SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIKAL

PEPERIKSAAN AKHIR

SESI I : 2024/2025

DET40073: POWER ELECTRONICS

TARIKH : 7 DISEMBER 2024
MASA : 8.30 PAGI – 10.30 PAGI (2 JAM)

Kertas ini mengandungi **LAPAN (8)** halaman bercetak.
Bahagian A: Struktur (3 soalan)
Bahagian B: Esei(2 soalan)
Dokumen sokongan yang disertakan : Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

SECTION A: 60 MARKS

BAHAGIAN A: 60 MARKAH

INSTRUCTION:

This section consists of **THREE (3)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **TIGA (3)** soalan berstruktur. Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1 (a) Compare SCR and TRIAC in terms of symbol, conduction mode and gate current.

Bandingkan SCR dan TRIAK dari segi symbol, mod pengaliran dan arus get.

[5 marks]
[*5 markah*]

CLO1 (b) Explain the ohmic region and cut-off region in the I-V characteristic curve of Insulated Gate Bipolar Transistor (IGBT) below.

Terangkan Kawasan ohmic dan Kawasan cut-off dalam lengkuk ciri I-V bagi IGBT.

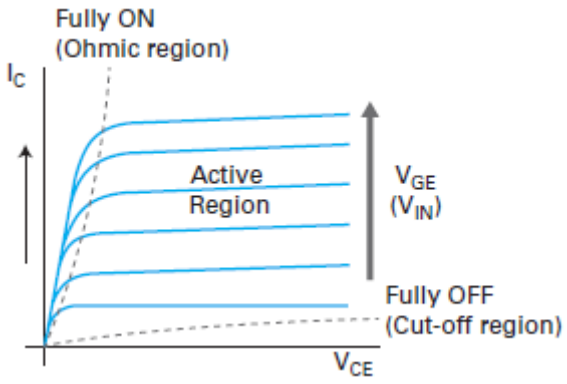

Figure A1(b) / Rajah A1(b)

[5 marks]
[*5 markah*]

CLO1

(c) A Single-Phase Half Wave Controlled Rectifier with resistive and inductive load in Figure A1(c) used to convert the input supply of 240V, 50Hz to 50Ω resistive load and 10mH inductive load at a firing angle, α, π/3° of and extinction angle of π/6º. Sketch the input voltage, output voltage, output current, and calculate the average output voltage $V_{o(avg)}$ and output current $I_{o(avg)}$.

Satu litar Penerus Terkawal Gelombang Separuh Fasa Tunggal dengan beban rintangan dan aruhan dalam Rajah A1(c) digunakan bagi menukarkan bekalan masukan 240V, 50Hz untuk beban perintang 50 Ω dan beban aruhan 10mH pada sudut picuan, α, π/3º dan sudut penghapusan, β, π/6º. Lukiskan voltan masukan, voltan keluaran, arus keluaran dan kirakan voltan keluaran purata dan arus keluaran purata.

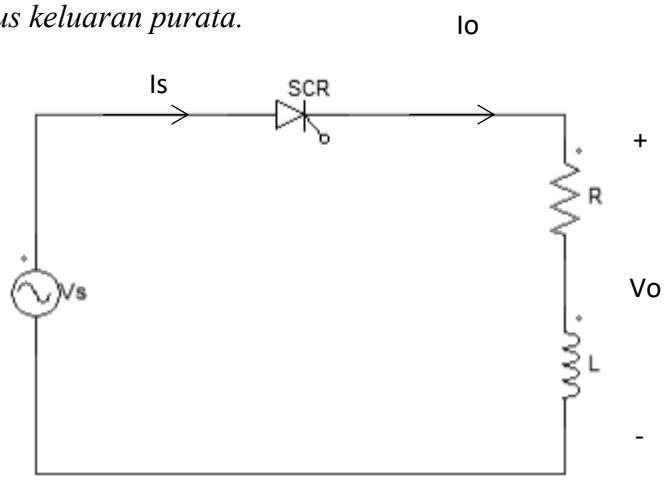

Figure A1(c) / *Rajah A1(c)*

[10 marks]
[*10 markah*]

QUESTION 2

SOALAN 2

CLO1

(a) Discuss the differences between buck chopper and boost chopper.

Bincangkan perbezaan antara pemenggal langkah turun dan pemenggal langkah naik.

[5 marks]
[*5 markah*]

CLO1

(b) Explain the operation principle of the circuit diagram in Figure A2(b) below.

Terangkan prinsip operasi rajah litar dalam Rajah A2(b) di bawah.

