Second Semester Examination
2017/2018 Academic Session

May/June 2018

EEK373 – ADVANCED POWER ELECTRONICS
(ELEKTRONIK KUASA LANJUTAN)

Duration : 3 hours
(Masa : 3 jam)

Please ensure that this examination paper consists of <u>THIRTEEN</u> (13) pages and <u>SEVEN</u> (7) pages of printed appendices material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi <u>TIGA BELAS</u> (13) muka surat dan <u>TUJUH</u> (7) muka surat lampiran yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: This question paper consists of **FIVE (5)** questions. Answer **ALL** questions. All questions carry the same marks.

[**Arahan:** Kertas soalan ini mengandungi **LIMA (5)** soalan. Jawab **SEMUA** soalan. Semua soalan membawa jumlah markah yang sama.]

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a) Describe and compare the operation of on-off control, phase control and cyclo-converter of AC-AC voltage converters. Sketch simple diagrams to illustrate the output waveform of each converter.

    Terang dan bandingkan operasi kawalan on-off, kawalan fasa dan penukar-siklo bagi penukar voltan AC-AC. Lakarkan gambar rajah mudah bentuk gelombang keluaran bagi setiap penukar

    (30 marks/*markah*)

    (b) The ac voltage controller is used for heating resistive load of R =5Ω and the input voltage Vs = 230V, 50Hz. The thyristor switch is on for n =125 cycles and is off for m = 75 cycles. Determine;

    Pengawal voltan AC-AC digunakan untuk pemanasan rintangan beban sebanyak R = 5Ω. Voltan masuk adalah Vs = 230V, 50Hz. Suis tiristor dihidupkan untuk n = 125 kitaran dan dimatikan untuk m = 75 kitaran. Tentukan;

    (i) The rms output voltage, V_o
    Nila rms voltan keluaran, V_o

    (10 marks/*markah*)

    (ii) The input power factor, PF
    Nilai faktor kuasa masuk, PF

    (10 marks/*markah*)

    (iii) The average and rms thyristor currents
    Nilai purata dan rms arus tiristor

    (10 marks/*markah*)

(c) A single phase full wave ac voltage controller has a resistive load of R =10 Ω and the input voltage is Vs = 230V, 50Hz. The delay angle of thyristor T1 and T2 are equal: α1 = α2 = α = π/3. Determine

Sebuah pengawal AC fasa tunggal penuh mempunyai beban rintangan R =10 Ω dan disambungkan kepada sumber Vs = 230V, 50Hz. Sudut kelewatan bagi tiristor T1 dan T2 adalah sama: α1 = α2 = α = π/3. Tentukan

(i) The rms output voltage V_o

Nilai rms voltan keluaran, V_o

(10 marks/*markah*)

(ii) The input power factor PF

Nilai faktor kuasa masuk PF

(10 marks/*markah*)

(iii) The average current of thyristor

Nilai arus purata tiristor

(10 marks/*markah*)

(iv) The rms current of thyristor

Nilai arus rms tiristor

(10 marks/*markah*)

2. (a) With the aid of diagram, explain the operation of forward converter for ON and OFF respectively, your answer should include the derivations and waveforms.

Dengan bantuan gambarajah, terangkan operasi bagi penukar depan semasa suis masing-masing dihidupkan dan dimatikan, jawapan anda mesti merangkumi penerbitan dan bentuk gelombang.

(50 marks/*markah*)

(b) A fly-back converter with a 1:3 turn ratio is supplied with 24 V as source voltage. The magnetizing inductance and the capacitance are 500 µH and 200 µF respectively. The load consists of 7 Ω and the output voltage across the load is 5 V. If the converter is operated with switching frequency of 40 kHz, calculate the following:

Satu penukar terbang-balik dengan nisbah pusingan 1:3 dibekalkan voltan 24 V. Kearuhan pemagnetan dan kemuatan masing-masing adalah 500 µH and 200 µF. Beban terdiri daripada 7 Ω dan voltan keluaran merentasi beban adalah 5 V. Jikalau penukar tersebut beroperasi pada frekuensi pensuisan 40 kHz, kirakan:

(i) required duty cycle.

kitar tugas yang diperlukan.

