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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014**

COURSE NAME : POWER ELECTRONICS
COURSE CODE : BEF 34503 / BEX 42303
PROGRAMME : BEV / BEE
EXAMINATION DATE : DECEMBER 2013
DURATION : 3 HOURS
INSTRUCTION : ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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Q1 (a) Rectifier is used to convert the AC input to the DC output. Two common devices can be used as a switching device which are the thyristor and the diode. Both of them can be categorized as controlled and uncontrolled converter.

i) Identify one switching device that can be used as a rectifier in order to have variable output voltage. (1 mark)

ii) The controlled devices need a firing angle to trigger on the device. State two methods that can generate this firing angle. (2 marks)

iii) Give two advantages of 3 phase rectifier compared to the full bridge rectifier. (2 marks)

(b) A three phase controlled rectifier with highly inductive load is shown in **Figure Q1**. The voltage for line to neutral is measured at the secondary side of the transformer and rated as 240 V. The load impedance for the inverter is given as 10Ω . For three phase inverter, the phase difference between the line to line voltage and line to neutral is 30°

i) Show that the average output voltage of V_{dc} is

$$= \frac{3\sqrt{3}}{\pi} V_m \cos(\alpha).$$

(5 marks)

ii) Show that the rms output voltage is

$$V_{rms} = \sqrt{3} V_m \left(\frac{1}{2} + \frac{3\sqrt{3}}{4\pi} \cos(2\alpha) \right)^{1/2}$$

(5 marks)

iii) Determine the delay angle of the thyristor when the average output voltage is 140V. (3 marks)

iv) Calculate the average output current. (2 marks)

v) Calculate the rms output current. (2 marks)

vi) Calculate the form factor. (2 marks)

vii) Determine the maximum rms output voltage. (1 mark)

Q2 (a) Inverter can be operated in two (2) condition modes which are the force and the phase control mechanism. Currently, the phase controlled is more widely used due to less harmonic output produced by the inverter.

i) Explain with the helps of diagram the technique that can be used for phase controlled inverter. (3 marks)

ii) Illustrate the different between the Pulse Width Modulation (PWM) and the Sinusoidal Pulse Width Modulation using the diagram. (3 marks)

iii) For a 3 phase inverter determine the signal that will contribute to the frequency output. (1 mark)

(b) **Figure Q2(a)** and **Q2(b)** show the 3 phase inverter and the switching algorithm. The 3 phase inverter is connected to the balanced R load. Given the V_{dc} input is 200V

i) Construct the V_{an} , V_{bn} , V_{cn} , V_{ab} , V_{bc} , V_{ca} output voltage using the equivalent circuit for sequence (T2, T3, T4), (T3, T4, T5) and (T4, T5, T6). (15 marks)

ii) As given, the $v_{ab} = \sum_{n=1,3,5}^{\infty} \frac{4V_{dc}}{n\pi} \cos\left(\frac{n\pi}{6}\right) \sin n\left(\omega t + \frac{\pi}{6}\right)$. Determine the fundamental rms output for V_{ab} . (2 marks)

iii) Determine the conduction mode of the inverter (1 marks)

Q3 (a) DC-DC converters are used to convert a constant dc input to a variable dc output. These converters are used for traction operation such as in electric vehicle, high speed train and etc.

i) List all the types of the dc-dc converters. (4 marks)

ii) The duty cycle (D) is needed for the dc-dc converters. With the help of the diagram, construct the D equation when it is ON and OFF state. (4 marks)

