Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	POWER ELECTRONICS
COURSE CODE	:	BEF 34503
PROGRAMME	:	BEV
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Demonstrate power electronics system by drawing a suitable block diagram. Then, explain the function of each block.

(7 marks)

(b) Explain diode reverse recovery time (t_{rr}) condition. You may consider suitable diagrams to support your answer.

(5 marks)

(c) A power switching device has maximum voltage and current of 280 V and 120 A, respectively. It takes 1.5 µs to fully turn-ON and 3.3 µs to fully turn-OFF. The switching period is 40 µs.

(i) Calculate the switching frequency.

(1 mark)

(ii) If the switching device is a MOSFET, sketch and label drain-source voltage (V_{DS}) and drain-source current (I_{DS}) waveforms with rise time (t_r) and fall time (t_f).

(6 marks)

(iii) Calculate average power dissipation of the switching device based on the parameters given in Q1(c).

(6 marks)

Q2 (a) Explain the operation of the rectifier circuit shown in **Figure Q2(a)**

(4 marks)

(b) **Figure Q2 (b)** shows a single phase half-wave controlled rectifier has a resistive load of $R = 10\ \Omega$, the voltage at the secondary transformer is 230 V with ratio 2:1, and the firing angle of thyristor is 60°.

(i) Calculate the average and rms load voltage.

(5 marks)

(ii) Determine the average and rms load current.

(4 marks)

(iii) Analyse the average output power.

(2 marks)

(iv) Determine the new firing angle, α. if the rectifier is connected to the load which consumes 75% less than maximum possible average output voltage.

(4 marks)

(v) Draw the input voltage (V_s), output voltage (V_o) and current waveforms (I_o) for the new firing angle (α).

(6 marks)

Q3 A single-phase full-bridge inverter has *RLC* loads with $R = 10\ \Omega$, $L = 31.5$ mH and $C = 112\ \mu$F is shown in **Figure Q3**. The inverter frequency is 50 Hz and the DC input voltage is 240 V. Determine,

(i) the instantaneous load current expressed as a Fourier series up to the 9th-order harmonic.

(16 marks)

(ii) the rms load current at the fundamental frequency.

(2 marks)

(iii) the %THD of the load current.

(3 marks)

(iv) the power absorbed by the load and the fundamental power.

(3 marks)

(v) the average DC supply current.

(1 mark)

Q4 (a) With adding the both Continuous Current Mode (CCM) and Discontinuous Current Mode (DCM) waveforms, explain briefly operation of the converter.

(6 marks)

(b) Design a boost converter to provide an output of 36 V from 24 V source for continuous current mode. The load is 50 W and the output voltage ripple must be less than 0.5%. The maximum inductor current should be 3 A. The converter circuit is shown in **Figure Q4(b)**. Assuming for the ideal components and the switching frequency is 40 kHz.

(i) Specify the duty cycle of the converter.

(2 marks)

(ii) Determine the capacitor size.

(4 marks)

(iii) Analyse the average inductor current.

(2 marks)

(iv) Derive and determine minimum inductor L_{min}, for Continuous Current Mode (CCM) operation.

(4 marks)

(c) **Figure Q4(c)** shows a single phase full wave AC voltage controller with resistor load. If the firing angle, $\alpha = 90°$, plot the waveform (in one period) of V_{sw}, I_o, and V_o.

(7 marks)

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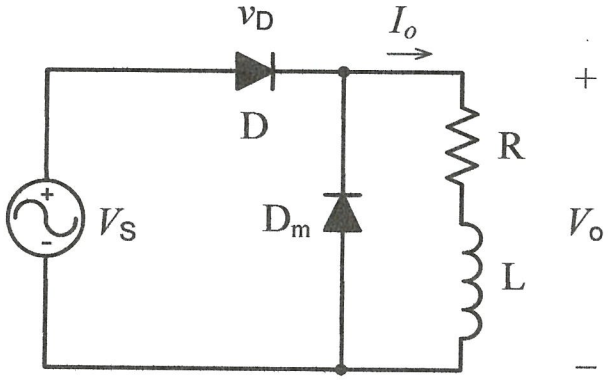

Figure Q2(a)

