Ref No.:Ex/EE/5/T/323/2023(S)

BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING) THIRD YEAR SECOND SEMESTER SUPPLEMENTARY EXAM - 2023

SUBJECT: POWER SYSTEM PERFORMANCE

Time: Three Hours

Full Marks: 100
(50 Marks for each part)

Use a separate Answer-Script for each part
Two marks for neat and well-organized answers

Question No.		Part-I	Marks
		Answer any three questions	
1.	(a)	"In a power system, P-δ and Q-V are strongly coupled" – justify the statement.	6
	(b)	Explain "Infinite Bus" and its characteristics.	4
	(c)	Derive the active power versus power angle curve for a salient pole rotor synchronous generator.	6
2.	(a)	For a generator delivering constant power to an infinite bus, the variation of excitation results in change of power factor – Explain with the help of proper phasor diagrams. Also explain "Synchronous Condenser".	8
	(b)	A turbo-generator feeds 0.25 p.u. power to infinite bus at 1 p.u. voltage. The excitation voltage is 1.5 p.u. and synchronous reactance is 1 p.u. Calculate the load angle and reactive power output of the generator. Also calculate the changes in active & reactive Power if (i) The turbine valve opening is increased corresponding to 100% increase in turbine torque keeping the excitation constant. (ii) The turbine valve opening is kept constant at the initial value and the excitation is increased by 20%.	8
3.	(a)	Derive the following expression $\Delta f = -\left(\frac{1}{B+(1/R)}\right)\Delta P_D$ where the symbols have their usual meanings. Assume an isolated complete automatic load frequency control system block diagram.	10

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(b) Two generators rated 400 MW and 600 MW are operating in parallel. The droop characteristics of their governors are 3% and 4% respectively from no load to full load. Assuming that the generators are operating at 50 Hz at no load, how would a load of 800 MW is shared between them and What will be the system frequency at this load? Assume linear governor operation. 6

4. (a) Explain the equal area criterion for stability. 8

(b) A 200 MVA, 100 kV, 50 Hz, 4 pole turbo alternator has an inertia constant of 6 MJ/MVA. 8

- (i) Find the stored energy in the rotor.
- (ii) The machine is operating at 120 MW when the load is suddenly increased to 160 MW. Find the rotor deceleration.

5. Write short notes on any two of the following: 2×8

- (i) Use of Auto-reclose CBs and Braking Resistors for improvement of transient stability.
- (ii) synchronizing power coefficient.
- (iii) Critical Clearing Angle.
- (iv) The function of over excitation and under excitation limiters and power system stabilizers in connection with an excitation system

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<u>Part II</u> (50 Marks)

Question No. — <u>*Answer any three questions(2 marks reserved for neat and well organized answers)*</u> — **Marks**

1\. a) Derive an expression for the complex power at the sending end of a transmission line in terms of the voltages at its two ends and transmission line parameters. Assuming that the magnitude of the voltage at the two ends of the line remains fixed, show that the locus of the complex power at the sending end would be a circle. Write down the expression for its radius and coordinates of the centre. What will be the effect on the locus diagram if the voltages at the two ends vary? — 8

b) A three phase overhead transmission line has circuit constants $A=0.98\angle 1^0$ and $B=210\angle 86^0$ ohm. The voltages at the sending end and receiving end are held constant at 225 kV and 220 kV respectively. Select a suitable scale and draw the receiving end power circle diagram. Compute graphically (i) the maximum power that might be delivered over the line (ii) the operating load angle when the line is supplying a load of 50 MW at 0.85 power factor lag at the receiving end. — 8

2\. a) Derive static load flow equations. Explain how the buses of a power system are classified in load flow study. Why is the concept of slack bus needed in load flow study? How is it chosen? — 4+4+4

b) Calculate the elements of the bus admittance matrix(approximated upto two decimal places) for a three bus power system having line data as follows: — 4

Line no.	From bus	To bus	Line impedance(p.u.)	Half-line charging admittance(p.u.)
1	1	2	0.01+j0.2	j0.001
2	1	3	0.01+j0.15	j0.002
3	2	3	0.02+j0.25	J0.003

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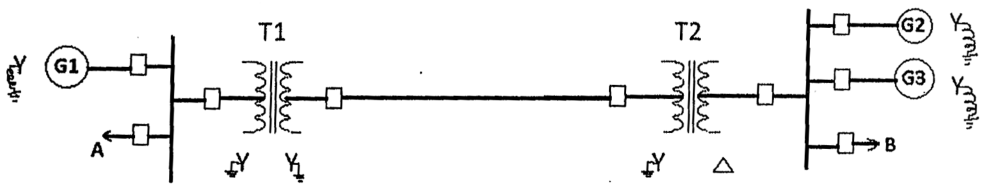
Use a separate Answer-Script for each part

3.a) Obtain the per unit impedance(reactance) diagram of the power system shown in the figure below. 10



Generator G1: 30 MVA, 10.5 kV, X" =1.6 ohms
Generator G2: 15 MVA, 6.6 kV, X" =1.2 ohms
Generator G3: 25 MVA, 6.6 kV, X" =0.56 ohms
Transformer T1: 15 MVA, 33/11 kV, X = 15.2 ohms per phase on HT side
Transformer T2: 15 MVA, 33/6.2 kV, X = 16 ohms per phase on HT side
Transmission line: 20.5 ohms/ phase
Load A : 15 MW, 11 kV, 0.9 lagging p.f.
Load B : 40 MW, 6.6 kV 0.9 lagging p.f.

b) Discuss the importance of the per unit method of calculation in the context of power system analysis. 6

4. a) Write down the expression for the fuel cost of a thermal power generating unit and justify it. Deduce the condition for most economic loading of alternators of a thermal power plant. 2+6

b) A load of 700 MW is to be shared by the three generators at a power plant. Determine the optimum distribution of the load assuming operating limits and the co-efficients of fuel cost characteristics of the generators as given below: 8

Generator No.	a(Rs./MW^2 H)	b(Rs./MW H)	c(Rs./Hr)	P_{min}(MW)	P_{max}(MW)
1	0.020	20	250	25	250
2	0.025	25	300	50	300
3	0.030	15	500	60	500

5. a) Mention the advantages of HVDC transmission. 6

b) Discuss different types of HVDC links with the necessary schematic diagram. 6

c) Mention the functions of major components of HVDC transmission system. 4