UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	POWER ELECTRONICS
COURSE CODE	:	BEV 30203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS
		2. THIS TEST IS CONDUCTED VIA
		☐ Open book
		☒ Closed book
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE TEST CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

TERBUKA   CONFIDENTIAL

Q1 (a) A single-phase full-wave rectifier produces a fix output $V_{o(avg)} = 197$ V from an AC source of $V_{peak} = 311$ V and frequency of 50 Hz. As an engineer working in Ababa Electric Sdn. Bhd., you are required to modified the switches such it produces a variable output $V_{o(avg)} = 99V \sim 197V$. Propose the required switches to allow the full-wave rectifier to produce a variable output voltages. Sketch the overall setup for the new system.

(5 marks)

(b) From **Q1(a)**, output $V_{o(avg)} = 99$ V is required to powered a load R = 10 Ω.

(i) Determine the operating angle of the system.

(4 marks)

(ii) Calculate the output power of the system.

(4 marks)

(iii) Calculate the power factor of the system.

(4 marks)

(iv) Plot the waveform (in one period) for output voltage V_o

(4 marks)

(v) Plot the waveform (in one period) for output current I_o

(4 marks)

Q2 (a) **Figure Q2(a)** shows a single-phase full-bridge square-wave voltage source inverter with a resistor R and inductor, L load of 10 Ω and 5 mH respectively connected in series. The inverter output frequency is 50 Hz. The transistor switching scheme is complementary bipolar.
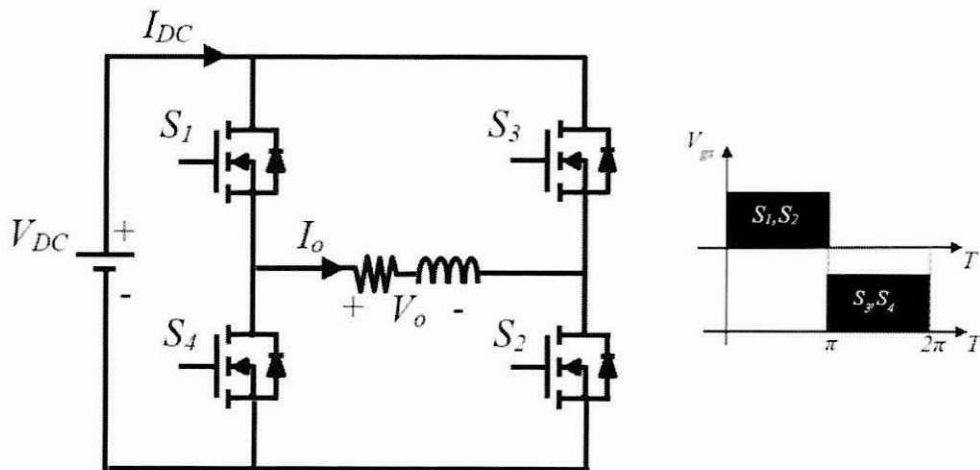

Figure Q2(a)

(i) Draw the output voltage and current waveforms

(2 marks)

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

(2 marks)

CONFIDENTIAL

(iii)   If the fundamental AC output voltage is 220 V, find the required DC input voltage for the inverter.

(2 marks)

(iv)   Find the instantaneous load current by considering until the 9th harmonics number.

(12 marks)

(v)   Calculate the total harmonic distortion (THD) of the load current. Use only the first three odd harmonics.

(2 marks)

(vi)   Sketch the harmonics spectrum for output current.

(3 marks)

(vii)   Show the displacement angle α, if 5th harmonic is to be eliminated.

(2 marks)

Q3   (a)   A conventional buck converter has the following parameters:

$$V_s = 24 \text{ V}$$
$$D = 0.7$$
$$L = 150 \text{ μH}$$
$$C = 200 \text{ μF}$$
$$R = 20 \text{ Ω}$$
$$f_{sw} = 25 \text{ kHz}$$

(i)   Sketch and label the equivalent circuit of the buck converter.

(2 marks)

(ii)   Calculate the output voltage.

(2 marks)

(iii)   Determine the maximum and minimum of the inductor ripple currents.

(4 marks)

(iv)   Determine the output voltage ripple by referring to the output voltage.

(2 marks)

(v)   Sketch and label waveforms of inductor voltage, inductor current and capacitor current in the same y – axis.

(6 marks)

CONFIDENTIAL

TERBUKA

(b) A continuous-current mode boost converter has an output ripple voltage of less than 0.5% when the input voltage is 14 V and the output voltage is 40 V. The load has a resistance of 50 Ω and the inductor has an inductance L = 120 uH; the switching frequency is 25 kHz. By analyzing the parameters of the changes from **Q3(a)**,

(i) Determine the new duty ratio.

(2 marks)

(ii) Determine the new maximum and minimum inductor currents which gives a continuous current mode.

(4 marks)

(iii) Calculate the new capacitance value for the capacitor.

(3 marks)

Q4 (a) "With (SCR) control, every electric light switch in the home becomes a potential light dimmer that provides continuously variable operation from full-off to full-on. In living and dining rooms, 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 theater, complete with stage light dimming equipment."

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

(i) Suggest one home appliance as a load that can be controlled using SCR devices and list down 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 clearly and appropriately sketched and labeled.

(4 marks)

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

(4 marks)

TERBUKA

(b) A pair of thyristors connected in inverse-parallel as shown in **Figure Q4(b)**; the thyristors are triggered at an angle α after their respective anode voltage zeros.
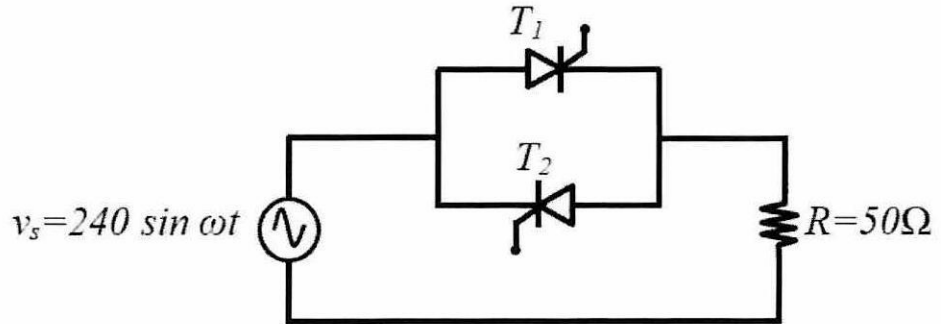

Figure Q4(b)

(i) Sketch the load voltage waveform for α=30°.

(3 marks)

(ii) Calculate the rms value voltage V_L and current I_L for α=30°.

(4 marks)

(iii) Calculate the output power for α=30°.

(2 marks)

(iv) If thyristor T_2 is fail to operate, what effect would this have on the value of the output voltage of the converter at α=30°.

(4 marks)

– END OF QUESTIONS –

TERBUKA