UNIVERSITI KUALA LUMPUR
Malaysian Institute Of Marine Engineering Technology

FINAL EXAMINATION
JANUARY 2016 SESSION

SUBJECT CODE	:	LEB 30103
SUBJECT TITLE	:	POWER ELECTRONICS
LEVEL	:	DEGREE
TIME / DURATION	:	3 HOURS
DATE	:	

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper has information printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration
5. This question paper consists of TWO (2) sections. Section A and B. Answer all questions in Section A. For Section B, answer THREE (3) questions only.
6. Answer all questions in English.

THERE ARE 10 PAGES OF QUESTIONS, INCLUDING THIS PAGE.

PART A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

Question 1

a. List of **6 (six)** among the diversity of knowledge to make the study of power electronics challenging as well as interesting

[3 marks]

b. Explain about the gate drivers. Why they are so important to Power Electronics.

[3 marks]

c.

Figure 1

Converters are classified by the relationship between input and output as shown in **Figure 1**. State the four basic types of power converter, provide names in common usage and briefly explain their examples respectively.

[8 marks]

d. For the circuit shown in **Figure 2** with ideal diodes (zero forward voltage drop and high reverse breakdown voltage),

(i) Describe the flow of current and the operation of diodes in this circuit.

[4 marks]

(ii) Determine the average power absorbed by the resistor.

[2 marks]

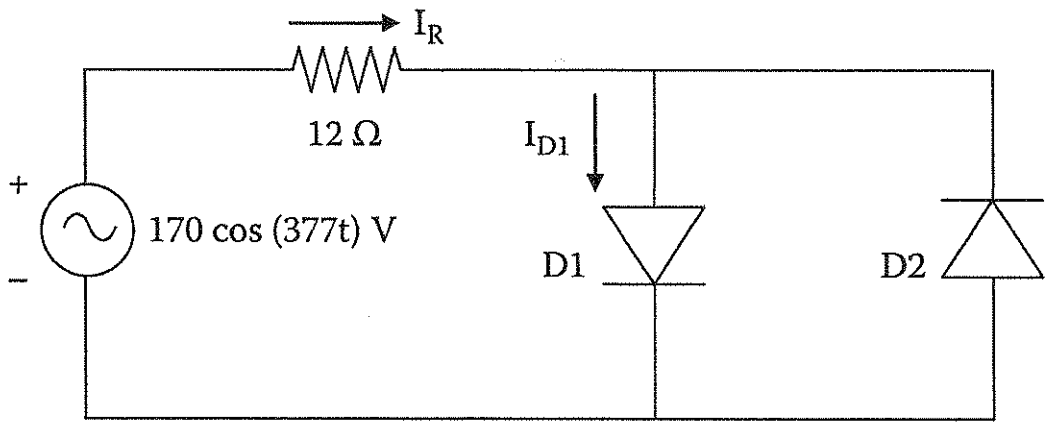

Figure 2

Question 2

a. Explain the advantages for a three-phase rectifier compared to a single-phase rectifier. [4 marks]

b. A full-wave bridge controlled rectifier is supplied form 240 V source with a load resistance of 50Ω. If the firing angle $\alpha = 30°$, determine

(i) The average load voltage [2 marks]

(ii) The average load current [2 marks]

(iii) The RMS load current [2 marks]

(iv) The power supplied by the load [2 marks]

(v) The power factor [2 marks]

(vi) Sketch the schematic diagram of full wave rectifiers and explain the operation. [6 marks]

PART B (Total: 60 marks)

INSTRUCTION: Answer only THREE (3) questions.

Please use the answer booklet provided.

Question 3

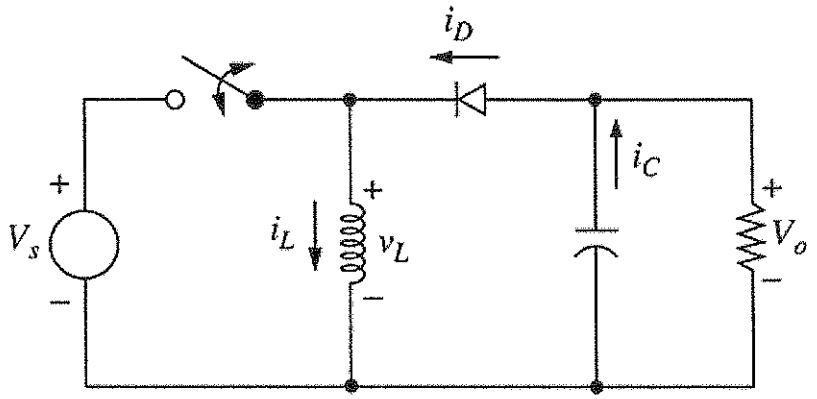

Figure 3

a. Average output voltage of a DC-to-DC buck-boost converter as in **Figure 3** is given by expression:

$$V_o = -V_s\left[\frac{D}{1-D}\right]$$

Where *Vs* is the dc source voltage and *D* is the duty cycle. Prove the equation above.

