

CITY UNIVERSITY OF HONG KONG

Course code & title : EE3127 Industrial Electronics

Session : Semester B, 1997-98

Time allowed : Two hours

This paper has FIVE pages. (Including this page)

Instructions to candidates:

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.
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Materials, aids & instruments permitted to be used during examination:

Portable battery operated calculator

Answer any FOUR questions

1. (a) Fig. Q1 shows a one-quadrant d.c. chopper. It is used to control the speed of the dc motor by controlling the armature voltage v_o . If the switching frequency is 500Hz and the duty cycle is 0.6, calculate
- i) the maximum and minimum values of i_o , [9 marks]
 - ii) the average value of the output voltage v_o , and [2 marks]
 - iii) the average value of the output current i_o . [2 marks]

State whether the inductor current is continuous or discontinuous. [2 marks]

Sketch and label clearly the steady-state waveforms of v_o and i_o . [4 marks]

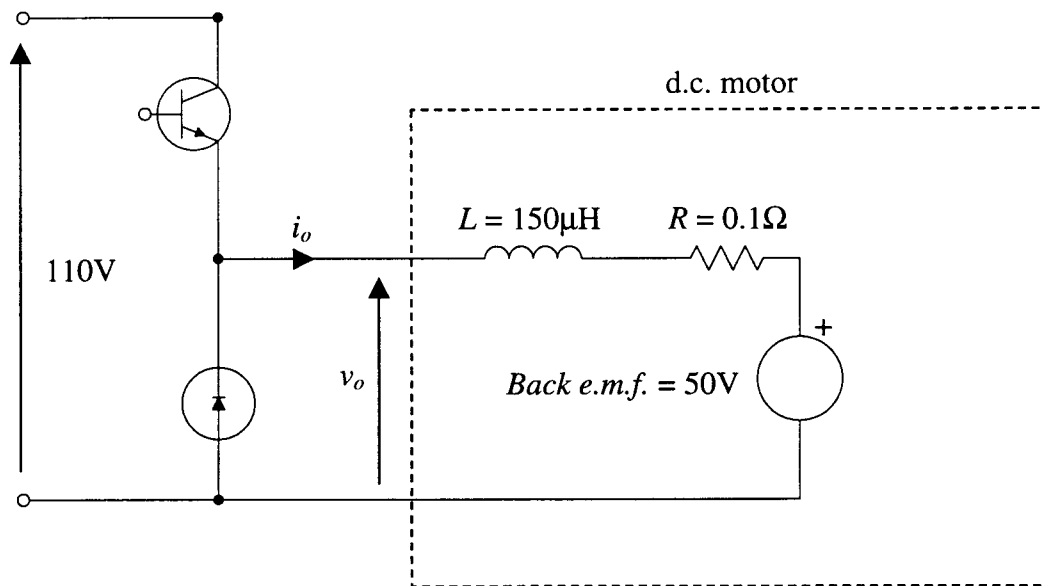


Fig. Q1

- (b) Suggest how the above one-quadrant chopper can be modified into a two-quadrant chopper. Briefly describe the operating principles and state one application. [6 marks]

2. (a) Fig. Q2 shows a thyristor-controlled reactor, which is constructed by connecting an inductor L to the ac voltage supply v_s through a pair of inverse-parallel connected thyristors.

- Derive expressions for the input current waveform i_{in} if the firing angle of the thyristors α lies between $\pi/2$ and π . [5 marks]
- Sketch the waveform of i_{in} and the voltage across L . [3 marks]
- Show that the r.m.s. value of i_{in} is

$$\sqrt{\frac{V_m^2}{\pi \omega^2 L} \left[(\pi - \alpha) (\cos 2\alpha + 2) + \frac{3}{2} \sin 2\alpha \right]}$$

and the fundamental component of i_{in} is

$$\frac{V_m}{\sqrt{2} \pi \omega L} (2\pi - 2\alpha + \sin 2\alpha). \quad [12 \text{ marks}]$$

