Ref. No.: Ex/EE/PC/B/T/321/2023(S)

B.E. ELECTRICAL ENGINEERING THIRD YEAR SECOND SEMESTER SUPPLEMENTARY EXAM 2023

POWER SYSTEM PERFORMANCE

Time: Three hours Full Marks: 100

(50 marks for each part)
Use separate answer script for each part.
PART I
Figures in the margin indicate full marks

Group-A
Answer any one question out of two

1. (a) Prove analytically that the locus of sending end complex power of any transmission line can be represented by a circle under certain conditions. State the conditions. (4)

(b) A 100 km long 50 Hz, three phase over-head transmission line has a series impedance of (0.02+ j0.10) ohm/km and delivers at the receiving end a load of 36 MW at 33 kV and 0.9 power factor lead. Draw the receiving end power locus with a scale of 1cm = 20MVA. Then find graphically (i) the sending end voltage, (ii) the load angle and (iii) the loadability limit for above values of voltages at the two ends, assuming that maximum load angle will not exceed 35^0. (10)

(c) Discuss how OLTC transformer and booster transformer help in improvement of voltage of a power system bus. (6)

2. (a) An alternator delivers a load of (20+j10) MVA at 11 kV to a load connected at the receiving end through a pair of on-load-tap-changing transformers, one, at each end of a 132 kV transmission line. The reactance of each transformer on 25 MVA, 132 kV base is 0.1 per unit, and the line reactance is 69.7 ohm. Assuming the tap ratio of each transformer to be reciprocal of each other, determine their tap settings which would maintain the load voltage at the same value as at no-load condition. assuming that the sending end voltage remains constant. Derive the formula used. (6)

(b) Show that the value of equivalent p.u. series impedance of a transformer is independent of the side to which it is referred. (4)

(c) Derive the expression for voltage drop in a lossless transmission line in terms of receiving end power, receiving end voltage and line reactance. Explain when and why following compensations are employed a) shunt capacitive compensation b) shunt inductive compensation. (10)

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Group-B
Answer any one question out of two

3. (a) A station operating at 33kV is divided into two sections A and B. Section A consists of three generators 15MVA each having a reactance of 15% and section B is fed from grid through a 75 MVA transformer of 8% reactance. The feeder circuit breakers have a rupturing capacity of 750MVA each. Determine the reactance of the reactor (in ohm) to be connected between two busbar sections to prevent the breakers from being overloaded if a symmetrical short circuit occurs on an outgoing feeder connected to A. (5)

(b) The parameters of a three bus system are as under: (5)

Line no.	Bus-code *p-q*	Line impedance (p.u.)	Line charging admittance (p.u.)
1	1-2	0.02+j0.2	j0.002
2	2-3	0.01+j0.25	j0.002
3	1-3	0.01+j0.3	j0.002

Compute the elements of bus admittance matrix.

(c) What do you understand by transient, sub-transient and steady state conditions? How an alternator would behave during the transient, sub-transient and steady state periods? (5)

4. Derive static load flow equations in the form suitable to solve using Gauss-Seidel iterative method. Explain why iterative method has to be employed for their solution. Write a flowchart or algorithm to compute bus voltages by Gauss-Seidel method of load flow analysis. (6+3+6=15)

Group-C
Answer any one question out of two

5. (a) Discuss the functions of the following components in a HVDC station (6)
   i) Smoothening reactor
   ii) AC and DC Filter
   iii) Reactive power compensator

(b) State the advantages and disadvantages of HVDC transmission over HVAC transmission. (3)

(c) Deduce the condition for most economic loading of alternators in a power plant. Discuss the steps to be taken if the power output as obtained from the above condition exceeds the generation limits of a generator. (6)

6. a) Write the fuel cost function of a turbo-alternator and explain it. (3)

b) Draw a neat schematic diagram of a six-pulse bridge converter and explain its operation. Sketch the input and output voltage waveforms when operating from a three phase sinusoidal ac source with a delay angle of α ($\alpha \leq 90^\circ$). (6)

c) Discuss different types of HVDC links with necessary schematic diagrams. Discuss their relative merits and demerits. (6)

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No. of Questions	PART -II Answer ONE question from EACH OF THE FOLLOWING GROUPS. Figures in the margin indicate full marks	Marks
	GROUP- A [CO 4, K3]	
1) a) i)	Illustrate and justify the following statements: "It is crucial to maintain the System Frequency within a narrow range."	(2×5= 10)
ii)	"Active power flow is strongly coupled with power angle and Reactive power flow is strongly coupled with voltage.".	
b)	Illustrate with proper phasor diagrams how, for a non-salient pole synchronous generator delivering constant power to an infinite bus, the power factor changes with variation of excitation.	(6)
c)	Illustrate "Infinite Bus". Explain its characteristics.	(4)
d)	Illustrate steady state stability criterion.	(2)
2) a)	Illustrate with proper discussion how the surplus power in the power system can be accounted for and develop the corresponding expressions. Assume ΔP_G = Increased Generator Power Output & ΔP_D= Change in Load and $\Delta P_G > \Delta P_D$.	(8)
b)	Illustrate with a proper block diagram the supplementary control in connection with Load frequency control.	(6)
c)	Two alternators, rated at 1000 kW and 800 kW, are connected in parallel and their frequency characteristics are respectively 4Hz/1000kW and 5Hz/800 kW, each having a no-load frequency of 50Hz. Find the operating frequency and the load shared by the two machines when the load is 1200 kW. If the load on the first machine is increased by 100 kW, determine the new operating frequency and the load shared by the other machine.	(8)
	GROUP- B [CO 5, K3]	
3) a)	A 50 Hz, 100 MVA four pole, synchronous generator has an inertia constant of 3.5 s and is supplying 0.16 p.u. power on a system base of 500 MVA. The input to the generator is increased to 0.8 p.u. Determine (i) K.E. stored in the moving parts of the generator and the (ii) acceleration of the generator. If the generator	(8)

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		continues for 7.5 cycles, calculate (iii) the change in rotor angle and (iv) the speed in rpm at the end of the acceleration.	
	b)	Develop the swing equation of a synchronous generator.	(6)
	c)	Illustrate rotor angle stability and voltage stability.	(3)
	d)	Illustrate the requirement of power system stability studies.	(3)
4)	a)	Illustrate with relevant diagrams the Equal Area Criterion for Transient Stability.	(8)
	b)	Illustrate how the steady-state stability of a power system can be improved.	(4)
	c)	Illustrate how the transient stability of a power system can be improved by the following: (i) auto-reclose circuit breakers and (ii) braking resistors.	(8)
		GROUP- C [CO 6, K3]	
5)		Illustrate the operations of the following (use proper diagrams wherever needed): **(any one)** (i) Static Excitation Systems. (ii) Alternator-supplied Controlled-rectifier Excitation system. (iii) Volt/Hz limiter and AC & DC regulators in the excitation system of an alternator.	(8)