

CITY UNIVERSITY OF HONG KONG

Course code & title : EE3918 Power Electronics and Drive Systems

Session : Semester A, 2003-04

Date : 16th December 2003

Time : 6:30 p.m. – 9:00 p.m.

Time allowed : 2 hours and 30 minutes

This paper has FIVE pages.

Instructions to candidates:

1. The paper consists of **FIVE** questions.
 2. Attempt any **FOUR** questions.
 3. All questions carry equal marks.
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Materials, aids & instruments permitted to be used during examination:

Approved portable battery operated calculator

Special materials (other than standard materials e.g. answer book or supplementary sheets) to be supplied to students:

1 graph paper

Q1.

A single-phase voltage controller using phase-angle control is shown in fig.Q1.

- (a) Derive a general expression for the harmonic content of the voltage of pure resistive load. State all the assumptions made. **[12 marks]**
- (b) Two thyristors are connected in inverse-parallel for the voltage control of a single-phase series RL load of phase angle $\Phi = 60^\circ$. The thyristors are each triggered at a firing angle $\alpha = 75^\circ$ with reference to their respective anode voltage waveforms. Explain how to estimate the current extinction angle, x for series RL load and hence, use this to calculate the load voltage displacement factor. **[13 marks]**

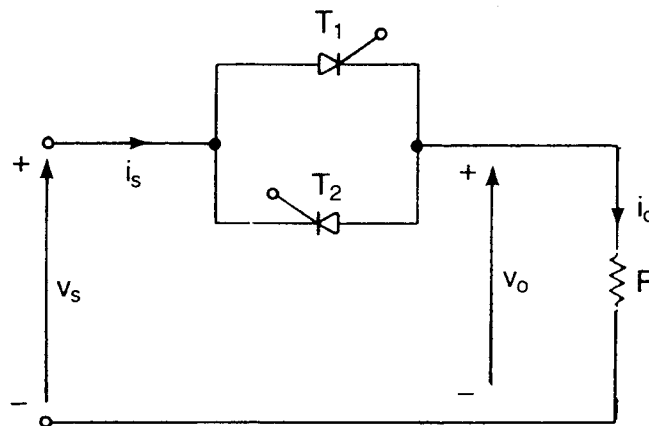


fig.Q1

Q2.

- (a) With the aid of a diagram, briefly describe the principle of operation of four-quadrant chopper drive for dc motor control. **[12 marks]**
- (b) What are the typical specifications for analogue motion transducers? For the following motion transducers:
- (i) potentiometer ,
 - (ii) LVDT ,
 - (iii) tachometer ,
 - (iv) piezoelectric accelerometer , and
 - (v) semiconductor strain gauge ,

state their corresponding measurand and hence compare their specifications.

[13 marks]

Q3.

- (a) A flyback regulator operating in continuous mode is shown in fig.Q3. Derive an expression in terms of the circuit parameters, switching frequency, f , and duty cycle, k , for the

(i) peak-to-peak output ripple voltage, Δv_c ,

(ii) peak-to-peak ripple current of the inductor, ΔI_L .

[11 marks]

- (b) The flyback regulator shown in fig.Q3 has an input voltage of $V_s = 9$ V. The duty cycle, $k = 0.4$, and the switching frequency is 20 KHz. The inductance $L = 200\mu\text{H}$ and the filter capacitor $C = 220\mu\text{F}$. The average load current $I_a = 1.5$ A. Determine the

(i) average output voltage, v_a ,

[2 marks]

(ii) peak-to-peak output ripple voltage, Δv_c ,

[2 marks]

(iii) peak-to-peak ripple current of the inductor, ΔI_L ,

[2 marks]

(iv) peak current of the transistor, I_p .

[3 marks]

- (c) With reference to fig.Q3, show that, for continuous mode operation, the following inequality holds

$$L > 0.5 RT(1-k)^2$$

where L , R and T are the inductance, load resistance, and switching period respectively.

