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FINAL
Examination Paper

(COVER PAGE)

Session	:	AUGUST 2016
Programmes	:	Diploma in Electrical and Electronic Engineering (DEEI)
Course	:	EEE2112: INTRODUCTION TO POWER ELECTRONICS AND DRIVES
Date of Examination	:	8 December 2016 (Thursday)
Time	:	8:00am – 10:00am
Duration	:	2 Hours Reading Time : Nil
Special Instructions	:	

This paper consists of SIX (6) questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

IMPORTANT NOTE	:	THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL BY THE STUDENTS.
Materials Permitted	:	Scientific Calculator (Model fx570 Series)
Materials Provided	:	Worksheet-Q2(a) and Worksheet-Q5(d) Laplace Transformation Table
Examiner(s)	:	Chan Tse Wei
Moderator	:	Dr. Ooi Beng Lee

This paper consists of 8 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE2112: INTRODUCTION TO POWER ELECTRONICS AND DRIVES
FINAL EXAMINATIONS: AUGUST 2016 SESSION

Instructions: This paper consists of SIX (6) questions. Answer any FOUR (4) questions in the answer booklet provided. All questions carry equal marks. The marks allocated to each sub-question are shown in square brackets at the right-hand margin. Present your answers neatly and clearly. The assessor reserves the rights to ignore your answers if they are ambiguous.

Question 1

a. Figure-Q1(a) shows a resistive power control circuit in which power is being delivered to R_{load}.

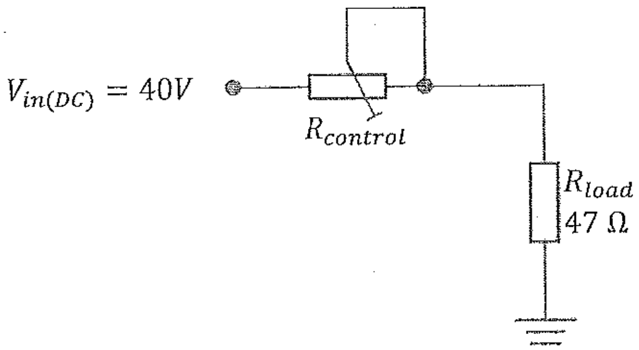


Figure-Q1(a)

i. If 10 W of power is to be delivered to R_{load}, determine the value of $R_{control}$ and the power transfer efficiency of the circuit. [8]

ii. Comment on the power transfer performance of the circuit. [3]

b. Explain in general, how modern power electronics technology improves the power transfer performance of the circuit in Figure-Q1(a). [4]

c. Quantitatively show how power electronics technology produces the same power delivered to R_{load} in part (a)(i) but with a much higher efficiency. [10]

Question 2

a. Figure-Q2(a) shows the IV characteristics of an SCR tested with its gate terminal open circuit.

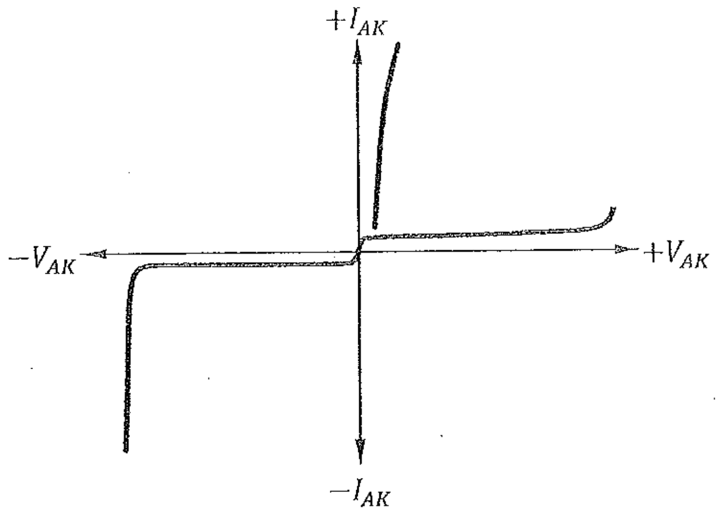


Figure-Q2(a)

i. Complete the IV characteristic graph by filling in all the blanks in the provided Worksheet-Q2(a). [5]

ii. Explain the characteristics of the SCR. [7]

b. Figure-Q2(b) shows the turn on characteristics of the same SCR in part (a).

