UNIVERSITI KUALA LUMPUR
Malaysian Institute of Marine Engineering Technology

FINAL EXAMINATION

OCTOBER 2025 SEMESTER SESSION

SUBJECT CODE	:	**LEB31003**
SUBJECT TITLE	:	**POWER ELECTRONICS**
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	**BACHELOR OF ELECTRICAL AND ELECTRONICS ENGINEERING TECHNOLOGY (MARINE) WITH HONOURS**
TIME / DURATION	:	**09.00 AM - 12.00 PM (3 HOURS)**
DATE	:	**30 JANUARY 2026**

INSTRUCTIONS TO CANDIDATES

1. Please read **CAREFULLY** the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of **FIVE (5)** questions.
4. Answer **FOUR (4)** questions **ONLY**.
5. Please write your answers on this answer booklet provided.
6. Answer **ALL** questions in English language **ONLY**.
7. Answer should be written in blue or black.
8. Formula is appended for your reference.

THERE ARE 3 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.

INSTRUCTION: Answer FOUR (4) questions only

Please use the answer booklet provided

Question 1

a) The basic element of Power Electronic Technology is the power processor, which can be seen to provide a number of different conversions. Define power electronics. Give ONE application of power electronics and a list of THREE examples.

(5 marks)

b) Describe the principle of power diodes and thyristors, then sketch the symbol on each component.

(8 marks)

c) The controlled single-phase full-wave rectifier circuit of Figure 1 has a resistive load with R = 20Ω and. The AC source is 120 V_{rms} at 60 H_z and delay angle is 45^0

Calculate:

i) The average load current

ii) The rms load voltage

iii) The rms load current

(12 marks)

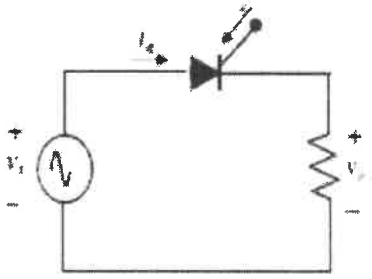

Figure 1

Question 2

a) Input to the step-up chopper is 200V. The output required is 600V. If the conducting time of the thyristor is 200 μsec, compute the chopping frequency.

(6 marks)

b) If the pulse width is halved for a constant frequency of operation, determine the new output voltage.

(6 marks)

b) DC chopper works on DC voltage as a step-up and step-down transformer. Briefly explain the principle of step-up and step-down DC choppers with R-L load of the transformer. [hint: Include together with the chopper circuit in answer]

(13 marks)

Question 3

a) List 5 characteristics of a good inverter and 5 applications of the inverter.

(5 marks)

b) Briefly explain the operation of a single-phase full-bridge inverter and sketch the waveform produced.

(12 marks)

c) The single-phase inverter is characterized by two distinct types of sources: the voltage source and the current source.

i) Draw the circuit of a single-phase half-bridge inverter, which includes a voltage source, two diodes, and two thyristors using a suitable circuit.

(4 marks)

ii) Draw the circuit of the single -phase full bridge inverter, which consists of four diodes and 4 thyristors by using a suitable circuit.

(4 marks)

Question 4

a) Explain:

i) the function of the buck-boost converter

(5 marks)

ii) the working principle of the buck converter

(5 marks)

b) The buck-boost converter has the following parameters

Vs = 24V, D = 0.4, R =10Ω, L 100μH, C = 400μF, F = 25kHz

Assuming ideal components, calculate;

i. The output voltage Vo

(4 marks)

ii. The maximum and minimum inductor current

(6 marks)

iii. The output voltage ripple.

(5 marks)

Question 5

a) i) State the FOUR components of Power System that need to be protected.

(2 marks)

ii) List FOUR devices in the power protection system.

(2 marks)

iii) Briefly explain any TWO protective devices in the power system.

(8 marks)

b) A DC chopper has a resistive load of 20Ω and input voltage VS = 220V. When chopper is ON, its voltage drop is 1.5 volts and chopping frequency is 10KHz. If the duty cycle is 80%, determine the average output voltage and the chopper on time.

(7 marks)

c) If the chopper circuit is operating on TRC at a frequency of 2KH on a 460V supply and the load voltage is 350V, calculate the conduction period of the thyristor in each cycle.

(6 marks)

END OF EXAMINATION PAPER

FORMULAS -LEB 31003

FUNDAMENTALS OF AC

$$I = I_0 \sin \omega t$$

$$V = V_0 \sin \omega t$$

$$I_{RMS} = \frac{I_0}{\sqrt{2}} = 0.707 I_0$$

$$V_{RMS} = \frac{V_0}{\sqrt{2}} = 0.707 V_0$$

$$Z = \frac{V_{RMS}}{I_{RMS}} = \frac{V_0}{I_0} = R$$

PURELY INDUCTIVE, L

$$\Delta\phi = \left(\omega t + \frac{\pi}{2}\right) - \omega t$$

$$\Delta\phi = \frac{\pi}{2} rad = 90°$$

$$X_L = 2\pi f L$$

RCL SERIES

$$V = IZ$$

$$\frac{V}{I} = Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\tan\phi = \frac{V_L - V_C}{V_R}$$

POWER OF PURELY RESISTIVE SERIES, R

$$P = (I_0 \sin \omega t)(V_0 \sin \omega t)$$

$$P = I_0 V_0 \sin^2 \omega t$$

$$P = \frac{I_0 V_0}{2} - \frac{I_0 V_0 \cos 2\omega t}{2}$$

$$P = \left(\frac{I_0}{\sqrt{2}} \cdot \frac{V_0}{\sqrt{2}}\right) - \left(\frac{I_0}{\sqrt{2}} \cdot \frac{V_0}{\sqrt{2}} \cdot \cos 2\omega t\right)$$

