Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	POWER ELECTRONICS
COURSE CODE	:	BEF 34503
PROGRAMME	:	BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	DECEMBER 2015 / JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) List **two (2)** application categories for power electronic devices.

(4 marks)

(b) State the conditions for turn ON and OFF of SCR component.

(4 marks)

(c) A battery charger circuit which is shown in **Figure Q1(c)** is used for charging a battery has rated voltage of E = 15V and rated capacity of 120Wh. If the average charging current is 5A, the rms charging current is 8.335A, the primary input voltage is 230 V at 50 Hz, and the transformer has a turn ratio of 4:1, calculate:

i) the conduction angle, δ of the diode .

(5 marks)

ii) the current-limiting resistance, *R*.

(4 marks)

iii) the charging time, h_0 in hours.

(4 marks)

iv) the rectifier efficiency, η.

(4 marks)

Q2 (a) Classified all **four (4)** types of converter that are in DC-DC converters family.

(4 marks)

(b) Voltage regulator is one of the DC-DC converters. If this converter is located at the distribution load and has variable outputs with less than input voltage, describe the functions of this converter with the help of the mathematical equations.

(4 marks)

(c) A description of DC buck converter that has an output voltage of 9V from 12 V input voltage source, the output voltage ripple which is less or equal to 1 %, the power absorbed by the load is 25 W and the switching frequency of the converter is 25 kHz is shown in **Figure Q2(c)**. Assume the converter is operated in continuous current mode (CCM),

i) calculate the duty ratio required for the converter.

(5 marks)

ii) obtain the minimum inductor and the capacitor size.

(5 marks)

iii) illustrate the inductor current with specific legend.

(2 marks)

iv) illustrate with complete axes legends of capacitor current.

(3 marks)

v) determine the diode current waveforms of the converter.

(2 marks)

Q3 (a) Draw the equivalent circuit of a single phase full bridge inverter which is given in **Figure Q3(a)** if,

(i) power semiconductor devices T_1 - T_2 are closed and T_3 - T_4 are open.

(2 marks)

(ii) power semiconductor devices T_1 - T_2 are open and T_3 - T_4 are closed.

(2 marks)

(iii) Draw the output voltage of the inverter if the condition in **Q3(a)(i)** is followed.

(2 marks)

(iv) Draw the output voltage of the inverter if the condition in **Q3(a)(ii)** is followed.

(2 marks)

(b) The parameters for quasi square-wave inverter are given where, the output frequency is 50Hz, a series load RL is R=20Ω, L=15mH and the firing angle is $\alpha = 0^0$.

(i) Obtain an expression of the inverter rms output voltage at the fundamental frequency.

(2 marks)

(ii) If the fundamental AC output voltage is 240 V, find the required DC input voltage for the inverter and the output current in Fourier Series expression by referring to information from **Q3(b)**

(8 marks)

(iii) Find the Total Harmonics Distortion (THD) for load current by considering until the seventh harmonics number.

(3 marks)

(iv) If the output voltage is to be a quasi-square wave, find the value of firing angle α in order to obtain the output voltage of $180V_{rms}$ at the fundamental frequency while keep the DC input voltage as same as obtained in **Q3(b)(ii).**

(4 marks)

Q4 (a) A three phase full wave AC converter is used to control the speed of the 3-phase induction machine,

(i) prove the concept of the bidirectional flows for this converter with a suitable firing range.

(2 marks)

(ii) explain why the firing angle of the three phase ac-ac converter is less than 150^0.

(2 marks)

(iii) create and explain how the speed of the induction machine can be changed using a three phase full wave ac converter.

(3 marks)

(b) A single phase full wave AC voltage converter is shown in **Figure Q4(b)**. The thyristors are used as the switching devices that caused the output voltage and current can be varied in the range of 0 V_{dc} to V_{dc}. If the load is connected to the converter that has resistive value of 20Ω and an input source of 120Vrms, 50Hz,

(i) formulate the power factor (pf) equation for the output if the given rms output voltage is $V_{rms} = \frac{V_m}{\sqrt{2}}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$.

(5 marks)

(ii) calculate the delay angle required to deliver 500 W to the load.

(3 marks)

(iii) calculate the rms source current.

(2 marks)

(iv) calculate the rms current in the SCR.

(2 marks)

(v) calculate the power factor.

(2 marks)

(vi) draw the output waveforms for the volatge and current with all the values that have been calculated from **Q4(b) ii)** to **Q4(b) v)**.

