



**INTI**

INTERNATIONAL COLLEGE PENANG (507232-U)  
LAUREATE INTERNATIONAL UNIVERSITIES

FINAL  
Examination Paper

(COVER PAGE)

Session : April 2013

Programme : Diploma in Electrical and Electronic Engineering

Course : EEE2102: INTRODUCTION TO POWER ELECTRONICS

Date of Examination : 30 July 2013

Time : 11 a.m. – 1p.m. Reading Time: Nil

Duration : 2 Hours

Special Instructions :

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

Materials permitted :  
Non-programmable calculator

Materials provided :  
Appendix

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Moderator : **Dr. Ooi Beng Lee**

*This paper consists of 9 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 : APRIL 2013 SESSION

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**Question 1**

- a. A DC source( $E$ ) of 20V is supplying power to a  $20\Omega$  resistive load( $R_L$ ) through a switch like Figure Q1(a). Find the average power to the load, if the switch is:
- i. Closed (2 marks)
  - ii. Open (2 marks)
  - iii. Open 40% of the time (3 marks)
  - iv. Closed 20% of the time (3 marks)

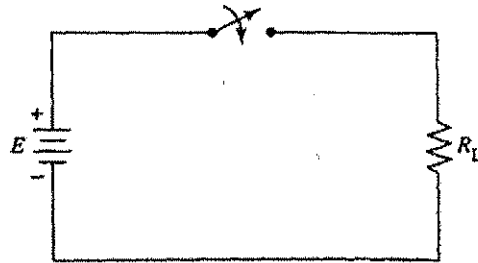


Figure Q1(a)

- b. For the circuit shown in Figure Q1(b), find  $I_1$ ,  $I_2$  and  $I_D$ . Assume the diode is silicon diode with 0.8V voltage drop. Hence, find the power consume by the diode. (8 marks)

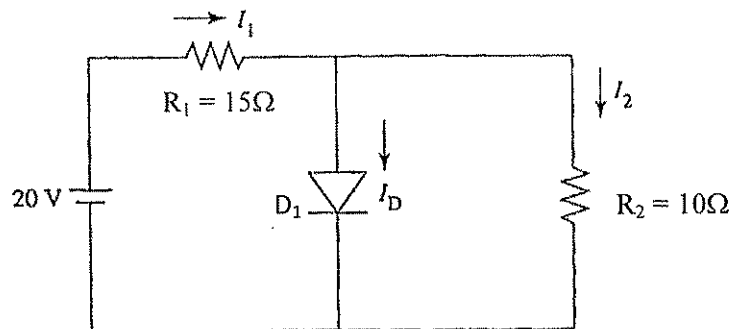


Figure Q1(b)

- c. In power converter circuit, power bipolar junction transistor is used as a switch. Which **TWO (2)** regions in the transistor output characteristics is used in switching applications. Sketch the output characteristics curve of practical transistor. (7 marks)

**Question 2**

- a. A transistor bias as shown in Figure Q2(a) is switching at 20kHz. The transistor rise time is  $1\mu\text{s}$  and fall time is  $2\mu\text{s}$ . Sketch the waveform of collector current and collector-emitter voltage when switching (at least 1 cycle). Find the energy loss for rise time and loss time respectively. Assume ideal components. (15 marks)

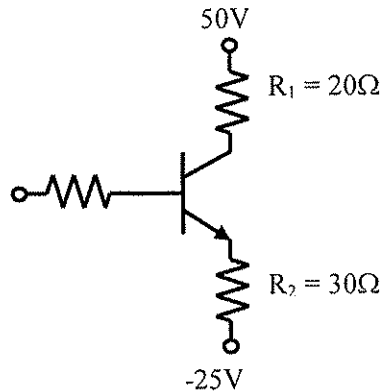


Figure Q2(a)

- b. The circuit in Figure Q2(b), the switch controls power to a resistive load from a  $460\text{V}_{\text{RMS}}$ , 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 (3 marks)
  - ii. Minimum switch voltage rating (3 marks)
  - iii. Average load power (4 marks)

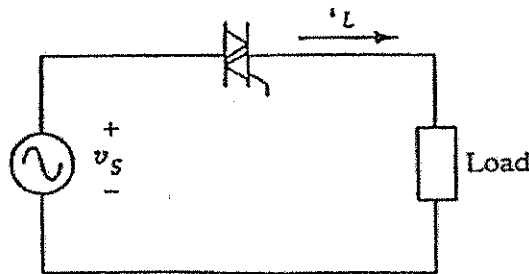


Figure Q2(b)

**Question 3**

- a. A full wave rectifier with resistive load as shown in Figure Q3(a) has a load of  $10\Omega$  and a source voltage of  $240\text{V}_{\text{RMS}}$ , 50Hz. Find :
- i. peak load voltage ( $V_L$ ) (2 marks)
  - ii. average load voltage (3 marks)
  - iii. average load current (2 marks)
  - iv. RMS load current (3 marks)
  - v. average power to the load (2 marks)