POWER OF PURELY CAPACITIVE SERIES, C

$$P = IV$$

$$P = (I_0 \cos \omega t)(V_0 \sin \omega t)$$

$$P = \frac{I_0 V_0}{2} \sin 2\omega t$$

POWER OF R, RC, RL AND RCL

$$P_{av} = I_{RMS} V_{R,RMS}$$

$$\cos\phi = \frac{V_R}{V}$$

$$V_R = V \cos\phi$$

$$P_{av} = I_{RMS} V_{RMS} \cos\phi$$

PURELY RESISTIVE, R

$$Z = \frac{V_{RMS}}{I_{RMS}} = \frac{V_0}{I_0} = R$$

PURELY CAPACITIVE, C

$$\Delta\phi = \omega t - \left(\omega t + \frac{\pi}{2}\right)$$

$$\Delta\phi = -\frac{\pi}{2} rad = -90°$$

$$X_C = \frac{1}{2\pi f C}$$

BOTH RC AND RL SERIES

$$V = IZ$$

$$\frac{V}{I} = Z = \sqrt{R^2 + X_{[C/L]}^2}$$

$$\tan\phi = \frac{V_{[C/L]}}{V_R}$$

RESONANCE FREQUENCY

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

POWER

$$P = IV$$

$$P_f = \cos\phi$$

$$P_{av} = P \cdot P_f = IV \cos\phi$$

$$P = (I_{RMS} V_{RMS}) - (I_{RMS} V_{RMS} \cos 2\omega t)$$

$$P_{av} = \frac{I_0 V_0}{2} = I_{RMS} V_{RMS}$$

POWER OF PURELY INDUCTIVE SERIES, L

$$P = (I_0 \sin \omega t)(V_0 \cos \omega t)$$

$$P = \frac{I_0 V_0}{2} \sin 2\omega t$$

$$P_{av} = 0$$

POWER FACTOR OF R, RC, RL AND RCL

$$P_f = \cos\phi = \frac{P_R}{I^2 Z}$$

$$P_f = \cos\phi = \frac{V_R}{V} = \frac{IR}{IZ} = \frac{R}{Z}$$

$$P_r = Average\ Real\ Power, \quad P_{av} = I^2 Z \cos\phi = P_r$$

HALF-WAVE RECTIFIER

$$V_O = \frac{V_m}{\pi}$$

$$I_0 = \frac{V_0}{R} = \frac{V_m}{\pi R}$$

$$V_{RMS} = \frac{V_m}{2}$$

$$I_{RMS} = \frac{V_m}{2R}$$

FULL-WAVE RECTIFIER

$$V_O = \frac{2V_m}{\pi}$$

$$I_O = \frac{V_O}{R} = \frac{2V_M}{\pi R}$$

$$V_O = \frac{Vm}{\pi}(1+\cos\alpha)$$

$$I_O = \frac{V_O}{R} = \frac{V_m}{\pi R}(1+\cos\alpha)$$

$$I_{RMS} = \frac{V_m}{R}\sqrt{\frac{1}{2} - \frac{\alpha}{2\pi} + \frac{\sin(2\alpha)}{4\pi}}$$

$$I_{S,RMS} = I_{0,RMS}$$

$$i_O(\omega t) = \frac{V_m}{Z}\left[\sin(\omega t - \theta) - \sin(\alpha - \theta)e^{-(\omega t - \alpha)/\omega\tau}\right]$$

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$\tau = \frac{L}{R}$$

BUCK AND BOOST CONVERTER

$$V_O = \frac{V_m}{\sqrt{2}}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

$$I_{O,RMS} = \frac{V_{0,RMS}}{R}$$

$$pf = \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

$$I_{SCR,avg} = \frac{V_m}{2\pi R}(1+\cos\alpha)$$

$$I_{rms,scr} = \frac{I_{O,RMS}}{\sqrt{2}}$$

$$V_O = \frac{V_S}{1-D}$$

$$I_L = \frac{V_S}{(1-D)^2 R}$$

$$I_{max} = \frac{V_S}{(1-D)^2 R} + \frac{V_S DT}{2L}$$

$$I_{min} = \frac{V_S}{(1-D)^2 R} - \frac{V_S DT}{2L}$$

$$\frac{\Delta_O}{V_O} = \frac{D}{RCF}$$

$$I_D = I_O = \frac{V_O}{R}$$

➢ On-Off control

- Output load voltage

$$Vo - rms = Vs\sqrt{\frac{n}{m+n}} = Vs\sqrt{k}$$

*K is duty cycle

➢ Phase control

- rms value output voltage

$$Vo = Vs\,[\frac{1}{2\pi}(2\pi - \alpha + \frac{sin2\alpha}{2})]^{1/2}$$

- average value output voltage

$$Vo = \frac{\sqrt{2}Vs}{2\pi}(cos\alpha - 1)$$

- RMS OUPUT VOLTAGE

$$Vorms = \frac{Vm}{\sqrt{2}}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

$$Vorms = \sqrt{PR}$$

$$Irms = \frac{Vorms}{R}$$

- POWER FACTOR OF THE LOAD

$$PF = \frac{P}{S}$$

- RMS SCR CURRENT

$$Iscr, rms = \frac{Io, rms}{\sqrt{2}}$$

- AVERAGE SCR CURRENT

$$Iscr, avg = \frac{Vm}{2\pi R}(1 + \cos\alpha)$$