(4 marks)

– END OF QUESTIONS –

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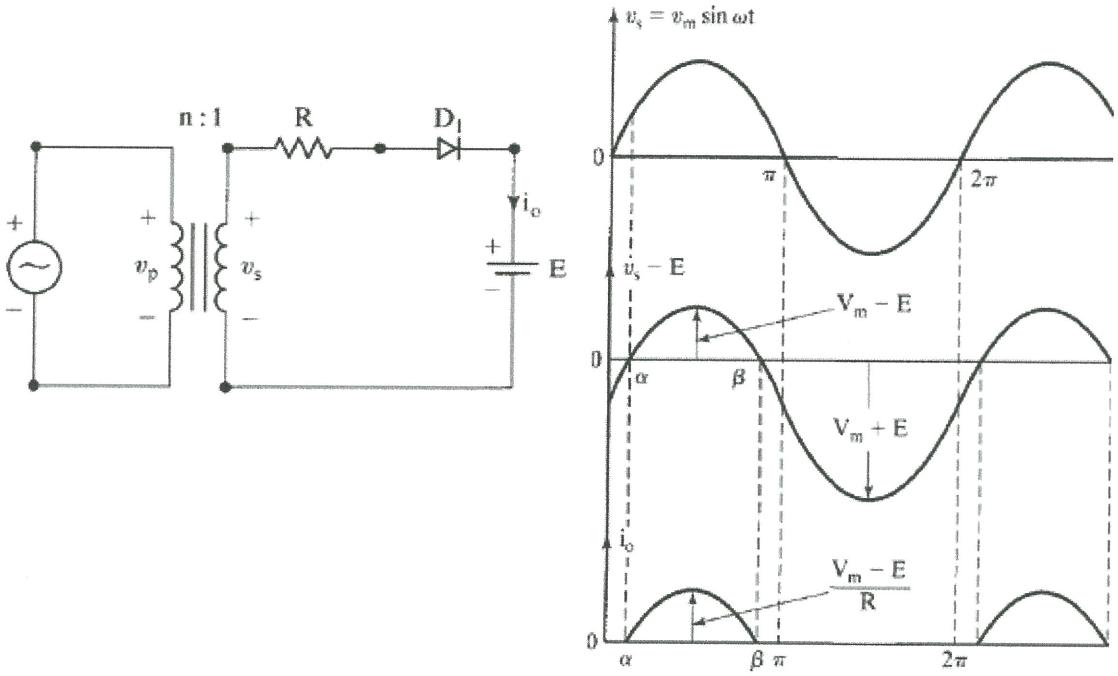

Figure Q1(c)

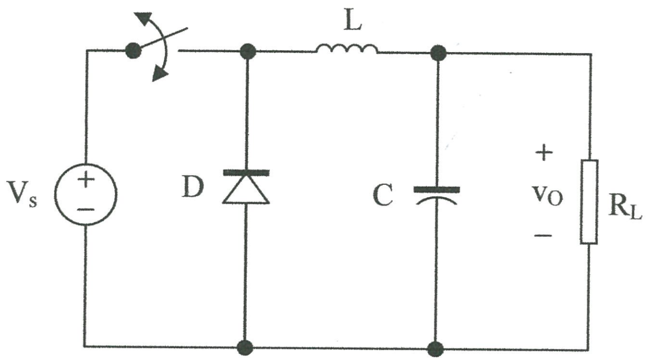

Figure Q2(c)

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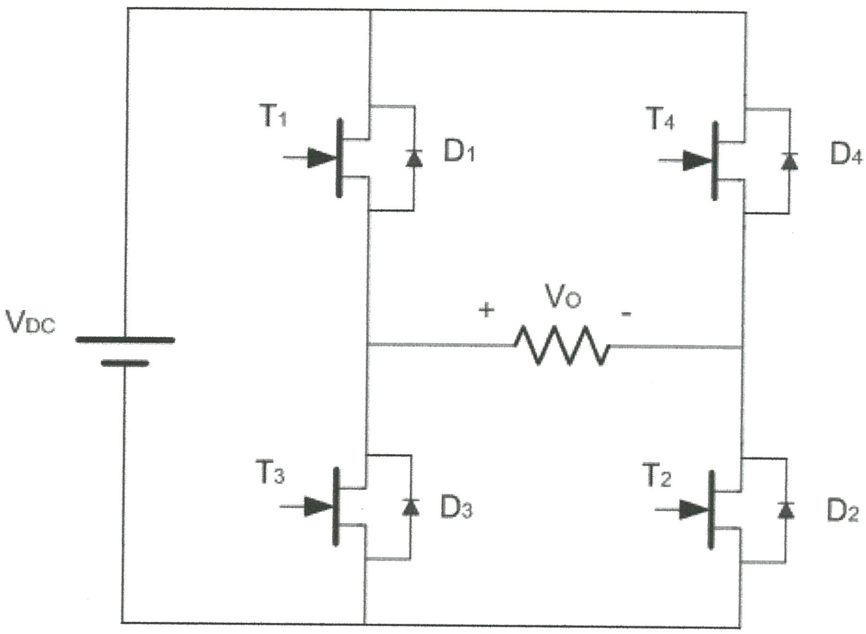

