Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Institute of Technology
Semester - 1

**Subject:** Power System Analysis - METEE11501

**Type of course:** Major

**Prerequisite:** Electrical Power System

## Rationale:

Power systems are typically characterized by large size and complex nature. Therefore, its analysis for various purposes is extremely important. The assessment of load flows under the presence of complex components, fault analysis of large systems, security assessment, contingency analysis, power system state estimation and voltage stability have become important in modern power systems.

## Teaching and Examination Scheme:

| Teaching Scheme | | | Credits | Examination Marks | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CI | T | P | C | Theory Marks | | Practical Marks | | CA | Total Marks |
| | | | | ESE | MSE | V | P | ALA | |
| 4 | 0 | 2 | 5 | 60 | 30 | 10 | 20 | 30 | 150 |

*Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment;*

## Course Content:

| Sr. No. | Content | Total Hrs | % Weightage |
|---|---|---|---|
| 1 | **Load flow**<br>Overview of Newton-Raphson, Gauss-Seidel, Fast decoupled methods, convergence properties, sparsity techniques,Handling Qmax violations in constant matrix, inclusion of frequency effects AVR in load flow, handling of discrete variables in load flow. | 7 | 10% |
| 2 | **Fault Analysis**<br>Simultaneous faults, Open conductors faults, Short Circuit Studies of a Large Power System Networks, Symmetrical Fault Analysis Using Bus Impedance, Matrix, Algorithm for Formation of Bus Impedance Matrix | 12 | 25% |

| | | | |
|---|---|---|---|
| 3 | **Security Analysis**<br>Power System Security: Introduction, Factors Affecting Power System Security, Contingency Analysis: Detection of Network Problems, Overview of security analysis, Linear Sensitivity Factors, Contingency Selection, Concentric Relaxation, Bounding Security state diagram, contingency analysis, generator, Shift distribution factors, Line outage distribution factor, multiple line outages, Overload index ranking. | 11 | 15% |
| 4 | **Power System Equivalents**<br>WARD equivalents, REI equivalents | 7 | 10% |
| 5 | **State Estimation**<br>Introduction to State Estimation in Power Systems, Power system state estimation, Maximum Likelihood Concept, Weighted Least Squares Estimation, Statistics in state estimation-Gaussian Probability Distribution Function, Matrix Formulation, State Estimation of an AC network, Development of Method, Structure of Jacobian in state estimation, State Estimation by Orthogonal Decomposition, An Introduction to Advanced topics in state estimation, Detection and Identification of Bad measurements : Bad by Chi- square technique, Network Observability and Pseudo measurements, Application of Power Systems State Estimation | 12 | 25% |
| 6 | **Voltage Stability**<br>Voltage stability, instability and collapse, Factors contributing voltage instability, Voltage Collapse Proximity Indices(VCPI) sensitivity based VCPI, Line indices, The continuation power flow, Predictor corrector technique, Q-V and P-V curves, multiple power flow solution, optimal multiplies load flow. | 11 | 15% |

## Continuous Assessment:

| Sr. No | Active Learning Activities | Marks |
|---|---|---|
| 1 | **Simu Lense**<br>Students are required to develop a simulation of a relevant module from the given problem. Upload a video on GMIU web portal. | 10 |
| 2 | **Quiz**<br>Faculty will provide the students a set of MCQs according to the learning objective of the course and students will answer it on the GMIU web portal. | 10 |
| 3 | **Poster**<br>Faculty will assign a topic for the poster on mathematical modelling of matrices and students need to submit it on the GMIU web portal. | 10 |
| Total | | 30 |

## Suggested Specification table with Marks (Theory):60

| Distribution of Theory Marks (Revised Bloom's Taxonomy) | | | | | | |
|---|---|---|---|---|---|---|
| Level | Remembrance (R) | Understanding (U) | Application (A) | Analyze (N) | Evaluate (E) | Create (C) |
| Weightage | 20% | 40% | 30% | 10% | - | - |

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

## Course Outcome:

| After learning the course the students should be able to: | |
|---|---|
| CO1 | Calculate voltage phasors at all buses, given the data using various methods of load flow. |
| CO2 | Analyze power system faults using the bus impedance matrix. |
| CO3 | Detect online network security problems in power systems. |
| CO4 | Assess network observability and identify bad measurements using statistical techniques. |
| CO5 | Interpret Q-V and P-V curves to understand factors leading to instability. |

## List of Experiments:

| Sr. No | Descriptions | Unit No. | Hrs |
|---|---|---|---|
| 1 | Develop MATLAB/Python scripts for Gauss-Seidel, Newton-Raphson, and Fast Decoupled load flow methods on a small network. Compare convergence. | 1 | 4 |
| 2 | To analyze the impact of system parameters (size, R/X) on convergence for different methods. Study the Jacobian matrix in Newton-Raphson. | 1 | 2 |
| 3 | To Implement sparse matrix storage for the Jacobian in Newton-Raphson for a larger system. Compare computational time and memory usage with and without sparsity. | 1 | 2 |
| 4 | Modify the load flow program to model tap-changing transformers with discrete taps. Simulate the effect of tap adjustments on voltage profiles. | 1 | 4 |
| 5 | Develop a MATLAB/Python script to implement the algorithm for forming the bus impedance matrix (Zbus) for a given network. Verify results for a small system manually. | 2 | 4 |
| 6 | To perform symmetrical fault studies on IEEE test systems. Analyze fault current distribution and voltage profiles. Investigate the role of protective devices. | 2 | 2 |
| 7 | Implement an algorithm (e.g., based on overload index) in MATLAB/Python to rank a set of contingencies based on their severity. Apply it to a sample power system and identify the most critical contingencies. | 3 | 4 |

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| | | | |
|---|---|---|---|
| 8 | Implement the REI equivalent in a load flow simulation and compare the results with the original system behavior. Implement a script (MATLAB/Python) to automate the REI equivalent calculation. | 4 | 2 |
| 9 | Implement a Chi-square test-based bad data detection algorithm in MATLAB/Python and apply it to simulated measurements with known errors. Analyze the effectiveness of the method in identifying bad measurements. | 5 | 2 |
| 10 | Calculate and analyze line-based voltage stability indices (e.g., Lmn index) for a sample power system under different loading conditions. Identify critical lines prone to voltage collapse. | 6 | 2 |
| 11 | Simulate scenarios (e.g., with high reactive loads and long lines) in power system software that may lead to multiple power flow solutions. Analyze these different solutions and discuss their implications for voltage stability. | 6 | 2 |
| | **TOTAL** | | **30** |

## Instructional Method:

The course delivery method will depend upon the requirement of content and the needs of students. The teacher, in addition to conventional teaching methods by black board, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory

The internal evaluation will be done on the basis of Active Learning Assignment

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in the laboratory.

## Reference Books:


[1] Rai. G.D., "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2011.

[2] Twidell, J.W. & Weir, "Renewable Energy Sources", EFN Spon Ltd., UK, 2006.

[3] C. S. Solanki, "Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009.

[4] Godfrey Boyle, "Renewable Energy, Power For A Sustainable Future", Oxford University Press, U.K., 1996.

[5] Tiwari. G.N., Solar Energy – "Fundamentals Design, Modelling & Applications", Narosa Publishing House, New Delhi, 2002


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