UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	ADVANCED POWER ELECTRONICS
COURSE CODE	:	MEE 10603
PROGRAMME CODE	:	MEE
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

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

Q1 (a) With the aid of suitable block diagrams, briefly illustrate and describe the power electronics system.

(7 marks)

(b) Differentiate between the snubber circuit and gate driver circuit.

(4 marks)

(c) A buck converter has the following parameters: V_s = 12 V, D = 0.6, L = 150 mH, C = 150 µF and R = 10 Ω. The switching frequency is 40 kHz.

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

(3 marks)

(ii) Calculate the output voltage, V_o.

(2 marks)

(iii) Derive the equations of maximum and minimum inductor current.

(4 marks)

(iv) Calculate the maximum and minimum inductor current.

(2 marks)

(v) Calculate the output voltage ripple.

(3 marks)

Q2 (a) A single-phase full-bridge square-wave voltage source inverter has R and L load of 25 Ω and 15 mH, respectively and the load is connected in parallel. The inverter output frequency is 50 Hz while the transistor switching scheme is complementary bipolar

(i) Define the expression of the RMS output voltage at the fundamental frequency.

(2 marks)

(ii) If the fundamental output voltage is 240 Vrms, identify the required DC input voltage for the inverter.

(2 marks)

(iii) Calculate the instantaneous load current by considering until the 7^{th} harmonics number.

(10 marks)

(iv) Sketch the harmonic spectrum for output current.

(3 marks)

(v) Calculate the total harmonic distortion (THD) of the load current. Use only the first **THREE (3)** odd harmonics.

(2 marks)

(b) A PWM switching technique was implemented in the Full-Bridge inverter as shown in **Figure Q2(b)(i).** Sketch the PWM signals for (V_a) and (V_b), and the output voltage (V_o) for **Figure Q2(b)(ii**) with the switches condition as shown below;

S_1 ON when $V_{sine} > V_{tri}$
S_4 ON when $V_{sine} < V_{tri}$
S_2 ON when $V_{sine} > 0$
S_3 ON when $V_{sine} < 0$

(6 marks)

Q3 (a) Theoretically, it was assumed that the source has no inductances and resistances in three-phase rectifier system. However, in a practical transformer and supply, the L and R components are presented, and the performance of rectifier is slightly changed. The effect of the source inductance is more significant than of resistance. Based on this phenomenon, you are required to explain thoroughly with the help of relevant circuits, waveforms and equations.

(12 marks)

(b) The three-phase diode bridge rectifier as shown in **Figure Q3(b)** is fed from a 415 V line-to-line supply, 50 Hz in three-phase system. The resistive-inductive load has R_L = 10 Ω and L = infinity (∞). By assuming the R-Y-B phase sequence and the diode commutation effects is neglected, determine:

(i) The average load voltage $V_{o(av)}$.

(5 marks)

(ii) The peak-to-peak output voltage ripple $V_{o(pk\text{-}pk)}$.

(5 marks)

(iii) The average power absorbed by the load.

(3 marks)

Q4 (a) "With SCR control, every electric light switch can be found at 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 puppeteer, the basement rumpus room can be converted into a theater, complete with theater as well as stage light dimming equipment."

From the statement, you are required to give suggestion and answer comprehensively on the problems as following,

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

(4 marks)

(ii) Suggest an appropriate converter circuit to control the load using SCR device. The suggested circuit must be written clearly with appropriate sketched and labeled.

(4 marks)

(iii) Explain the operation of the suggested converter in **Q4(a)(ii)** in order to fulfil the suggested load and grid requirements. Any diagram, circuit or equation might be required to support your explanation.

(4 marks)

(b) **Figure Q4(b)(i)** and **Figure Q4(b)(ii)** are referred. Initially the switching profiles of switch voltage $V_{sw1}(t)$, switch current $I_{sw1}(t)$ and switch power $P_{sw1}(t)$ is shown in **Figure Q4(b)(i)**. Due to high switching loss, $P_{sw1}(t)$ in (**Figure Q4(b)(i)**) during transition from turn-on to turn-off, it causes electromagnetic interference (EMI) noise to the gate driver circuit. From this condition, you are required to

(i) Explain the switching loss at $P_{sw1}(t)$ and $P_{sw2}(t)$ conditions. Diagrams, circuits or equations must be included in your answer to support your explanation.