[5 marks]

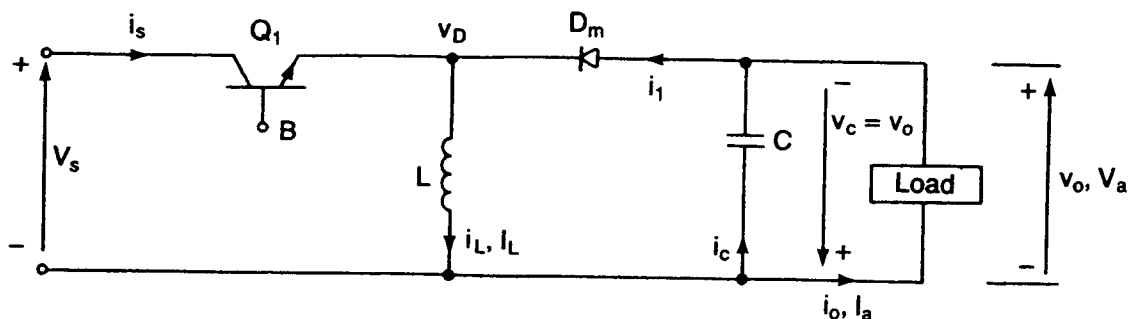


fig.Q3

Q4.

- (a) What are the performance parameters of rectifiers? Define these performance parameters. **[13 marks]**
- (c) A single-phase half-wave rectifier shown in fig.Q4 is operated from a 220 V, 50 Hz supply. If the resistive load, $R = 4 \Omega$ and the firing angle, $\alpha = 45^\circ$,
- (i) Derive the average voltage, V_{dc} and the rms voltage, V_{rms} of the load output voltage in term of the firing angle, α . **[6 marks]**
- (ii) Determine the V_{dc} , V_{rms} , form factor, FF and ripple factor, RF for load output voltage of the rectifier in fig.Q4. **[6 marks]**

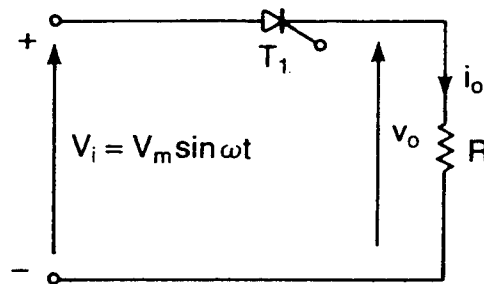


fig.Q4

Q5.

A three-phase 455 V, 60 Hz four-pole Y-connected induction motor has the following equivalent circuit parameters :

stator resistance, $R_s = 0.2 \, \Omega$;
rotor resistance, $R_r = 0.3 \, \Omega$;
stator reactance, $X_s = 0.7 \, \Omega$;
rotor leakage reactance, $X_r = 1.3 \, \Omega$;
motor reactance, $X_m = 12 \, \Omega$;

The no-load loss, $P_{no \, load} = 50 \, W$ and the rotor speed is 3000 rpm. Use the approximate equivalent circuit shown in fig.Q5 to determine the

- (a) synchronous speed, ω_s and slip, s ; [4 marks]
- (b) input current, I_i and input power, P_i ; [6 marks]
- (c) power factor of the supply, PF_s and gap power, P_g ; [4 marks]
- (d) developed torque, T_d and efficiency, η ; [5 marks]
- (e) starting rotor current, I_{rs} and the starting torque T_s ; [4 marks]
- (f) slip for maximum torque, s_m ; [2 marks]

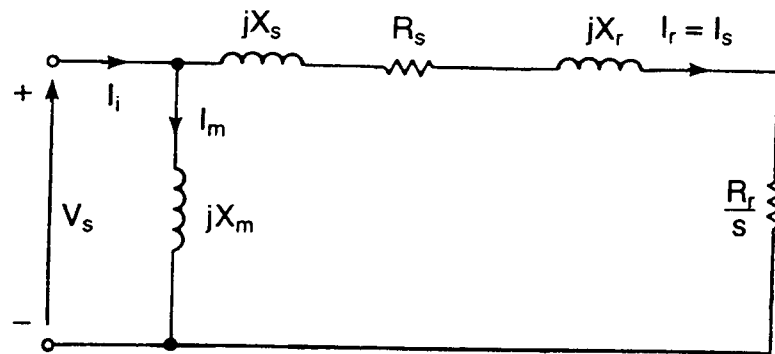


fig.Q5

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