Module 1

Chapter 1 : Load Flow Studies 1-1 to 1-97

Syllabus : Introduction, network model formulation, formation of Y bus using step by step method, formation of Y bus by singular transformation, Load flow problem, Load flow Equation and methods of solution, Approximate Load flow study, Gauss-Seidel method, Newton - Raphson method, Decoupled load flow method, Fast decoupled load flow method, comparison of load flow method. (Numerical)

1.1 Introduction 1-1
1.2 Network Model Formulation 1-1
1.2.1 Network Topology 1-1
1.2.2 Driving Point and Transfer Admittance 1-2
1.2.3 Driving Point Admittance 1-2
1.2.4 Transfer Admittance 1-2
1.2.5 Modelling Power System into Electrical network 1-2
1.3 Formation of Y- bus Matrix 1-3
1.3.1 Methods of Formation of Y- bus Matrix 1-3
1.4 Formation of Y Bus Matrix using Direct Method 1-6
1.4.1 Formulation of Y-bus Matrix using Direct Method 1-6
1.5 Formation of y_{Bus} Matrix using Step by Step Method 1-13
1.6 Formulation of Y_{BUS} Matrix using Singular Transformation Method 1-17
1.6.1 Graph Theory 1-17
1.6.2 Primitive Network 1-18
1.6.3 Bus Incidence Matrix 1-19
1.6.4 Formulation of Y_{bus} and Z_{bus} 1-21
1.7 Load Flow Analysis 1-36
1.7.1 Classification of Buses 1-37
1.8 Load flow equation and methods of solution 1-38
1.8.1 Load flow equations 1-38
1.8.2 Methods of solution 1-39
1.8.3 Revision 1-39
1.9 Approximate Load Flow Study 1-40
1.10 Gauss – Seidel Method 1-51
1.10.1 Acceleration Factor 1-51
1.10.2 G-S method with no PV (generator) buses 1-51
1.10.3 G-S Method when PV (generator) Buses are present 1-53
1.11 Newton Raphson [N-R] Method 1-65
1.11.1 Solution of algebraic equations using N-R method 1-66
1.11.2 Newton Raphson Method for Load Flow Analysis using Polar Co-ordinates 1-71
1.11.2.1 Algorithm of N-R Method for Load Flow Studies 1-73
1.12 Decoupled Load Flow Method 1-82
1.12.1 Mathematical Derivation to prove "J2"(N) and "J3"(J) are negligible 1-83
1.13 Fast Decoupled Load Flow method 1-85
1.13.1 Sparsity 1-88
1.13.2 Comparison of methods used for load flow study 1-88

Module 2

Chapter 2 : Economic Operation of Power System 2-1 to 2-44

Syllabus : Optimal operation of generators in thermal power station, heat rate curve, input-output curve, IFC curves, optimum generation scheduling neglecting Transmission losses (coordinate equation), optimum generation scheduling considering transmission losses (Exact coordinate equation),Transmission loss formula, B_{mn} coefficient, Inherent procedure of solving co-ordination equation, optimal unit commitment : dynamic programming method, Reliability considerations (Numerical).

2.1 Introduction 2-1
2.2 Optimal Operation of Generators in Thermal Power Station 2-1
2.3 Heat Rate Curve 2-2
2.4 Input- Output Curve 2-3
2.5 IFC (Incremental Fuel Cost) Curve 2-3
2.5.1 Incremental Fuel Rate (IFR) curve 2-3
2.5.2 Incremental fuel cost curve 2-3
2.6 Optimum Generation Scheduling Neglecting Transmission Losses 2-4
2.6.1 Optimum Generation Scheduling Between Two Units 2-4
2.6.2 Optimum Generation Scheduling With 'm' Number of Units 2-4
2.7 Optimum Generation Scheduling Considering Transmission Losses (Exact Co-ordinate Equation) 2-18
2.7.1 Exact Co-ordinate Equation 2-19
2.8 Transmission Loss Formula 2-20
2.9 Bmn coefficient 2-22

2.10 Inherent Procedure of Solving Co-ordination equation 2-23
2.11 Optimal Unit Commitment 2-36
2.11.1 Dynamic Programming Method 2-36
2.12 Reliability Considerations 2-42

Module 3

Chapter 3 : Automatic Generation and Voltage Control 3-1 to 3-23

Syllabus : Introduction, Basic control loops in generator, AVR loop, Thermal control, speed governing system and transfer function, steam turbine and power system transfer function, Load frequency control(single area),state and dynamic response. Load frequency control of Two area system, static and dynamic response analysis of two area system, Load frequency control with generation rate constraints, Dead band and its effect on AGC(Numerical).

