End Semester Examination–2016
B. Tech VI Sem. (Electrical)
Subject: Power Electronics (EE-1601)

Time: 3.0 Hrs. **MM: 60**

NOTE: Attempt *ANY FIVE* Questions.

Q1(a). Discuss the two transistor model of SCR. Derive an expression of anode current and explain there from the turn-on mechanism of the SCR. [5]

(b). Explain the working of an UJT oscillator. Derive the expression for the frequency of triggering and firing angle delay. A UJT used in relaxation oscillator, has following data:

$\eta = 0.67$, $I_v = 10$ mA, $V_v = 2.5$ V, $I_p = 15$ μA

An oscillator, with an oscillation frequency of 1 kHz, is to be designed by using this UJT. Compute the values of charging resistor and external resistors needed in the base circuit. Take C = 0.4 μF and forward voltage drop of E-B_1 junction as 0.5 V. Source voltage is 24 V dc and triggering pulse width is 50 μs. What is the possible variation in the frequency by this oscillator? [7]

Q2(a). Describe the various input and output performance parameters of the rectifier. Compare their values for a single-phase half-wave diode rectifier (1-pulse) with that of single-phase full-bridge diode rectifier (2-pulse). [6]

(b). A three-phase diode-bridge rectifier charges a 240 V battery. The input voltage to the rectifier is 3-phase, 230 V, 50 Hz. Current limiting resistance in series with battery is 8 Ω and an inductor makes the load current ripple free. Determine, (i) Power delivered to the battery and the load, (ii) Input displacement factor, (iii) Input power factor, (iv) Input THD (v) Transformer rating. [6]

Q3(a). Discuss the challenges in connecting the SCRs in series and parallel. What is the purpose of static and dynamic equalizing circuits and how its components are designed? [6]

(b). A single phase full-controlled rectifier with freewheeling diode feeds an R-L load. The source voltage is $v_s = \sqrt{2}V_s\sin(\omega t)$. For a firing angle of α, show that average load voltage is $Vo = 0.9V_s(1+\cos\alpha)/2$. If R = 4 Ω, L = 500 mH and α = 30°, V_s = 240 V and supply frequency of 50 Hz, find (i) rms and average value of output currents, (ii) Average and rms values of thyristor currents, (iii) Average and rms values of diode currents and (iv) input power factor. Load inductance may be assumed to be large enough to make the load current ripple free. [6]

Q4(a). A single-phase half-wave controlled rectifier is supplying power to the RL load having freewheeling diode connected across the load. Explain the operation of the circuit with the help of plots of output voltage (v_o), output current (i_o), thyristor current (i_T), supply current (i_s), freewheeling diode current (i_{fd}) and thyristor voltage (v_T).

Also derive the expressions for load current (i_o), average load voltage (V_o), average load current (I_o), rms load voltage (V_{or}), power delivered to the load (P_o) and supply power factor. What are the advantages of using freewheeling diode? [8]

(b). During the turn-off process in a thyristor, the reverse recovery current of 10 A is interrupted in a time interval of 4 μs. The thyristor is connected in series with an inductance of 6 mH with no resistance in the circuit. If the source voltage during turn-off process is -300 V, calculate: (i) Peak voltage across the thyristor when the reverse current is interrupted and (ii) the value of snubber circuit resistance in case snubber capacitance C_s = 0.3 μF and damping ratio is 0.65. [4]

Q5(a). With the help of neat circuit diagram and necessary waveforms discuss the operation of single-phase dual converter in different modes along with its relative merits and demerits. Derive the expression for its circulating current. [6]

(b). A three-phase full controlled thyristor rectifier is operated from an ac supply of 400 V (rms) line to line. When the converter is operated in rectifier mode, at a control angle of $\alpha = 30°$, the overlap angle (μ) due to line reactance is 15°. Calculate the regulation in the dc output voltage due to the overlap. If the converter operates in the inverter mode, α being 120°, without any change in the in the load current what will be the overlap angle (μ)? [6]

Q6(a). With the help of neat circuit diagram, explain the operation of class-C chopper. Sketch the wave forms of output voltage (v_o), output current (i_o), thyristor current (i_T), supply current (i_s). Derive the expressions for average load voltage (V_o), average load current (I_o). Give three applications of class-C chopper. [6]

(b). For an ideal type-A chopper feeding RLE load, (i) show that the average input (or thyristor) is given by- $I_{TAV} = \frac{\alpha(V_s - E)}{R} - \frac{L}{RT}(I_{max} - I_{min})$, (ii) derive the expression for the average current in the freewheeling diode for a continuous load current, (iii) from parts (i) and (ii), prove that the average value of load current is given by $I_{AV} = \frac{V_a - E}{R}$. [6]

Q7(a). With the neat sketch of the circuit diagram and necessary waveforms, explain the operation of the single-phase full bridge inverter. Draw its load voltage, and load current waveforms for different (R, RL, RLC overdamped and RLC underdamper) loads. Also mark the conducting devices at different interval of time. Under what condition the forced commutation will not be required? [4]

(b). A single-phase full bridge inverter, employing transistors, is supplying an RLC load having $R = 6\ \Omega$, L = 30 mH and C = 180 μF. Inverter is fed from 220 V dc and its output frequency is 50 Hz. (i) Calculate THD of the output voltage and its distortion factor, (ii) obtain an expression for the load current in Fourier series up to 7th harmonics, (iii) THD of load current and its distortion factor, (iv) load power and average dc source current. Considering only the fundamental component of load current, calculate (vi) conduction time of each transistor and diode, and (vii) peak and rms current of each transistor. [8]