SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

II SEMESTER

1916201 –Power System Dynamics

Regulation – 2019

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Prepared by

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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SUBJECT : 1916201-POWER SYSTEM DYNAMICS

SEM / YEAR: I Year II SEM M.E., Power Systems Engineering

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.

PART –A

Q.No	Questions	BT Level	CO	Competence
1.	Draw the schematic diagram of a synchronous generator.	BTL-1	1	Remembering
2.	Define armature and field structure of synchronous machine.	BTL-1	1	Remembering
3.	Define mathematical description of a synchronous machine.	BTL-1	1	Remembering
4.	Distinguish between direct and quadrature axis flux linkage in synchronous machine.	BTL-4	1	Analyzing
5.	Express the voltage equation for rotor in dq0 coordinates	BTL-2	1	Understanding
6.	Define physical interpretation of dq0 transformation.	BTL-1	1	Remembering
7.	Illustrate Swing Equation as two first order differential equation?	BTL-3	1	Applying
8.	Define park's transformation.	BTL-1	1	Remembering
9.	Express the voltage equation for stator in dq0 coordinates.	BTL-2	1	Understanding
10	Differentiate between stator self and stator mutual inductances.	BTL-4	1	Analyzing
11	Describe stator to rotor mutual inductances?	BTL-2	1	Understanding
12	Explain Lad reciprocal per unit system.	BTL-5	1	Evaluating
13	Explain park transformation?	BTL-4	1	Analyzing
14	Explain power invariant form of park's transformation.	BTL-5	1	Evaluating
15	Give the schematic diagram of rotor construction of synchronous	BTL-2	1	Understanding
16.	Explain inertia constant and mechanical starting time of synchronous machine?	BTL-4	1	Analyzing
17	Prepare the list of assumptions associated with the mathematical model of a synchronous machine?	BTL-6	1	Creating
18	Explain the effect of neglecting transformer emf in stator voltage	BTL-4	1	Analyzing
19	Define rotor angle stability. List out two categories of rotor angle	BTL-1	1	Remembering
20	Prepare the list of methods for producing changing flux linkages.	BTL-6	1	Creating

PART – B

1	Explain the phasor representation and equivalent circuit used in the steady state analysis of synchronous machine in detail.	BTL-4	1	Analyzing
2	Discuss the procedure used to compute steady state values ofsynchronous machines.	BTL-2	1	Understanding