(16 marks/*markah*)

(ii) average, maximum and minimum magnetizing inductance currents.

nilai purata, maxima dan minima bagi arus kearuhan pemagnetan.

(24 marks/*markah*)

(iii) output voltage ripple in percentage.

riak voltan keluaran dalam peratus.

(10 marks/*markah*)

25

3.   (a)   A three-phase inverter bridge shown in Figure Q 3 transfers power from an ideal DC bus bar of V_d =600 V to a three-phase resistive load of R = 100 Ω per phase using 120° conduction. The switching and voltage waveforms of phase voltages V_{as}, V_{bs} and V_{cs} are given in Figure Q 3.

Satu penyongsang tiga fasa yang ditunjukkan dalam Rajah Q 3 mengalami pindahan kuasa dari satu palang bus unggul V_d =600 V ke satu beban rintangan tiga fasa R = 100 Ω per fasa dengan 120° mod pengaliran. Gelombang pensuisan dan voltan fasa V_{as}, V_{bs} dan V_{cs} adalah yang seperti ditunjukkan dalam Rajah Q 3.
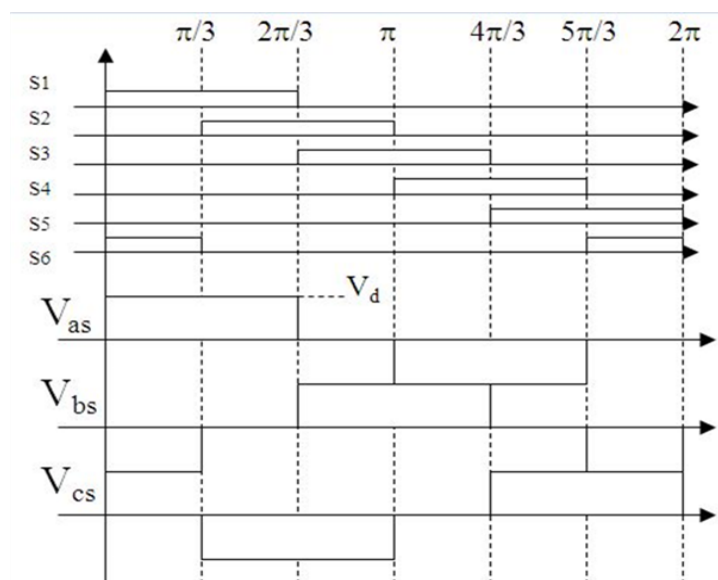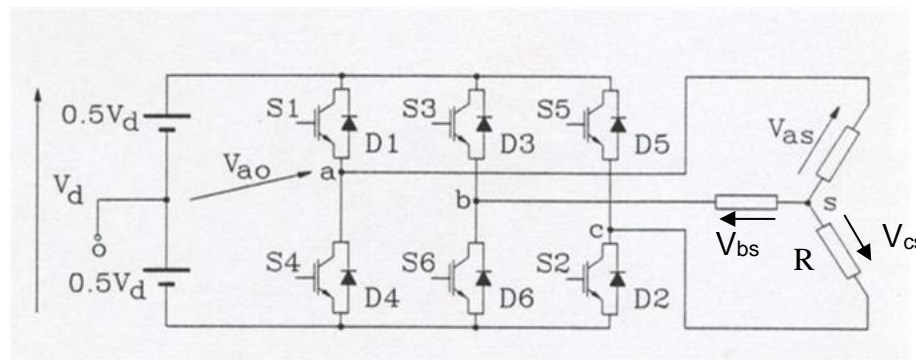

Figure Q 3 Switching and voltage waveforms of phase voltages V_{as}, V_{bs} and V_{cs}

Rajah Q 3 Gelombang pensuisan dan voltan fasa V_{as}, V_{bs} dan V_{cs}

      (i)   Indicate which of the six switches are conducting during each interval of the cycle.

