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CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR

Malaysia France Institute

FINAL EXAMINATION

JANUARY 2014 SESSION

SUBJECT CODE	:	**FLB35203**
SUBJECT TITLE	:	**POWER ELECTRONICS & DRIVES**
LEVEL	:	**BACHELOR**
DURATION	:	**3 HOURS**
DATE / TIME	:	

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **This question paper is 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 two (2) question only.**
6. **Answer all questions in English.**

THERE ARE 6 PRINTED PAGES OF QUESTIONS EXCLUDING THIS PAGE.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

(a) Give 3 (three) types of power conversion and each converter's name. (Hint: AC-AC, cycloconverter)

(6 marks)

(b) Provide 1(one) condition for a thyristor to switch ON and 1(one) condition to Turn OFF.

(2 marks)

(c) Briefly explain the existence of the extinction angle and the negative spike in the half wave rectifier with RL load.

(4 marks)

(d) A domestic load equivalent to 22 Ω is to be supplied with adequate DC power. The DC power shall be converted using a type of rectifier which input is sourced from Malaysian utility system (240 Vrms, 50 Hz). Determine:

i. The DC Power, P_{DC}, and the AC power , P_{AC}, obtained using a half wave rectifier.

(4 marks)

ii. The DC Power, P_{DC}, and the AC power , P_{AC}, obtained using a full wave rectifier.

(4 marks)

iii. Compare/calculate the efficiencies of both systems. State which rectifier type is better.

(2 marks)

(Hint : HALF WAVE : $V_{DC} = \frac{V_M}{\pi}; V_{RMS} = \frac{V_M}{2}$ and
FULL WAVE BRIDGE : : $V_{DC} = \frac{2 \cdot V_M}{\pi}; V_{RMS} = \frac{V_M}{\sqrt{2}}$)

Question 2

(a) Name 3 types of DC-DC Converters.

(3 marks)

(b) In a certain portable walkie-talkie project, the engineer is provided with a portable battery of 2AH 7V (can be operated from 5V to 9V). The walkie talkie has circuits which need a supply of 3.3V.

(i) Draw the circuit of suitable DC-DC converter type.
(ii) Produce the equivalent schematic when the main transistor switches ON
(iii) Produce the equivalent schematic when the main transistor switches OFF.

(6 marks)

(c) A single-phase half-wave thyristor converter is supplied with Malaysian utility supply (240Vrms 50Hz). The firing angle α is set to 30°. The converter supplies a 270 Ω load. Perform the analysis as follows :

(i) Draw the waveforms of source voltage and output voltage.

(2 marks)

(ii) Calculate the average output voltage ($V_{OUT(DC)}$) and the DC power obtained. Given $V_{DC} = \frac{V_M}{2\pi} * (1 + \cos\alpha)$.

(3 marks)

(iii) Calculate the RMS output voltage ($V_{OUT(DC)}$) and the AC power obtained. Given $V_{RMS} = \frac{V_M}{2}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}}$.

(4 marks)

SECTION B (Total: 60 marks)

INSTRUCTION: Answer TWO (2) questions only.
Please use the answer booklet provided.

Question 3

(a) **Figure 1** shows circuit of a three-phase bridge rectifier with purely resistive load. Calculate the peak value of the phase voltage given the rectifier delivers an output voltage of V_{dc} = 280.7V.

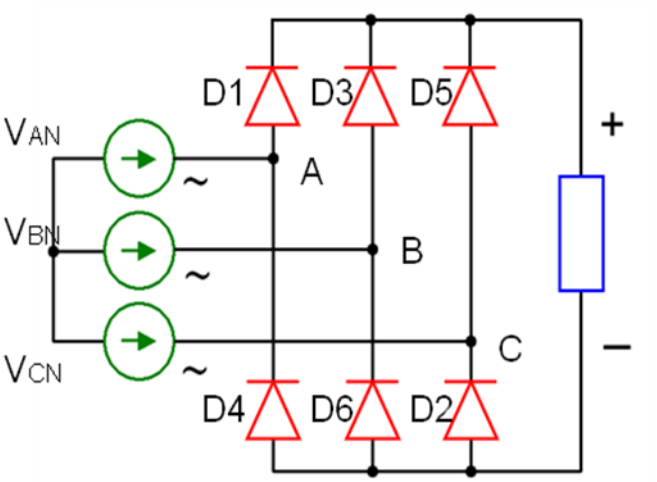

Figure 1

(6 marks)

(b) A DC chopper is used to charge a 240V battery from 600V DC source. The average battery current is 20A with a peak-to-peak ripple of 2A. Calculate the duty cycle, switch ON time interval and the inductor inductance of the DC chopper given the chopper frequency is 200 Hz.

