y bus formation by singular Transformation methods,	R4 6.2
7	To know the Y bus formation	Numerical Problems	R4 6.2

8	Able to understand formation of ZBUS	FORMATION OF ZBUS: Partial network	R4 6.1.1
9	Able to understand formation of ZBUS	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to reference	R4 6.1.2
10	Able to understand formation of ZBUS	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to an old bus	R4 6.1.2
11	Able to understand formation of ZBUS	Algorithm for the Modification of Z Bus Matrix for addition element between an old bus to reference Addition of element between two old busses (Derivations and Numerical Problems without mutual coupling)	R4 6.1.2
12,13	Able to obtain Static load flow equations	POWER FLOW ANALYSIS - I: Necessity of Power Flow Studies – Data for Power Flow Studies – Derivation of Static load flow equations	T2 6.4
14	To know how to find Load flow solutions using Gauss Seidel Method.	Load flow solutions using Gauss Seidel Method: Acceleration Factor,	T2 6.5
15	To know how to find Load flow solutions using Gauss Seidel Method	Load flow solution with and without P- V buses, Algorithm and Flowchart.	T2 6.5
16,17	Able to think solution for load flow problem.	Numerical Load flow Solution for Simple Power Systems (Max. 3- Buses): Determination of Bus Voltages, Injected Active and Reactive Powers (Sample One Iteration only).	T2 6.5
18,19	To understand Newton Raphson Method	POWER FLOW ANALYSIS - II: Newton Raphson Method in Rectangular Form: Load Flow Solution with or without PV Busses-Derivation of Jacobian Elements.	T2 6.6
20	To understand Newton Raphson Method	Newton Raphson Method in Polar Co-Ordinates Form: Load Flow Solution with or without PV Busses-Derivation of Jacobian elements	T2 6.6
21, 22	To understand Decoupled and Fast Decoupled Methods	Decoupled and Fast Decoupled Methods.	T2 6.7
23	To compare different load flow methods	Comparison of Different Methods – DC load Flow.	T2 6.8
24, 25	To understand short circuit problem.	SHORT CIRCUIT ANALYSIS: Short Circuit Current and MVA Calculations	T2 6.9
26	To understand Fault levels	Fault levels	T2 6.9
27	To understand application of Series Reactors	Application of Series Reactors,	T2 6.10
28	To solve numerical Problems	Numerical Problems (Symmetrical fault Analysis).	T2 6.10
29	To know Symmetrical Component transformation	UNBALANCED FAULT ANALYSIS: Symmetrical Component transforma tion, Positive, Negative and Zero sequence components	T2 10.1

30	To understand Sequence networks	Sequence networks	T2 10.2
31	To know sequence Voltages, Currents and Impedances	Sequence Voltages, Currents and Impedances	T2 10.2
32	To solve problems on symmetrical components.	Numerical Problems.	T2 10.2
33-36	To analyze LG fault	LG, fault with and without fault impedance, Numerical Problems.	T2 11.3
34	To analyze LL fault	A. fault with and without fault impedance, Numerical Problems.	T2 11.4
35	To analyze LLG fault	LLG fault with and without fault impedance, Numerical Problems.	T2 11.5
36	To solve problems on faults	LG, LL, LLG faults with and without fault impedance, Numerical Problems.	T2 11.8
37	To understand basic concepts of power system stability	POWER SYSTEM STEADY STATE STABILITY ANALYSIS: Elementary concepts of Steady State, Dynamic and Transient Stabilities.	T2 12.1
38	To understand Steady State Stability Power Limit, Transfer Reactance, Synchronizing Power Coefficient	Description of Steady State Stability Power Limit, Transfer Reactance, Synchronizing Power Coefficient	T2 12.2
39,40	To understand Power Angle Curve	Power Angle Curve and Determination of Steady State Stability	T2 12.3
41,42	To understand Methods to improve steady state stability	Methods to improve steady state stability	T2 12.4
43,44	To derive swing equation and to solve numerical problems	Power System Transient State Stability Analysis: Derivation of Swing Equation.	T2 12.10
45,46	To know Equal Area Criterion	Determination of Transient Stability by Equal Area Criterion	T2 12.8
47,48, 49,50	Able to apply Equal Area Criterion	Application of Equal Area Criterion to different cases	T2 12.8 & 12.9
51,52	To derive expression for Critical Clearing Angle	Critical Clearing Angle Calculation	T2 12.11
53, 54	To solve problems on critical clearing angle	Numerical problems	T2 12.12
55	To understand Point-by-Point Method.	Solution of Swing Equation: Point-by-Point Method.	T2 12.6
56	To understand methods to improve Stability	Methods to improve Stability	T2 12.6
57	To know the recent trends in circuit breaker technology	Application of Auto Reclosing and Fast Operating Circuit Breakers.	T2 12.6

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
I	H		H	S									H		
II	H	S	H	S	H						S	S		S	S
III		H		H		S					S		H		S
IV	S		H	S										S	S
V	S		H	H								H	H		

S – Supportive **H = Highly Related**

XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES:

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	H	S	H	S									H		
2	H		H	S	S								H	S	
3	H		H	S									H		S
4	H	S	H	S	H						S	S		S	S
5	H	S	H	S	H						S	S		H	S
6	H	S	H	S	H						H	S		S	S
7	S	H		H		S					S		H		S
8		H		H		S					S		H		S
9		H	S	H		S					S		H		S
10	S		H	S										S	S
11	S	H	H	S										S	
12	S	S	H	S											S
13	S		H	H								H	H		S
14	S	S	H	H								H	H		S
15	S		H	H								H	H		
16	H	H	S	H		S							H		
17			H	H	H						H	H	H	S	

S – Supportive **H = Highly Related**

Prepared by:
Mr. S Srikanth, Assistant Professor

HOD, EEE