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CS/M.Tech (EE)/SEM-1/EEP-101/2009-10

2009

POWER ELECTRONICS – I

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) A voltage source of $v(t) = 230 \cos \omega t$ volts is applied to a converter. The input current given by $i(t) = 6 + 13 \cos(314t - 45^\circ) + 5 \cos(3 * 314t + 45^\circ) + 2 \cos(5 * 314t - 60^\circ)$. Calculate

   i) the power absorbed by the load, assuming that the converter absorbs no power

   ii) the distortion factor of the input current

   iii) the THD of the input current

   iv) the input power factor of the converter.

$1\frac{1}{2} + 1\frac{1}{2} + 1\frac{1}{2} + 2$

b) A *d.c.-d.c.* flyback converter has a turns ratio $N_2/N_1 = 1{\cdot}8$. The *d.c.* supply voltage *Vd* = 12 V. The required output voltage *Vo* is 18 V. The switching frequency of the converter, *fs* = 100 kHz. The maximum load up to which the converter transformer core is required to demagnetise completely in each switching period is 120 W.

i) Find the duty cycle *D* for the maximum load power of 120 W.

ii) Find the maximum leakage inductance *Lm* the transformer can have.

iii) Find the capacitance *C* to keep the peak-peak output voltage ripple ΔVo within 0·5% of *Vo*.

$2\frac{1}{2} + 2\frac{1}{2} + 2\frac{1}{2}$

2. a) A Cuk converter has the following parameters : Vd = 10 V, D = 0·6, $L1$ = 1 mH, $L2$ = 2 mH, $C1 = C$ = 20 mF, fs = 25 kHz, R = 12 Ω.

i) Assuming continuous conduction, calculate the output voltage, Vo.

ii) Calculate the average, maximum and minimum currents in $L1$ and $L2$.

iii) Calculate the ΔVo in the output voltage. 3 + 3 + 3

b) A Es *d.c.* source, Rs and the gate of a SCR are connected in series. Eg = 7·5 + 1·8 Ig. Gate pulse train has 10 V, $T_{on} = T_{off} = 75\mu s$. Find Rs to limit the peak power dissipation in gate to 2 W. Also calculate average power dissipation in gate. 5

3. For a single-phase bridge rectifier, the supply voltage to the rectifier is 240 V (rms) at 50 Hz. The total source inductance to the rectifier is L_S = 2 mH. Assume the load current at all times is smooth and ripple free.

   i) Calculate the *d.c.* load voltage when the source inductance is neglected.

   ii) Calculate the overlap angles μ when the load current is 20 A and 40 A and the source inductance is not neglected.

   iii) Calculate the *d.c.* output voltage of the rectifier for the load currents in (ii).

   iv) Sketch the output voltage waveforms for the loads in (ii)

   v) Sketch the input voltage waveforms to the rectifier for the loads in (ii). 2 + 3 + 3 + 3 + 3

4. Draw the circuit and explain the operation of a boost regulator with different waveforms. Deduce the expression ΔVc and ΔI. Also find out the conditions for continuous inductor current.

5. a) A three phase bridge rectifier supplies a load at a *d.c.* voltage of 300 V and current of 30 A from a 415 V three phase supply via a delta-star transformer. Determine the required diode and transformer specification. Assume all diode forward drops of 0·7 V and smooth ripple-free load current. 9

   b) A 10 V *d.c.* source, R = 200 Ω, L = 1 mH and a SCR are connected in series, SCR I_L = 15 mA. SCR gets fired or not ? Justify. If not, find minimum gate pulse duration. 5

6. a) Explain a practical driver circuit for MOSFET or IGBT. 6

   b) Explain the disturbances in commercial power supply and power conditioning in terms of power quality problems. 8

7. Write short notes on any *two* of the following : 2 × 7

a) 12-pulse converter

b) Power factor improvement of converter

c) Protection and cooling of power devices

d) Designing of a transformer or an inductor for converter.

8. Develop a dynamic model of a current controlled boost converter feeding a purely resistive load from either a pure D.C. or a 1-phase, 230 V, 50 Hz. Plot the phase and bifurcation diagram.

9. How a chopper based closed loop D.C. drives systems is developed using microprocessor ? Explain in detail.

OR

Design a chopper circuit (both power circuit and control circuit) for the following specifications :

Input : 220 V DC

Load : Highly inductive load with rated current of 30 A at 220 V DC

Operating frequency of chopper : 25 kHz