(6 marks)

(c) A 200V DC source is connected to a 4-quadrant switching converter operating at a carrier frequency of 8 kHz. It is required to generate a sinusoidal voltage with an effective value of 240V at a frequency of 60 Hz and a phase angle of 35˚ lagging. Calculate the value of the amplitude modulation ratio, the frequency modulation ratio, and derive an expression for the duty cycle.

(6 marks)

(d) A rectifier shown in **Figure 2** has load of *R*=15 Ω and, *Vs*=220 *sin* 314 *t* and unity transformer ratio. If it is required to obtain an average output voltage of 70 % of the maximum possible output voltage, calculate:

i. The delay angle

ii. The rectification efficiency

iii. The ripple factor

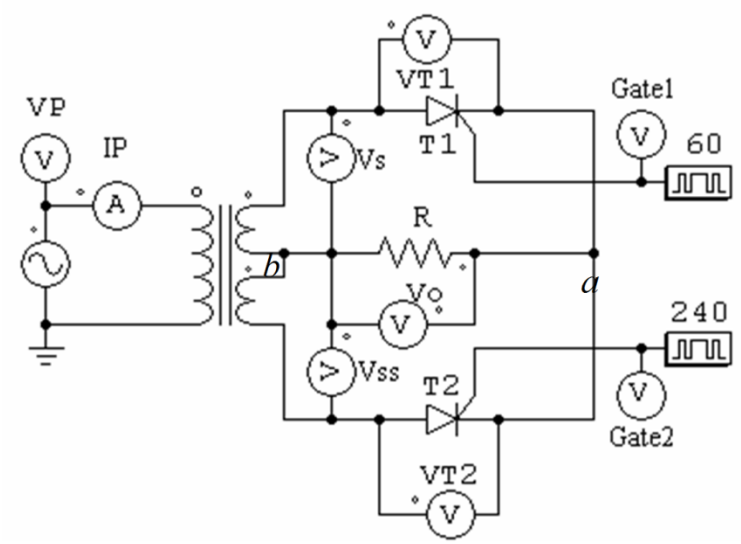

Figure 2

(12 marks)

Question 4

(a) A free-wheeling diode circuit shown in **Figure 3** has an AC source of V_m = 100V 60Hz with resistive load of 2Ω and inductive load of 25mH. Determine:

i. The average output voltage and output current

ii. The AC voltage amplitudes

iii. The Fourier impedance

iv. Power absorbed by the resistive load

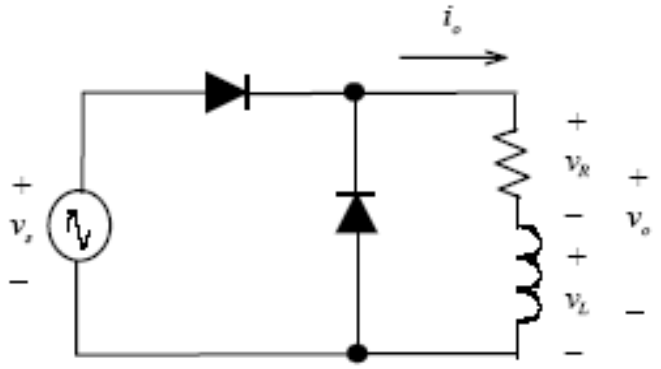

Figure 3

(15 marks)

(b) A general form of the Fourier series is given as

$$v_o(\omega t) = V_o + \sum_{n=1,2,...}^{\infty} \left(a_n \cos n\omega t + b_n \sin n\omega t\right)$$

Express the output voltage waveform of the square-wave inverter shown in **Figure 4** as a Fourier series.