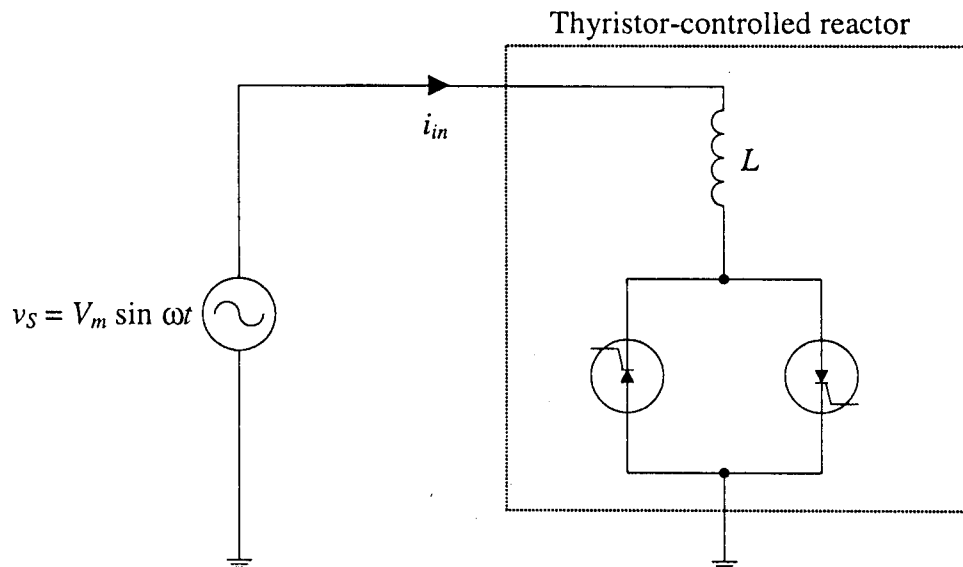


Fig. Q2

- (b) If a fixed capacitor is connected across the above reactor, briefly describe how they can be used to absorb or generate reactive power. [5 marks]

- Q.3 Fig. Q3 shows a basic pulse-width-modulated (PWM) buck/boost regulator, operating in continuous conduction mode. It is used to give a regulated output voltage. The input voltage and the output load vary over the range of 5-9V dc and 10-30 Ω , respectively. The output ripple voltage is limited to 1% of the rated output voltage that will be determined in part a). Determine,
- the value of the regulated output voltage, [2 marks]
 - the minimum value of the capacitor C , and [8 marks]
 - the minimum value of the inductor L . [10 marks]

Briefly describe how it can be modified in order to have isolation between the input side and the output side. [5 marks]

