INTI
INTERNATIONAL COLLEGE PENANG (507232-U)
LAUREATE INTERNATIONAL UNIVERSITIES

FINAL
Examination Paper

(COVER PAGE)

Session : August 2012

Programme : DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING

Course : EEE2102 : INTRODUCTION TO POWER ELECTRONICS

Date of Examination : 12 December 2012

Time : 11a.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 Scientific Calculator

Materials provided :

Appendix

Examiner(s) : **Liong Han Wen**

Moderator : **Chai Yoon Yik**

This paper consists of 9 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME
EEE 2102 : INTORDUCTION TO POWER ELECTRONICS
FINAL EXAMINATION : AUGUST 2012 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.

Question 1

a. A DC source(E) of 20V is supplying a 20Ω resistive load(R_L) through a switch as shown in Figure Q1(a). Find the average voltage to the load , if the switch is :

i. Closed (2 marks)
ii. Open (2 marks)
iii. Open 40% of the time (2 marks)
iv. Closed 20% of the time (2 marks)

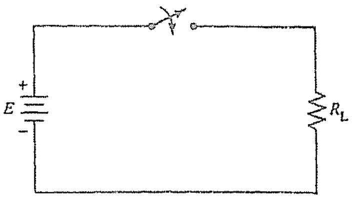

Figure Q1(a)

b. List down three categories of power diodes and describe the characteristic for each category. (6 marks)

c. Draw circuit model of a SCR by using npn and pnp transistor symbol. Indicate clearly the anode, cathode and gate terminal. (4 marks)

d. For the circuit in Figure Q1(d),

i. What is the minimum V_{IN} that will fire the SCR, if the gate current needed to fire the SCR is 20mA. Assume V_{GK} is 0.8V. (3 marks)

ii. If the E is connected to 10V.What is the power dissipated by the SCR if R_L = 50Ω. Assume the SCR anode-cathode voltage when turn on is 1.2V. (4 marks)

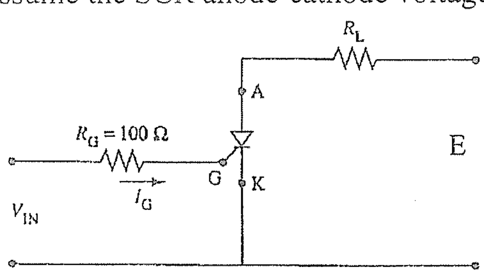

Figure Q1(d)

Question 2

a. For a SCR turn off circuit as shown in Figure Q2(a), given $E = 300V$, $R = 20\Omega$, $C = 2.0\mu F$ and $V_C(0) = -200V$. The switch closed at $t = 0$. Sketch and label the waveform for i_A and V_C for $0 \leq t < \infty$. Hence, find the value for the time when Vc is negative(t_q). (14 marks)

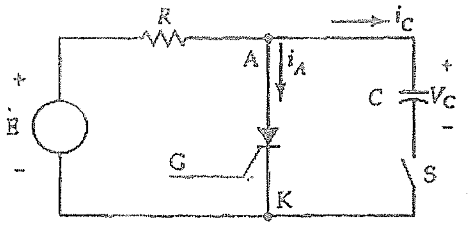

Figure Q2(a)

b. Explain what is reverse recovery for a diode. (3 marks)

c. A single phase half wave bridge diode rectifier with resistive load of 20Ω and a source voltage $240V_{RMS}$, 60Hz. Find :

i. Peak output current (2 marks)

ii. Average load current (2 marks)

iii. RMS load current (2 marks)

iv. Power to the load (2 marks)

Question 3

a. In the power electronic circuit shown in Figure Q3(a), the SCRs are respectively turn on and off. Sketch the current(i_1, i_2, i_C and i_D) and voltage waveform(V_C) of the circuit and describe the SCR turn off process of the circuit. Assume that the capacitor is charged by previous action, $V_C(0) = -E$ and the load inductance is infinite. (15 marks)