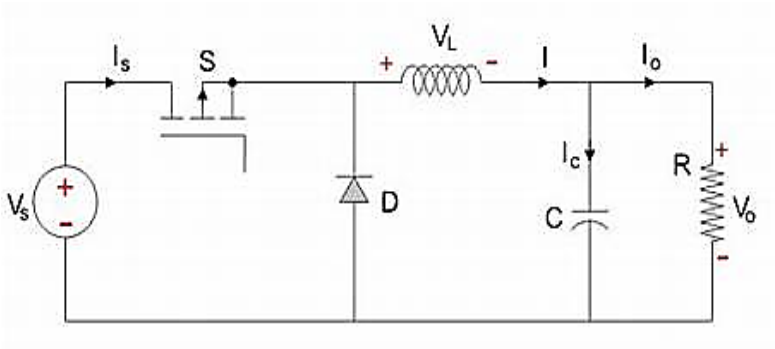

Figure A2(b) / *Rajah A2(b)*

[5 marks]
[*5 markah*]

CLO1 (c) The chopper in Figure A2(c) is operated at 50kHz with input voltage is 120V and the output voltage is 350V. Given that the value of L = 100µH and R = 50Ω, calculate the value of duty cycle (D), conducting period (T_{on}) and the maximum inductor current (I_{Lmax}). Also calculate the value of output voltage (V_O) if duty cycle is 30%.

Pemenggal dalam Rajah A2(c) beroperasi pada 50kHz dengan voltan masukan 120V dan voltan keluaran 350V. Diberi nilai L = 100µH and R = 50Ω, kirakan nilai kitar kerja (D), tempoh kendalian (T_{on}) dan arus aruhan maksima (I_{Lmax}). Juga kirakan nilai voltan keluaran (V_O) jika kitar kerja ialah 30%.

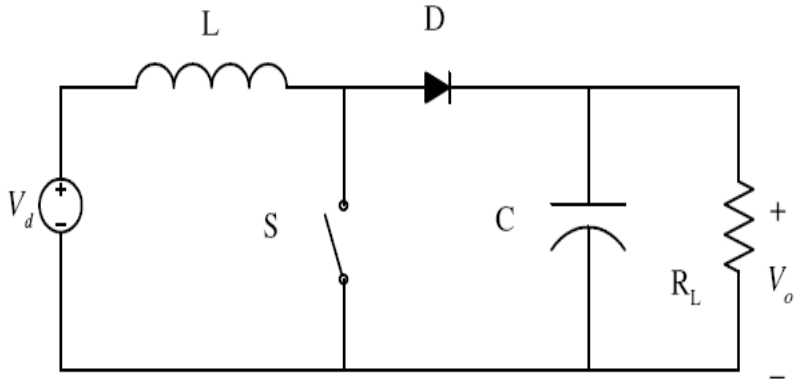

Figure A2(c) / *Rajah A2(c)*

[10 marks]
[*10 markah*]

QUESTION 3

SOALAN 3

CLO1

(a) A voltage source inverter or VSI is a device that converts unidirectional voltage waveform into a bidirectional voltage waveform. Compare **TWO (2)** differences switching schemes in VSI between pulse-width modulation (PWM) and square wave.

*Penyongsang punca voltan atau VSI ialah peranti yang menukarkan bentuk gelombang voltan satu arah kepada bentuk gelombang voltan dua arah. Bandingkan **DUA (2)** perbezaan skema pensuisan dalam VSI antara modulasi lebar denyut (PWM) dan gelombang persegi.*

[4 marks]
[4 *markah*]

CLO1

(b) Figure A3(b) shows the circuit diagram of the single-phase inverter with resistive load. Draw the output waveform of the inverter, then calculate the rms output voltage ($V_{o,rms}$) and rms output current ($Io_{,rms}$) if a given DC input voltage is 50V and the load resistance is 25Ω

Rajah A3(b) menunjukkan rajah litar bagi penyongsang satu fasa dengan beban perintang. Lukiskan gelombang keluaran bagi penyongsang tersebut dan kirakan voltan keluaran ($V_{o,ppkd}$) dan arus keluaran ($I_{o,ppkd}$) jika voltan masukan AT ialah 50V dan beban perintang ialah 25Ω.