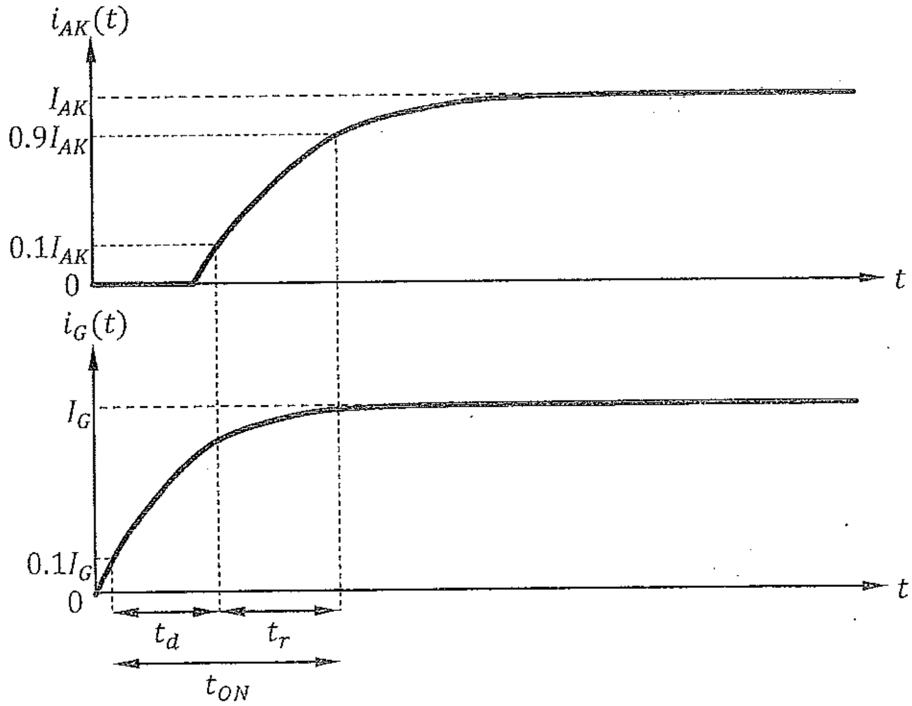


Figure-Q2(b)

The three timing parameter shown inFigure-Q2(b) are,

- t_d = delay time
- t_r = rise time
- t_{ON} = ON time

While the current parameters are,

- I_{AK} = on-state current
- I_G = steady-state gate current.

i. Define the three timing parameters, delay time, rise time and ON time. [3]

ii. Explain how does this turn-on characteristic graph aid the proper operation of the SCR. [2]

c. Describe three major considerations in designing a gate control circuit for an SCR. [6]

d. Draw the two-transistor model of an SCR. [2]

Question 3

Figure-Q3 shows a basic switched-mode converter having the following assumptions:

- Diode D is ideal.
- All analysis is done in the steady-state condition.
- The capacitor is large enough to establish a constant output voltage across R_{load}.
- The switch is controlled with a 40 kHz pulse at 0.45 duty cycle (d).
- The total input power equals the total output power.

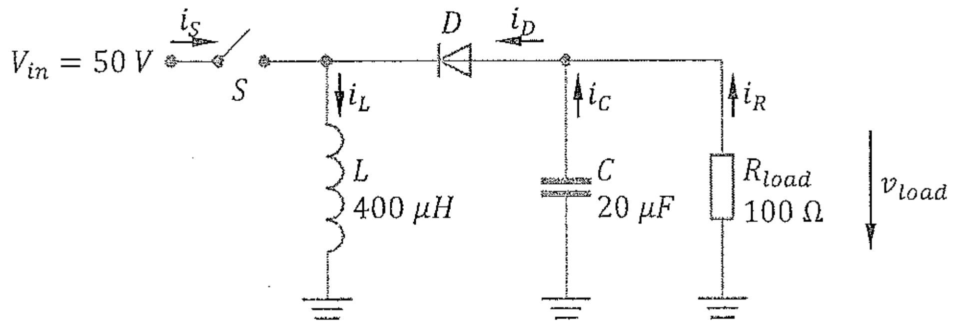


Figure-Q3

a. Identify the name of the switch-mode converter given in Figure-Q3(a). [2]

b. Derive the expression of the load voltage, v_{load} in terms of d and V_{in}. Hence, calculate this value based on the given switching parameters. [8]

c. Derive the respective expression of $I_{L(max)}$ and $I_{L(min)}$. Hence, calculate their respective value. [10]

d. If the 400 μH inductor is to be replaced, determine the lowest inductance value to ensure continuous flow of inductor current, i_L. [5]

Question 4

a. i. Explain the main function of an inverter. [4]

ii. State two industrial applications of inverters. [2]

b. Figure-Q4(b) shows a basic configuration of a single-phase full-bridge inverter delivering power to an resistive-inductive load.