(4 marks)

(ii) Proposed the suitable circuit that can reduce the switching losses from $P_{sw1}(t)$ to $P_{sw2}(t)$. A comprehensive explanation of the suggested circuit is required. In addition, the suggested circuit must be clearly and appropriately sketched and labeled.

(5 marks)

(c) In Flexible AC Transmission Systems (FACTS), compensation techniques of critical parameters are crucial in order to enhance controllability and power transfer capability in AC systems. Thus, you are required to identify and explain the operation and characteristic of common compensation techniques. Any diagram, circuit or equation must be included to support your explanation.

(4 marks)

-END OF QUESTIONS –

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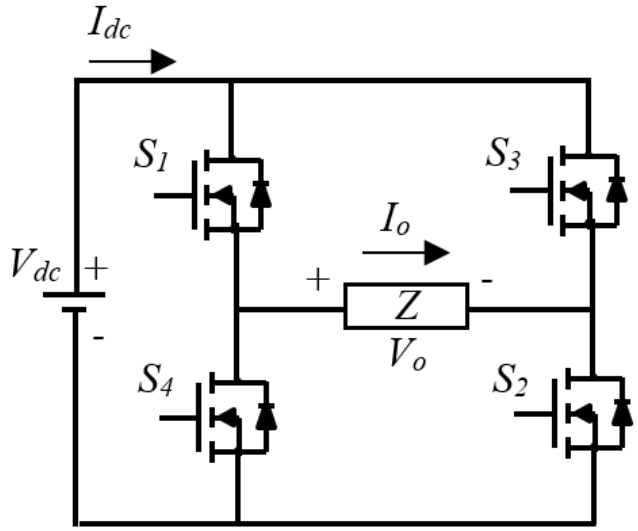

