



**INTI**  
**International College Penang**  
LAUREATE INTERNATIONAL UNIVERSITIES®

FINAL  
Examination Paper

(COVER PAGE)

Session : JANUARY 2015

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Programmes : DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (DEE)

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Course : EEE2102: INTRODUCTION TO POWER ELECTRONICS

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Date of Examination : 13 March 2015 (Friday)

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Time : 8:00am – 10:00am Reading Time: Nil

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Duration : 2 Hours

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Special Instructions :

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

**Students are not allowed to remove this question paper from the examination venue.**

Materials permitted : Non Programmable Scientific Calculator

Materials provided: Appendix

Examiner(s) : Mr. Liong Han Wen

Moderator : Dr. Ooi Beng Lee

*This paper consists of 7 printed pages, including the cover page.*

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME  
EEE 2102 : INTRODUCTION TO POWER ELECTRONICS  
FINAL EXAMINATION: JANUARY 2015 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 brackets at the right-hand margin.

**Question 1**

- a. An inductor of  $100\mu\text{H}$  is connected as shown in Figure Q1(a) to a 5V source. The switch is closed for  $100\mu\text{s}$  and then opened. Assume the initial current is zero. Find :
  - i. The inductor current  $100\mu\text{s}$  after the switch is closed, assuming  $R = 0\Omega$ . (4 marks)
  - ii. The inductor current at  $t = 100\mu\text{s}$  if  $R = 0.01\Omega$ . Assume the initial inductor current is 1A (4 marks)
  - iii. The inductor current for part (b) after the switch has been open for  $200\mu\text{s}$ . The freewheeling diode is ideal. (3 marks)



Figure Q1(a)

- b. The two diodes shown in Figure Q1(b) below conduct a total of 100A. Neither diode must not conduct more than 55A. Find :
  - i. The value of the two equal resistors to be inserted in series with each diode to produce this condition. (6 marks)
  - ii. Total loss for both resistors. (3 marks)

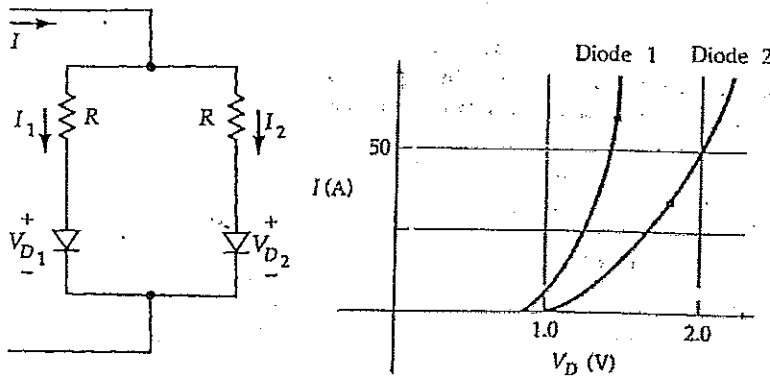


Figure Q1(b)

- c. What are the 5 requirements for ideal power switches? (5 marks)

**Question 2**

- a. An SCR is used as power switch to control power deliver to the load R as shown in Figure Q2(a). A RC snubber circuit is connected parallel to the SCR for power device protection purpose. The maximum  $(dV_c/dt)$  allowed is  $200V/\mu s$ . Assume that the capacitor initial voltage equal to zero when charging.
- What will be the minimum value of  $C_s$ ? (5 marks)
  - Initial discharge of C should be limited to 4A at SCR turn on. Find the maximum value of  $R_s$ . (4 marks)

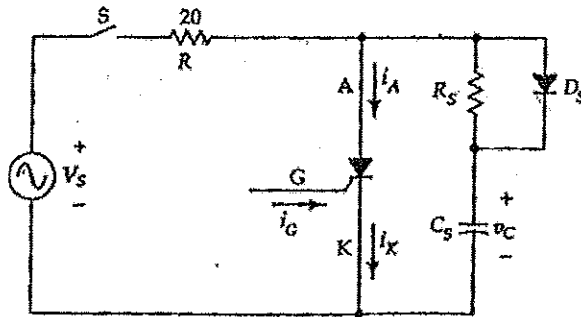


Figure Q2(a)

- b. For a SCR turn off circuit as shown in Figure Q2(b), given  $E = 300V$ ,  $R = 20\Omega$ ,  $C = 2.0\mu F$  and  $V_C(0) = -200V$ . Find the minimum time when the  $V_{AK}(t_q)$  is negative value. (8 marks)