3.	Draw the schematics of stator and rotor circuits of a synchronous machine and develop the basic equation of stator and rotor of synchronous machine. Draw all the necessary illustrations.	BTL-4	1	Analyzing
4.	(i) Explain the swing equation of a synchronous machine in detail and discuss the calculation of inertia constant. (ii) Explain the two axis model of the synchronous machine with amortisseur windings neglected.	BTL-5	1	Evaluating
5.	(i) Write down the flux linkage and voltage equations of a synchronous machine from its model and there from formulate the electromagnetic torque equation. (ii) Describe shortly on Park's transformation.	BTL-3	1	Applying
6.	Describe briefly the per unit representation of Lad -reciprocal per unit system and that from power invariant form of park's transformation.	BTL-1	1	Remembering
7.	Describe about the mathematical description of a synchronous machine with required diagram.	BTL-1	1	Remembering
8.	Using the d-q variable model of synchronous machine with rotor having field winding and one q-axis winding .discuss the procedure to compute the steady state values. Also calculate δi,ed,eq,id,iq,ilq,ifd,efd,ψfd,ψ1q,Te for the generator parameters given as $L_{ad}=L_{aq}=1.66$, $L_l=0.15$, $R_a=0.003$, $L_{fd}=0.165$, $R_{fd}=0.00006$, $L_{lq}=0.7252$, $R_{lq}=0.00619$ Assume that the generator is delivering rated MVA at 0.8(lag) pf at rated voltage and the effect of saturation is neglected.	BTL-3	1	Applying
9.	(i) The following data pertains to per-unit unsaturated values of d-axis reactance of a 500MW, 588 MVA,15.75KV,50Hz,2-pole turbo generator on its rating: Xd =2.35; Xd'=0.253; Xd''=0.172; Xleakage=0.179. The direct axis open circuit time constants are:T' do =8.0 sec and T'' do =0.04 seconds. Evaluate the elements of the inductance matrix encountered in d-axis rotor winding voltage equations using the appropriate data conversion procedure. (ii)Explain briefly the effect of neglecting transformer EMF terms in stator voltage equation of the synchronous machine model for stability analysis.	BTL-5	1	Evaluating
10.	Develop the synchronous machine voltage and flux linkages equations in Park's coordinates with the following Sign conventions: (i) Source convention for stator windings and load convention for field winding, (ii) Flux linkage produced by a current in a winding carries the same sign as the current and (iii) The quadrature axis leads the direct axis in the direction of rotor. Assume power –invariant form of Park's transformation. Also give the corresponding d and q axis and corresponding equivalent circuit.	BTL-6	1	Creating
11.	A synchronous generator is operating at rated speed and on no-load. The open circuit voltage is 1.0 pu. There is a sudden three phase short circuit at the generator terminals at t = O. Obtain expression for i_d,i_q, i_f and T_e as function of time. Assume that the transients in the armature are neglected. Also neglect armature resistance.	BTL 2	1	Understanding
12.	A synchronous generator is operating at rated speed and on no-load. The open circuit voltage is 1.0 pu. There is a sudden three phase short circuit at the generator terminals at t = O. Obtain expression for i_d,i_q, i_f and T_e as function of time. Assume that the transients in the armature are also considered with Ra=0. Also neglect armature resistance.	BTL 2	1	Understanding

13.	Draw the phasor diagram and derive the expressions for flux linkage and stator and rotor voltage equations of a synchronous machine in dqo coordinates.	BTL 1	**1**	**Remembering**
14.	Derive the various basic equations governing synchronous machine and also write the basic assumptions necessary to develop basic equations.	BTL 1	**1**	**Remembering**
	PART – C			
1	A 555MVA, 24KV,0.9 p.f.,60Hz, 3phase,2 pole synchronous generator has the following inductances and resistances associated with the stator and field windings: laa=3.2758+0.0458cos(2θ) mH ; lab=-1.6379-0.0458cos(2θ+π/3)mH;lafd=40.0cosθmH Lffd=576.92mH; Ra=0.0031Ω; Rfd=0.0715 Ω. a. Determine Ld and Lq in henrys b. If the stator leakage inductance Ll is 0.4129 mH, determine Lad and Laq in Henrys c. Using the machine rated values as the base values for the stator quantities, determine the per unit values of the following in the Lad- base reciprocal per unit system: L_l, L_{ad}, L_{aq}, L_d, L_q,L_{afd},L_{ffd}, L_{fd},R_a,R_{fd}	BTL 5	1	Evaluating
2	The following are the parameters in per unit on machine rating of a 555MVA, 24KV, 0.9p.f., 60Hz, 3600RPMturbinegenerator L_l=0.15,L_{ad}=1.66L_{aq}=1.61L_{fd}=0.165R_{fd}=0.0006, L_{1d}=0.1713, R_{ld}=0.0284 L_{lq}=0.7252, R_{lq}=0.00619, L_{2q}=0.125,R_{2q}=0.02368, R_a=0.003,L_{fkd} is assumed to be equal to L_{ad}. When the generator is delivering rated MVA at 0.9p.f.(lag) and rated terminal voltage,compute internal angle δ_i in electrical degrees, per unit values of e_d, e_q ,i_d,i_q,i_{1d},i_{1q},i_{2q},$i_{fd}$$e_{fd}$,$\psi_{fd}$, ψ_{1d} ,ψ_{1q} , ψ_{2q},Airgap torque $T_e$in per unit and in Newton-meters. Assume that the effect of magnetic saturation at the given Operating condition is to reduce Lad and Laqto 83.5% of the value given above. Compute the internal angle δ_i and field current i_{fd} for the above operating condition ,using the approximate equivalent circuit. Neglect R_a.	BTL 5	1	Evaluating
3	The following data pertains to per-unit unsaturated values of d-axis reactance of a 500MW, 588 MVA,15.75KV,50Hz,2-pole turbo generator on its rating: Xd =2.35; Xd'=0.253; Xd''=0.172; Xleakage=0.179. The direct axis open circuit time constants are: T'do =8.0 sec and T''do =0.04 seconds. Evaluate the elements of the inductance matrix encountered in d-axis rotor winding voltage equations using the appropriate data conversion procedure. (ii)Explain briefly the effect of neglecting transformer EMF terms in stator voltage equation of the synchronous machine model for stability analysis.	BTL 5	1	Evaluating
4	A 555MVA, 24KV,0.9 p.f.,60Hz, 3phase,2 pole synchronous generator has the following inductances and resistances associated with the stator and field windings: laa=3.2758+0.0458cos(2θ)mH ; lab=-1.6379-0.0458cos(2θ+p/3)mH; lafd=40.0cosθmH Lffd=576.92mH; Ra=0.00310; Rfd=0.0715 0. (i) Determine Ld and Lq in henrys (ii). If the stator leakage inductance Ll is 0.4129 mH, determine Lad and Laq in Henrys (iii). Using the machine rated values as the base values for the statorquantities, determine the per unit values of the following in the Lad base reciprocal per unit system: Ll, Lad, Laq, Ld, Lq,Lafd,Lffd, Lfd,Ra,Rfd.	BTL 5	1	Evaluating

