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**CONFIDENTIAL**

**SET A**

# UNIVERSITI KUALA LUMPUR
## Malaysia France Institute

## FINAL EXAMINATION
## SEPTEMBER 2014 SESSION

| | | |
|---|---|---|
| **SUBJECT CODE** | : | **FLB35203** |
| **SUBJECT TITLE** | : | **POWER ELECTRONICS AND DRIVES** |
| **LEVEL** | : | **BACHELOR** |
| **TIME / DURATION** | : | **2.00 PM – 12.00 PM ( 3HOURS )** |
| **DATE** | : | **11 JANUARY 2015** |

### 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) questions only.**
6. **Answer all questions in English.**

**THERE ARE 6 PRINTED PAGES OF QUESTIONS, EXCLUDING THIS PAGE AND APPENDIX.**

## SECTION A (Total: 40 marks)

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

### Question 1

(a) Give the definition of POWER ELECTRONICS.

(3 marks)

(b) Explain by using a simple table, 2 advantages of IGBT in terms of power rating and switching frequency as compared to bipolar transistor and MOSFET.

(6 marks)

(c) A portable electric hair dryer is equivalent to 200 Ω load. It 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 that can produce more heat.

(3 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) Explain the following thyristor turn-off method:

i. Natural / line commutation

ii. Forced commutation

(6 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 student is designing a linear power supply using a power transistor. The load is supplied through the collector and the transistor is operated in common emitter configuration. Given $h_{FE}$ = 20, find the required base current, $I_B$ if the transistor is used to supply current of 240.0 A to the load.

(3 marks)

(d) A single-phase half-wave thyristor converter is supplied with Malaysian utility supply. (240Vrms 50Hz). The firing angle $\alpha$ is set to 30°. The converter supplies a 100 Ω load. Calculate the DC and RMS values of output voltages.

(5marks)

## SECTION B (Total: 60 marks)

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

### Question 3

A railway vehicle uses an inverter shown in **Figure 1.** It is used to supply an industrial load which can be assimilated as a resistor and an inductor. Given $V_{DC}$ = 750V, R=15 ohms, L=30mH, f= 50Hz.

(a) Prove that the amplitudes of the Fourier series output voltage is $V_n = \frac{4 \cdot V_{DC}}{n \cdot \pi}$.

(10 marks)

(b) Calculate the amplitudes of Fourier series for output voltage $V_n$, output current $I_n$, impedance $Z_n$, and power absorbed by load, $P_n$, for n = 1,3 and 5. Show your calculation for each amplitude values ($V_n$, $I_n$, $Z_n$ ,$P_n$ $P_{RMS}$). Summarize all amplitudes values in a table as shown in **Figure 2**.

(17 marks)

(c) Compute the power absorbed by load, $P = \sum P_{n,RMS}$ .

(3 marks)

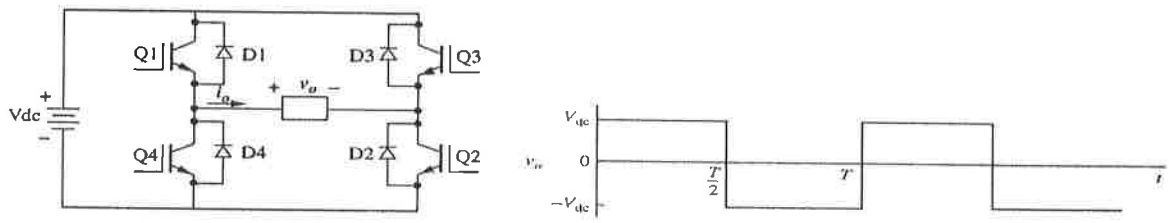


**Figure 1**

| n | F(hz) | Vn(V) | Zn(ohms) | In(A) | Pn(W) | $P_{RMS}$(W) |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 3 | | | | | | |
| 5 | | | | | | |

**Figure 2**

## Question 4

Express the output voltage waveform of the FULL WAVE rectifier shown in **Figure 3** as a Fourier series.

(a) Find and derive the expression of average value of output voltage, $V_{OUT(DC)} = a_0$.

(8 marks)

(b) Find and derive the expression of the amplitudes of the even part of the fourier series, $a_n$ .

(10 marks)

(c) Find and derive the expression of the amplitudes of the odd part of the fourier series, $b_n$ .