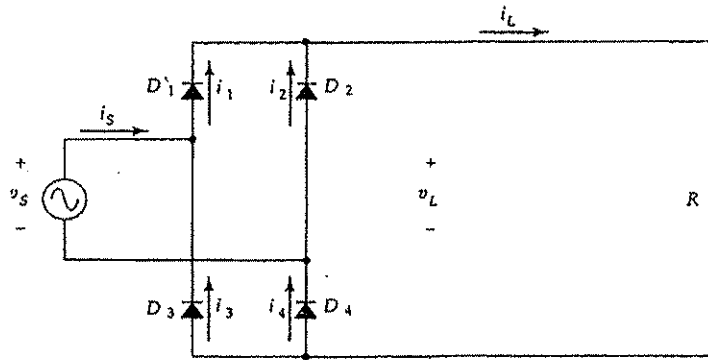


Figure Q3(a)

b. A 3-phase diode half wave rectifier is supplied by a line voltage  $480V_{RMS}$  60Hz sinusoid source as shown in Figure Q3(b). The load is a  $25\Omega$  resistance. Find:

- i. Average load current (3 marks)
- ii. Peak diode current (2 marks)
- iii. Average diode current (2 marks)

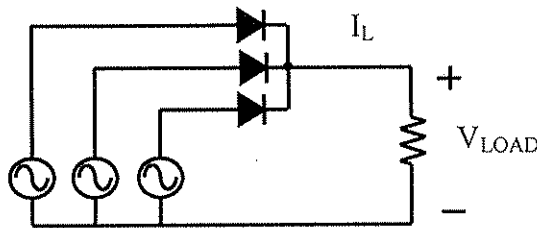


Figure Q3(b)

c. Explain the role of snubber circuit in power electronic converter, the design of snubber circuit and how it work. (6 marks)

**Question 4**

- a. A circuit consisting of two diodes connected in series with current sharing resistors as shown in Figure Q4(a). Figure Q4(b) shows the characteristics of the two diodes. The total reverse voltage is 4700V of which 60% of voltage appears across diode 1. Compute
  - i. The reverse voltage for each diode and resistance value connected in parallel with each diode to limit the reverse voltage. (5 marks)
  - ii. The total reverse current and the power consumed in the voltage sharing resistors. (4 marks)

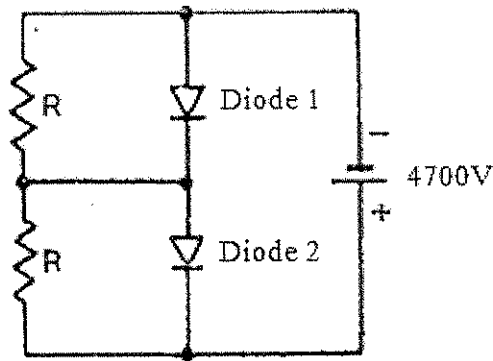


Figure Q4(a)

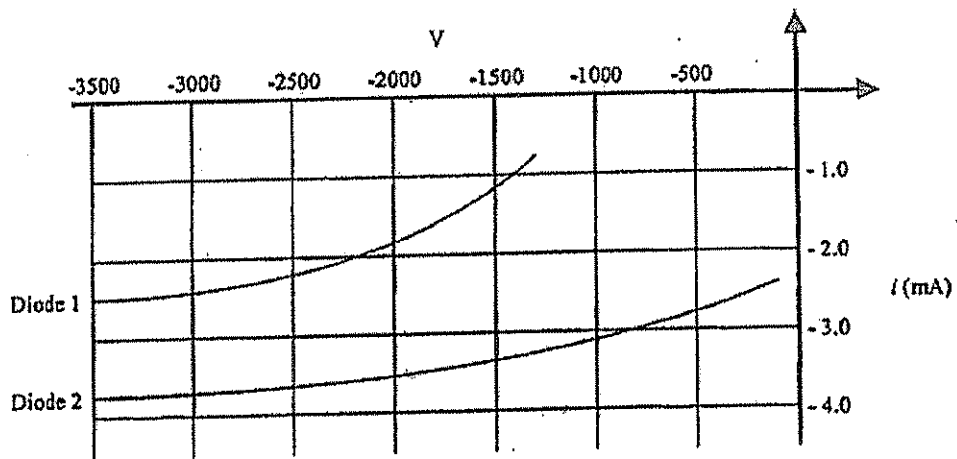


Figure Q4(b)

- b. A single phase full wave controlled rectifier with an infinite inductive load has the resistive part of the load equal to  $10\Omega$  and a source voltage of  $250V_{RMS}$   $60\text{Hz}$  sinusoid. The firing angle is  $30^\circ$ . Find :
- i. Average load current (3 marks)
  - ii. RMS load current (3 marks)
  - iii. Power to the load (3 marks)
  - iv. Average current in each SCR (3 marks)
  - v. Sketch the output voltage and current waveform for at least one cycle. (4 marks)