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SUBJECT : 1916201-POWER SYSTEM DYNAMICS

SEM / YEAR: I Year II SEM M.E., Power Systems Engineering

UNIT II - MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS

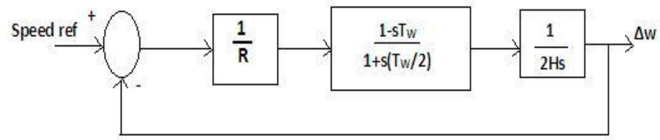
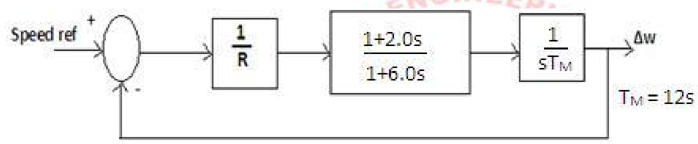
Excitation System Requirements; Elements of an Excitation System; Types of Excitation System; Control and protective functions; IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System Modeling: Functional Block Diagram of Power Generation and Control, Schematic of 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.

PART –A

Q.No	Questions	BT Level	CO	Competence
1.	Define excitation system	BTL 1	2	Remembering
2.	Prepare the list of elements of an excitation systems	BTL 6	2	Creating
3.	Classify the different types of AC excitation system?	BTL 3	2	Applying
4.	Explain speed governing system?	BTL 5	2	Evaluating
5.	Illustrate the functional block diagram of the excitation control system.	BTL 3	2	Applying
6.	Classify the transfer function of hydraulic turbine	BTL 3	2	Applying
7.	Discuss the role of governor in hydraulic urbine?	BTL 2	2	Understanding
8.	Explain the characteristics of hydraulic cturbine	BTL 5	2	Evaluating
9.	Show the electrical analogue of hydraulic turbine	BTL 3	2	Applying
10.	Give the list of protective functions applied in modeling of Excitation system	BTL 2	2	Understanding
11.	Give the block diagram of governor with transient droop compensation	BTL 2	2	Understanding
12.	Define steam turbine modeling	BTL 1	2	Remembering
13.	List the control functions used in modeling of excitation system	BTL 1	2	Remembering
14.	Define transient droop. List the requirements for transient droops?	BTL 1	2	Remembering
15.	Describe dynamic simulation	BTL 2	2	Understanding
16.	Define generic speed governing system model	BTL 1	2	Remembering
17.	Define turbine governing system	BTL 1	2	Remembering
18.	Compose the advantages of hydro electric plant	BTL 6	2	Creating
19.	Illustrate the difference between generic speed governing system model. ndturbine governingmodel	BTL 3	2	Applying
20.	Explain load control function?	BTL 4	2	Analyzing

