# GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. SEMESTER: V

DEGREE IN ELECTRICAL ENGINEERING

Subject Name: **Power System Analysis and Simulation**

## A: Power System Analysis

| Sr. No | Course content |
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| 1. | **Current and Voltage Relations on a Transmission Line:** Representation of line, The short transmission line, The medium-length line, The long transmission line: Solution of the differential equations, The long transmission line: Interpretation of the equations, The long transmission line: Hyperbolic form of the differential equations, The equivalent circuit of a long line, Power flow through a transmission line, Reactive compensation of transmission lines. |
| 2. | **System Modeling:** Construction of the synchronous machine, Armature reaction in a synchronous machine, The circuit model of a synchronous machine, The effect of synchronous-machine excitation, The ideal transformer, The equivalent circuit of a practical transformer, The Autotransformer, Per-Unit Impedances in single-phase Transformer circuits, Three-phase transformers, Per-Unit Impedances of Three-winding Transformers, The one-line diagram, Impedance and Reactance Diagrams, The advantages of Per-unit Computations. |
| 3. | **Symmetrical Three-Phase Faults:** Transients in RL Series circuits, Short-Circuit currents and the reactances of Synchronous machines, Internal voltages of loaded machines under transient conditions, The bus impedance matrix in fault calculations, A bus impedance matrix equivalent network, The selection of circuit breakers. |
| 4. | **Symmetrical Components:** Synthesis of Unsymmetrical phasors from their symmetrical components, Operators, The symmetrical components of unsymmetrical phasors, Phase shift of symmetrical components in Star-Delta Transformer Banks, Power in terms of symmetrical components, Unsymmetrical Series impedances, Sequence Impedances and sequence networks, Sequence networks of Unloaded Generators, Sequence impedances of circuit elements, Positive and negative sequence networks, Zero sequence networks. |
| 5. | **Unsymmetrical Faults:** Single line to ground fault on an unloaded generator, Line to Line fault on an unloaded generator, Double Line to Ground fault on an unloaded generator, Unsymmetrical faults on power systems, Single line to Ground fault on a power system, Line to Line fault on a power system, Double Line to Ground fault on a power system, Interpretation of the interconnected sequence networks, Analysis of unsymmetrical faults using the bus impedance matrix, Faults through impedance, Computer calculations of fault currents. |
| 6. | **Corona:** Critical Disruptive Voltage, Corona Loss, Line Design based on Corona, Disadvantages of Corona, Radio Interference, Inductive interference between Power and Communication lines. |

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| 7. | **Neutral Grounding:**<br>Effectively Grounded System, Ungrounded system, Resonant Grounding, Methods of Neutral Grounding, Generator Neutral Breaker, Grounding Practices. |
| 8. | **Transients in Power Systems:**<br>Transients in Simple Circuits, 3-phase Sudden Short Circuit of an Alternator, The Restriking Voltage after Removal of Short Circuit, Travelling Waves on Transmission Lines, Attenuation of Travelling Waves, Capacitance Switching, Overvoltage due to Arcing Ground. |

## B: SIMULATION

The simulations/experiments are to be done on a computer to give exposure of available tool/software to students. The teacher should help students to perform as many simulations as possible. The programming exercises preferably should be done using C or C++.

## Suggested but not limited to, list of simulations/experiments, is given below:

1. Solution of set of linear equations using one or two suitable numerical methods (like Gaussian Elimination).
2. Solution of ordinary differential equation using Euler's method. The simulation should show the effect of variation in time step on the performance of the methods. The solution of set of ODE should also be done with the same method using matrix notations.
3. Same as above with modified Euler's method. (Some other method like Runge-Kutta or trapezoidal can also be demonstrated).
4. Solution of a single nonlinear equation and a set of non linear algebraic equation using G-S method.
5. Solution of a single nonlinear equation and a set of non linear algebraic equation using N-R method.
6. Computation of leakage inductance of a transformer using FEM analysis.
7. Computation of force on a plunger exerted by electromagnet using FEM analysis.
8. To analyse the performance of transmission line for specified receiving end quantities.
9. To analyse the performance of transmission line for specified sending end quantities.
10. To analyse the performance of transmission line for specified load impedance.
11. To obtain receiving end power circle diagram of a transmission line.
12. To obtain voltage profile and loadability curve for a transmission line.
13. To obtain circle diagram of a three phase induction motor.
14. To plot characteristic of a diode.
15. To plot input and output characteristics of transistor.
16. To simulate uncontrolled rectifier with R, RL and C filter, with and without load.
17. To simulate phase controlled rectifier with R, RL and C filter, with and without load.
18. To simulate DC-DC converter (Buck, Boost and Buck-Boost converters).

## Note for Finite Element Method (FEM) related experiments:

The basic theory related to Finite Element Method (FEM) and the tutorial problems can be downloaded from following link: www.ee.iitb.ac.in/~fclab/academics.html

Students can use the free public domain software such as FEMM (www.femm.info/wiki/HomePage) for solving the tutorial problems.

## Note for simulation of electrical and power electronic circuits:

The open source software known as Sequel can be downloaded from the following link:
**http://www.ee.iitb.ac.in/~sequel**

Please note that use of these suggested softwares, is not mandatory for students or teachers, they can use software of their choice.

## Reference Books:


1. Elements of Power Systems Analysis : W. D. Stevenson Jr., 4th Edition, McGraw Hill International.
2. Electrical Power systems: C. L . Wadhwa, 5th Edition, New Age International Publishers.
3. Power Systems Analysis by A R Bergen, Vijay Vittal, 2nd edition, Pearson Education.
4. Electric Energy Systems Theory An Introduction by Olle I Elgerd, Tata McGraw Hill.
5. Modern Power system Analysis by I J Nagrath, D P Kothari, Tata McGraw Hill.
6. Power System Analysis by Hadi Saadat, Tata McGraw Hill.
7. Advanced Engineering mathematics by E. Kreyszig, (8th Edition), John-Wiley-India (1999).
8. Linear Algebra and its applications by G. Strang, (4th Edition), Thomson (2006).
9. Numerical Techniques in Electromagnetics with MATLAB by Matthew N.O. Sadiku, Third Edition, CRC press, 2009, chapter 6.
10. Finite element analysis of electrical machines by S. J. Salon, Springer, India
11. Simulation of Power Electronic Circuits by M.B. Patil, V. Ramanarayanan, V.T. Ranganathan, Narosa, 2009.
12. Fundamentals of Power Electronics with MATLAB By Fandall Shaftar, Cengage publications
13. “Power Electronics - circuits, devices and applications”, Prentice Hall of India, 2nd ed., 2000- Muhammad H. Rashid.