Ref. No.: Ex/PG/EE/T/1210C/2024

M.E. ELECTRICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAMINATION 2024
POWER ELECTRONICS APPLICATION IN EHV TRANSMISSION

Time: Three hours | Full Marks: 100 (50 marks for each part)

Part-I

Answer **any two** questions.
Figures in the margin indicate full marks

1.(a) A lossless transmission line is maintaining the voltage magnitude at both of its ends as V. Derive the expression for the midpoint voltage of the line in terms of V and load angle (δ). Also derive the expressions for active and reactive power both at sending end and receiving end of a lossless transmission line in terms V and δ. (13)

(b) Discuss the effect of midpoint compensation in power transmission in terms of active and reactive power transferred to receiving end of the line with suitable derivation. Is it possible to obtain flat voltage profile throughout the length of a transmission line using midpoint compensation? – Justify your answer. (12)

2(a) Draw a schematic diagram to implement an UPFC using two back to back voltage source converters and explain its operation. (7)

(b) With the help of phasor diagram, discuss how UPFC is capable to control voltage regulation, line impedance compensation, phase shifting between end bus voltages or any of these three operations at a time for a EHV transmission line. (18)

3.(a) Derive the expression for complex power flow through the transmission line supported with TCSC. (10)

(b) Write the equations in matrix form, to be solved by N-R method of load flow when a TCSC is installed in a line of a multibus power network. Derive the expressions for new elements of Jacobian matrix, introduced due to the TCSC. (15)

4.(a) Discuss about the HVDC converter characteristics both in rectifier and inverter mode with suitable diagrams. (6)

(b) How many mode of control in operation of a HVDC link is available? Discuss about each of them stating the operating conditions and relevant equations. (16)

(c) Why reactive power compensating devices are installed in HVDC sub-stations? (3)

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PART-II.

Answer *any two* questions from this part.

6. a) Draw the schematic diagram of a twelve-pulse converter based HVDC transmission system indicating both receiving and sending end and the transmission line equivalent circuit. 12

b) Explain the operation of the above converter along with voltage waveforms at both sending and receiving ends. 8

c) Enumerate the advantage and the disadvantages of the 12-pulse configuration over 6-pulse version. 5

7. a) Explain with proper waveforms how harmonics are injected in to the AC line by the converters operated for HVDC transmission system. 10

b) Explain with circuit diagrams how the above mentioned injected harmonics can be eliminated along with relative merits and demerits of each schemes. 5

c) The ac line current waveform in one phase at the HVDC converter input is shown in the figure below. Determine the fundamental and harmonic currents up to 7^{th} order and design a single tuned filter to reduce the 5^{th} order harmonics. 10

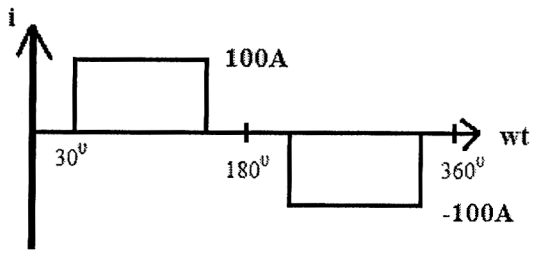

Fig.

8. a) Draw and explain the schematic diagram of a six-pulse converter based HVDC transmission system and indicate how line inductance plays a role for ripple free dc current for transmission. 10

b) A six-pulse converter based double line HVDC transmission system has ac side voltages of 220kV, 3phase, 50Hz ac at both sending and receiving ends. The line parameters are 5 ohm and 100mH for each line. A power of 1000MW is to be transmitted at the receiving end. For a DC transmission voltage at the receiving end of 250kV, find the sending end DC voltage, operating triggering angles of both the converters, input power, and the line losses. 15

(Assume negligible converter losses and continuous current operation of the converters)