PART – B

Q.No	Questions	BT Level	CO	Competence
1.	Discuss the elements of excitation system in detail.Also explain the various control and protective scheme of excitation system.	BTL 2	2	Understanding
2.	Describe in detail about the hydroelectric plant with its characteristics.	BTL 4	2	Analyzing
3.	Discuss in detail the functional block diagram of the excitation control system. What are the classification of Excitation systems?Explain in detail with necessary equations and IEEEsimulation block diagrams for the DC excitation system.	BTL 2	2	Understanding
4.	Draw the schematic of the potential source controlled Rectifier system and explain the operation in detail.	BTL 4	2	Analyzing
5.	Describe in detail about the hydro electric plant with its characteristics.	BTL 1	2	Remembering
6.	What are the requirements must be satisfied by the excitation system? Draw block diagram of a typical excitation control system for a large synchronous generator and explain each component in detail.	BTL 4	2	Analyzing

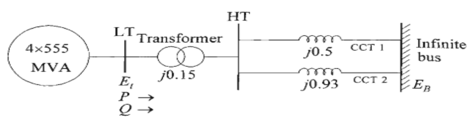
7.	In detail describe three forms of static excitation systems with diagrams.	BTL 3	2	Applying
8.	Illustrate the concept of turbine nd governing system modelling.	BTL 1	2	Remembering
9.	Describe the mathematical modeling for single reheat tandem-	BTL 1	2	Remembering
10.	(i)Using the block diagram shown in fig calculate(1)the lowest value of the droop(R) for which the speed control is stable and(2)the value Of R for which the speed control is critically damped. The H-constant of the generator is 5.0s and the water starting Time T_W=4.0s. 	BTL 3	2	Applying
11.	Describe the block diagram of Governor with transient droop	BTL 1	2	Remembering
12.	Explain the mathematical model of the governor for hydraulic	BTL 6	2	
13.	Explain the mathematical modeling of governor for hydraulic turbine.	BTL 5	2	Evaluating
14.	Discuss in detail about the Steam power plant with its characteristics.	BTL 2	2	Understanding
	PART – C			
1.	The blockdiagram shown in figurere presents Speed control of thermal unit feeding an isolated load. Evaluate (i)the lowest valueof(R)forwhich the speed control is stable and(ii)and value of R to yield critical damping. 	BTL 5	2	Evaluating
2.	A generator equipped with an alternator supplied controlled rectifier excitation system without load compensator is operating in steady state with an output E_{FD} of 2.598p.u. and a terminal voltage of 1.0p.u.Design the simulation block diagram recommended by IEEE(1992) and compute V_{ref}.Data for the excitation system model (IEEE, 1992):	BTL 6	2	Creating
3.	Describe the mathematical modeling for single reheat tandem-Compound steam turbine.	BTL 5	2	Evaluating
4.	Design a block diagram to investigate the stability of hydraulic governor loop formed by the following blocks:(a)governor represented by a simple gain (reciprocal of the droop)(b)non ideal hydraulic turbine represented by a simple transfer function with water starting time=2.0s.(c)Generator feeding an isolated load represented by its inertia(H=5.0s) and damping ignored. Determine (i) the lowest value of droop for which the speed control is stable and (ii) value of $R_{to.}$	BTL 6	2	Creating

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.