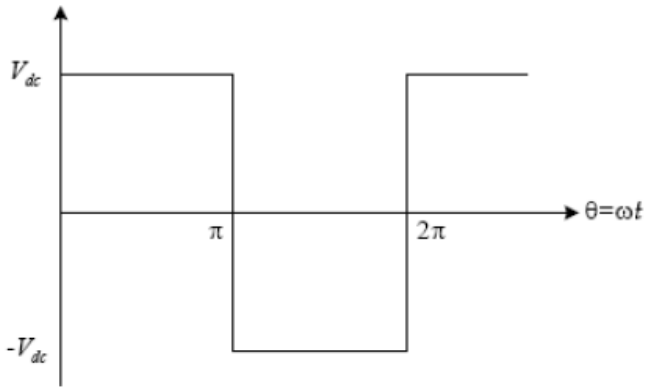

Figure 4

(15 marks)

Question 5

(a) A single-phase bridge rectifier shown in **Figure 5** has an AC source of V_m = 240V at 60 Hz and R-L load with R = 10Ω and L = 10mH. Determine the average current in the load, the first two higher order harmonics of the load current and the power absorbed by the load.

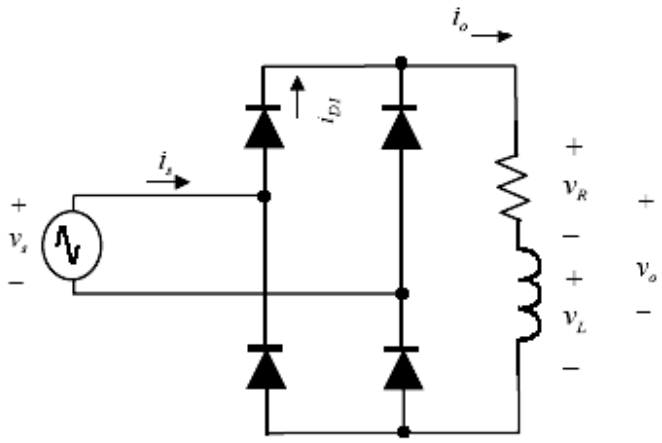

Figure 5

(12 marks)

(b) A three-phase half wave rectifier shown in **Figure 6** is operated from 460 V 50 Hz supply at secondary side and the load resistance is R=20Ω. If the source inductance is negligible, determine:

i. The rectification efficiency

ii. The form factor

iii. The ripple factor

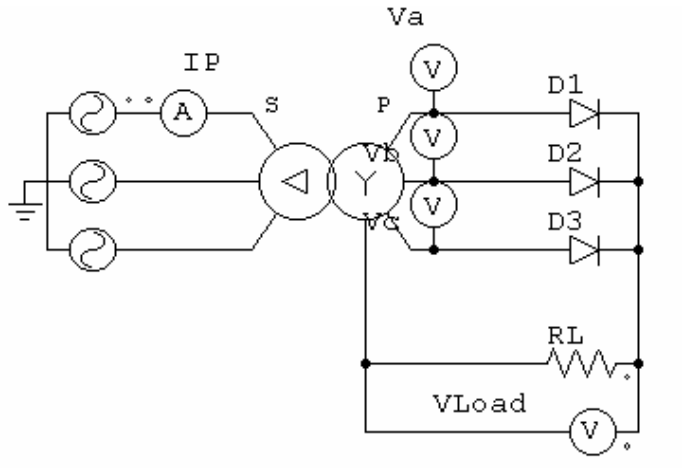

Figure 6

(12 marks)

(c) The switch of a DC chopper shown in **Figure 7** opens and closes at a frequency of 15 Hz and remains closed for 4 ms per cycle. A DC ammeter connected in series with the load indicates a current of 60 A. If a DC ammeter is connected in series with the source, what current will it indicate?

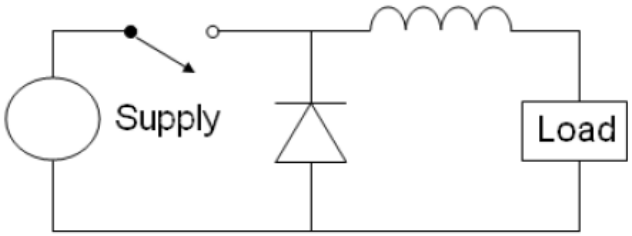

Figure 7

(6 marks)