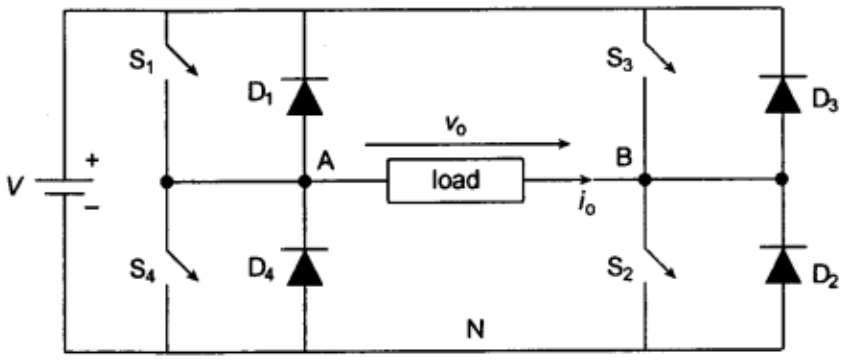

Figure A3(b) / *Rajah A3(b)*

[8 marks]
[8 *markah*]

CLO1

(c) Three phase bridge inverter as being show in Figure A3(c) is a combination of three single-phase inverters. Table A3(c) shows the operation of switches for three phase VSI 120° conduction mode. Complete the table by writing the value of V_{AN}, V_{BN}, V_{CN}, V_{AB}, V_{BC} and V_{CA}. Sketch the output waveform of V_{AN} and V_{AB}

Penyongsang tetimbang tiga fasa seperti yang ditunjukkan dalam Rajah A3(c) adalah gabungan tiga penyongsang fasa Tunggal. Jadual A3(c) menunjukkan operasi suis bagi mod pengaliran 120° VSI tiga fasa. Lengkapkan jadual tersebut dengan menuliskan nilai bagi V_{AN}, V_{BN}, V_{CN}, V_{AB}, V_{BC} and V_{CA}. *Lakarkan gelombang keluaran bagi* V_{AN} *dan* V_{AB}.

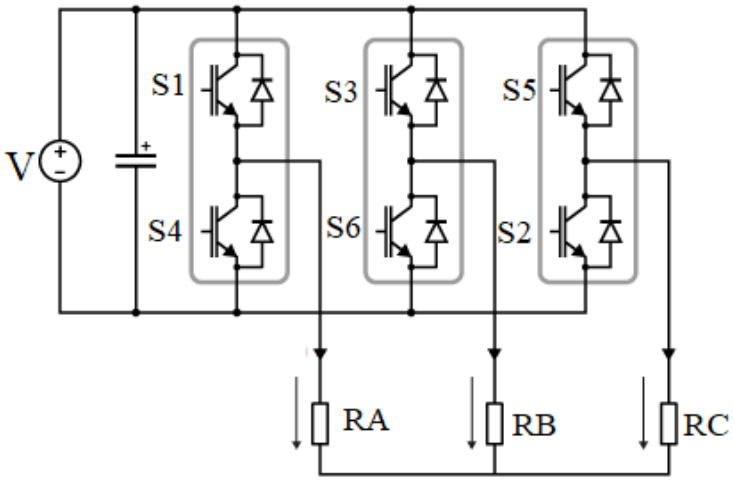

Figure A3 (c) / *Rajah A3 (c)*

PERIOD	S1	S2	S3	S4	S5	S6	VAN	VBN	VCN	VAB	VBC	VCA
0-60	ON	OFF	OFF	OFF	OFF	ON						
60-120	ON	ON	OFF	OFF	OFF	OFF						
120-180	OFF	ON	ON	OFF	OFF	OFF						
180-240	OFF	OFF	ON	ON	OFF	OFF						
240-300	OFF	OFF	OFF	ON	ON	OFF						
300-360	OFF	OFF	OFF	OFF	ON	ON						

Table A3(c) / *Jadual A3(c)*

[8 marks]
[*8 markah*]

SECTION B: 40 MARKS
BAHAGIAN B: 40 MARKAH

INSTRUCTION:
This section consists of **TWO (2)** essay question. Answer **ALL** questions.

ARAHAN:
*Bahagian ini mengandungi **DUA (2)** soalan esei. Jawab **SEMUA** soalan.*

CLO1 **QUESTION 1**
SOALAN 1

A single-phase full wave controlled bridge rectifier has an input voltage of 240V, 50Hz with a RL load value of 50Ω and 5mH respectively. Illustrate the circuit diagram, waveforms of input voltage, output voltage and output current if given firing angle, α is 60° and extinction angle, β is 45°. Also, calculate the value of average output voltage, $V_{o(avg)}$. If a freewheeling diode (FWD) is connected parallel to the load, sketch the output voltage, and output current waveforms. Then calculate the new average output voltage, $V_{o(avg)}$. Finally analyze the effect of adding FWD in the rectifier circuit.