- iii) Determine the suitable range of the duty cycle for the dc-dc converter. (2 marks)
- (b) The buck converter is used to step down the input voltage. If the dc motor with the input rating of 100 V generates the power of 1 kW is attached to the buck converter.
- i) Design the suitable buck converter circuit if the given input source is 240 V_{dc}, peak to peak ripple voltage is 20 mV, switching frequency is 25 kHz and the peak to peak ripple current for the inductor is 0.8 A. (10 marks)
- ii) Draw the output waveforms of the buck converter which is followed in the design criteria. (5 marks)
- Q4 (a)** An AC voltage converter is used to convert the fix AC input source to the variable AC rms output voltage. It is used for heating, lighting, transformer tap changing and many more. It is also known as a power transfer converter to transfer from one AC source to another AC source.
- i) List two types of control that can be used for the AC converter. (2 marks)
- ii) State two differences between the half wave AC converter with the full wave AC converter. (2 marks)
- iii) Sketch the output voltage and current with the help of diagram of the single phase full wave controller that consists of RL load. (3 marks)
- (b) A single phase full wave AC voltage converter is shown in Figure Q4. With the thyristor as the switching devices, the output voltage and current can be in the range of 0 V_{dc} to V_{dc}. If the load connected to the converter is resistive (20Ω) with an input source of 120V_{rms}, 50Hz
- i) Formulate the power factor (pf) equation for the outputs if the given rms output voltage is $V_{rms} = \frac{V_m}{\sqrt{2}} \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$ (5 marks)
- ii) Calculate the delay angle required to deliver 500 W to the load (3 marks)

- iii) Calculate the rms source current (2 marks)
- iv) Calculate the rms current in the SCR (2 marks)
- v) Calculate the power factor (2 marks)
- vi) Draw the output waveform for the volatge and current with all the values that have been calculated from ii) to vi) (4 marks)

- END OF QUESTIONS -

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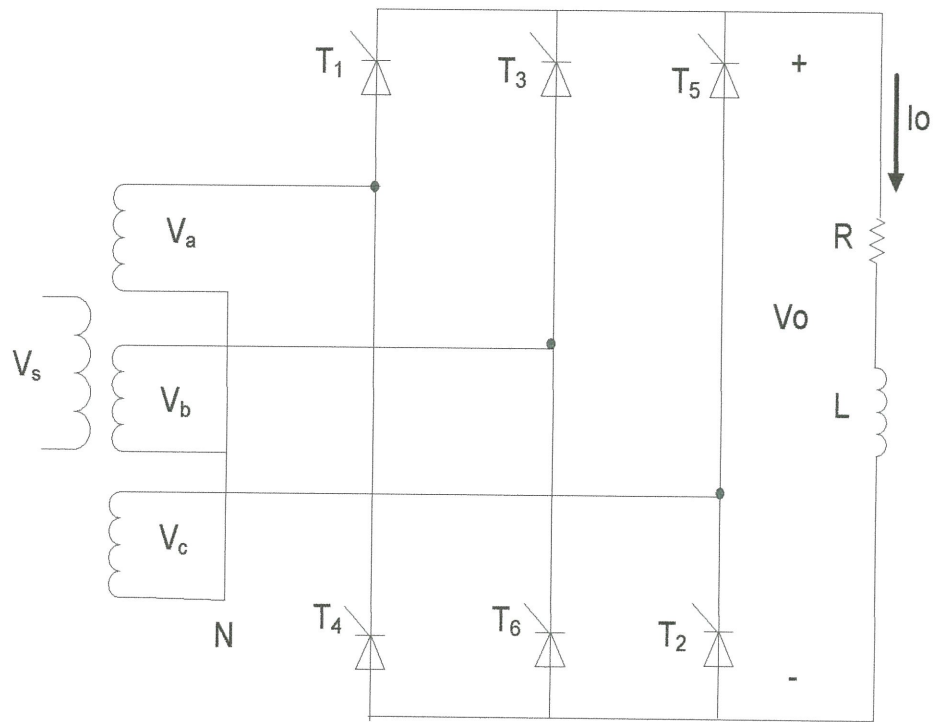