Q.No	Quest	BT Level	CO	Competence
	PART – A			
1.	Define the Classification of stability.	BTL 3	3	Applying
2.	Define the basic concept of rotor angle stability.	BTL 1	3	Remembering
3.	Describe the fundamental concept of stability of dynamic	BTL 2	3	Understanding
4.	Define rotor angle stability	BTL 1	3	Remembering
5.	Illustrate the state space representation?	BTL 3	3	Applying
6.	List the stability of dynamics systems	BTL 1	3	Remembering
7.	Define linearization in stability analysis	BTL 1	3	Remembering
8.	Prepare the Eigen properties of the state matrix	BTL 6	3	Creating
9.	Distinguish between Eigen values and Eigenvectors.	BTL 2	3	Understanding
10.	Discuss mode shape and participation factor?	BTL 2	3	Understanding
11.	Show the block diagram of SMIB configuration represented by classical Model.	BTL 3	3	Applying
12.	List the effects of field circuit's dynamics in synchronous	BTL 1	3	Remembering
13.	Infer the Classical machine model stability analysis with numerical	BTL 4	3	Analyzing
14.	Express the linearised system equations	BTL 2	3	Understanding
15.	Illustrate the block diagram of synchronous machine with k constants	BTL 3	3	Applying
16.	Explain the effect of field flux variation on system stability	BTL 4	3	Analyzing
17.	How does the global stability differ from localstability	BTL 4	3	Analyzing
18.	Explain the basic function of power system stabilizer?	BTL 5	3	Evaluating
19.	Differentiate between steady state and transient stability.	BTL 4	3	Analyzing
20.	Describe the SMIB configuration.	BTL 2	3	Understanding
	PART – B			
1.	(i)Briefly explain the fundamental concepts of stability of dynamicSystems. (ii) Why is linearization required for stability analysis? Describe with the suitable example.	BTL 1	3	Remembering
2.	Obtain the equation for Eigen properties of the state matrix and its characteristics of Eigen value and stability.	BTL 6	3	Creating
3.	Explainthesmallsignalstabilityofsinglemachineinfinitebussystem withClassical generator model. Derive all the necessary equations.	BTL 5	3	Evaluating
4.	Develop the following of field circuit's dynamics. (a).Synchronous Machine equation& (b).Network equations	BTL 6	3	Creating
5.	Briefly explain the single-machine infinite bus (SMIB)configuration.	BTL 4	3	Analyzing
6.	Discussindetailtheeffectsoffieldcircuitdynamicsinsmallsignalstab ility analysis.	BTL 2	3	Understanding
7.	Describe the state space representation in detail.	BTL 1	3	Remembering