           Tunjukkan suis yang dihidupkan setiap selang masa bagi kitar tersebut.

(15 marks/*markah*)

      (ii)   Sketch the waveforms for line voltages V_{AB}, V_{BC} and V_{CA}.

           Lakarkan gelombang bagi voltan talian V_{AB}, V_{BC} and V_{CA}.

(18 marks/*markah*)

(b)   With the balanced three-phase resistive load of R = 100 Ω connected in star shown in Figure Q 3, calculate:

     Dengan satu beban rintangan seimbang tiga fasa R = 100 Ω disambung secara bintang seperti yang ditunjukkan dalam Rajah Q 3, kirakan:

      (i)   the rms phase current.

           Nilai rms arus fasa.

(13 marks/*markah*)

      (ii)   the source current.

           arus bekalan.

(10 marks/*markah*)

(c)   A single-phase voltage source inverter is supplied with input voltage V_{dc} = 200 V for RL load. Calculate the following for 180° conduction mode:

Satu penyongsang sumber voltan satu fasa dibekalkan dengan voltan masukan V_{dc} = 200 V bagi bebanan RL. Dengan menggunakan 180° mod pengaliran, kirakan:

(i)   Distortion factor.
       faktor herotan.

                                                              (29 marks/*markah*)

(ii)   the total harmonic distortion.
       jumlah herotan harmonik.

                                                              (15 marks/*markah*)

4.   (a)   A series resonant inverter circuit as shown in Figure Q 4 (a), has C = 5 µF, L = 30µH, R = 0, and V_S = 220V. The turn-off time of transistor, t_{off} = 15µs. The output frequency is f_o = 20 kHz.

Suatu siri litar penyongsang resonan seperti ditunjukkan dalam Rajah Q 4 (a), mempunyai C = 5 µF, L = 30µH, R = 0, dan V_S = 220V. Masa mematikan transistor, t_{off} = 15µs. Frekuensi keluaran adalah f_o = 20 kHz.
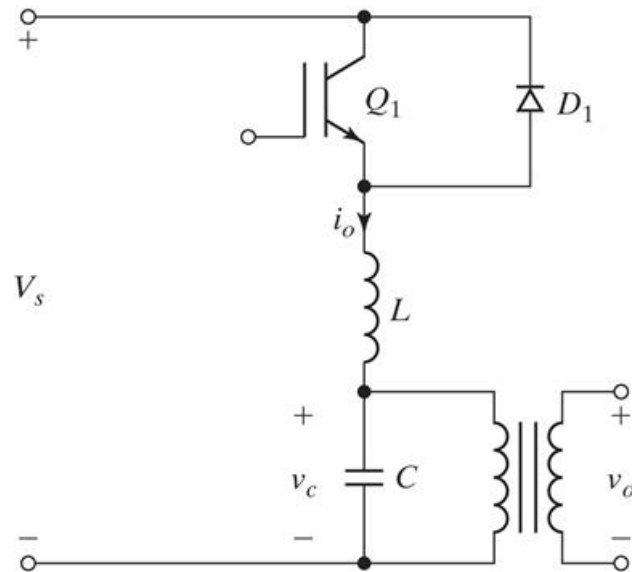
Figure Q 4 (a)

Rajah Q 4 (a)

(i)   Determine the peak supply current I_p

Tentukan arus masukan puncak I_p.

(5 marks/*markah*)

(ii) Determine the average current I_A

Tentukan arus purata I_A.

(15 marks/*markah*)

(iii) Determine the rms device current I_R

Tentukan nilai rms arus peranti I_R.

