

CITY UNIVERSITY OF HONG KONG

Module code & title : EE3127 Industrial Electronics

Session : Semester B 1996-97

Time allowed : Two hours

This paper has SEVEN pages. (Including this page)

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1. This paper consists of five questions.
 2. Attempt any FOUR questions.
 3. All questions carry equal marks.
 4. Start each question on a new page.
 5. Use separate answer books for each section.
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Materials, aids & instruments permitted to be used during examination :

Portable battery operated calculator

Question 1

- (a) Fig. Q1 shows the circuit of boost dc/dc converter. Briefly describe its principle of operation. [3 marks]

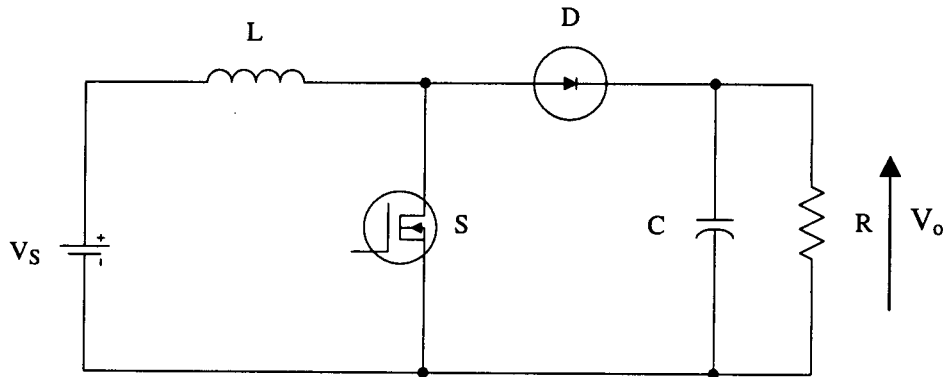


Fig. Q1

- (b) If all circuit components are assumed to be ideal and the value of C is large, derive the voltage conversion ratio (i.e. V_o / V_S) when the circuit is operating in
- continuous conduction mode and [3 marks]
 - discontinuous conduction mode, respectively. [8 marks]

Derive an expression for the value of L which determines the operating mode.

[4 marks]

- (c) The above converter is required to give an output voltage of 15V and load current of 2A from an input voltage of 5V. If the switching frequency is 25kHz and L equals to $5\mu\text{H}$, determine,
- the duty cycle of the MOSFET S and [5 marks]
 - the peak current through the diode D . [2 marks]

Question 2

- (a) Sketch the circuit diagram and output voltage waveform of a 3-phase full-wave fully-controlled bridge rectifier. Show that the d.c. output voltage v_{dc} is given by:

$$v_{dc} = \frac{3\sqrt{6} V_s}{\pi} \cos \alpha$$

where V_s : r.m.s. phase voltage

α : delay angle

Ignore the effect of overlap.

[6 marks]

- (b) The above bridge rectifier is fed from an ideal three-phase voltage source of 380V, 50Hz. It is supplying to a load of 20Ω connected in series with a large smoothing inductor. If the delay angle is 45° , sketch the input current waveform and calculate,

- (i) the average load voltage and load current, [4 marks]
- (ii) the output power, [1 mark]
- (iii) the r.m.s. value of the input current, [2 marks]
- (iv) the input power factor, [2 marks]
- (v) the displacement factor, [1 mark]
- (vi) the distortion factor, [2 marks]
- (vii) the r.m.s. value of the fundamental component of the input current, and [2 marks]
- (viii) the required voltage and current ratings of the thyristors. [3 marks]

- (c) What are the effects of the supply reactance on the output voltage and input power factor ? [2 marks]

Question 3

- (a) Derive an expression for the ideal total switching losses of a bipolar junction transistor (BJT) with resistive load without snubber circuit, in terms of the off-state voltage V_{OFF} , on-state current I_{ON} , turn-on time t_{ON} , turn-off time t_{OFF} , and switching frequency f_s . [7 marks]

- (b) Fig. Q3 shows the switching characteristics of a BJT, where I_C is the collector current and V_{CE} is the collector-emitter voltage.

