Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.TECH (EE)/SEM-2/MEE-2.1/2010

2010

INDUSTRIAL POWER ELECTRONICS

Time Allotted : 3 Hours Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer any *five* questions. 5 × 14 = 70

1. a) Explain the phenomenon of conductivity modulation. 4

   b) Analyze the 'latch up' for IGBT. 4

   c) Resistance triggering circuit uses an SCR with Ig (min) = 0·1 mA and Vg (min) = 0·5 V. The diode is silicon and the peak amplitude of the input is 24 V. Determine the trigger angle α for R_2 = 100 kΩ and R_1 = 10 kΩ . 6

2. a) Describe the switching behaviour of MOSFET with equivalent circuits & waveforms. 7

   b) A power transistor is used as switch and parameters for the transistor circuit are as under :

   V_{CC} = 200 V, V_{CES} = 2·5 V, I_{CS} = 60 A, t_d = 0·5 μs, t_r = 1 μs, t_n = 40 μs, t_s = 4 μs, t_f = 3 μs, t_o = 30 μs, f = 10 kHz.

Collector to emitter leakage current = 1·5 mA.

Determine 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. Sketch the instantaneous power loss during t_{on} and t_n.

7

3. a) Draw the following for a 3-phase fully controlled rectifier with inductive load with a firing angle of 70° using graph paper :

i) Load voltage

ii) Supply current

iii) Voltage across SCR 1

iv) Current through SCR 3. 7

b) A-3 phase fully controlled thyristor bridge converter is operated from an a.c. supply of 400 V r.m.s. (line to line). When the converter is operated in the rectifier mode at a control angle α = 30°, the overlap angle (μ) due to the line reactance is 15°. Calculate the reduction in d.c. output voltage due to the overlap. If the coverter operates in the inverter mode with α = 120° and without any change in the d.c. load current, what will be the overlap angle (μ) ? 7

4. a) With an appropriate circuit diagram discuss the principle of working of a three phase bridge inverter. Draw phase and line voltage waveforms on the assumption that each thyristor conducts for 180° and the resistive load is star connected. Also prepare a table which shows the sequence of firing of various SCRs. 7

b) In a Cuk converter operating at 50 kHz, $L_1 = L_2$ = 10 mH and C_1 = 5 μF. The output capacitor is sufficiently large to yield an essentially constant output voltage. Here V_d = 10 V and the output voltage is regulated to be constant at 5 V. It is supplying 5 W to a load. Assume ideal components.

Calculate the percentage errors in assuming a constant voltage across C_1 or in assuming constant currents i_{L_1} and i_{L_2}. 7

5. a) Design a dual converter to achieve at four-quadrant operation for I_d = 10 A at 200 V. The converter is supplied from 400 V, 3-phase and 50 Hz supply and I_{ripple} = 2 A. 7

b) A 3-phase semi-converter bridge circuit is fed from 400 V, 3-phase mains supply. The load resistance is 10 ohms. The average output voltage is 50% of maximum possible output voltage. Find (i) firing angle, (ii) average output current, (iii) r.m.s. output current and voltage, (iv) average and r.m.s. thyristor current, (v) rectification efficiency, (vi) transformer utilization factor, (vii) power factor at input terminals. 7

6. a) An HVDC transmission system using two six-pulse converters for bipolar transmission, is rated at 1000 MW, ± 250 kV. Determine the r.m.s. current and peak reverse voltage ratings for each of the thyristor valves. 6

b) Two six-pulse converters and used in bipolar HVDC transmission system. The a.c. systems are 3-phase, 11 kV, 50 Hz. The input transformers have a leakage inductance of 8 mH per phase. Resistance of each transmission line is 0·8 Ω . The inverter marginal angle is 18° and rectifier firing angle is 15°. Calculate current in d.c. line, rectifier output voltage and d.c. link voltage. 8

7. a) Describe flyback SMPS with relevant equivalent circuit and waveforms. Derive the various expressions for voltages and currents involved. 6

b) A flyback SMPS supplies a load of 40 A at 5 V. The source voltage is 240 V d.c. and the transformer initial magnetizing current is 0·4 A. The power MOSFET is operating at a frequency of 50 kHz with a duty cycle of 0·4. Determine the transformer turns ratio from primary to secondary and its inductance. Assume ideal component and no ripple in load voltage. Find also the open circuit voltage across the semiconductor device.

8

8. a) Explain the working of a zero current switching (ZCS) resonant converter. 5

b) Design a UJT relaxation oscillator for a single phase controlled converter fed from 50 Hz mains. Use 2N2646 UJT whose parameters at junction temperature 25°C are as under :

Maximum value of V_{BB} = 35 V, maximum average power dissipation = 300 mW, range of R_{BB} = 4·7 kΩ to 9·1 kΩ (typical value 5·6 kΩ at V_{BB} = 12 V), valley point current = 4 mA, η = 0·56 to 0·75 (typical value 0·63), valley point voltage = 2 V, peak point current = 5 μA, maximum gate voltage which will not trigger SCR = 0·18 V.

Also find the minimum & maximum values of firing angle. 9