(15 marks/*markah*)

(iv) Determine the peak to peak capacitor voltage V_{pp}

Tentukan nilai puncak ke puncak voltan capacitor V_{pp}.

(5 marks/*markah*)

(v)   Determine the maximum inverter frequency f_{max}

       Tentukan frekuensi maksimum penyongsang f_{max}.

(10 marks/*markah*)

(vi)   Determine the average supply current I_s

       Tentukan arus purata bekalan I_s.

(5 marks/*markah*)

(b)   A parallel resonant inverter as in Figure Q 4 (b) delivers a load power of P_L = 3 kW at a peak sinusoidal load voltage of Vp = 220 V and at resonance. The load resistance is R = 7.5 Ω. The resonant frequency is f_o = 30 kHz.

      Suatu penyongsang resonan sejajar seperti dalam Rajah Q 4 (b) menyampaikan kuasa beban sebanyak P_L = 3 kW pada voltan beban sinusoidal puncak V_p = 220 V dan pada resonan. Rintangan beban adalah R = 7.5 Ω. Frekuensi resonan adalah f_o = 30 kHz.
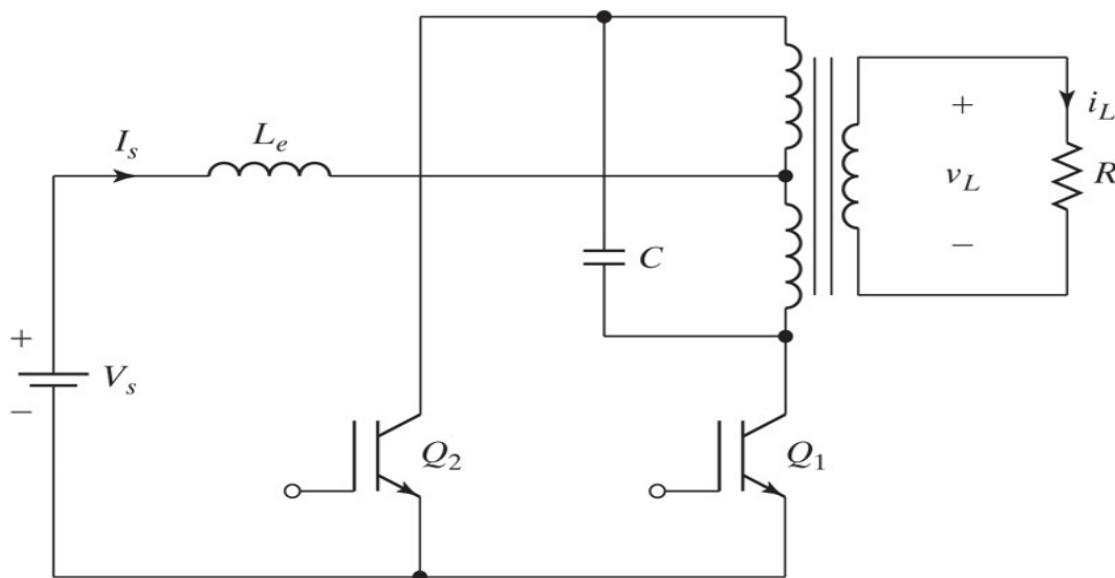

Figure Q 4 (b)

Rajah Q 4 (b)

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(i)   Determine the dc supply input current I_s

Tentukan arus masukan dc bekalan I_s.

(10 marks/*markah*)

(ii)   Determine the quality factor Q_p if it is required to reduce the load power to 1500 W by frequency control so that u = 1.25

Tentukan factor kualiti Q_p jika kuasa beban perlu dikurangkan kepada 1500 W oleh frekuensi kawalan supaya u = 1.25

(10 marks/*markah*)

(iii)   Determine the capacitor C value

Tentukan nilai muatan C.

(10 marks/*markah*)

(iv)   Determine the inductor L value

Tentukan nilai aruhan L.