8.	Evaluate the small signal stability analysis of the SMIB configuration as per the data given. Draw the Equivalent circuit for the SMIB system and find the synchronizing torque coefficient, eigen values, damping ratio, natural frequency and sensitivity w.r.t K_D=10. Data for the SMIB system Generator: 588MVA, 500MW, 21KV, 50Hz; Ra=0.0023, Xd=2.35, Xq=2.15,X'd=0.253,T'do=6.0s;H=3.07MW-s/MVA,Step up transformer Leakage reactance=j0.15Transmission line : X_{pos}=j1 per circuit. All reactance in pu on 588 MVA . Initial Operating condition: Active power out put of the generator P=0.85p.u; Reactive power output Q=0.52p.u (lagging);terminal voltage of the generator V_t=1.0p.u.Allresistances,shuntsincludinghalflinechargingandtheseriesimpedances between the double circuit transmission line and infinite bus ignored. This assumptions yields external impedance	BTL 1	3	Remembering
9.	Two identical machines feed a common load. The impedance between each machine terminal and the load bus is 0+j0.8p.u. on machine rated MVA. Other relevant data is given below. The terminal voltage of each machine is 1.0p.u. Determine the network equations in the individual machine rotor (d-q) coordinates for small signal stability analysis. Assume uniform damping and classical models for the machines; ignore governor action. Generator data: Both generators are identical, rating of each =123.5MVA; reactance parameters of each machine on its own rating are Xd=2.225,Xq =2.11, X'd =0.266, T'do=7.0sec.Total kinetic energy stored at synchronous speed of both machines=379.2MJ; rated frequency =50Hz. Loading Data: Both generators are identically loaded; active power output of each machine=0.5p.u. On total rated MVA; power factor=0.85.choose the base MVA as 247. Also, (i) Derive linearised network equations suitable for small signal stability analysis. (ii) Derive state equations for small signal stability analysis (iii) Compute Eigen values and comment on stability. Assume uniform damping and classical models for the machines; ignore governor action.	BTL 3	3	Applying
10.	Discuss the following terms in detail (i) Effects of fields flux variation on system stability. (ii) Mode shape and participation factor.	BTL 2	3	Understanding
11.	Explain the block diagram representation of small signal model of single machine infinite bus system with K constants.	BTL 1	3	Remembering
12.	Describe the fundamental concept of stability for dynamic systems.	BTL 2	3	Understanding
13.	Discuss about the effect of field flux linkage variation on power system stability. Draw the supporting diagram.	BTL 3	3	Applying
14.	Differentiate total saturation from incremental saturation with diagram and write the procedure of state matric formulation.	BTL 4	3	Analyzing
	PART C			

1.	Two identical machines feed a common load. The impedance between each machine terminal and the load busis0+j0.8 p.u.on total ratedMVA.Other relevant data is given below.The terminals a voltage of each machine is 1.0p.u.Ignore damping and assume classical models for the machines; ignore governor action and stator resistance. Generator data: Both generators are identical,rating of each=80MVA;reactance parameters of each machine on its own rating are X_d=3.4p.u, X_q=3.28p.u.,X'_d=0.49p.u., T'_{do}=6.0sec.Total kinetic energy stored at synchronous speed of both machines=379.2MJ; rated frequency=60Hz. Loading Data:Both generators are identically loaded; active power output of each machine =0.5p.u.On total rated MVA;power factor=0.85.choose the base MVA as160. (i) Evaluate the network equations in the individual machin rotor coordinates for small signal stability analysis. (ii)Linearised network Equations in the individual machine rotor coordinates (iii) Numerical expression for electrical torque.	BTL 5	3	Evaluating
2.	Summarize the effects of field circuit dynamics in small signal Stability analysis.	BTL 5	3	Evaluating
3.	Develop the equation for Eigen properties of the state matrix and its characteristics of Eigen value and stability.	BTL 6	3	Creating
4.	The figure shows the system representation applicable to a thermal Generating station consisting of four 555MVA, 24KV, 60 Hz units.  The network reactances shown in figare in per unit on2220MVA,24KVbase.Resistances are assumed to be negligible .The post fault system condition in per unit onthe2220MVA, 24KVbase is as follows. P=0.9 Q=0.3 over excited $E_t=1.0\angle 36°$ $E_B=0.99\angle 0°$. The generators are to be modeled as a single equivalent generator to represented by the classical model with the following parameters expressed in per unit on 2220MVA, 24KV base H=3.5MWs/MVA.a) Write the linearise equation of the system. Evaluate the eigen value damping frequency of oscillation in Hz, damping ratio and under damped natural frequency for each of the following values of damping coefficient K_D=10.(b) For K_D=10 find the left and right eigen vectors and participation matrix.	BTL 5	3	Evaluating

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. Metheds of improving stability.

