Ref No.: Ex/EE/5/T/323/2023

BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING) THIRD YEAR SECOND SEMESTER - 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)	Derive the active power versus power angle curve for a cylindrical rotor synchronous generator.	6
	(b)	Explain "Infinite Bus" and its characteristics.	4
	(c)	"In a power system, P-δ and Q-V are strongly coupled" – justify the statement.	6
2.	(a)	Draw phasor diagrams to represent an alternator under normal excited condition, over excited condition and under excited condition, when delivering constant real power.	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
	(b)	Two synchronous generators rated 200 MW and 400 MW having governor droop characteristics of 4 % and 5 % are operating in parallel. If the generators operate on no load at 50 Hz, determine how a total load of 600 MW is shared between them and at what frequency would they now operate.	6

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4. (a) Derive and explain the swing equation for synchronous generators. State the assumptions you make. 8

(b) A 50Hz, four pole turbogenerator rated 100MVA, 11kV has an inertia constant of 8MJ/MVA 8

(i) Find the stored energy in the rotor at synchronous speed

(ii) If the mechanical input is suddenly raised to 80MW for an electrical load of 50MW, find rotor acceleration, neglecting mechanical and electrical losses

(iii) If the acceleration calculated in part (ii) is maintained for 10 cycles, find the change in torque angle and rotor speed in revolution per minute at the end of this period.

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) Steady state stability of power system.

(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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Bachelor of Engineering (Electrical Engineering) Third Year Second Semester Examination-2023

SUBJECT : POWER SYSTEM PERFORMANCE

Full Marks -100

Time : Three hours

Use a separate Answer-Script for each part

No. of question	Part II (50 Marks) Answer any three questions (Question no. 1 carries 18 marks)	Marks
1. a)	Explain the advantages of per unit system in power system.	4
b)	Three generators are rated as follows: G_1 : 100 MVA, 35 kV, reactance=10% G1 : 150 MVA, 32 kV, reactance=12% G1 : 110 MVA, 30 kV, reactance=9% Choosing 200 MVA and 33 kV as base quantities, compute per unit reactances of three generators referred to these base quantities. Draw the reactance diagram. The generators are connected to common bus bars.	10
c)	Show that the value of per unit equivalent series impedance of a transformer is independent of the side to which it is referred.	4
2. a)	Derive static load flow equations (SLFE) in terms of the bus admittance matrix and bus voltage. Explain why and how the buses of a power system are classified in load flow study.	7
b)	Write the load flow equation in the form suitable for solution by Gauss-Siedal iterative method and explain why some iterative method has to be employed for their solution. Write a flowchart or algorithm to compute bus voltages by Gauss-Siedal method of load flow analysis.	9
3.a)	Derive an expression for the complex power at the receiving end of a transmission line in terms of the voltages at its two ends and the transmission line parameters. Assuming the magnitude of the voltages at the two ends of the line to remain fixed, show that the locus of the complex power at the receiving end would be a circle. Write down the expression for its radius and coordinates of its centre.	6
b)	A three phase over-head transmission line has circuit constants $A=0.9\angle 2^0$ and $B=150\angle 85^0$ ohm. The voltages at the sending and receiving ends are held constant. The line delivers at the receiving end a load of 80 MW at 220 kV and 0.9 power factor lead. Draw the receiving end power circle diagram with a scale of 1cm=50 MVA. Find graphically (i) the sending end voltage, (ii)operating load angle. Also calculate (iii) the output of the VAR compensator connected at the receiving end so that the same load can be supplied with a sending end voltage of 220kV.	10

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Table 1 Laboratory test data of CBR test

Penetration		PRIVING RING		
STRAIN DIAL	mm	Dial Gauge Reading		
50.0	0.5	21	8	12
100.0	1.0	39	19	18
150.0	1.5	58	29	21
200.0	2.0	73	39	29
250.0	2.5	86	49	36
300.0	3.0	99	58	41
350.0	3.5	110	67	47
400.0	4.0	119	75	52
450.0	4.5	127	82	56
500.0	5.0	135	88	59
600.0	6.0	148	97	166
700.0	7.0	160	105	171
800	8.0	170	111	176.5
900	9.0	179	118.5	181.5
1000	10.0	188	123	186
1250	12.5	207	135	296

Table 2.0 Laboratory test data of Marshall Test

Binder content	Thickness of specimen (mm)			Weight in Air (gm)			Weight in Water (gm)		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
4.00%	63.26	62.48	61.61	1228	1219.5	1205.5	716.5	712.2	705.3
4.50%	64.98	63.96	63.28	1277	1252.6	1243.5	747.3	733.3	730.7
5.00%	63.58	63	63.44	1254	1238.3	1239	738.2	726.8	724.9
5.50%	62.93	65.93	64.87	1238	1300	1273.6	727	763.6	746.9
6.00%	63.21	64.46	65.77	1237	1264	1286.4	724.1	740.6	752.4

Binder content	Thickness of specimen (mm)			Weight in Air (gm)		
	S1	S2	S3	S1	S2	S3
4.00%	1049.4	991.2	1012.4	2.2	2.07	2.15
4.50%	1148.5	1085.9.	1102.2	2.57	2.35	2.31
5.00%	1114.7	1147.4	1142.5	3.18	3.24	3.12
5.50%	1020.6	1031.5	1039.7	3.64	3.54	3.66
6.00%	788.2	879.1	833.3	3.86	3.78	3.75

Component	Specific Gravity	Weight (g)
Coarse Aggregate	2.76	8000
Fine Aggregate	2.66	4000
Filler	2.77	414
Bitumen	1.05	Depends on %