

**BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING) THIRD YEAR
SECOND SEMESTER - 2024**

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 are reserved for neat and well-organized answers

Question No.	Part-I	Marks
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Answer any three questions

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| 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 cylindrical rotor hydro generator is feeding an active power of 0.25 p.u. into a large network bus which is held at 1 p.u. voltage. The generator is overexcited with an induced voltage of 1.5 p.u. The synchronous impedance of the generator and the connecting link are $j0.75$ p.u./phase and $j0.11$ p.u./phase, respectively. Calculate the percentage change in reactive power output measured at the network bus if the turbine torque is held constant at the initial value but excitation is increased by 20 %. (Neglect saturation). | 8 |
| 3. | (a) | With relevant sketches explain the operation of the speed governor system and derive its transfer function. | 10 |
| | (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 |

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4. (a) Derive and explain the swing equation for synchronous generators. State the assumptions you make. 8
- (b) With relevant sketches, discuss how the fault clearing time affects the stability of the system. Also evaluate the critical clearing time for the system. 8
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) Synchronous Condenser.
 - (iv) The function of over excitation and under excitation limiters and power system stabilizers in connection with an excitation system

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Part II (50 Marks)

Question No.	Answer any three questions (Question no. 1 carries 18 marks)	Marks
1. a)	Discuss how p.u. values of impedance changes with change in base values. Show that the value of equivalent p.u. series impedance of a transformer is independent of the side to which it is referred.	4+4
b)	A three phase over-head transmission line has circuit constants $A=0.95 \angle 2^\circ$ and $B=50 \angle 85^\circ$ ohm. The voltages at the sending and receiving ends are held constant. The line delivers at the receiving end a load of 50 MW at 66 kV and 0.8 power factor lag. Draw the receiving end power circle diagram with a scale of 1cm=20 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 70kV.	10
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. Why is the concept of slack bus needed in load flow study? How is it chosen?	(4+4+4)
b)	What do you understand by shunt reactive compensation and series reactive compensation in power system? When and why are they needed?	4
3. a)	What is symmetrical fault? What is unsymmetrical fault? Name different type of symmetrical and unsymmetrical faults.	6
b)	There is a solid three phase fault at HT terminal of the motor transformer in the power system shown in Fig.1. Draw the reactance diagram of the network under faulted condition and calculate the fault current and fault MVA. Also calculate fault MVA.	10

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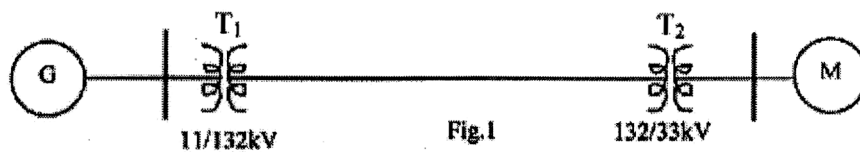
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G : 60 MVA, 13.8 kV, X=20%, M: 50 MVA, 30 kV, X=15%
 T₁ : 50 MVA, 11/132 kV, X=10% T₂ : 60MVA, 132/33 kV, X=12%
 Line: X=j75 Ω

4. a) Determine the bus admittance matrix of 4-bus system, the parameters of which are given below: 8

Bus code	Line impedance(p.u.)	Half-line charging admittance (p.u.)
1-2	0.02+j0.06	0.0+j0.030
1-3	0.08+j0.24	0.0+j0.025
2-3	0.06+j0.18	0.0+j0.020
2-4	0.06+j0.18	0.0+j0.020
3-4	0.01+j0.03	0.0+j0.010

- b) The fuel cost of a three unit plant is given below: 8

$$C_1 = 0.5P_1^2 + 215P_1 + 5000 \text{ Rs/hr}$$

$$C_2 = 1.0P_2^2 + 270P_2 + 5000 \text{ Rs/hr}$$

$$C_3 = 0.7P_3^2 + 160P_3 + 9000 \text{ Rs/hr}$$

Where P₁, P₂ and P₃ are in MW. The plant supplies a load of 320 MW. Find economic load scheduling of the three units and incremental fuel cost. Neglect losses.

5. a) Draw the input and output voltage waveforms of a six pulse converter operating at zero delay angle and fed from a sinusoidal source. Derive an expression for the average dc output voltage of the converter in terms of firing angle of the thyristors and line to line rms voltage of the ac side. 10

- b) What are the main advantages and disadvantages of HVDC transmission over its ac counterpart? 6