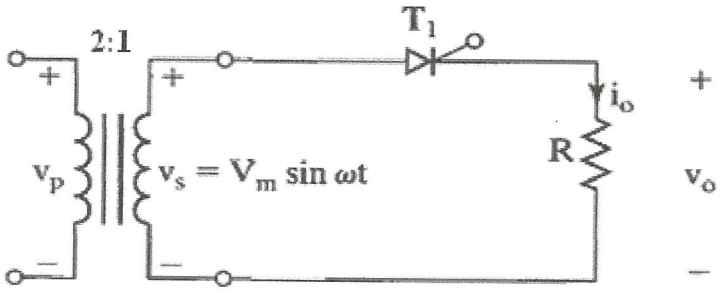

Figure Q2(b)

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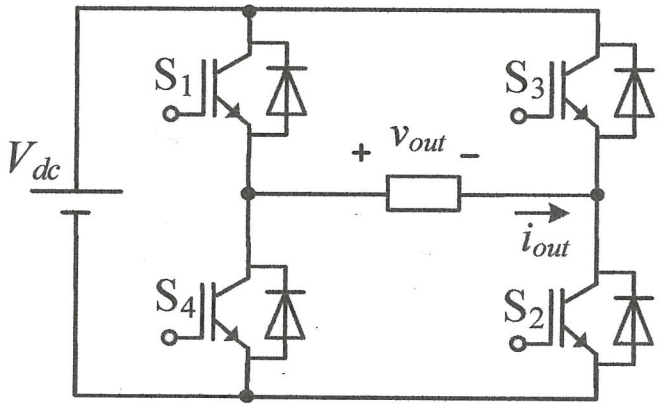

Figure Q3

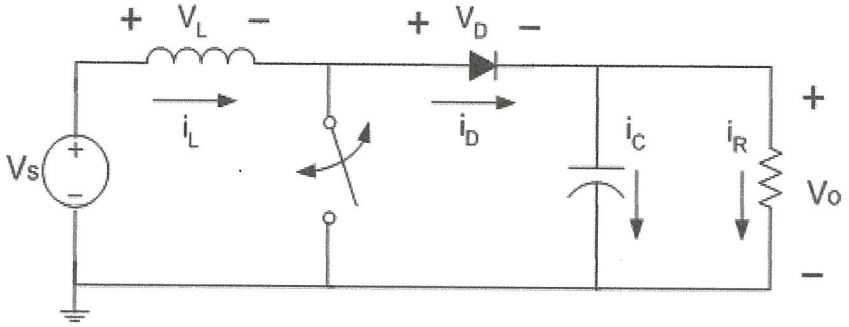

Figure Q4(b)

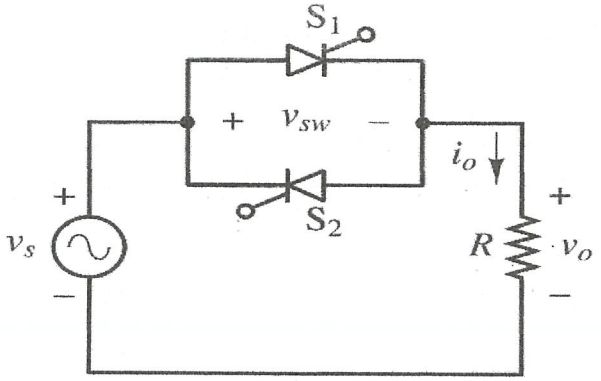

Figure Q4(c)

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FORMULAE

Half-wave controlled rectifier rms voltage

$$V_{rms} = \frac{V_m}{2}\left[\frac{1}{\pi}\left(\pi - \alpha + \frac{1}{2}\sin 2\alpha\right)\right]^{\frac{1}{2}}$$

Instantaneous output voltage

$$v_O = \sum_{n=1,3,5,\ldots} \frac{4V_{DC}}{n\pi}\sin n\omega t$$

Instantaneous load current

$$i_o = \sum_{n=1,3,5,\ldots}^{\infty} \frac{4V_{DC}}{n\pi\sqrt{R^2 + (n\omega L)^2}}\sin\left(n\omega t - \theta_n\right)$$

Impedance for the *n*th harmonic

$$|Z| = \sqrt{R^2 + \left(n\omega L - \frac{1}{n\omega C}\right)^2}$$