Figure Q2(b)(i): A Full-Bridge inverter

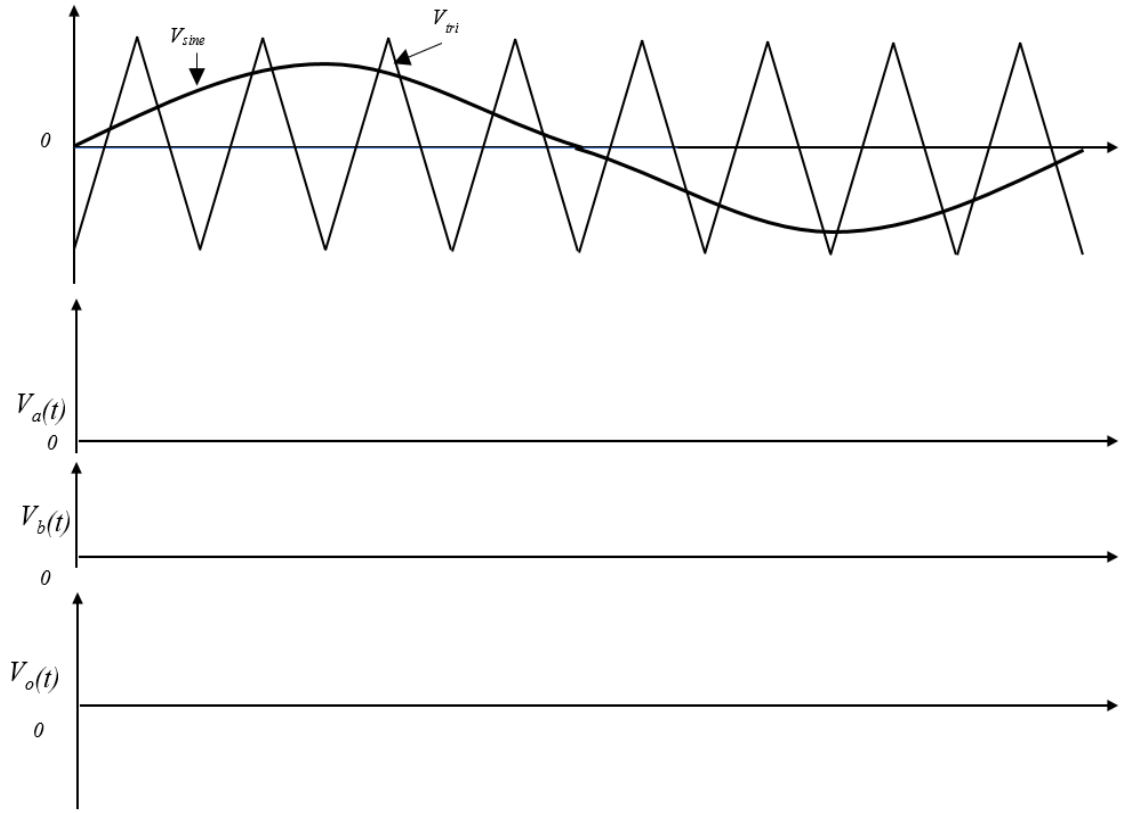

Figure Q2(b)(ii): The PWM signals for (V_a) and (V_b), and the output voltage (V_o)

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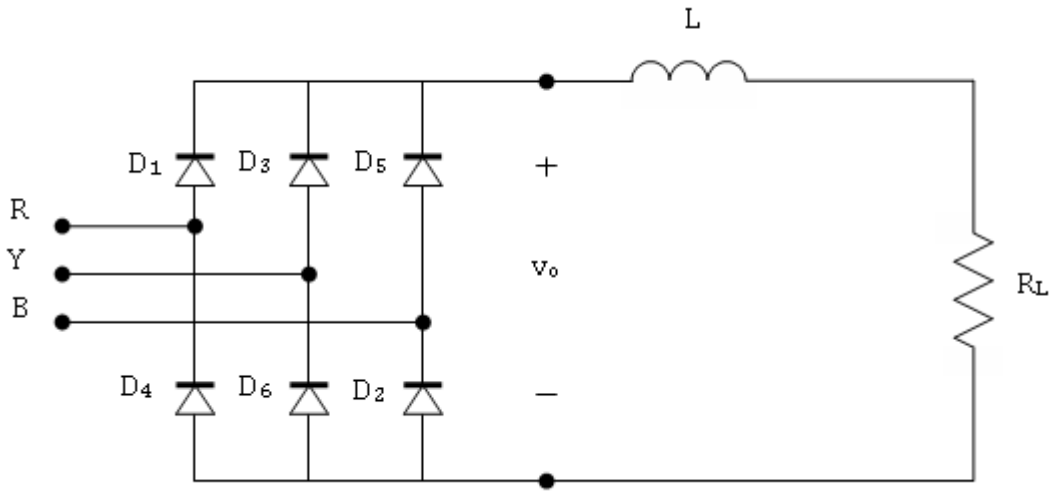

Figure Q3(b): The three-phase diode bridge rectifier

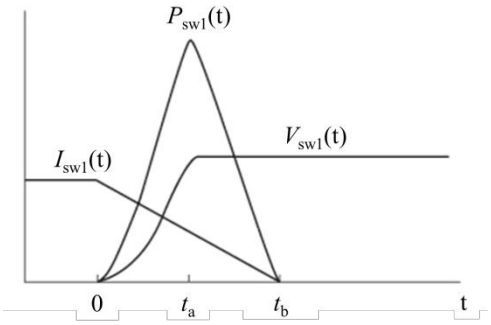

Figure Q4(b)(i): Initial switching profile

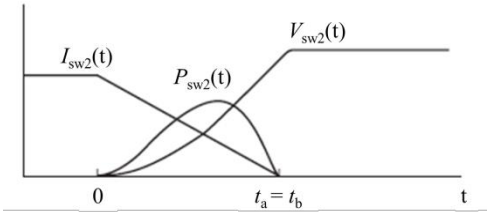

Figure Q4(b)(ii): A switching profile