Ref. No.: Ex/PE/IEE/T/226/2017

B. E. Power Engineering 2nd Year 2nd Semester Examination 2017

Power Electronics

Time: 3 hours **Full Marks: 100**

*Attempt any **four** questions from the following*

1.

(a) The forward characteristic of a power diode can be represented by $v_f = 0.88 + 0.015 i_f$. Determine the average power loss and rms current for a constant current of 50 A for 2/3 of a cycle.

(b) For a power diode, the reverse recovery time is 3.9 μs and the rate of diode current decay is 50 A/ μs. For a softness factor of 0.3, calculate the peak inverse current and the storage charge.

(c) A power transistor is used as a switch. The parameters for the transistor circuit are $V_{CC} = 200\,V$, $V_{CES} = 2.5\,V$, $t_d = 0.5\,\mu s$, $t_r = 1\,\mu s$, $t_n = 40\,\mu s$, $t_s = 4\,\mu s$, $t_f = 3\,\mu s$, $t_o = 30\,\mu s$, $f = 10\,KHz$. Collector to emitter leakage current is 1.5 mA. Determine the average power loss due to collector current during t_{on} *and* t_n. Find also the peak instantaneous power loss due to collector current during turn-on time.

5+5+15

2.

(a) In a single-phase full-wave diode bridge rectifier, the diodes have a reverse recovery time of 40 μs. For an ac input voltage of 230 V, determine the effect of reverse recovery time on the average output voltage for a supply frequency of 50 Hz and 2.5 KHz.

(b) A diode is connected in series with LC circuit. If this circuit is switched on to dc source of voltage V_s at t=0, derive expressions for current through and voltage across capacitor. The capacitor is initially charge to a voltage of $-V_o$. Sketch waveforms for i, v_C, v_L *and* v_D.

(c) Explain with suitable diagram the significance of freewheeling diode in power electronic circuits.

5+15+5

3.

(a) Explain two-transistor model of a thyristor with necessary mathematical deductions.

(b) For an SCR, gate-cathode characteristics is given by $V_g = 1 + 10 I_g$. Gate source voltage is a rectangular pulse of 15 V with 20 μs duration. For an average gate power dissipation of 0.3 W and a peak gate-driver power of 5 W, compute the resistance to be connected in series with the SCR gate, the triggering frequency and the duty cycle of the triggering pulse.

(c) Discuss the turn-on and turn-off characteristics of an SCR.

10+8+7

4.

(a) An RL load is fed from single-phase supply through a thyristor. Derive an expression for load current in terms of supply voltage, frequency and load components. Indicate the time limits during which this solution is applicable. For this thyristor-load combination, draw waveforms for load voltage, load current, source current and voltage across thyristor.

(b) A single-phase full converter bridge is connected to RLE load. The source voltage is 230 V, 50 Hz. The average load current of 10 A is constant over the working range. For $R = 0.4\Omega$ *and* $L = 2\,mH$, compute firing angle delay for E = 120 V and E=-120V. Indicate which source is delivering

power to load in each of these cases. Also sketch the time variations of output voltage and load current for both the cases.

15+10

5.

(a) For an ideal type A chopper feeding RLE load, show that the average input (or thyristor) current is given by

$$I_{TAV} = \frac{\alpha(V_S - E)}{R} - \frac{L}{RT}(I_{max} - I_{min})$$

Derive an expression for the average current in the freewheeling diode for a continuous load current. Prove that average value of load current is given by

$$I_{av} = \frac{V_O - E}{R}$$

(b) Draw the possible configurations of a single-phase voltage controller and compare them.

(c) A single phase unidirectional voltage controller is connected to a load of R=10 Ω. Input voltage is 230 V, 50 Hz. Firing angle delay is 30°. Determine the rms value of output voltage, average and rms values of thyristor current, and average and rms values of diode current

10+5+10

6. Write short notes on:

(a) Reverse recovery characteristics of power diode
(b) Turn-on mechanisms of SCR
(c) Snubber circuits
(d) IGBT
(e) Step-up chopper circuits

5X5

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