

# POWER SYSTEM ANALYSIS II

ENEE 252

**Lecture** : 3  
**Tutorial** : 1  
**Practical** : 3/2

**Year** : II  
**Part** : II

## Course Objectives:

The objective of this course is to provide foundational knowledge of interconnected power systems, focusing on the mathematical modeling of electrical networks. It aims to equip students with the ability to analyze load flow, symmetrical and unsymmetrical faults, and perform stability analysis of power systems.

### 1 Interconnected Power System (4 hours)

- 1.1 Overview of interconnected power system
- 1.2 Types: Isolated Vs. interconnected, need and importance
- 1.3 Real power-frequency (P-f), Reactive power-voltage (Q-V) problem and basic control mechanisms
- 1.4 Grid: Local, regional, national and international grid

### 2 Mathematical Model of Electrical Network (4 hours)

- 2.1 Basic concepts: Node equation and loop equation
- 2.2 Equivalent circuit of transformer and phase shift transformer
- 2.3 Admittance matrix: Formulation and modification
- 2.4 Applications of bus admittance matrixes in network analysis
- 2.5 Basic concept of bus impedance matrixes

### 3 Load Flow Analysis (9 hours)

- 3.1 Load flow problem, bus classification
- 3.2 Development of load flow equations
- 3.3 An approximate load flow solution
- 3.4 Iterative approaches for solving power flow equations
  - 3.4.1 Gauss-Seidal method
  - 3.4.2 Newton- Raphson method
  - 3.4.3 Fast decoupled load flow method
- 3.5 Power flow studies in system design and operation

### 4 Symmetrical Fault Analysis (6 hours)

- 4.1 Definition and purpose of fault calculation
- 4.2 Types of faults in power system, symmetrical fault calculation

- 4.3 Short circuit computations of a synchronous machine (On no load and load)
- 4.4 Effect of short circuits

**5 Symmetrical Components and Sequence Networks (6 hours)**

- 5.1 Basic concepts
- 5.2 Symmetrical components transformation
- 5.3 Sequence components of the voltages, currents, impedance and power invariance
- 5.4 Phase shift in star-delta transformer
- 5.5 Sequence impedances and networks of transformers
- 5.6 Sequence impedances and networks of transmission lines
- 5.7 Sequence impedances and networks of synchronous machine

**6 Unsymmetrical Faults Analysis (7 hours)**

- 6.1 Symmetrical components analysis of unsymmetrical faults
- 6.2 Single line to ground fault
- 6.3 Line to line faults
- 6.4 Double line to ground faults
- 6.5 Open conductor faults
  - 6.5.1 Two conductors open
  - 6.5.2 One conductor open

**7 Power System Stability (9 hours)**

- 7.1 Concepts, classification
- 7.2 Dynamics of a synchronous machine
- 7.3 Swing equation
- 7.4 Power angle equation
- 7.5 Steady state stability, synchronizing power coefficients
- 7.6 Transient stability, equal area criterion
- 7.7 Numerical solution of swing equation
- 7.8 Stability enhancement techniques

**Tutorial (15 hours)**

- 1. Problems on node and loop equations, impedance matrix, admittance matrix formulation including transformer in a network
- 2. Problems on development of load flow equations, bus classification, and iterative methods (Gauss-Seidel, Newton-Raphson, Fast Decoupled)
- 3. Problems on symmetrical faults in power system network (no load and loaded synchronous machine) and symmetrical components of machine, transformer (with different configurations), transmission line, and impedance
- 4. Problems on unsymmetrical fault analysis
- 5. Problems on the swing equation, steady-state/transient stability, and equal area criterion

**Practical****(22.5 hours)**

1. Introduction to simulation of short, medium, and long transmission lines
2. Formation of Ybus matrix and Zbus matrix
3. Load flow analysis by Gauss-Seidel, Newton-Raphson, and fast decoupled method (any one method)
4. Symmetrical fault analysis
5. Unsymmetrical fault analysis (L-G fault only)

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

<b>Chapter</b>	<b>Hour</b>	<b>Marks Distribution *</b>
1 and 2	8	10
3	9	12
4	6	8
5	6	10
6	7	10
7	9	10
<b>Total</b>	<b>45</b>	<b>60</b>

\* There may be minor deviation in marks distribution.

**References**

1. John J., Grainger, William, D., Stevenson, Jr. (1994). Power System Analysis. McGraw-Hill.
2. D.P Kothari, I.J Nagrath, (2011). Modern Power System Analysis. Tata McGraw Hill Education Private Limited.
3. Kundur, P. (2006). Power System Stability and Control. McGraw Hill, Inc.
4. Wadhwa, C.L. (2018). Electrical Power Systems. New Academic Science Limited.
5. Stagg, G. W., El-Abiad, A. H. (1968). Computer Methods in Power System Analysis. Colombia: McGraw-Hill.
6. Hadi, S. (2002). Power System Analysis. McGraw Hill.