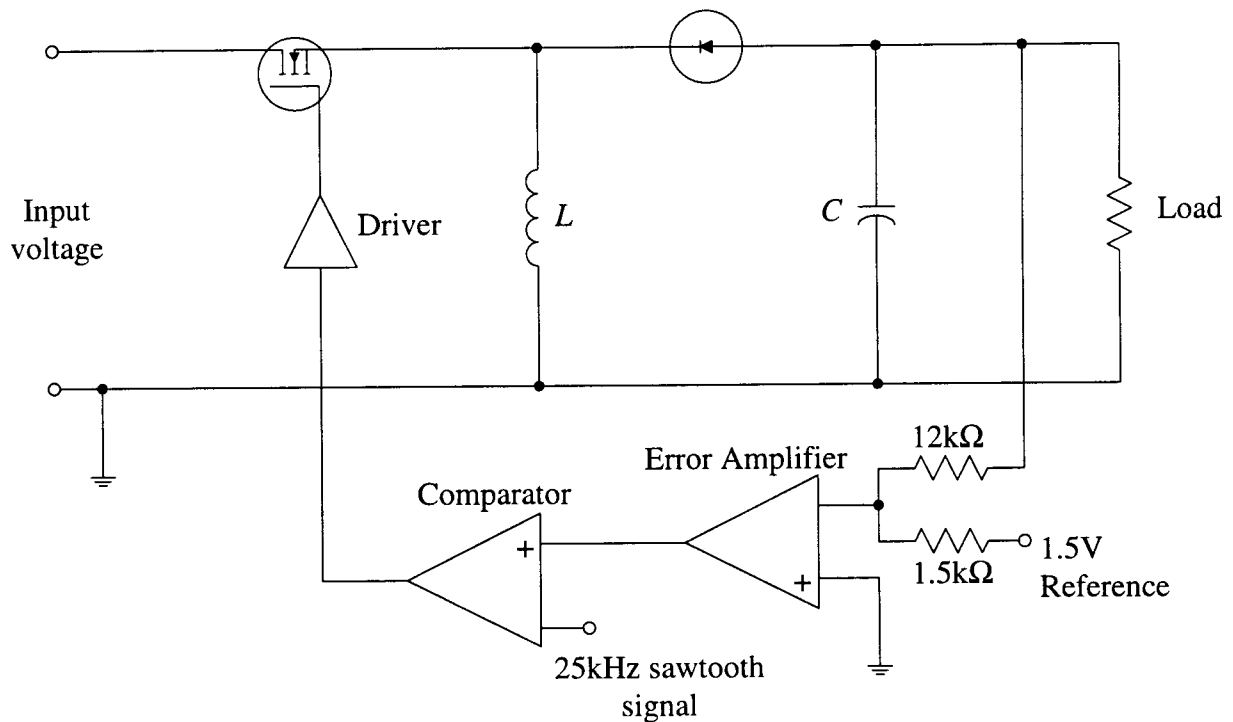


Fig. Q3

- Q.4 Fig. Q4 shows a full-bridge inverter supplying to a series RLC load, where $R = 10\Omega$, $L = 20\text{mH}$ and $C = 100\mu\text{F}$, from a dc source of 110V . The inverter frequency is 50Hz . It is assumed that the voltage waveform across the load is symmetric and perfectly square. By considering up to the 9th harmonics, determine,
- an expression for the load voltage and load current in Fourier series, [15 marks]
 - the total harmonic distortion of the load current, [4 marks]
 - the total power and the fundamental power absorbed by the load, [4 marks]
 - the average input current. [2 marks]

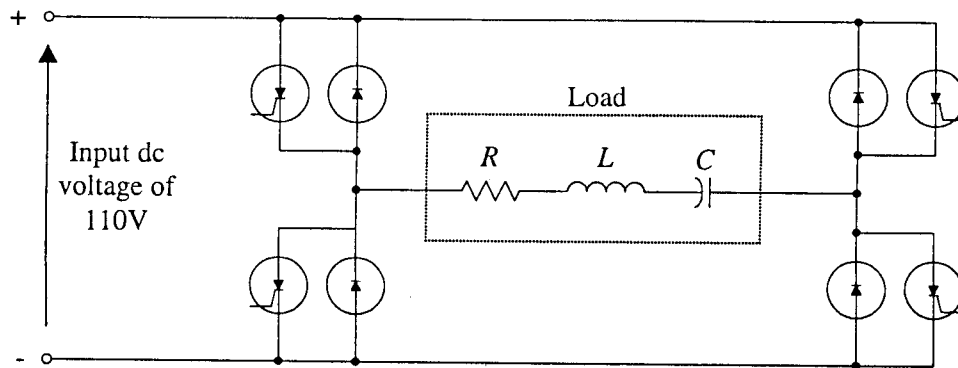


Fig. Q4

- Q.5 (a) Sketch the circuit diagrams for single-phase
- fully-controlled bridge rectifier and
 - half-controlled bridge rectifier.
- Discuss their operational differences. [9 marks]
- (b) With the aid of suitable waveforms, derive an expression for the power factor of the supply current to a single-phase
- fully-controlled bridge rectifier and
 - half-controlled bridge rectifier
- when the rectifier is phase-delayed to give half of its maximum output voltage. State any assumptions made in your calculations. [16 marks]