3.1 Introduction 3-1
3.1.1 Modern Equipment for Load Frequency and Excitation Voltage Regulator for Turbo Generator 3-1
3.2 Basic Control Loop in Generator 3-2
3.2.1 AVR (Automatic Voltage Regulator) Loop 3-3
3.3 Speed Governing system 3-5
3.3.1 Transfer Function of Steam Governing System 3-6
3.4 Steam Turbine Transfer Function / Model 3-8
3.5 Load Frequency Control and Economic Dispatch Control 3-9
3.5.1 Steady State Response 3-10
3.5.2 Dynamic Response 3-11
3.5.3 Dynamic Response with integral Control Action 3-11
3.6 Load Frequency (LF) control with Generation Rate constraints (GRCS) 3-13
3.7 Dead Band and it's effect on AGC 3-22

Module 4

Chapter 4 : Power System Stability 4-1 to 4-64

Syllabus : Introduction to stability, types of stability, Power angle curve, dynamics of synchronous machine, power angle equation, steady state stability, swing equation, transient stability, equal area criterion, application of equal area criterion, point by point solution of swing equation, some techniques for improving transient stability.(Numerical)

4.1 Introduction to Stability 4-1
4.2 Types of Stability 4-1
4.3 Power Angle Curve 4-2
4.3.1 Generator Loaded at its Terminals 4-2
4.3.2 Generator Connected to Infinite Bus 4-4
4.3.3 Power Transfer through Impedance 4-5
4.4 Dynamics of Synchronous Machine 4-11
4.4.1 Swing Equation 4-12
4.4.2 Reduction of Two Machine System into Single Machine System 4-15
4.5 Power Angle Equations 4-20
4.6 Steady State Stability 4-20
4.6.1 Methods of Improving steady-state stability limit 4-27
4.7 Swing Equation 4-28
4.8 Transient stability 4-28
4.9 Equal Area Criterion 4-29
4.9.1 Applications of equal area criterion 4-31
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4.9.1.2 Pre fault, During fault and Post fault analysis 4-32
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4.11 Some Techniques for Improving Transient Stability 4-60

Module 5

Chapter 5 : Voltage Stability 5-1 to 5-27

Syllabus : Introduction, definitions, short circuit capacity, comparison of rotor angle and voltage stability, reactive power flow and voltage collapse, voltage stability. Surge impedance loading, PV and V-Q curves, Various methods of voltage control, shunt compensation, series compensation, and comparison of series and shunt compensation.

5.1 Introduction 5-1
5.2 Definitions 5-1
5.3 Short Circuit Capacity 5-2
5.4 Comparison of Rotor Angle Stability and Voltage Stability 5-3
5.5 Reactive Power Flow and Voltage Collapse 5-3
5.5.1 Reactive Power Flow 5-3
5.5.2 Voltage Collapse 5-8
5.6 Voltage Stability 5-9
5.6.1 Voltage Stability Analysis 5-10
5.7 Surge Impedance Loading 5-13

5.8 P – V and V – Q Curves 5-15
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5.9 Various Methods of Voltage Control (For improving voltage stability) 5-17
5.9.1 On Generation Side 5-18
5.9.2 On Transmission Side 5-19
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5.9.4 Overall Power System Operation 5-20
5.10 Shunt Compensation 5-21
5.11 Series Compensation 5-25
5.12 Comparison of Series and Shunt Compensations 5-26

Module 6

Chapter 6 : Power System Security and Interchange of Power 6-1 to 6-18

Syllabus : Power system security : Introduction, System state classification, security analysis, contingency analysis, sensitivity factor.

Interchange of power : Interchange of power between interconnected utilities, types of interchange, capacity and diversity interchange, energy banking, power pools.

6.1 Introduction 6-1
6.1.1 Functions of system security to be carried out in energy control centre 6-1
6.2 System State Classification 6-2
6.2.1 Flow Chart 6-3
6.3 Security Analysis 6-4
6.4 Contingency Selecting 6-5
6.5 Contingency Analysis 6-5
6.6 Sensitivity Factors 6-9
6.6.1 Types of sensitivity factors 6-10
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6.6.1.2 Line outage Distribution factors (dli) 6-10
6.7 Interchange of Power between Interconnected Utilities 6-11
6.8 Transfer Capability 6-12
6.8.1 Terms used in transfer capacity 6-12
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6.10 Types of Interchange or Types of Transactions 6-14
6.10.1 Capacity Interchange 6-14
6.10.2 Diversity Interchange 6-15
6.10.3 Emergency Power Interchange 6-16
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➢ **Appendix-A ..... A-1 to A-2**

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