(10 marks/*markah*)

5.   (a)   Figure Q 5 (a) shows an example of Flyback converter. There are two modes of operation: (1) mode 1 when switch Q1 is turned on, and (2) mode 2 when switch Q1 is turned off.

Rajah Q 5 (a) menunjukkan contoh penukar Flyback. Terdapat dua mod operasi: (1) mod 1 apabila suis Q1 dihidupkan, dan (2) mod 2 apabila suis Q1 dimatikan.
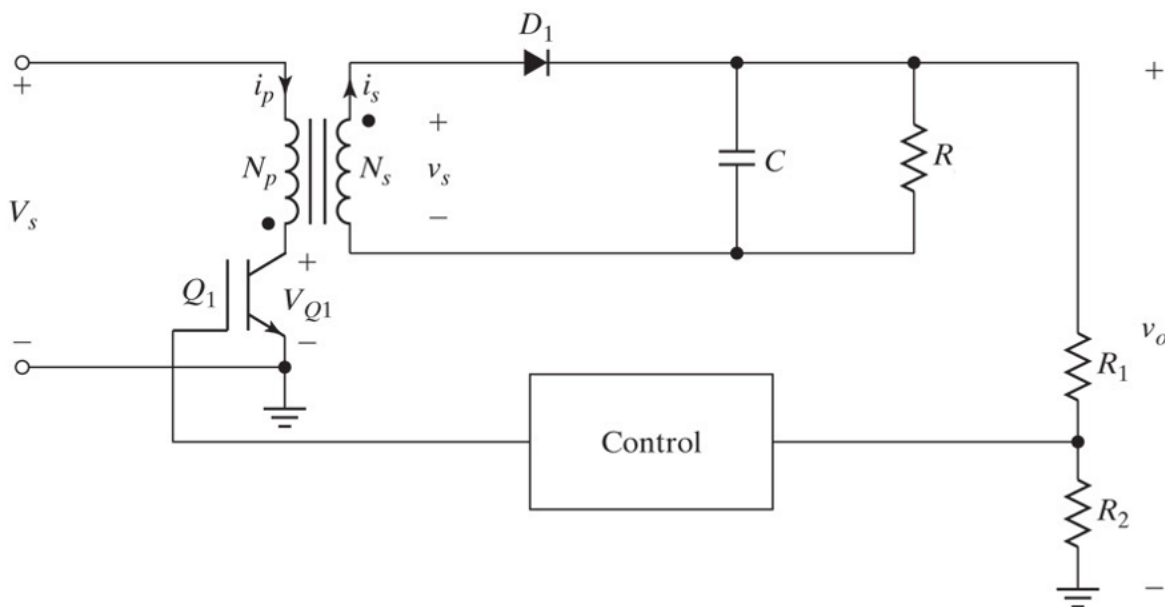
Figure Q 5 (a)

Rajah Q 5 (a)

(i)   Explain briefly about the operation of the circuit, subjected to the main application of this circuit and the two operation (1) mode 1 when switch Q1 is turned on, and (2) mode 2 when switch Q1 is turned off.

Terangkan secara ringkas mengenai operasi litar, tertakluk kepada aplikasi utama litar ini dan dua operasi (1) mod 1 apabila suis Q1 dihidupkan, dan (2) mod 2 apabila suis Q1 dimatikan.

(15 marks/*markah*)

(ii)   Sketch waveforms of transistor Q1 voltage V_{Q1}, secondary voltage V_s, primary current I_p, secondary current I_s and output voltage V_o

Lakarkan bentuk gelombang voltan transistor Q1 V_{Q1}, voltan sekunder V_s, arus premier I_p, arus sekunder I_s dan voltan keluaran V_o.

(30 marks/*markah*)

(iii) Double-ended Flyback converter is used when the voltage supply is too high and above voltage V_{Q1}. Draw a double-ended flyback converter by referring to Figure Q 5 (a).

