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EEL794 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

TIME-TWO HOURS **MAJOR TEST** **MAXIMUM MARKS: 300**

Q.1 (a) Draw circuits of (i) passive shunt tuned 3-phase ac filter, (ii) passive shunt high pass 3-phase ac filter (iii) active shunt tuned 3-phase ac filter, (iv) passive shunt tuned dc filter, and (v) active shunt tuned dc filter for HVDC systems. [20]

(b) Draw circuits of five schemes of HVDC systems. [20]

(c) Draw circuits of following converters to be operated with fundamental frequency switching (i) 12-pulse thyristor based CSC, (ii) 12-pulse GTO based VSC, (iii) 12-pulse thyristor based CCC, (iv) 12-pulse GTO based CSC, and (v) 24-pulse GTO based VSC for HVDC systems. [20]

(d) Explain with proper diagram how capacitor commutated thyristor converter in HVDC system can have reduced reactive power requirements. [20]

(e) Explain the difference between unified and sequential methods of ac-dc load flow solution. How are the convergence characteristics of the two methods? [20]

Q.2 (a) A three-phase twelve-pulse bi-directional boost AC-DC converter (GTO based VSCs coupled with transformers having primaries connected in series to ac mains with the star/delta and star/star secondaries connections in parallel to a common dc bus) draws 20 kW from 254V per phase, 50Hz, 3-phase ac mains with and sinusoidal wave voltage. The ac inductor is 5.0 mH. The displacement factor is corrected close to unity. The VSC is operated in a mode to cancel 5^{th} and 7^{th} harmonics in VSC output voltage. Determine (i) an output dc voltage, (ii) value phase shift in fundamental component of VSC ac voltage and supply voltage, (iii) fundamental phase current, (iv) THD in VSC ac voltage and (v) THD in ac current. [25]

(b) A HVDC link is operating with an ac line voltage to the rectifier of 175kV. When the dc current is 1000 A, the rectifier delay angle is 10° and the inverter's extinction angle is 20°. The resistance of the line is 23 ohms, commutating reactance of the rectifier is 22 ohms and the commutating reactance of the inverter is 21 ohms. Calculate overlap angles, the dc voltages at the rectifier and inverter terminals as well as the ac line voltage at the inverter. [25]

(c) A 3-phase 415 V, 50 Hz fed 12-pulse thyristor converter drawing 500 A constant dc current at 30° firing angle of its thyristors. It consists of a transformer with single primary star connected winding and two secondary windings connected in star and delta with same line voltages and the turns ratios to provide 30° phase shift between two sets of three-phase output voltages. Two 6-pulse thyristors bridges are connected in series to form 12-pulse ac-dc converter. Design a set of ac tuned passive shunt filters for this converter system to compensate the reactive power and 11^{th},13^{th}, 23^{rd} and 25^{th} harmonics at input ac mains. [25]

(d) A three-phase bi-directional PWM boost PFC AC-DC converter feeds 7.5 kW to 250V per phase, 50Hz, 3-phase ac mains from a battery. The switching frequency is 20 kHz and ac inductor is 3.5mH. The power-factor is corrected close to unity and PWM modulation index is 0.9. Determine an output dc voltage, an input ac rms current, dc average current and phase shift in fundamental component of PWM voltage and supply voltage. Draw the phasor diagram for fundamental voltages. [25]

Q.3 (a) A HVDC system of 220kV, 50Hz ac mains fed an isolated 12-pulse thyristor bridge rectifier is transmitting a dc power at a dc voltage of 500kV, 1.2kA constant dc current at 15^0 firing angle of its thyristors. It consists of an ideal transformer with single primary star connected winding and two secondary windings connected in star and delta with equal line voltages to provide 30^0 phase shift between two sets of three phase output voltages. Two 6-pulse thyristor bridges are connected in series to provide 12-pulse output voltage. Calculate (i) thyristor rms current rating, (ii) transformer secondary voltages, (iii) current in each winding of transformer, (iv) kVA rating of transformer, (v) supply rms current, (vi) supply fundamental rms current and (vii) supply current THD. [40]

(b) A three-phase shunt active power filter (APF) is employed for harmonics currents and reactive power compensation for a three-phase 415 V, 50 Hz fed 12-pulse thyristor bridge converter drawing 200 A constant dc current at 30° firing angle of its thyristors. It consists of a transformer with single primary star connected winding and two secondary windings connected in star and delta with same line voltages and the turns ratios to provide 30° phase shift between two sets of three-phase output voltages. Two 6-pulse thyristors bridges are connected in series to form 12-pulse ac-dc converter. Calculate (i) fundamental active power drawn by the load, (ii) fundamental reactive power drawn by the load, (iii) VA rating of APF to provide only harmonics current compensation, and (iv) VA rating of APF to provide harmonics current and reactive power compensation at unity power factor. [40]

(c) Find the inductance of the dc reactor required to prevent consequent failure in the inverter (LCI) for the HVDC system having data as. Number of the bridges per pole: 2; Rated dc voltage per bridge: 300 kV; Rated current: 1.4 kA; I_{s2} (peak current due to commutation reactance's short circuit): 8.4 kA; Frequency: 50Hz. Consider normal extinction angle γ_n: 15°; minimum extinction angle to be permitted as a result of collapse of dc voltage as γ_m= 7°. [10]

(d) For an SCR of 2.5, X_c=0.2 pu, firing angle $\alpha = 15^0$. Calculate the voltage regulation after total load rejection at the rectifier end. [10]

*******BEST OF LUCK*******