UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEK373 – Advanced Power Electronics

Duration : 2 hours

Please check that this examination paper consists of **EIGHT (8)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **FOUR (4)** questions. Answer **THREE (3)** questions only.

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1. a) A single phase fully controlled thyristor bridge converter supplies a load consisting of R, L and Ec as shown in Figure 1. The inductance L in the circuit is so large that the output current may be considered to be virtually constant. Assume the thyristor to be ideal with the following data: RMS supply voltage = 220V, load resistance = 0.5Ω, DC output current =10A. Determine;

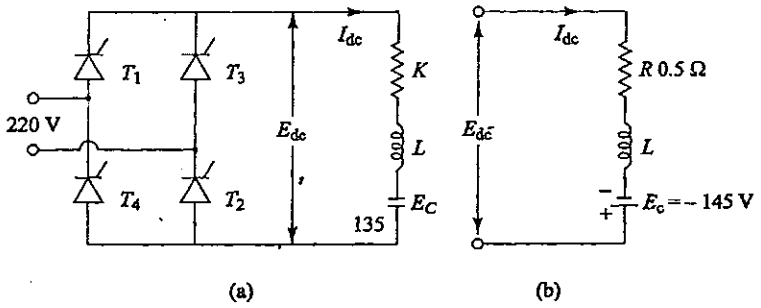

Figure 1. Single Phase Controlled Rectifier

(i). Firing angle α if Ec = 135V (Figure 1(a)) and Ec= -145V (Figure 1(b))

(30marks)

(ii). Which source (AC or DC) is supplying power in Figure 1(a) and 1(b)?

(20 marks)

b) Three phase full wave controlled rectifier was in favor in industries over single phase controlled rectifier.

(i). Sketch an output voltage waveform of three phase full wave controlled rectifier with α = 60 degree for resistive load using the template given in Appendix 1.

(25 marks)

(ii). Sketch an output voltage waveform of three phase full wave controlled rectifier with α =90 degree for RL load (highly inductive) using the template given in Appendix 1.

(25 marks)

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2. A single-phase full-wave ac voltage controller in Figure 2 has a resistive load of R=10Ω and the root-mean square (rms) input voltage is V_s=120 V, 60 Hz. The delay angle of thyristor T_1 and T_2 are $\alpha_1=\alpha_2=\alpha=\pi/2$. Determine

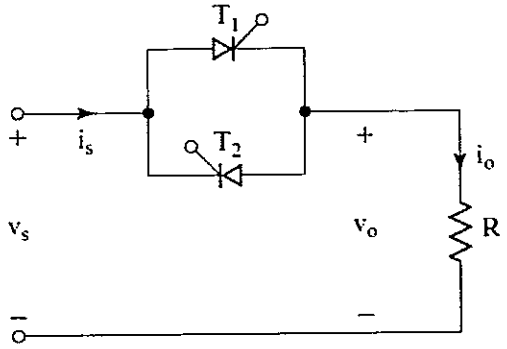

Figure 2. Single Phase AC AC Controller

a) The rms output voltage V_o, (25 marks)

b) The input power factor, (25 marks)

c) The average current of thyristors I_A and (25 marks)

d) The rms current of thyristors I_r. (25 marks)

3. Design a buck converter to produce an output voltage of 18 V across a 10 Ω load resistor. The output voltage ripple must not exceed 0.5 percent. The DC supply is 48 V and the switching frequency is 40 kHz. The converter should operates in continuous current mode. Determine:

a) the duty cycle.

(10 marks)

b) the values of inductor and capacitor.

(20 marks)

c) the values of maximum and minimum inductor currents.

(20 marks)

d) the peak voltage rating of switch, diode, inductor and capacitor.

(40 marks)

e) the peak capacitor current.

(10 marks)

4. a) For the circuit shown in Figure 4a, the input voltage is 200V, load resistance is 20Ω and the output voltage frequency is 50Hz. The circuit is operating with conduction mode of 180°.

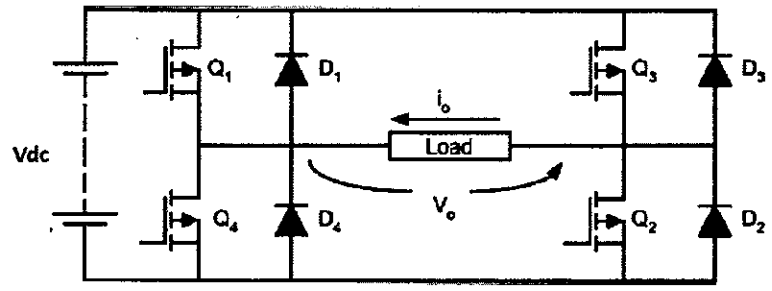

Figure 4a. Circuit configuration

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(i). What is the circuit name?

(5 marks)

(ii). Sketch output voltage waveform and load current waveform for the case of resistive load.

(20 marks)

(iii). Determine the rms value of the output voltage.

(10 marks)

(iv). Determine the output power.

(10 marks)

(v). Determine the distortion factor.

(15 marks)

(vi). Determine the total harmonic distortion.

(5 marks)

b) A three-phase inverter shown in Figure 4b operates in conduction mode of 180°, obtain phase voltages, V_{as}, V_{bs} and V_{cs} then finally the line voltage V_{ab} in terms of V_d for $\pi/3 < \omega t < 2\pi/3$.