Penukar Flyback dua hala digunakan apabila bekalan voltan terlalu tinggi dan melebihi voltan V_{Q1}. Lukiskan penukar flyback dua hujung dengan merujuk kepada Rajah Q 5 (a).

(15 marks/*markah*)

(b) Figure Q 5 (b) shows an example of Forward converter.
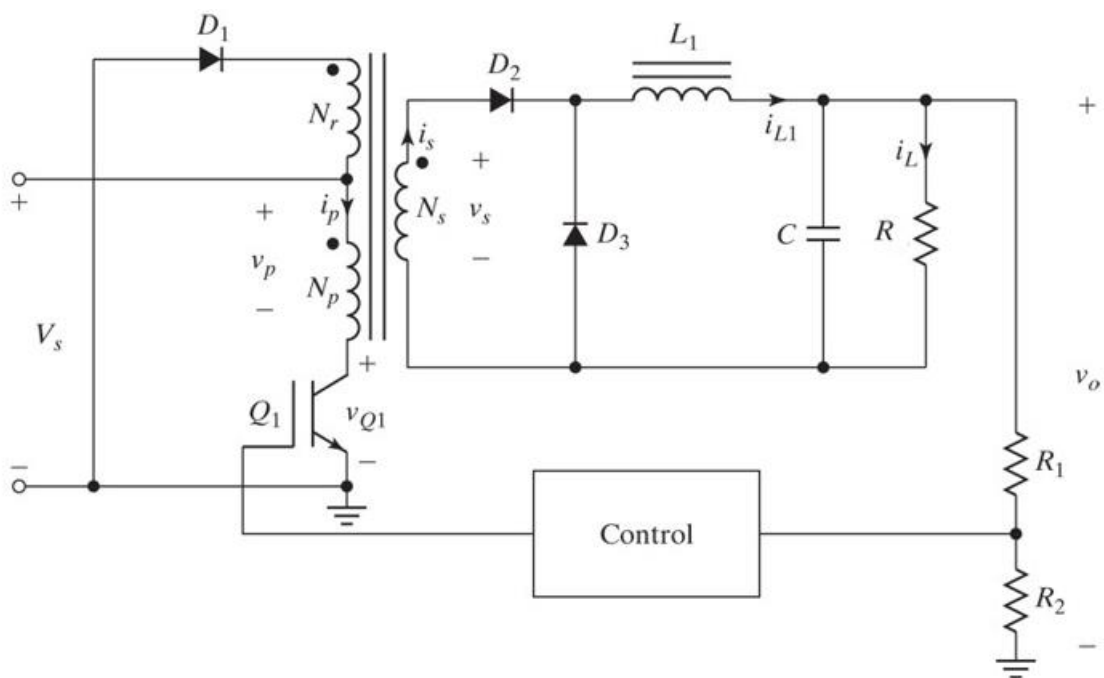*Rajah Q 5 (b) menunjukkan contoh penukar hadapan.*

Figure Q 5 (b)

Rajah Q 5 (b)

(i) Sketch waveforms of primary voltage V_P, transistor Q1 voltage V_{Q1}, primary current I_p, current of diode D3 I_{D3}, current of Inductor I_{L1} and output voltage V_o.

Lakarkan bentuk gelombang voltan premium V_p, voltan transistor Q1 V_{Q1}, arus premier I_p, arus diode D3 I_{D3}, arus arahan I_L dan voltan keluaran V_o.

(30 marks/*markah*)

(ii) Explain briefly the differences between Flyback and forward converter.

Jelaskan secara ringkas perbezaan antara penukar Flyback dan penukar hadapan.

(10 marks/*markah*)

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APPENDIX

LAMPIRAN

Course Outcomes (CO) – Programme Outcomes (PO) Mapping
Pemetaan Hasil Pembelajaran Kursus – Hasil Program

Questions *Soalan*	CO	PO
1	1	2
2	1	2
3	2	3
4	2	3
5	3	3
6		