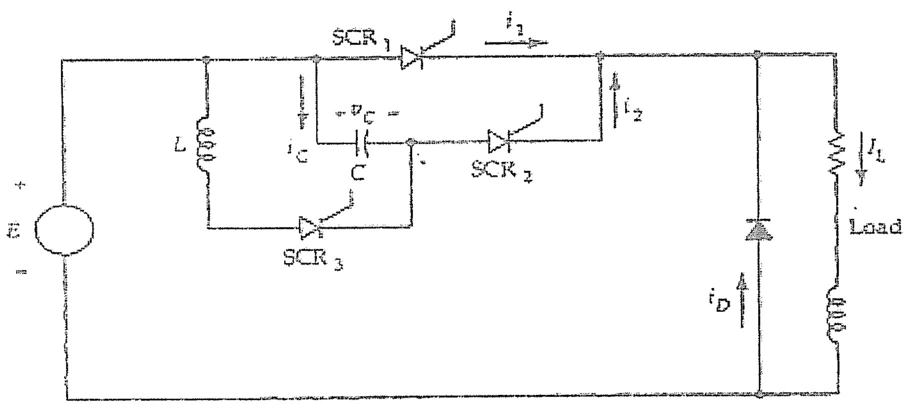

Figure Q3(a)

b. For the circuit shown in Figure Q3(b), Given V1 = 200V, L1 is 0.2H and SCR latching current is 100mA. Assume zero forward voltage drop across SCR.

i. What is the gate pulse width required to successfully turn ON a SCR. (5 marks)

ii. Repeat part i. if the L1 is in series with a 20Ω resistor. (5 marks)

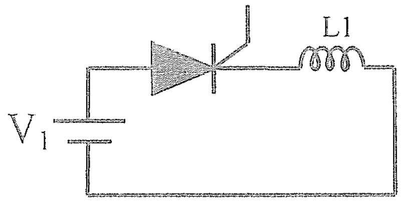

Figure Q3(b)

Question 4

a. In the Figure Q4(a), the MOSFET is turned on and off periodically at 50Hz. The gate current supply is +100mA for 5μs and then -60mA for 15μs. The value of V_{GS} is limited to +10V or 0V by the action of zener diode connected to the gate. The load inductance is large enough that the load current may be assumed constant(10A) during each cycle. Find the MOSFET switching loss for the operations. (25 marks)

Cgs = 500pF and Cgd = 2000pF for $V_{DG} < 0$
Cgs = 1200pF and Cgd = 50pF for $V_{DG} > 0$
$V_T = 3.8V$
K = 4A/V
$R_{DS(on)} = 0.5\Omega$
$V_{DD} = 200V$

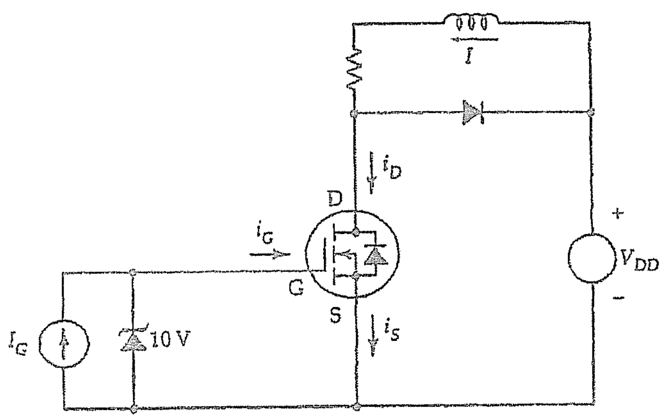

Figure Q4(a)

Question 5

a. A 3-phase diode rectifier is supplied by a line voltage 480V_{RMS} 60Hz sinusoid source as shown in Figure Q5(a). The load is a 25Ω resistance. Find :

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

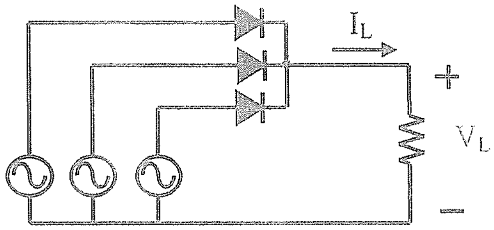

Figure Q3(a)

b. A full wave diode rectifier with an inductive load as shown in Figure Q5(b), has the resistive part of the load equal to 20Ω and a source voltage of 240V_{RMS}, 60Hz. Assume the load inductance is very large.