Figure Q3(a)

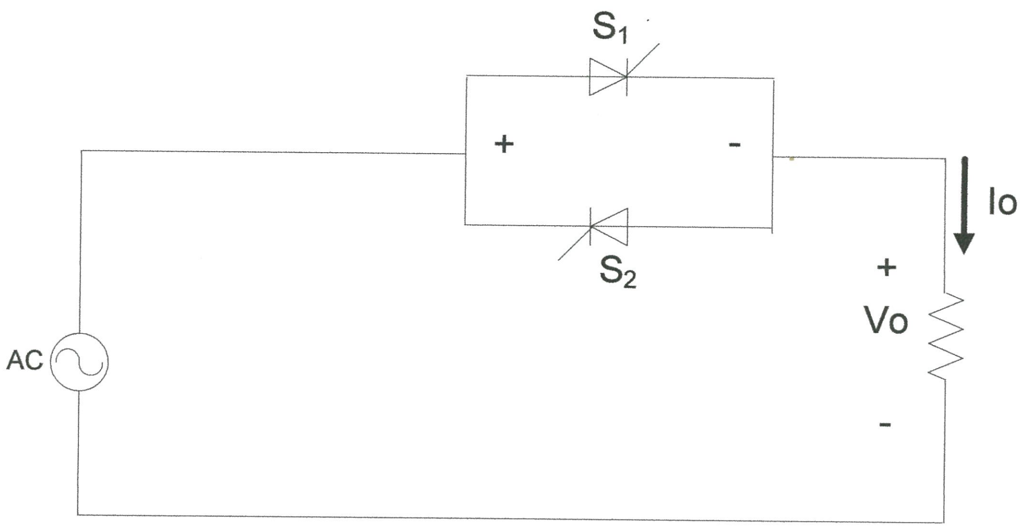

Figure Q4(b)

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FORMULAS

Half Wave AC Converter

For $0 \leq \alpha \leq 90^0$

$$V_0 = \sqrt{3}V_s \left[\frac{1}{\pi}\left(\frac{\pi}{3} - \frac{\alpha}{4} + \frac{\sin 2\alpha}{8}\right)\right]^{\frac{1}{2}}$$

For $90^0 \leq \alpha < 120^0$

$$V_0 = \sqrt{3}V_s \left[\frac{1}{\pi}\left(\frac{11\pi}{24} - \frac{\alpha}{4}\right)\right]^{\frac{1}{2}}$$

For $120^0 \leq \alpha \leq 210^0$

$$V_0 = \sqrt{3}V_s \left[\frac{1}{\pi}\left(\frac{7\pi}{24} - \frac{\alpha}{4} + \frac{\sin 2\alpha}{16} - \frac{\sqrt{3}\cos 2\alpha}{16}\right)\right]^{\frac{1}{2}}$$

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FORMULAS

Full Wave AC Converter

For $0 \leq \alpha \leq 90^0$

$$V_0 = \sqrt{6}V_s\left[\frac{1}{\pi}\left(\frac{\pi}{6} - \frac{\alpha}{4} + \frac{\sin 2\alpha}{8}\right)\right]^{\frac{1}{2}}$$

For $90^0 \leq \alpha < 120^0$

$$V_0 = \sqrt{6}V_s\left[\frac{1}{\pi}\left(\frac{\pi}{12} + \frac{3\sin 2\alpha}{16} - \frac{\sqrt{3}\cos 2\alpha}{16}\right)\right]^{\frac{1}{2}}$$

For $120^0 \leq \alpha \leq 210^0$

$$V_0 = \sqrt{6}V_s\left[\frac{1}{\pi}\left(\frac{5\pi}{24} - \frac{\alpha}{4} + \frac{\sin 2\alpha}{16} - \frac{\sqrt{3}\cos 2\alpha}{16}\right)\right]^{\frac{1}{2}}$$

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

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

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

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

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

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

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

$$P_s = \frac{1}{2} V_d I_o f_s \left(t_{c(on)} + t_{c(off)}\right)$$

$$V_{avg} = \frac{1}{T} \int_0^T V_s \sin(\omega t) \partial(\omega t)$$

$$V_{rms} = \left[\frac{1}{T} \int_0^T \left(V_m \sin(\omega t)\right)^2 \partial(\omega t) \right]^{1/2}$$

PERFORMANCE PARAMETERS

$$\eta = \frac{P_{dc}}{P_{ac}} \; ; \qquad V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2} \; ;$$

$$FF = \frac{V_{rms}}{V_{dc}} \; ; \qquad RF = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{FF^2 - 1} \; ;$$

$$TUF = \frac{P_{dc}}{V_s I_s}$$