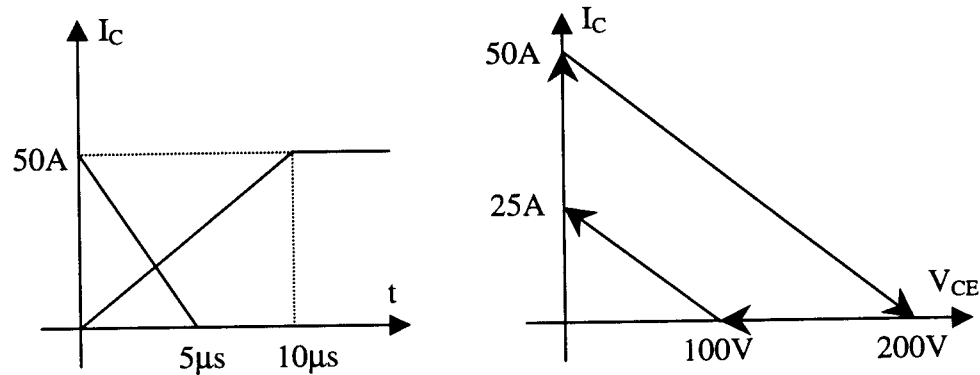


Fig. Q3

Sketch the waveforms of I_C and V_{CE} in one switching cycle.

Determine the power loss if the BJT is switched at 20kHz. [5 marks]

- (c) Briefly explain, with the aid of circuit diagrams, the major functions of a unified snubber for protecting power BJT. [7 marks]
- (d) Suggest a method of improving the reliability of three BJTs connecting in series in order to increase the overall voltage rating. [2 marks]
- (e) Discuss the major losses of switching devices. [4 marks]

Question 4

- (a) Briefly describe the working principles of forced commutation of SCR when it is used in a dc chopper. [4 marks]
- (b) Fig. Q4 shows a thyristorized dc step-down chopper.

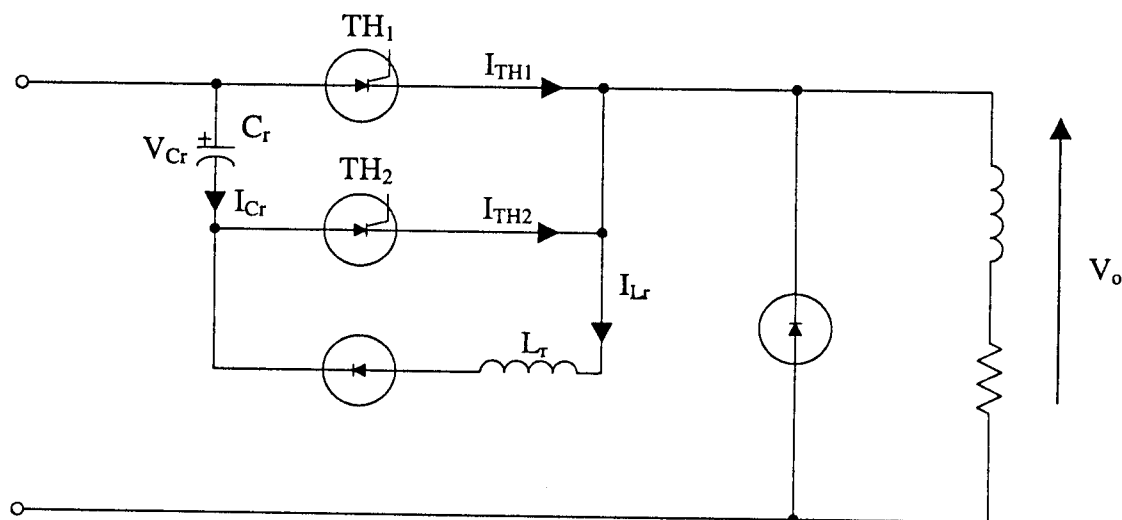


Fig. Q4

Sketch the stages of operation and the waveforms of I_{TH1} , I_{TH2} , I_{Cr} , I_{Lr} , and V_o on same time axis. [10 marks]

- (c) For the chopper circuit in Fig. Q4, the inductor L_r is 0.5mH. It is required to supply an output power of 3600W at 180V from a dc source of 240V. The switching frequency is 500Hz. Determine,
- the average load current, [1 mark]
 - the minimum value of C_r if the turn-off time of the thyristors is 40 μ s, [1 mark]
 - the peak current through TH_1 , [2 marks]
 - the average input current, and [1 mark]
 - the duty time of the thyristors. [6 marks]

State any assumption made.

Question Q5

- (a) Distinguish the operating principles between the phase-angle control and integral-cycle control for single-phase ac voltage controllers. Hence comment on their relative merits. [7 marks]

- (b) A pure resistive load fed from a single-phase ac voltage controller via a triac is operated in integral-cycle control. Show that the magnitude of the n -th output voltage harmonic component v_{on} for N cycles 'ON' in M cycles is

$$v_{on} = \begin{cases} \frac{2 M V_s}{\pi (M^2 - N^2)} \sin\left(\frac{n \pi N}{M}\right) & \text{for } n \neq M \\ \frac{N V_s}{M} & \text{for } n = M \end{cases}$$

[15 marks]

- (c) If the n -th harmonic component is greater than the supply frequency component, show that

$$0.6M < n < M$$

[3 marks]

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