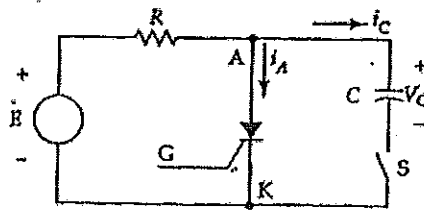


Figure Q2(b)

- c. Describe the four limits of the Safe Operating Area(SOA) of a power Bipolar Junction Transistor(BJT) (8 marks)

**Question 3**

a. In the circuit below, the following data are known :  $E = 50V$ ,  $R = 100k\Omega$  and  $C = 0.1\mu F$ .

DIAC characteristic:

DIAC breakover voltage = 30V

DIAC forward voltage drop = 5V

DIAC holding current = 10mA

DIAC on internal resistance =  $5\Omega$

SCR characteristic:

$V_{GK} = 1.0V$

$R_{GK} = 20\Omega$

Find :

- i. Capacitor peak voltage. (2 marks)
- ii. Total capacitor discharge time for each cycle. (4 marks)
- iii. Capacitor voltage at end of discharge interval. (7 marks)
- iv. Duration of charging interval. (6 marks)
- v. Frequency at which gate pulse are produced. (3 marks)

Assume the current source by E is too small and can be ignore when capacitor is discharging.

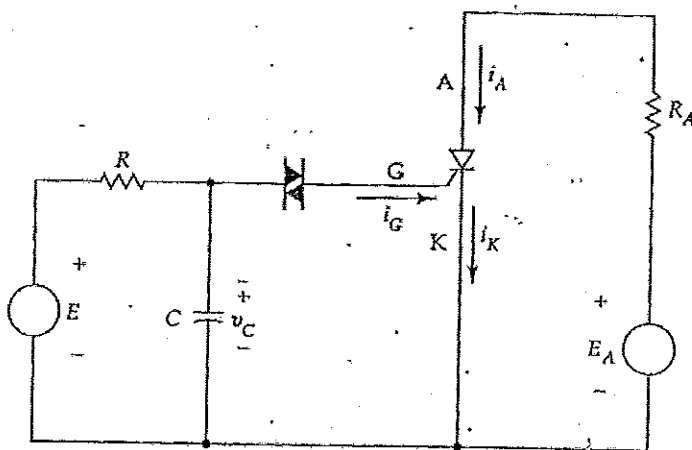


Figure Q3(a)

- b. List down three categories of power diode. (3 marks)

**Question 4**

a. A full wave diode rectifier with an inductive load as shown in Figure Q4(a), has the resistive part of the load equal to  $20\Omega$  and a source voltage of  $240V_{RMS}$ ,  $60\text{Hz}$ . Assume the load inductance is very large. Find:

- i. Average load current (3 marks)
- ii. RMS load current (2 marks)
- iii. Average power to the load (3 marks)
- iv. Average current in each diode (4 marks)
- v. Sketch the current  $i_D$  and  $i_L$  for at least one cycle. (4 marks)

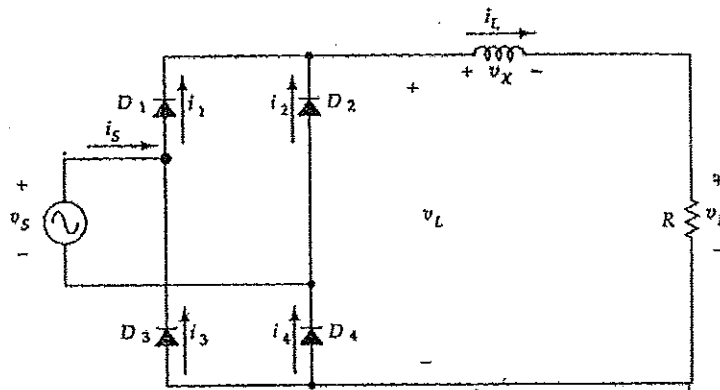


Figure Q4(a)

b. For a switching circuit shown in Figure Q4(b), the transistor is turned on and off at frequency  $20\text{kHz}$ . Collector current rise time is  $1\mu\text{s}$  and fall time is  $0.75\mu\text{s}$ . Given  $V_{CC} = 350\text{V}$  and  $R = 25\Omega$ . Find the average switching power loss. (9 marks)

