UNIVERSITY OF ESWATINI
MAIN EXAMINATION, MAY 2019

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**POWER ELECTRONICS**
COURSE NUMBER:	**EE422/EEE422**
TIME ALLOWED:	**THREE HOURS**

INSTRUCTIONS:

1. There are four questions in this paper. **Answer ALL questions.**
2. Each question carries its own mark as shown in all questions.
3. Marks for different sections are shown on the right hand margin.
4. Show the steps clearly in all your calculations including any assumptions made.

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THIS PAPER HAS FOUR (4) PAGES INCLUDING THIS PAGE

QUESTION 1 ***(25 marks)***

a- A single-phase transformer whose secondary winding voltage $V_s = 100 \sin \omega t$ is connected with a full-wave single-phase diode rectifier, a 5 Ω resistor and 50 V battery as shown in Fig.1. Compute the average output current for this circuit. *(10-marks)*

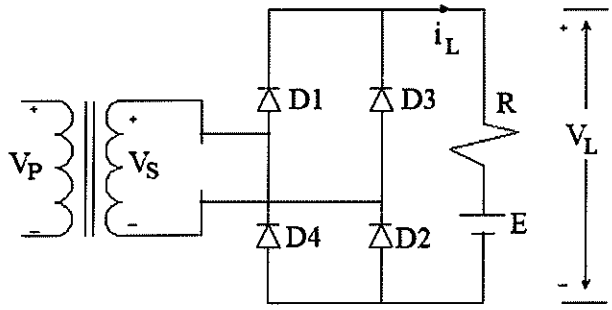

Fig. 1.

b- A three-phase half-wave controlled-rectifier connected to a resistive load. It's firing angle (α) is ≤ π /6, prove that the average output voltage is: *(5-marks)*

$$V_{dc} = \frac{3\sqrt{3}}{2\pi} V_m \cos\alpha$$

c- A three-phase half-wave controlled-rectifier is operated from a three-phase Y-connected 400 V, 50 Hz supply feeding a restive load of 10 Ω. If the average output voltage is 90% of the maximum possible output voltage, calculate:

i- the delay angle α, *(3-marks)*
ii- the rms load voltage and current, *(2-marks)*
iii- the average load voltage and current, *(2-marks)*
iv- the efficiency (rectification ratio), *(1-mark)*
v- the form factor (FF) and ripple factor (RF) *(2-marks)*

QUESTION 2 ***(25 marks)***

a- A single-phase full-wave ac voltage controller has a resistive load R = 50 Ω, the input voltage is 230 V (rms), and input frequency is 50 Hz. The delay angles of thyristors T_1 and T_2 are $\alpha_1 = \alpha_2 = \alpha = \pi/4$. Determine the following:

i- the rms load voltage, *(6-marks)*
ii- the rms load current, and *(2-marks)*
iii- the ac output power. *(2-marks)*

b- Draw the voltage waveform v_{cn} and the six gate signals of three-phase full-wave ac voltage controller with a Y-connected resistive load as shown in Fig. 2. If the firing angle is 45° and the Firing sequence of the thyristors is: T_1, T_2, T_3, T_4, T_5, and T_6. *(5-marks)*

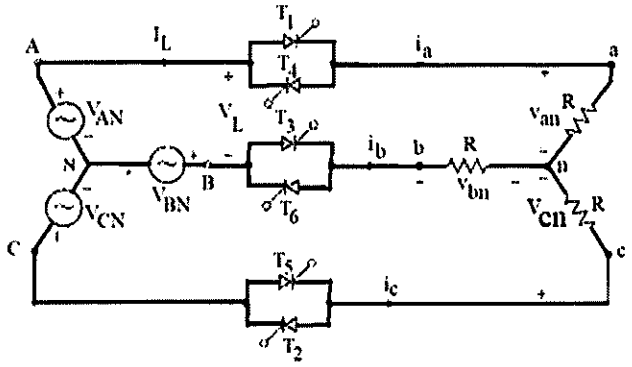

Fig. 2.

(10-marks)

c- Explain the three-phase to three-phase Cycloconverters concept, types, power circuits and differentiate between the blocking and circulating current modes of operation.

QUESTION 3 ***(25 marks)***

a- For boost converter shown in Fig. 3, prove the following:

i- the output voltage $V_o = \dfrac{V_s}{1-D}$ *(4-marks)*

ii- the ripple current $\Delta I = \dfrac{DV_s}{fL}$ *(3-marks)*

iii- the ripple voltage $\Delta V_c = \dfrac{I_o D}{fC}$ *(3-marks)*

b- Draw the waveforms of : e_L, I_L, I_c, I_o and V_o for the boost converter in Fig. 3.

(5-marks)

c- In a buck-boost converter the source voltage is 10 V. The average output voltage is 25 V and the load current is 0.75 A. The switching frequency is 150 KHz. If the ripple inductor current and capacitor voltage is 0.09 A and 5 mV respectively, determine the following:

i- The duty cycle, *(6-marks)*

ii- Filter inductance, and *(2-marks)*

iii- Filter capacitance. *(2-marks)*

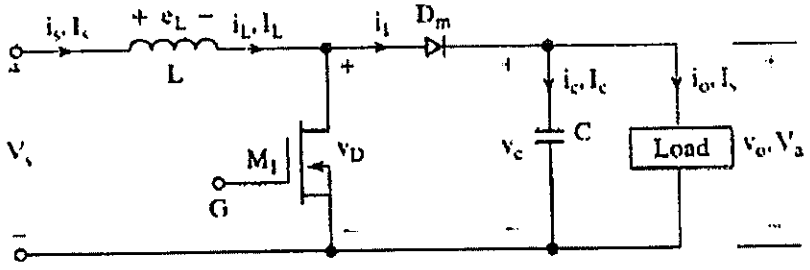

Fig. 3.

QUESTION 4 ***(25 marks)***

a- For a single-phase bridge inverter has a resistance of 2.4 Ω and dc input voltage 48 V. Determine the following:

i- rms output voltage at fundamental frequency (V_{o1}), *(2-marks)*
ii- output power, *(2-marks)*
iii- the average and peak current for each transistor, *(2-marks)*
iv- Total Harmonic Distortion (THD), and *(2-marks)*
v- Distortion Factor (DF). *(2-marks)*

b- Explain the 180°-conduction mode of the three-phase square wave inverters using circuit, waveforms and conduction table. *(10-marks)*

c- What is a notch inverter? Select one inverter circuit as an example and clarify how the notch inverter is important for some power applications? *(5-marks)*

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