PART – A

Q.No	Question	BT Level	CO	Competence
1.	Give the effect of excitation system	BTL 2	4	Understanding
2.	Define the simple thyristor excitation system	BTL 1	4	Remembering
3.	Show the block diagram with the excitation system	BTL 3	4	Applying
4.	Define power system stabilizer	BTL 1	4	Remembering
5.	Discuss the need for AVR?	BTL 2	4	Understanding
6.	Differentiate between AVR&PSS.	BTL 4	4	Analyzing
7.	Illustrate the principle of PSS application.	BTL 3	4	Applying
8.	Give the equations in a common reference frame of multi machine.	BTL 2	4	Understanding
9.	Classify the model for synchronous machines	BTL 3	4	Applying
10.	Define delta-omega stabilizers and p-omega stabilizers.	BTL 1	4	Remembering
11.	Differentiate between delta-omega&deltap-omega stabilizers	BTL 4	4	Analyzing
12.	Define PSS.	BTL 1	4	Remembering
13.	Illustrate the formation of system state matrix for a two machine system	BTL 3	4	Applying
14.	Define stabilization.	BTL 1	4	Remembering
15.	List the function of controllers used in small signal stability analysis	BTL 1	4	Remembering
16.	Define system state matrix.	BTL 1	4	Remembering
17.	Compose the principle behind the small signal stability improvements.	BTL 6	4	Creating
18.	Explain excitation	BTL 5	4	Evaluating
19.	Define K-constant.	BTL 1	4	Remembering
20.	What are the small signal stability improvement methods?	BTL 1	4	Remembering

PART – B

Q.No	Question	BT Level	CO	Competence
1.	Explain the stability analysis of a two machine system with classical model for a synchronous machine.	BTL 4	4	Analyzing
2.	Draw and explain the block diagram representation with exciter and AVR.	BTL 5	4	Evaluating
3.	Summarize the technical notes on the small stability improvement methods.	BTL 5	4	Evaluating
4.	Summarize the technical notes on the small stability of multi machine system.	BTL 2	4	Understanding
5.	(i)Explain the block diagram of power system stabilizer with AVR in detail. (ii) Explain a simple thyristor excitation system and AVR	BTL 4	4	Analyzing
6.	Draw the schematic diagram of P omega stabilizer and delta omega stabilizer and compare their properties and operation in detail.	BTL 3	4	Applying
7.	Briefly explain the principles of PSS applications with numerical examples	BTL 3	4	Applying

8.	Briefly differentiate between the delta omega & delta p-omega stabilizers	BTL 4	4	Analyzing
9.	Develop the state equation model for the multi machine system with one axis model.	BTL 6	4	Creating
10.	Discuss in detail with necessary equations and block diagram of SMIB configuration with the inclusion of PSS and the effect of increasing the phase lead provided by the PSS.	BTL 2	4	Understanding
11.	Discuss about shaft speed signal based stabilizer and frequency based stabilizer operation.	BTL 1	4	Remembering
12.	Write a short note on (i) Stabiliser limits and (ii) Stabiliser signal washout stabilizer gain.	BTL 1	4	Remembering
13.	In detail explain the operation of thyristor excitation system with AVR and examine the effect of AVR on synchronizing and damping torque components.	BTL 1	4	Remembering
14.	Discuss the behavior of thyristor excitation system with AVR and PSS.	BTL 1	4	Remembering
	PART – C			
1.	(i)Briefly Illustrate the formation of system state matrix for a two machine system with classical models.	BTL 4	4	Analyzing
2.	Design a small signal model of single machine infinite bus system with Kco.	BTL 6	4	Creating
3.	Compare the properties and operation in detail of P omega stabilizer and delta omega stabilizer with schematic diagram.	BTL 5	4	Evaluating
4.	Formulate the state equation model for the multi machine system with one axis model.	BTL 6	4	Creating

