Ref. No.: Ex/EE/5/T/522E/2023

BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING) FIFTH YEAR SECOND SEMESTER EXAM 2023

ADVANCED TOPICS IN POWER SYSTEMS

Time: Three hours Full Marks: 100

(50 marks for each part)

Use separate answer script for each part.

PART I

Answer **any five** questions.

Figures in the margin indicate full marks

1. Explain clearly how a FC-TCR type SVC maintains the voltage of a power system bus. Draw its voltage-current characteristics and explain it. (10)

2. Derive the expressions for reactive powers both at sending end and receiving end of a lossless transmission line in terms of SIL, load angle and electrical length of the line when both the sending end and receiving end are maintaining same voltage magnitude. Show the variation of reactive power at the two ends with increase in loading of the line and explain it. (10)

3. With proper explanation discuss the different control modes and related operating characteristics of the converters in an HVDC link for proper operation of the link. (10)

4. Derive the expression for the active power transferred through a lossless transmission line in terms of SIL, load angle and electrical length of the line when both the sending end and receiving end are maintaining same voltage magnitude. Also derive the expression for the active power transferred through the line when a SVC is connected at the midpoint of the line and maintaining same voltage level as of the two line ends. Find the ratio of maximum power transferred for these two cases. (10)

5. A 3-phase, 50 Hz, 400 kV, 900 km long transmission line having parameter value $Z_c = 300\Omega$ and $\beta = 0.06^0$ / km (the symbols have their usual significance) is operating with $V_S = V_R = 1.0$ p.u. and $\delta = 60^0$. A SVC with slope reactance 0.05 p.u. is connected at the midpoint of the line to increase its power transfer capacity. The limits on the control range of SVC correspond to $\delta = 30^0$ and $\delta = 90^0$ with its reference voltage corresponds to $\delta = 60^0$. Calculate the operating range of SVC susceptance. (10)

[Turn over

6.(a) Draw a neat schematic diagram of a six-pulse bridge converter and explain its operation. Sketch the input and output voltage wave-forms when operating from a three phase sinusoidal ac source with a delay angle of α ($\alpha \leq 90^{o}$). (6+4)

b) Deduce expression for the output dc voltage of a six-pulse bridge converter in terms of ac rms voltage and α, where α is the firing angle.

7.(a) Find the Thevenin's equivalent circuit at the midpoint of a lossless transmission line. (2+8)

(b) A SVC with slope reactance, X_{SL} and reference voltage, V_{ref} is installed at the midpoint of a lossless transmission line. Derive the expression for the active power transferred in terms of X_{SL} , V_{ref}, X_{Th} , V_{Th}. Where X_{Th} , V_{Th} are the Thevenin's equivalent reactance and voltage respectively at the midpoint of the line without SVC. Compare the amount of power transferred in presence of SVC with the case when SVC is absent in the system. What will happen when SVC will hit its maximum or minimum limit?

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No. of Questions		PART -II Answer any Three (Two marks reserved for well-organized answers)	Marks
1)		With regard to a power system explain system security and its functions. In this regard with relevant diagrams also explain optimal dispatch, post contingency dispatch, secure dispatch and secure post contingency dispatch.	(16)
2)		Briefly explain contingency analysis procedure. Why A.C load flows are generally not used for contingency analysis? In this regard define generation shift factor and line outage distribution factors. Explain how these factors are used in contingency analysis.	(16)
3)		Explain State estimation and state its applications. With a complete flowchart explain the Weighted Least Square Estimation (WLSE) for Power System State Estimation.	(16)
4)	a)	Discuss the modelling of the following for harmonic analysis in power system.: (i) Induction Motor, (ii) Power grid (iii) transmission line.	(10)
	b)	Give a brief account of the sources of harmonics in a power system.	(6)
5)	a)	Discuss the basic components of a digital protection scheme.	(8)
	b)	In what ways digital relaying may be considered to be superior to the conventional relaying techniques.	(8)