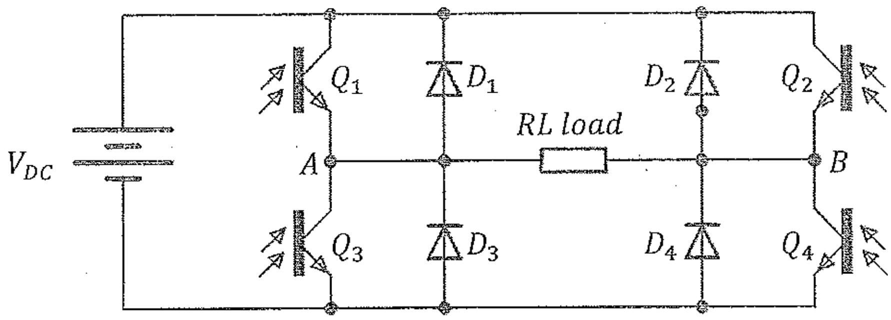


Figure-Q4(b)

i. Explain why it is more convenient to use phototransistors in the inverter instead of ordinary NPN BJTs. [4]

ii. Explain the need of the four diodes, D_1 to D_4 in the circuit. [4]

iii. Sketch the timing diagram of $v_{AB}(t)$, assuming the diagonal-pair of transistors are triggered at equal time interval. [2]

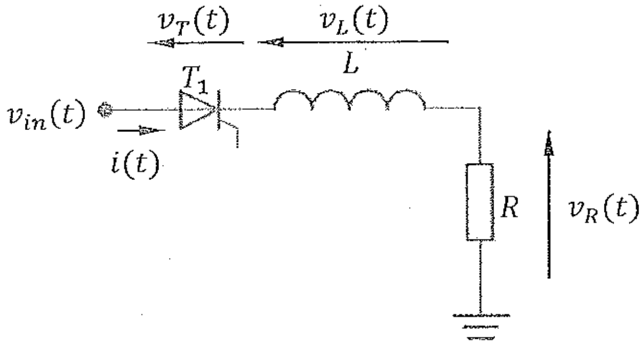
iv. State the RMS value of V_{AB}. [2]

v. State the expression of $v_{AB}(t)$. [2]

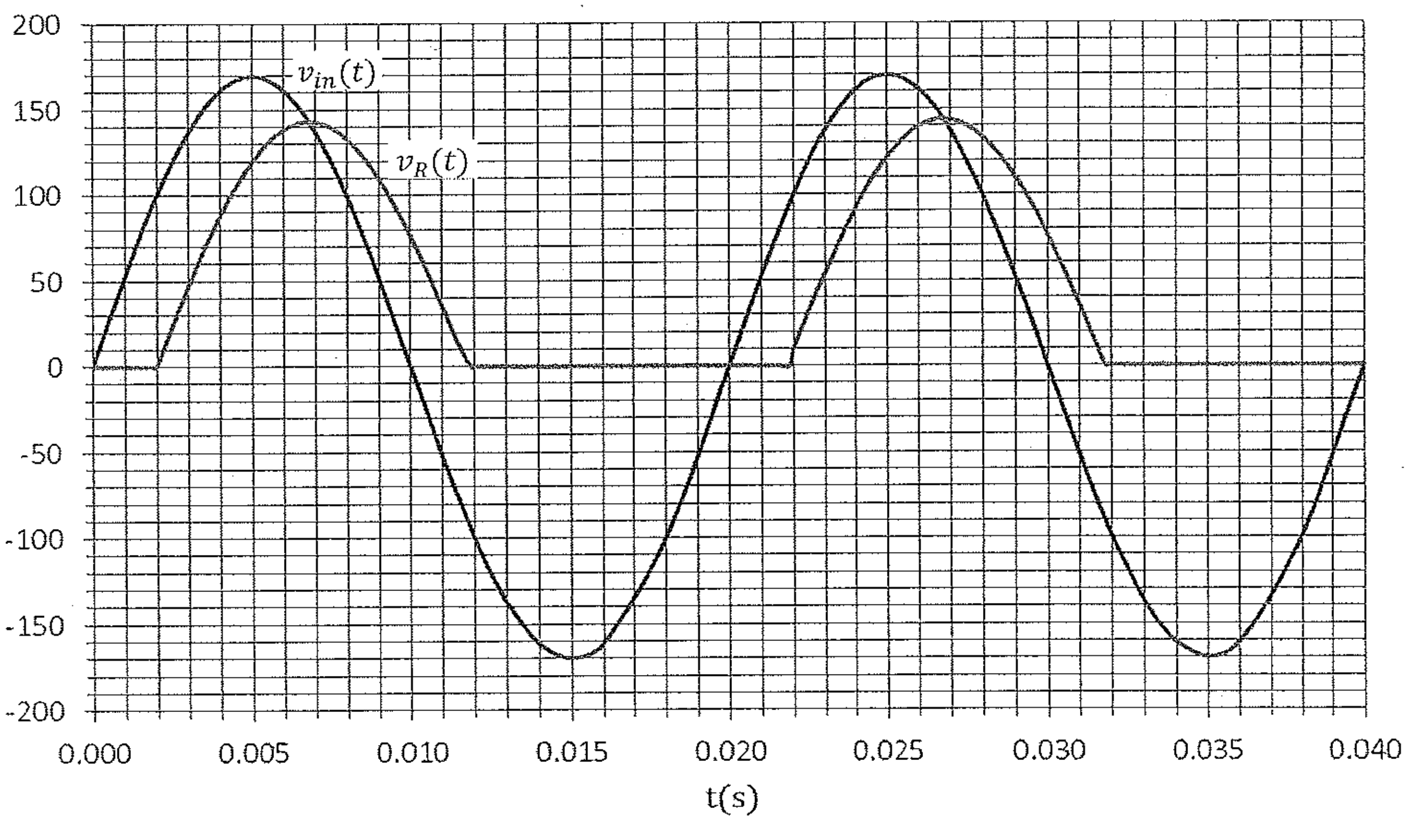
vi. Calculate the peak current of the fundamental current flowing through the load if $V_{DC} = 20V,\ R = 10\ \Omega, L = 50\ mH$ and $T = 20\ ms$. [5]