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

PART – A

Q.No	Questions	BT Level	CO	Competence
1.	Explain power stabilizer	BTL 4	5	Analyzing
2.	List the types of stabilizers.	BTL 1	5	Remembering
3.	Explain small signal stability?	BTL 5	5	Evaluating
4.	Define exciter gain	BTL 1	5	Remembering
5.	Describe phase lead compensation	BTL 2	5	Understanding
6.	Give the stabilizer limits	BTL 2	5	Understanding
7.	Define frequency based stabilizers	BTL 1	5	Remembering
8.	Comparison between delta omega& deltap-omega stabilizers	BTL 5	5	Evaluating
9.	Discuss enhancement of small signal stability	BTL 2	5	Understanding
10.	Describe shaft speed signal?	BTL 2	5	Understanding
11.	On what basis the stabilizers are classified?	BTL 4	5	Analyzing
12.	Prepare the list of merits & demerits of digital stabilizers	BTL 3	5	Applying
13.	List the applications of frequency based stabilizers	BTL 1	5	Remembering
14.	Write the expression for stabilizing signal washout stabilizer gain.	BTL 1	5	Remembering
15.	Explain how to enhance the signal stability	BTL 3	5	Applying
16.	Classify the power system stabilizers	BTL 1	5	Remembering
17.	Comparison between phase lead &lag compensations	BTL 5	5	Evaluating
18.	Compose the need for digital stabilizer.	BTL 6	5	Creating
19.	Prepare the list of major disadvantages associated with delta-omega stabilizer?	BTL 6	5	Creating
20.	Explain stabilizer gain.	BTL 4	5	Analyzing
	PART – B			
1.	What is power system stabilizer and why it is used?How can you design a power system stabilizer?	BTL 6	5	Creating
2.	Explain the Special techniques for the analysis of very large systems.	BTL 4	5	Analyzing
3.	Explain the following briefly: (a).Digital excitation (b).Design of Phase lead compensation.	BTL 4	5	Analyzing
4.	Discuss the role of power system stabilizers for the enhancement of small signal stability	BTL 2	5	Understanding
5.	Explain the following briefly: (a). Digital stabilizers (b). Excitation control design	BTL 5	5	Evaluating
6.	Describe briefly the stabilizing signal washout stabilizer gain with some examples	BTL 1	5	Remembering
7.	Briefly differentiate between delta omega & delta p-omega stabilizers.	BTL 2	5	Understanding
8.	Explain in detail with necessary equation and block diagram the Supplementary control of synchronous machine excitation using three types of PSS.	BTL 4	5	Analyzing
9.	Write short notes on: (i) Digital Stabiliser (ii) Phase lead compensation and (iii) Delta –P-Omega stabilizer.	BTL 5	5	Evaluating
10.	(i)Compare the properties of P-Omega stabilizer and Delta Omega stabilizer. (ii)Explain with a neat function block diagram, the excitation control design.	BTL 5	5	Evaluating
11.	Draw the schematic diagrams of P omega stabilizer and delta omega stabilizer and compare their properties and operation in detail.	BTL 1	5	Remembering
12.	Explain the following: (i) Phase lead compensation (ii) Excitation control design..	BTL 1	5	Remembering

13.	What are power system stabilizers? Explain the alternative type of PSS.	BTL 1	5	Remembering
14.	Explain the operation of stabilizer based on shaft speed signal.	BTL 2	5	Understanding
PART – C				
1.	(i) Explain with a neat schematic diagram the operation of a power system stabilizer. (ii) Explain with a neat diagram the frequency based stabilizer.	BTL 5	5	Evaluating
2.	Explain the generator tripping and what are the types of control measures for improving system stability.	BTL 6	5	Creating
3.	Summarize the role of power system stabilizers for the enhancement of small signal stability.	BTL 4	5	Analyzing
4.	Design a Power system stabilizer (PSS).	BTL 6	5	Creating

COURSE OUTCOMES (CO):

1. **Learners will be able to understand on dynamic modeling of synchronous machine.**
2. **Learners will be able to understand the modeling of excitation and speed governing system for stability analysis.**
3. **Learners will attain knowledge about stability of dynamic systems.**
4. **Learners will understand the significance about small signal stability analysis with controllers.**
5. **Learners will understand the enhancement of small signal stability.**