Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	POWER ELECTRONICS
COURSE CODE	:	BEV 30203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION		1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS A **CLOSED BOOK** ASSESSMENT. 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA **CLOSED BOOK**.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) State three (3) applications of controlled DC-DC boost converters

(3 marks)

(b) The converter in **Figure Q1(b)** is designed to produce an output voltage of -36V from 24V of input DC voltage source. If the power absorbed by the load is 108W and the switching frequency of the converter is 50kHz.

(i) Determine the duty cycle of the converter

(3 marks)

(ii) Determine the minimum inductor value to provide continuous current mode (CCM) operation.

(2 marks)

(iii) Choose a capacitor value to ensure 2% ripple output voltage.

(2 marks)

(iv) Modify the inductance such that the minimum inductor current is 40% of average value.

(3 marks)

(c) **Figure Q1(c)** shows a typical DC-DC Buck converter circuit with an ideal component and the parameter are V_{dc}=50V, D=0.4, C=100μF, L=400μH, f=20kHz and R=20 Ω.

(i) Determine the output voltage.

(2 marks)

(ii) Calculate the maximum and minimum inductor current.

(4 marks)

(iii) Calculate the output voltage ripple.

(2 marks)

(iv) From the results obtained in Q1(c)(ii)-(iii), state your conclusion.

(4 marks)

Q2 (a) Explain the advantages and disadvantages of a half-bridge and a full-bridge inverter. Both inverters must be properly sketched and labeled.

(7 marks)

(b) As an engineer working in ABABA Sdn. Bhd., you are required to design a single-phase half-bridge inverter for home lighting purposes.

Input Grid Supply = 220Vrms / 50Hz
DC Input Inverter, Vdc = 100V
Load Power, Po = 500W

With the given specifications :

(i) Sketch a circuit diagram of your proposed design.

(6 marks)

(ii) Determine the inverter's fundamental output voltage.

(1 marks)

(iii) Calculate the first five (5) harmonics of inverter voltage.

(5 marks)

(iv) Calculate the average current in each switch.

(6 marks)

Q3 (a) The AC-DC converter has been widely used in home appliances. List four (4) appliances that can be found

(2 marks)

(b) Rectifier circuit that uses thyristor switches and MOSFET switches have different usages and advantages. Compare three (3) differences between the power switches

(3 marks)

(c) A single-phase thyristor bridge rectifier is required to charge a battery for an electric car application as shown in **Figure Q3(c)**. Given the battery voltage Vdc = 200V with a capacity of 2000wH and battery current Idc = 50A. If the input voltage is 240 Vrms.

(i) Calculate the firing angle for the thyristor to produce 200V output voltage

(3 marks)

(ii) Determine the conduction angle for each thyristor

(1 marks)

(iii) Calculate the resistive load (Ro) if the inductor is highly inductive impedance

(3 marks)

(iv) Determine the output voltage of the rectifier

(2 marks)

(v) Calculate the output current of the rectifier in rms

(3 marks)

(vi) Estimate the charging time of the battery for this rectifier circuit

(3 marks)

(vii) Estimate the efficiency of the rectifier due to battery charging condition.
(2 marks)

(viii) Draw and label the output voltage waveform, input waveform, and current output waveform.
(3 marks)

Q4 (a) With silicon-controlled rectifier (SCR) control, every light switch in the home becomes a potential light dimmer that provides continuous variable operation from full **OFF** to full **ON**. Light dimmers can provide just the right degree of illumination to fit any mood, and, for amateur puppeteers, the basement rumpus room can be converted into a theatre, complete with theatre as well as stage light dimming equipment.

From the above-mentioned statement, you are required to give suggestions and answer the problems comprehensively as follows,

(i) Suggest one home appliance as a load that can be controlled using SCR devices, and list down the electrical specifications that are suitable for the suggested load, control circuit, and grid requirement.
(4 marks)

(ii) Suggest an appropriate converter circuit for controlling the suggested load using SCR devices. The suggested circuit must be clear and appropriately sketched and labeled.
(4 marks)

(iii) Explain the operation of the suggested converter circuit to fulfill the suggested load and grid requirements. Diagrams, circuits, or equations might be required to support your explanation.
(4 marks)

(b) A single-phase ac voltage controller in **Figure Q4(b)** has a resistive load of $R = 5\Omega$ and the RMS input voltage is $Vs = 240V$, 50Hz. The delay angle of thyristor $T = \pi/3$,

(i) Draw or sketch the necessary waveforms (input voltage, output voltage, output current, and gate signal) to demonstrate circuit operation for at least one full cycle on the same y-axis. All waveforms and axes must be labeled appropriately.
(4 marks)

(ii) Determine the RMS value of output voltage, Vo.
(3 marks)

(iii) Determine the input power factor, PF.
(3 marks)