Question 5

Figure-Q5(i) shows a controlled half-wave rectifier circuit with RL load, while Figure-Q5(ii) shows the timing diagram of $v_{in}(t)$ and $v_R(t)$ respectively.



(i)



(ii)

Figure-Q5

a. Approximate the firing angle, α, of thyristor T_1. [3]

b. Approximate the extinction angle, β, of thyristor T_1. [3]

c. Based on the answers obtained in part (a) and (b), determine the conduction angle, γ, of thyristor T_1. [2]

d. Sketch the timing diagrams as accurate as possible for $v_L(t)$ and $v_T(t)$ respectively, on the given "Worksheet-Q5(d)". Assume ideal thyristor operation. [10]

e. For the circuit in Figure-Q5(i), the instantaneous current, $i(t)$, within $\alpha \leq \omega t \leq \beta$, is expressed as,

$$i(t) = \frac{V_m}{\sqrt{R^2 + \omega^2 L^2}} \left[\sin\left(\omega t - \tan^{-1}\left(\frac{\omega L}{R}\right)\right) - \sin\left(\alpha - tan^{-1}\left(\frac{\omega L}{R}\right)\right) e^{-\frac{R}{\omega L}(\omega t - \alpha)} \right]$$

Where,

V_m = amplitude of the input sinewave

α = firing angle of thyristor T_1 in radians

β = extinction angle of thyristor T_1 in radians

ω = input frequency in rad/s

Determine the average current, I_{DC} that flows through the circuit if $R = 20\ \Omega$ and $L = 0.04\ H$. [7]

Question 6

a. Figure-Q6(a) shows a simple transistor switching circuit controlling energy delivered to the inductive load.

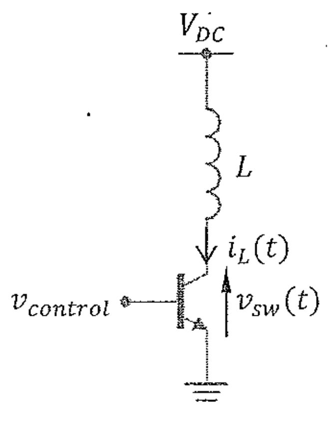


Figure-Q6(a)

Quantitatively explain the consequences of turning off the switching element in Figure-Q6(a) from its saturation state. [6]

b. i. Explain the two basic functions of a snubber circuit. [4]

ii. Draw a RCD snubber circuit onto the circuit in Figure-Q6(a) that will improve the performance of the circuit. [3]

iii. Explain the operation of the RCD snubber circuit drawn in part (b)(ii) to improve the performance of the circuit. [3]

c. i. Explain the method where power transistors increase the rate at which heat is removed from the devices. [3]

ii. Sketch a power derating curve for a power transistor. Label the axes clearly. [2]

iii. A power transistor has a maximum collector dissipation of 4W for an ambient temperature of 30°C. If the maximum junction temperature is 170°C and the thermal resistance θ_{JS} between junction (device) and heat sink is 4°C/W, calculate the maximum possible thermal resistance for the heat sink. [4]

~ The End ~