PS5201 POWER SYSTEM DYNAMICS

DETAILED SYLLABUS

UNIT I SYNCHRONOUS MACHINE MODELLING

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: power invariant form of Park‟s transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies : Neglect of stator transients, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS

Excitation System Requirements; Elements of an Excitation System; Types of Excitation System; Control and protective functions; IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System Modeling: Functional Block Diagram of Power Generation and Control, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modeling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed- governing system model for normal speed/load control function.

UNIT III SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State-

space representation, stability of dynamic system, Linearization, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation factor. Single Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K- constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

UNIT IV SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabilizer: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small- signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT V ENHANCEMENT OF SMALL SIGNAL STABILITY

Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta –P- Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain – Phase lead compensation – Stabilizing signal washout stabilizer gain – Stabilizer limits

REFERENCES

1 P. W. Sauer and M. A. Pai, “Power System Dynamics and Stability”, Stipes Publishing Co,

2 P. Kundur, “Power System Stability and Control”, McGraw-Hill, 1993.

3 P.M Anderson and A.A Fouad, “Power System Control and Stability”, Iowa State University Press, Ames, Iowa, 1978.

4 R.Ramunujam,” Power System Dynamics Analysis and Simulation, 2009