**Question 5**

- a. A chopper circuit shown in figure Q5(a) supplies 24V to a resistive load of  $12\Omega$  from 60V source. The inductor current is continuous and chopping frequency is 5kHz.
- What type of chopper is this? (2 marks)
  - Sketch the waveforms of  $i_L$ ,  $i_S$ ,  $i_D$ ,  $i_C$ ,  $V_L$  and  $V_O$ . (12 marks)
  - Find the value of duty cycle. (2 marks)
  - Find the minimum value of  $L$  required. (2 marks)
  - Find the minimum and maximum value of  $i_L$  if  $L$  is 1.5mH. (4 marks)
  - Calculate the power from the source. (3 marks)

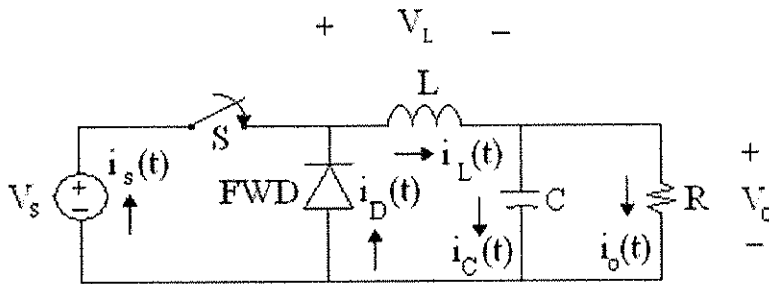


Figure Q5(a)

**Question 6**

- The output voltage for a buck regulator is 200V and the input voltage is 350V. The switching off time is  $100\mu s$ . Calculate the switching frequency of the buck regulator. (8 marks)
- What is the minimum gate pulse width required to successfully turn ON a SCR in Figure Q6(b) if the latching current is 100mA. Assume  $V_1 = 200V$  and zero forward voltage drops across SCR and inductor initial current is zero. (7 marks)

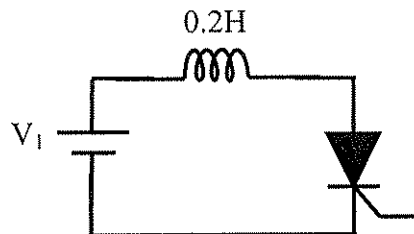


Figure Q6(b)

- Repeat part b if the inductor is in series with a  $20\Omega$  resistor. Assume inductor initial current equal to zero. (7 marks)
- State two methods to turn off a SCR. (3 marks)

**--THE END--**

## Appendix A: Table of Laplace Transform

Remember that we consider all functions (signals) as defined only on  $t \geq 0$ .

### General

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$$f(t) \qquad F(s) = \int_0^{\infty} f(t)e^{-st} dt$$

$$f + g \qquad F + G$$

$$\alpha f \ (\alpha \in \mathbf{R}) \qquad \alpha F$$

$$\frac{df}{dt} \qquad sF(s) - f(0)$$

$$\frac{d^k f}{dt^k} \qquad s^k F(s) - s^{k-1} f(0) - s^{k-2} \frac{df}{dt}(0) - \dots - \frac{d^{k-1} f}{dt^{k-1}}(0)$$

$$g(t) = \int_0^t f(\tau) d\tau \qquad G(s) = \frac{F(s)}{s}$$

$$f(\alpha t), \ \alpha > 0 \qquad \frac{1}{\alpha} F(s/\alpha)$$

$$e^{at} f(t) \qquad F(s - a)$$

$$t f(t) \qquad \frac{dF}{ds}$$

$$t^k f(t) \qquad (-1)^k \frac{d^k F(s)}{ds^k}$$

$$\frac{f(t)}{t} \qquad \int_s^{\infty} F(s) ds$$

$$g(t) = \begin{cases} 0 & 0 \leq t < T \\ f(t - T) & t \geq T \end{cases}, \ T \geq 0 \qquad G(s) = e^{-sT} F(s)$$

## Specific

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1	$\frac{1}{s}$
$\delta$	1
$\delta^{(k)}$	$s^k$
$t$	$\frac{1}{s^2}$
$\frac{t^k}{k!}, k \geq 0$	$\frac{1}{s^{k+1}}$
$e^{at}$	$\frac{1}{s-a}$
$\cos \omega t$	$\frac{s}{s^2 + \omega^2} = \frac{1/2}{s - j\omega} + \frac{1/2}{s + j\omega}$
$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2} = \frac{1/2j}{s - j\omega} - \frac{1/2j}{s + j\omega}$
$\cos(\omega t + \phi)$	$\frac{s \cos \phi - \omega \sin \phi}{s^2 + \omega^2}$
$e^{-at} \cos \omega t$	$\frac{s + a}{(s + a)^2 + \omega^2}$
$e^{-at} \sin \omega t$	$\frac{\omega}{(s + a)^2 + \omega^2}$

## Appendix B : 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:

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

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

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

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

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