i. Sketch the current i_1 and i_L (6 marks)

Find :

ii. Average load current (4 marks)
iii. RMS load current (2 marks)
iv. Average power to the load (3 marks)
v. Average current in each diode (3 marks)

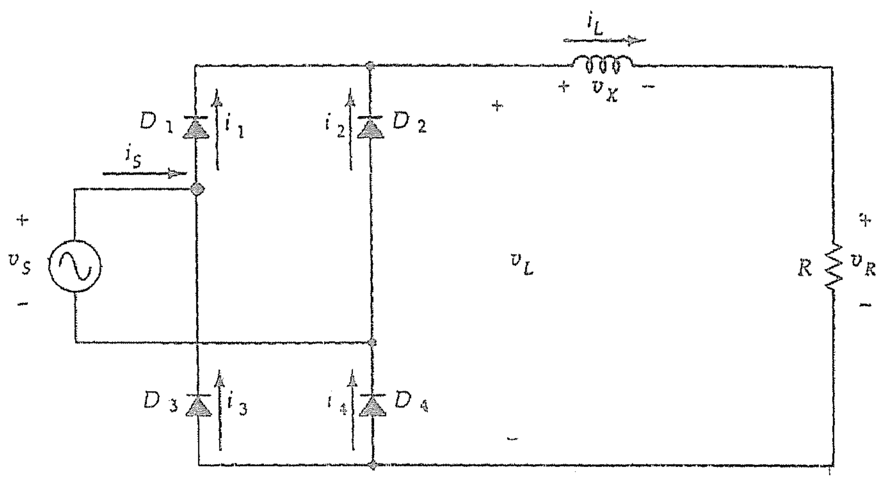

Figure 5(b)

Question 6

a. A buck-boost chopper shown in the Figure Q6(a) supplies dc power to a resistive load, R = 10Ω. Given L = 5mH. The source voltage is 100 V and the load voltage is 150 V. The switching frequency is 1KHz.

i. Sketch the waveform for i_L, i_D, i_i, i_C and V_L (10 marks)

Determine :

ii. The duty cycle (2 marks)

iii. The peak-to-peak ripple in the inductor current (4 marks)

iv. The average value of the input current (3 marks)

v. The average value of the diode current (3 marks)

vi. The minimum inductance required for continuous current operation (3 marks)

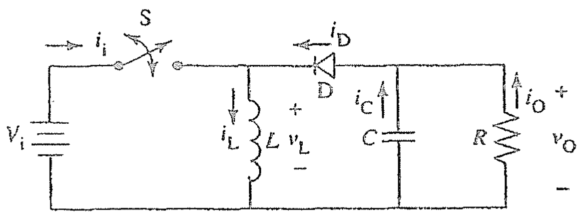

Figure Q6(a)

--THE END--

Appendix A: Table of Laplace Transform

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

General

$f(t)$	$F(s) = \int_0^\infty f(t)e^{-st}\, dt$
$f + g$	$F + G$
$\alpha f \ (\alpha \in \mathbb{R})$	αF
$\frac{df}{dt}$	$sF(s) - f(0)$
$\frac{d^k f}{dt^k}$	$s^k F(s) - s^{k-1} f(0) - s^{k-2}\frac{df}{dt}(0) - \cdots - \frac{d^{k-1} f}{dt^{k-1}}(0)$
$g(t) = \int_0^t f(\tau)\, d\tau$	$G(s) = \frac{F(s)}{s}$
$f(\alpha t),\ \alpha > 0$	$\frac{1}{\alpha} F(s/\alpha)$
$e^{at} f(t)$	$F(s - a)$
$t f(t)$	$-\frac{dF}{ds}$
$t^k f(t)$	$(-1)^k \frac{d^k F(s)}{ds^k}$
$\frac{f(t)}{t}$	$\int_s^\infty F(s)\, ds$
$g(t) = \begin{cases} 0 & 0 \leq t < T \\ f(t-T) & t \geq T \end{cases},\ T \geq 0$	$G(s) = e^{-sT} F(s)$

Specific

1	$\frac{1}{s}$
δ	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:

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

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

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

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

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

Pythagorean Identities:

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

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

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

Half angle formulas:

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

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

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

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

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