END OF QUESTION PAPER

APPENDIX 1 : IMPORTANT FORMULA

FOURIER SERIES

$$v(\theta) = a_0 + \sum_{n=1}^{\infty} (a_n \cos n\theta + b_n \sin n\theta)$$

$$a_0 = \frac{1}{T} \cdot \int_0^T v(\theta) d(\theta)$$

$$a_n = \frac{2}{T} \cdot \int_0^T v(\theta) \cdot \cos n\theta \, d(\theta)$$

$$b_n = \frac{2}{T} \cdot \int_0^T v(\theta) \cdot \sin n\theta \, d(\theta)$$

Diode Shockley Equation

$$I_D = I_S \cdot \left(e^{V_D/(n \cdot V_T)} - 1\right)$$

Bridge Rectifier

$$V_{dc} = \frac{1}{\pi} \int_0^{\pi} V_m \sin \omega t \; d\omega t = \frac{2V_m}{\pi}$$

$$V_{rms} = \left[\frac{1}{\pi} \int_0^{\pi} (V_m \sin \omega t)^2 \; d\omega t \right]^{1/2} = \frac{V_m}{\sqrt{2}}$$

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{V_{dc} I_{dc}}{V_{rms} I_{rms}}$$

$$FF = \frac{V_{rms}}{V_{dc}}$$

$$RF = \frac{\sqrt{V_{rms}^2 - V_{dc}^2}}{V_{dc}} = \sqrt{\frac{V_{rms}^2}{V_{dc}^2} - 1} = \sqrt{FF^2 - 1}$$

Half Wave Controlled Rectifier

$$V_{(O)DC} = \frac{V_M}{2\pi}[1 + \cos \alpha]$$

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

Integration Of Trigonometry

$$\int \sin ax \; dx = -\frac{1}{a} \cos ax$$

$$\int \sin^2 nx \; dx = \frac{x}{2} - \frac{\sin 2nx}{4n}$$

$$\int \cos^2 nx \; dx = \frac{x}{2} + \frac{\sin 2nx}{4n}$$

$$\int \cos ax \; dx = \frac{1}{a} \sin ax$$

$$\int \cos ax \sin bx \; dx = \frac{\cos[(a-b)x]}{2(a-b)} - \frac{\cos[(a+b)x]}{2(a+b)}, a \neq b$$

$$\int \cos x \sin x \; dx = -\frac{1}{4} \cos 2x \cdot$$

$$\int \sin mx * \sin nx \; dx = \frac{\sin(m-n)x}{2(m-n)} - \frac{\sin(m+n)x}{2(m+n)} \quad (m \neq n)$$

$$\int \cos mx * \cos nx \; dx = \frac{\sin(m-n)x}{2(m-n)} + \frac{\sin(m+n)x}{2(m+n)} \quad (m \neq n)$$

SPECIAL INTEGRATION RESULTS

$$\int_0^{\pi} \cos(\theta)\cos(n\theta) d\theta = \begin{cases} 0 & n > 1, n = 2,3,4,5,6,7\ldots \\ \pi/2 & n = 1 \end{cases}$$

$$\int_0^{\pi} \sin(\theta)\sin(n\theta) d\theta = \begin{cases} 0 & n > 1, n = 2,3,4,5,6,7\ldots \\ \pi/2 & n = 1 \end{cases}$$

$$\int_0^{\pi} \sin(\theta)\cos(n\theta) d\theta = \begin{cases} \frac{2}{1-n^2} & n > 1, n = 2,4,6,8\ldots \\ 0 & n > 1, n = 3,5,7,9\ldots \\ 0 & n = 1 \end{cases}$$

APPENDIX 1 : IMPORTANT FORMULAS (cont'd)

COMMONLY USED FUNCTIONS

$-A$	$90 \pm A$	$180 \pm A$	$270 \pm A$	$360\,k \pm A$
$-\sin A$	$\cos A$	$\mp \sin A$	$-\cos A$	$\pm \sin A$
$\cos A$	$\mp \sin A$	$-\cos A$	$\pm \sin A$	$\cos A$

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\sin 2A = 2 \sin A \cos A$$

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

$$\sin A + \sin B = 2 \sin \frac{A + B}{2} \cos \frac{A - B}{2}$$

$$\sin A - \sin B = 2 \cos \frac{A + B}{2} \sin \frac{A - B}{2}$$

$$\cos A + \cos B = 2 \cos \frac{A + B}{2} \cos \frac{A - B}{2}$$

$$\cos A - \cos B = 2 \sin \frac{A + B}{2} \sin \frac{B - A}{2}$$

$$\sin A \sin B = \frac{1}{2}[\cos(A - B) - \cos(A + B)]$$

$$\cos A \cos B = \frac{1}{2}[\cos(A - B) + \cos(A + B)]$$

$$\sin A \cos B = \frac{1}{2}[\sin(A - B) + \sin(A + B)]$$