[8 marks]

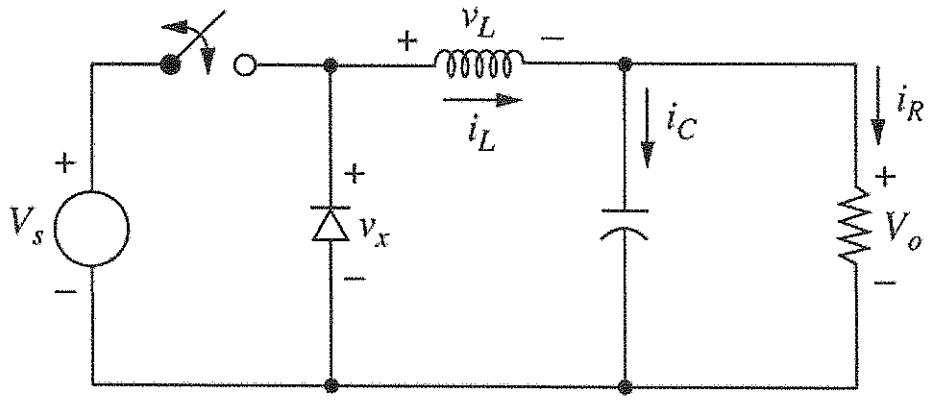

Figure 4

b. A DC-to-DC buck converter as shown in **Figure 4**, operating at a switching frequency of 1kHz and 40% duty cycle has a 10mH inductor in the series arm and a 33μF capacitor is parallel with the load R=15ohm. Given that the converter operates at a switching frequency of 1kHz and 40% duty cycle and source voltage is 30volt. Calculate:

i. The average output voltage

[2 marks]

ii. The maximum and minimum values of the inductor current

[4 marks]

iii. The percentage output voltage ripple

[3 marks]

iv. Sketch the graph for maximum and minimum inductor current

[3 marks]

Question 4

a. Describe the differences between PWM bipolar and unipolar switching scheme.

[5 marks]

b. The full-bridge series resonant inverter of **Figure 5** has 12 Ω resistive load that requires a 400 Hz, 80 Vrms sinusoidal voltage. The THD of the load voltage must be no more than 5 %.

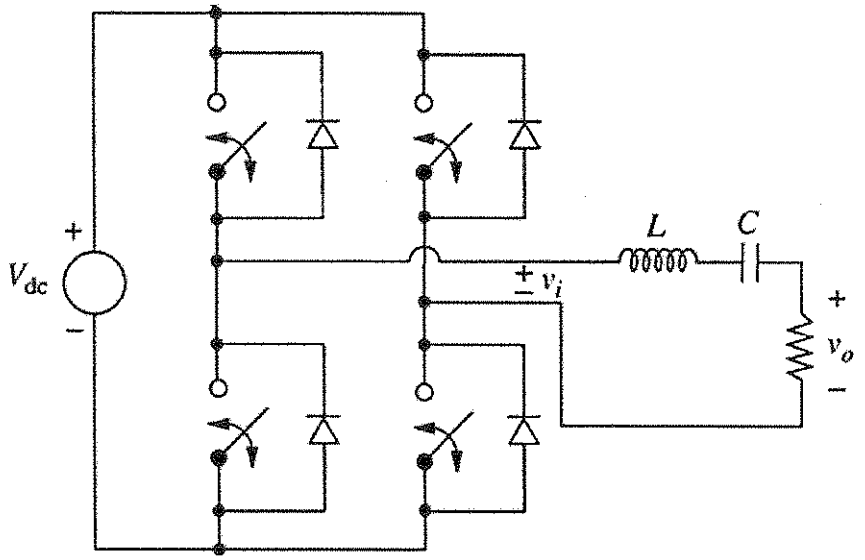

Figure 5

(i) Describe the operation of full-bridge series resonant inverter. (Draw and explain the current and voltage waveforms of the load- associated waveforms)

[6 marks]

(ii) Determine the required DC input for this resonant inverter.