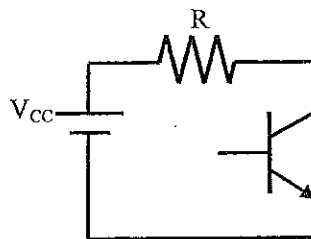


Figure Q4(b)

**Question 5**

a. A half wave, phase controlled rectifier with resistive load has a load of  $20\Omega$  and a source voltage of  $240V_{RMS}$ ,  $60\text{Hz}$  sinusoid. The circuit operates with  $\alpha = 20^\circ$ . Find:

- i. average load current (4 marks)
- ii. RMS load current (4 marks)
- iii. power to the load (2 marks)

- b. A 3-phase SCR rectifier is supplied by a line voltage  $480V_{(line)RMS}$  60Hz sinusoid source. The load is a  $25\Omega$  resistance. The circuit operates with  $\alpha = 10^\circ$ . Find:
- i. Average load current (4 marks)
  - ii. Peak diode current (2 marks)
  - iii. Average diode current (2 marks)
- c. Repeat part b)i. if the  $\alpha$  is changed to  $70^\circ$ . (5 marks)
- d. State two methods to turn off SCR. (2 marks)

**Question 6**

- a. The input to the circuit in Figure Q6(a) is 120V D.C. with  $\pm 10\%$  ripple. The output is desired to range from 30 V to 150 V regulated D.C. Find the minimum inductance to use if the circuit is to be operated in continuous-conduction mode with the switching speed maintained at 10 kHz. The output power is to be maintained at 10W. (15 marks)

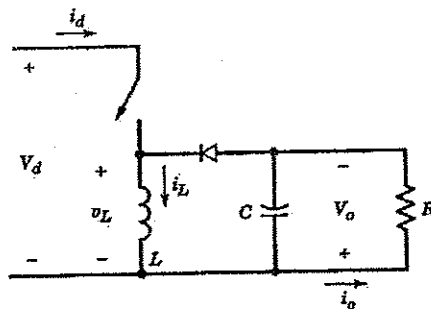


Figure Q6(a)

- b. The circuit in Figure Q6(b), the switch controls power to a resistive load from a  $460V_{RMS}$ , sinusoid 60Hz source by using phase control method. The load resistance is  $20\Omega$  and  $\alpha$  is  $35^\circ$ . Find :
- i. Minimum switch current rating (2 marks)
  - ii. Minimum switch voltage rating (2 marks)
  - iii. Average load power (6 marks)

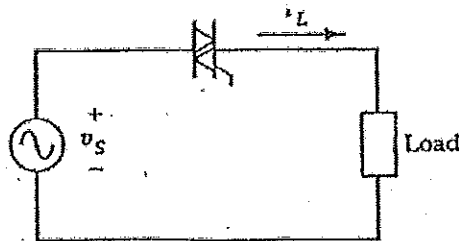


Figure Q6(b)

--THE END--

## Appendix: Trigonometry Identities

### Sum or difference of two angles:

$$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$$

$$\cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$$

$$\tan(a \pm b) = \frac{\tan a \pm \tan b}{1 \mp \tan a \tan b}$$

### Double angle formulas:

$$\sin 2\theta = 2 \sin \theta \cos \theta$$

$$\cos 2\theta = 1 - 2 \sin^2 \theta$$

$$\tan 2\theta = \frac{2 \tan \theta}{1 - \tan^2 \theta}$$

$$\cos 2\theta = 2 \cos^2 \theta - 1$$

$$\cos 2\theta = \cos^2 \theta - \sin^2 \theta$$

### Pythagorean Identities:

$$\tan^2 \theta + 1 = \sec^2 \theta$$

$$\sin^2 \theta + \cos^2 \theta = 1$$

$$\cot^2 \theta + 1 = \csc^2 \theta$$

### Half angle formulas:

$$\sin^2 \theta = \frac{1}{2}(1 - \cos 2\theta)$$

$$\cos^2 \theta = \frac{1}{2}(1 + \cos 2\theta)$$

$$\sin \frac{\theta}{2} = \pm \sqrt{\frac{1 - \cos \theta}{2}}$$

$$\cos \frac{\theta}{2} = \pm \sqrt{\frac{1 + \cos \theta}{2}}$$

$$\tan \frac{\theta}{2} = \pm \sqrt{\frac{1 - \cos \theta}{1 + \cos \theta}} = \frac{\sin \theta}{1 + \cos \theta} = \frac{1 - \cos \theta}{\sin \theta}$$