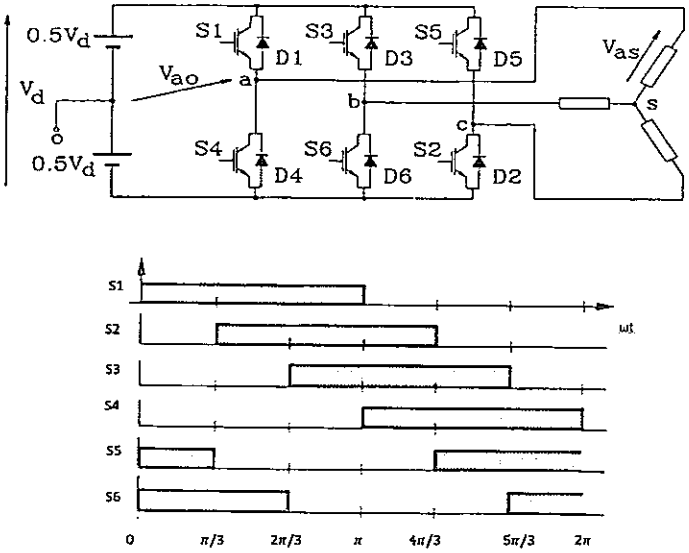

Figure 4b. Three-phase inverter and its switching signals

(35 marks)

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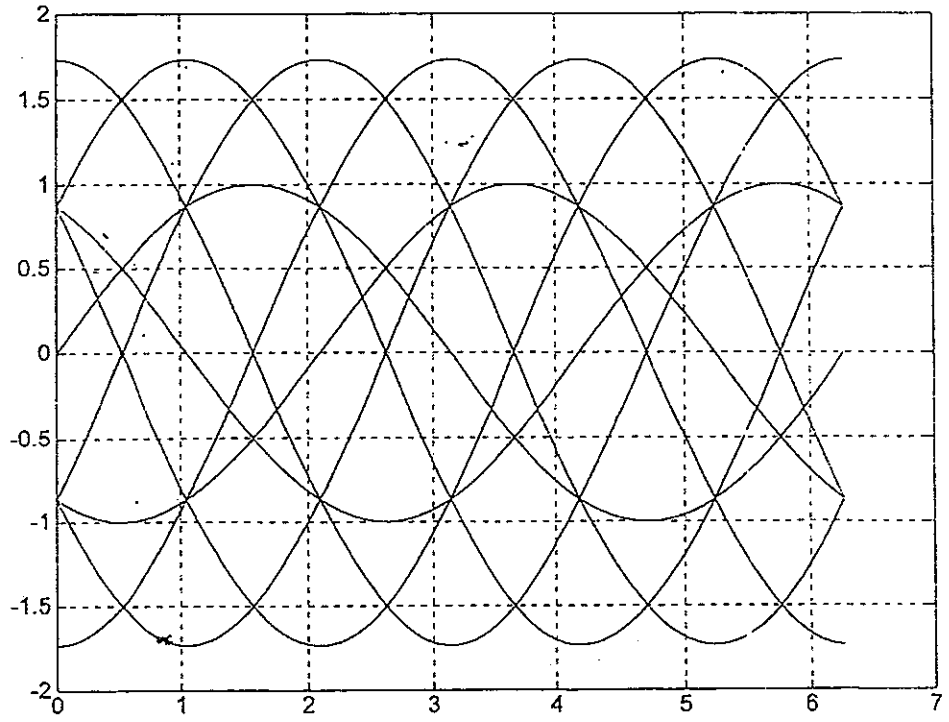
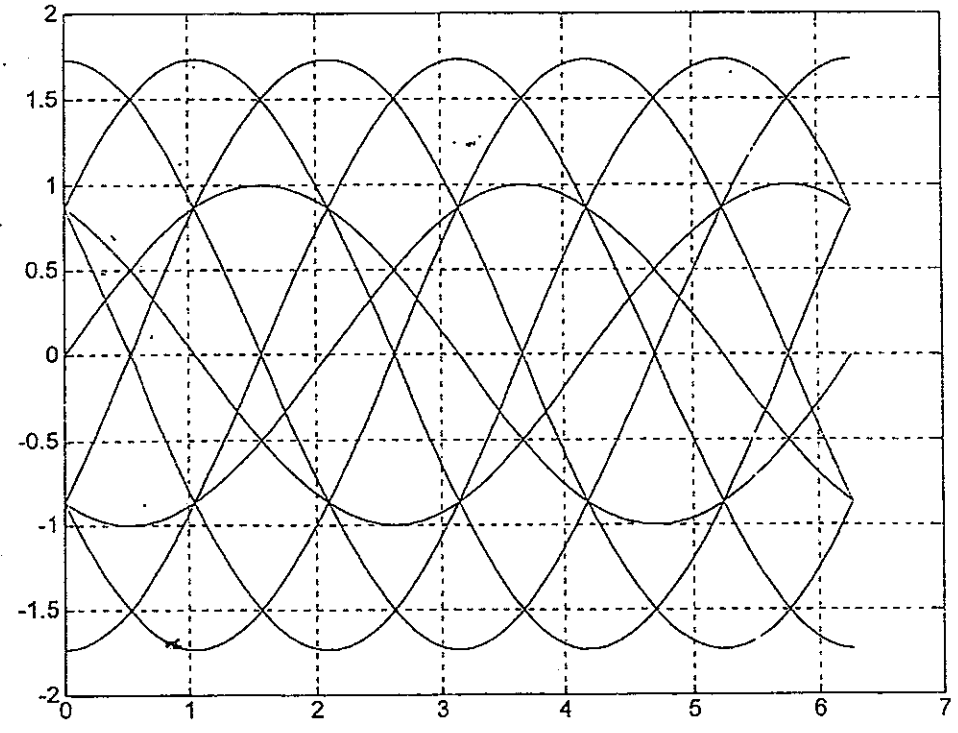
APPENDIX 1. Drawing Template





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APPENDIX 2

Question	Course Outcome (CO)	Programme Outcome (PO)
1	1	2
2	2	3
3	1	2
4	2	3