Penerus tetimbang fasa tunggal terkawal gelombang penuh mempunyai voltan masukan 240V, 50Hz dengan nilai beban RL masing-masing 50Ω dan 5mH. Ilustrasikan litar, bentuk gelombang voltan masukan, voltan keluaran dan arus keluaran jika diberi sudut picuan, α ialah 60° dan sudut penghapusan, β is 45°. *Juga, kirakan nilai voltan keluaran purata Vo(avg). Jika satu diode meroda bebas disambungkan secara selari dengan beban, lakarkan bentuk gelombang voltan keluaran dan arus keluaran. Kemudian kirakan voltan keluaran purata Vo(avg) yang baru. Akhir sekali, Analisa kesan penambahan diod meroda bebas dalam litar penerus tersebut.*

[20 marks]
[*20 markah*]

CLO1

QUESTION 2

SOALAN 2

A Single-Phase Bidirectional Controller operates using phase angle control. Given the voltage supply is 240V, 50Hz and the load, R is 50Ω. Draw the input waveform, output voltage waveform and switches gating signal waveforms if the switches used is delayed at $\alpha = 60^{o}$. Then, with the aid of circuit diagram, explain the operation principle of the controller. Finally, calculate the output power produced at load.

Sebuah Pengawal Dwiarah satu fasa beroperasi menggunakan teknik kawalan sudut fasa. Diberi, voltan bekalan ialah 240V, 50Hz dan beban R ialah 50Ω. Lukiskan bentuk gelombang voltan masukan, gelombang voltan keluaran dan gelombang isyarat get jika suis-suis yang digunakan dilambatkan pada $\alpha = 60^{o}$. Kemudian, dengan bantuan gambarajah litar, terangkan prinsip operasi bagi pengawal. Akhirnya, kirakan kuasa keluaran yang dihasilkan pada beban.

[20 marks]
[*20 markah*]

SOALAN TAMAT

FORMULA

$V_{o(avg)} = \frac{V_m}{\pi}$	$V_{o(rms)} = \frac{V_m}{2}$
$V_{o(avg)} = \frac{V_m}{2\pi}(1 - cos\beta)$	$V_{o(rms)} = \frac{V_m}{2}\sqrt{\left(\frac{\beta}{\pi} - \frac{sin2\beta}{2\pi}\right)}$
$V_{o(avg)} = \frac{V_m}{2\pi}(1 + \cos\alpha)$	$V_{o(rms)} = \frac{V_m}{2}\sqrt{1 - \frac{\alpha}{\pi} + \frac{sin(2\alpha)}{2\pi}}$
$V_{o(avg)} = \frac{V_m}{2\pi}(\cos\alpha - \cos\beta)$	$V_{o(rms)} = \frac{V_m}{2}\sqrt{\left[\frac{\beta}{\pi} - \frac{\alpha}{\pi} - \frac{sin(2\beta)}{2\pi} + \frac{sin(2\alpha)}{2\pi}\right]}$
$V_{o(avg)} = \frac{2V_m}{\pi}$	$V_{O(rms)} = \frac{V_m}{\sqrt{2}}$
$V_{o(avg)} = \frac{V_m}{\pi}(1 + \cos\alpha)$	$V_{o(rms)} = V_m\sqrt{\frac{1}{2} - \frac{\alpha}{2\pi} + \frac{sin(2\alpha)}{4\pi}}$
$V_{o(avg)} = \frac{V_m}{\pi}(\cos\alpha - \cos\beta)$	$V_{o(avg)} = \frac{2V_m cos\alpha}{\pi}$
$V_{o(avg)} = \frac{3\sqrt{3}}{2\pi}V_m$	$V_{o(rms)} = \sqrt{\frac{V_m^2}{2\pi}\left[\beta - \alpha - \frac{sin(2\beta)}{2} + \frac{sin(2\alpha)}{2}\right]}$
$V_{o(avg)} = \frac{3\sqrt{3}\,V_m\cos\alpha}{2\pi}$	$Z = \sqrt{R^2 + (\omega L)^2}$
$I_{Lmax} = V_O\left[\frac{1}{R} + \frac{(1-D)}{2Lf}\right]$	$I_{L\,min} = V_O\left[\frac{1}{R} - \frac{(1-D)}{2Lf}\right]$
$I_{Lmax} = \frac{V_S}{(1-D)^2\,R} + \left[\frac{V_S}{2L}DT\right]$	$I_{L\,min} = \frac{V_S}{(1-D)^2\,R} - \left[\frac{V_S}{2L}DT\right]$
$L_{min} = \frac{(1-D)R}{2f}$	$\Delta V_O = \frac{V_O\,(1-D)}{8LCf^2}$
$L_{min} = \frac{D(1-D)^2R}{2f}$	$\Delta V_o = \frac{V_o D}{RCf}$
$V_{o(rms)} = V_s\sqrt{\frac{1}{2\pi}\left[2\pi - \alpha + \frac{sin2\alpha}{2}\right]}$	$V_{o(rms)} = V_s\sqrt{\frac{1}{\pi}\left[\pi - \alpha + \frac{sin2\alpha}{2}\right]}$