(10 marks)

(d) Express the full expression of Fourier series of output voltage.

(2marks)

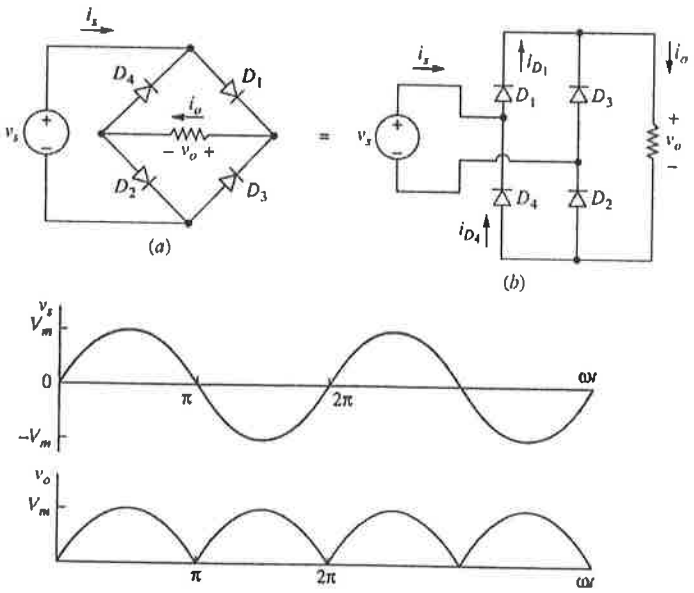


**Figure 3**

**Question 5**

A certain electronic system is to be operated from 15 Vdc and is equivalent to 8 Ω. However the only source available is 48 Vdc. As an electronics trainee engineer, you are required to design a suitable DC-DC to address the problem. The design requires continuous inductor current. For a guaranteed performance of the DC circuit, the output voltage ripple must be no greater than 0.5 percent. Use a switching frequency of f= 100 kHz. Assume ideal components. Use also the assumption that the variation of inductor current, $\Delta I_L$ , to be 40% of average inductor current $I_L$ .

(a) Calculate main parameters as follows.

(i) Calculate the duty cycle , D.

(3 marks)

(ii) Determine the value of the inductor

(7 marks)

(iii) Calculate the value of capacitor.

(5 marks)

(b) Specify the components ratings as follows :

(i) Determine the maximum subjected voltage for the main transistor switch, $V_{max,\ switch}$

(2 marks)

(ii) Determine the maximum subjected voltage for the diode, $V_{max,\ diode}$

(2 marks)

(iii) Determine the maximum subjected current for the main transistor switch, $I_{max,\ switch}$ .

(3 marks)

(iv) Determine the average subjected current for the main transistor switch, $I_{avg,\ switch}$.

(3 marks)

(v) Determine the maximum subjected current for the diode, $I_{max,\ diode}$ .

(2 marks)

(vi) Determine the average subjected current for the diode, $I_{avg,\ diode}$ .

(3 marks)

**END OF QUESTION PAPER**

# APPENDIX: FORMULAS

## BUCK CONVERTERS

$$D = \frac{V_o}{V_s}$$

$$I_L = \frac{V_0}{R}$$

$$L = \frac{(V_s - V_o)D}{(\Delta i_L)f}$$

$$C = \frac{1-D}{8L\left(\frac{\Delta V_o}{V_o}\right)f}$$

## FOURIER SERIES

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

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

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

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

## HALF WAVE THYRISTOR CONVERTER

$$V_{dc} = \frac{V_m}{2\pi}(1+\cos\alpha)$$

$$Vrms = \frac{Vm}{2}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}}$$

## SPECIAL INTEGRATION RESULTS

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

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

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

## BOOST CONVERTERS

$$V_o = \frac{V_s}{1-D}$$

$$V_L = L\cdot\frac{\Delta I_L}{D\cdot T}$$

$$(\Delta i_L)_{closed} = \frac{V_s DT}{L}$$

$$|\Delta Q| = \left(\frac{V_o}{R}\right)DT = C\Delta V_o$$

$$\frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

# APPENDIX: FORMULAS

## COMMONLY USED FUNCTIONS

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

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

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

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

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

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

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

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

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

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

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

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

$$\int \sin nx \, dx = -\frac{\cos nx}{n}$$

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