Department of Electrical Engineering IIT Delhi

EEL 746/842 Power Quality / Power Conditioners

Max Marks 50 Major Test Time 2 hrs

Attempt all questions

Q1 A series cascaded 12-pulse thyristor converter is fed from a 3-phase 400V Δ : Δ/Δ connected transformer having 1 : 1 : √3 turns ration. The 6-pulse (Δ-Δ) converter is operated at $\alpha_1 = 30°$ and the other 6-pulse (Δ-Δ) converter is operated at $\alpha_2 = 0°$. The converter dc bus current I_{dc} is ripple free.

(a) From the basics draw resultant input current waveform of the 12-pulse converter. (b) Derive the expressions for amplitude and phase of the 7th harmonic input current in terms of I_d, α_1 and α_2. (c) Find the amplitude and phase of the 7th harmonic input current for $I_{dc} = 10A$. [4+4+2]

Q2. Give complete layout of a UPS having half bridge converter / inverter in AC/DC and DC/AC conversion, with a step-down/step up chopper for linking batteries. Describe fully its operation from the view point of rectification, inversion and battery charging / discharging. Also provide adequate control features to the converter, battery and inverter operation. How the converter is operated at 1-Φ if? [3+3+3+1]

Q3 Describe the basic principle of operation of an UPFC. Derive the expressions for transmitted power P and the reactive power at the receiving end Q_r as a function of supply and receiving end voltages $V_s \angle \delta°$, $V_R \angle 0°$, transmission line reactance X, UPFC voltage V_{pq} ∠f. It is known that $|V_s| = |V_R| = V$ and P is measured with respect to the $V_s \angle \delta$. Show the control region attainable for P and Q_r with UPQC in E.H.V transmission line. if at $\delta = 30°$, under the existing

operating conditions. When the transmission line has a series capacitor compensation with $X_C = \frac{X_L}{3}$, obtain the power P and Q at $\delta = 30°$. Get $V_{pq}/\underline{\rho}$ for transmission line operating with UPQC for corresponding P and Q as achieved with series capacitor compensator. [2+3+2+3]

Q4. A UPQC system has been used to block low frequency sub harmonic voltage injection along with blocking 5th / 7th current harmonic due to 6-pulse converter non linear load and pumping harmonic currents into the corresponding passive filters. (a) Give complete layout of the system (b) Describe operation / functioning of the entire set up using the principles of synchronous reference frame for phase locking of desired harmonics. (c) Give suitable strategy for operation of the UPQC with adequate explanation for proper harmonic elimination. [2+4+4]

Q5. A power network having the following filter configuration as shown in the figure below. If the filters (each) are tuned to resonant frequency n_k and the harmonic frequency order due to the nonlinear load be h where $h \neq n_k$ from the bases, show that the h^{th} harmonic impedance of the n_k^{th} harmonic filter at fundamental base impedance is $\frac{S_b}{Q_{nk}} \frac{h^2 - n_k^2}{h(n_k^2 - 1)}$, where S_b is the fundamental base VA of the system and Q_{nk} is the fundamental var loading of n_k^{th} filter. Suitably describe the system. [4+6]