(iv) Determine the RMS input current, Is.
(3 marks)

– END OF QUESTIONS –

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Formula

$$-V_o = V_{IN}\left(\frac{D}{1-D}\right)$$

$$I_{max} = \frac{V_{IN}\,.\,D}{R(1-D)^2} + \frac{V_{IN}\,.\,D\,.\,T}{2\,.\,L}$$

$$I_{min} = \frac{V_{IN}\,.\,D}{R(1-D)^2} - \frac{V_{IN}\,.\,D\,.\,T}{2\,.\,L}$$

$$\Delta V_o = \frac{V_o\,.\,D}{R\,.\,f\,.\,C}$$

$$L_{min} = \frac{(1-D)^2.R}{2\,.\,f}$$

$$V_o = D\,.\,V_{IN}$$

$$I_{max} = V_0\left[\frac{1}{R} + \frac{(1-D)}{2\,.\,L\,.\,f}\right]$$

$$I_{min} = V_0\left[\frac{1}{R} - \frac{(1-D)}{2\,.\,L\,.\,f}\right]$$

$$\Delta V_o = \frac{(1-D)}{8\,.\,L\,.\,C\,.\,f^2}\ x\ V_o$$

$$L_{min} = \frac{(1-D)}{2\,.\,f}\ x\ R$$

$$V_{o1(rms)} = 0.45\,.\,V_{DC}$$

$$V_{n,THD} = \left(\frac{V_{01(rms)}}{n}\right)$$

$$V_o = \frac{V_{DC}}{2}$$

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Formula

$$V_{o(dc)} = \frac{2\,.\,V_{IN(rms)}.\sqrt{2}\,.\cos\alpha}{\pi}$$

$$I_{o(rms)} = \sqrt{{I_{o(dc)}}^2 + \Sigma_{n=2,4,6}^{\infty}\,(\frac{In}{\sqrt{2}})^2}$$

$$a_n = \frac{2\,.\,V_{IN(rms)}.\sqrt{2}}{\pi}\left[\frac{\cos((n+1)x\,\alpha)}{n+1} - \frac{\cos((n-1)x\,\alpha)}{n-1}\right]$$

$$b_n = \frac{2\,.\,V_{IN(rms)}.\sqrt{2}}{\pi}\left[\frac{\sin((n+1)x\,\alpha)}{n+1} - \frac{\sin((n-1)x\,\alpha)}{n-1}\right]$$

$$V_n = \sqrt{(a_n)^2 + (b_n)^2}$$

$$Efficiency(\%) = \frac{Pout}{Pout+Ploss}x100$$

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

$$V_{o(avg)} = \frac{\sqrt{2}\,x\,V_{s(rms)}}{2\pi}\,x\,(\cos(\alpha) - 1)$$

$$Power\ Factor = \frac{True\ Power\ (W)}{Apparent\ Power\ (VA)}$$

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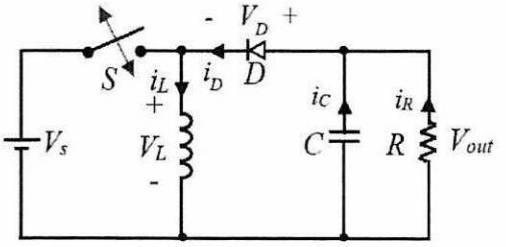

Figure Q1(b)

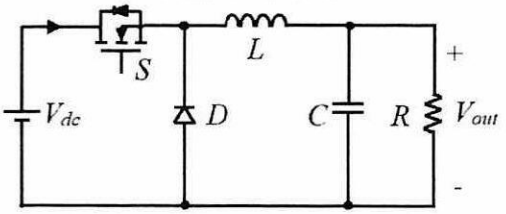

Figure Q1(c)

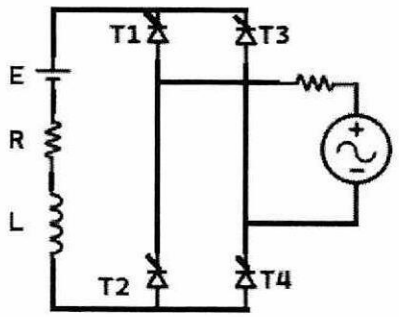

Figure Q3(c)

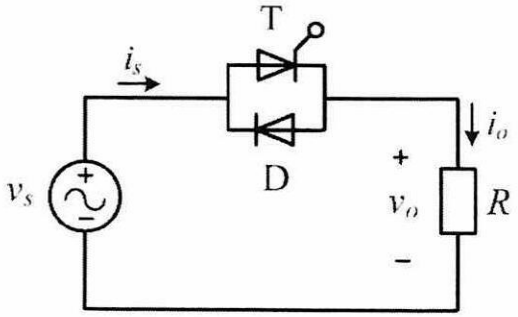

Figure Q4(b)