[2 marks]

(iii) Determine the suitable value for L (inductance) and C (capacitance).

[4 marks]

(iv) Determine the peak voltage across C and the peak current in L.

[3 marks]

Question 5

a. List of three (3) ways to control speed and torque of induction motor. List of two (2) disadvantages of DC Motor.

[5 marks]

b. A separately excited DC motor has a constant torque load of 60N-m. The motor is driven by a full wave converter connected to a 240Vac supply. The field constant of the motor $KI_f = 2.5$ and the armature resistance is 2Ω. Calculate the triggering angle for the motor to operate at 200rpm. Assume the current is continuous.

[4 marks]

c. The speed of a separately excited DC Motor is controlled by a single phase full wave converter at armature side. The field circuit is controlled by a single phase semi-converter that is set to maximum possible value. The ac supply to the armature and field converters in one phase, 230V, 50Hz. The armature resistance, $R_a = 0.25\Omega$, field resistance, $R_f = 140\Omega$ and the motor voltage constant is $K_V = 1.125V/A/rad/s$. The load torque is $T_L = 60N.m$ at 1000rpm. The friction and no load losses are negligible. The inductance of the armature and field current continuous and ripple free. Determine:

(i) The motor Back EMF, E_g

[3 marks]

(ii) The delay angle of the converter in the armature circuit, α_a

[4 marks]

(iii) If the load torque, T_L decrease to 45N.m at 1100rpm, calculate (i) and (ii)

[4 marks]

Question 6

a. Explain the operation of Zero Current Switching (ZCS) buck converter with the help of neat circuit diagram and associated waveforms.

[10 marks]

b. A MOSFET mounted on a heat sink absorbs a thermal power of 18 W. The thermal resistances are 0.7°C/W from the junction to the case and 1.0°C/W for the case to the heat sink. The ambient temperature is 40°C. Determine the maximum thermal resistance from the heat sink to ambient such that the junction temperature does not exceed 110°C.

[5 marks]

b. **Table 1** below shows the reading for Fourier series quantities taken from harmonics waveform. Analyze total Harmonic Distortion for current (THDi) and total Harmonic Distortion for voltage (THDv)

n	f(Hz)	Vn(V)	Zn(Ω)	In(A)
1	60	127	13.7	9.27
3	180	0	30	0
5	300	25.5	48.2	0.53
7	420	18.2	66.7	0.27
9	540	0	85.4	0
11	660	11.6	104	0.11

Table 1

[5 marks]

END OF QUESTION

FORMULA'S

HALF-WAVE RECTIFIER CONVERTER

$$V_O = \frac{V_m}{\pi}$$

$$I_0 = \frac{V_0}{R} = \frac{V_m}{\pi R}$$

$$V_{RMS} = \frac{V_m}{2}$$

$$I_{RMS} = \frac{V_m}{2R}$$

$$V_o = \frac{V_m}{2\pi}[1 + \cos\alpha]$$

$$V_{o(RMS)} = \frac{V_m}{2}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

FULL-WAVE RECTIFIER

$$V_O = \frac{2V_m}{\pi}$$

$$I_O = \frac{V_O}{R} = \frac{2V_M}{\pi R}$$

$$V_O = \frac{Vm}{\pi}(1 + \cos\alpha)$$

$$I_O = \frac{V_O}{R} = \frac{V_m}{\pi R}(1 + \cos\alpha)$$

BUCK AND BOOST

$$I_L = \frac{V_S}{(1-D)^2 R}$$

$$I_L = \frac{Vout}{R}$$

$$\frac{\Delta V_O}{V_O} = \frac{D}{RCF}$$

$$\frac{\Delta Vo}{Vo} = \frac{1-D}{8LCf^2}$$

$$I_D = I_O = \frac{V_O}{R}$$

$$I_{L(\max)} = I_L + \frac{\Delta i_L}{2}$$

$$I_{L(\min)} = I_L - \frac{\Delta i_L}{2}$$

RESONANT INVERTER

$$\frac{V_o}{V_i} = \frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} = \frac{1}{\sqrt{1 + \left(\frac{\omega L}{R} - \frac{1}{\omega RC}\right)^2}}$$

$$V_1 = \frac{4V_{dc}}{\pi} \qquad \omega_o = \frac{1}{\sqrt{LC}} \qquad Q = \frac{\omega_o L}{R} = \frac{1}{\omega_o RC}$$

$$\frac{V_o}{V_i} = \frac{1}{\sqrt{1 + Q^2\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)^2}}$$