FIGURE Q1

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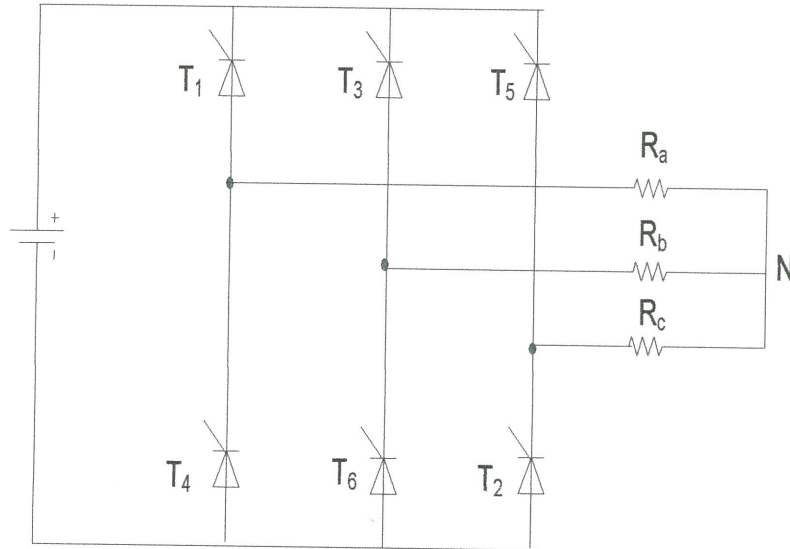


FIGURE Q2(a)

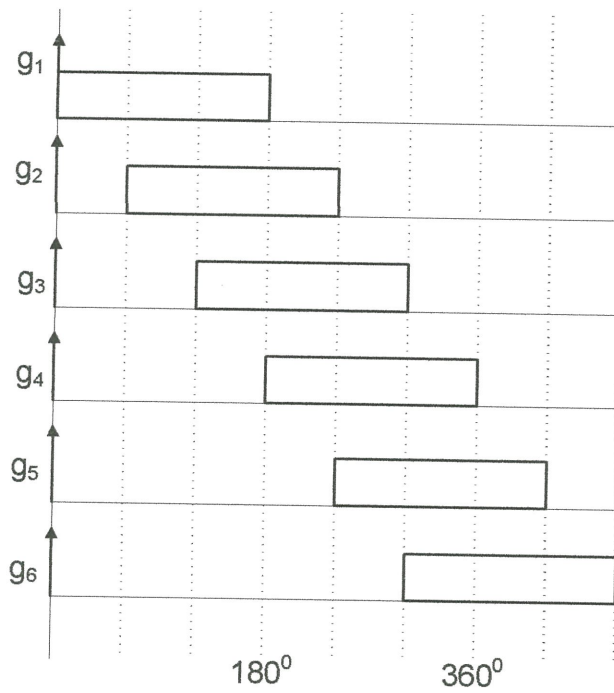


FIGURE Q2(b)

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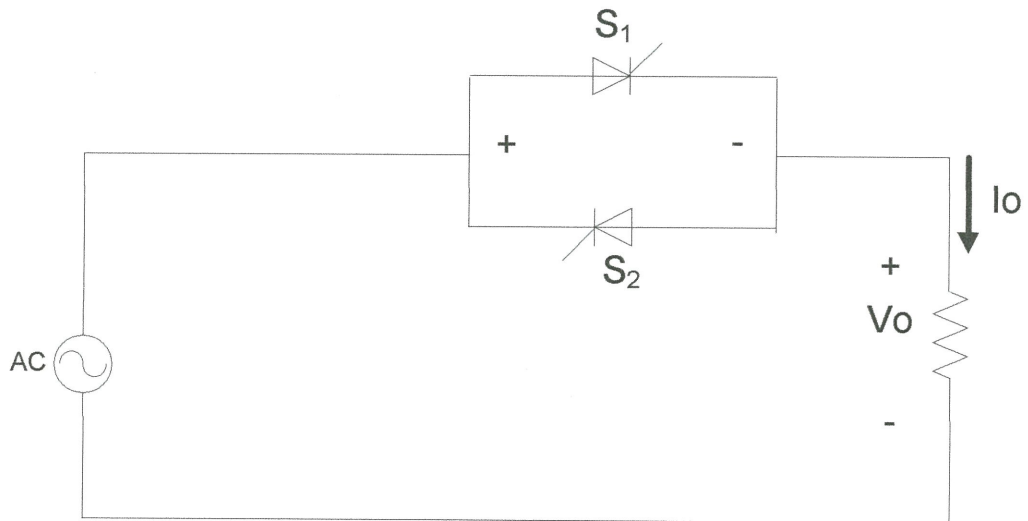


FIGURE Q4