



# UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, NOVEMBER, 2018

COURSE NO : EL 472

COURSE NAME: POWER ELECTRONICS

CLASS: EL IV

TIME: 3 HOURS

Name: \_\_\_\_\_ Index Number: \_\_\_\_\_

## SECTION A

*The gaps numbered 1 to 16 in the passage below represent missing words. For each of the gaps given, choose from the table that follows, the LETTER corresponding the word that best fills the gap.*

Thyristors are widely used as power electronic switches mainly because of their **-1-**. Like diodes, thyristors have a higher power loss during **-2-** than **-3-**. But unlike diodes, even when a positive voltage is applied to the anode of a thyristor with respect to the cathode, there exists a reverse biased **-4-** junction. For this reason, thyristors require an additional input, a **-5-** **-6-** injected into the gate before conduction can take place. When this gate is triggered, anode current flows over a **-7-** region near the gate during **-8-**. Consequently, **-9-** must be checked as it could lead to a high **-10-** at the gate region and subsequent **-11-** and destruction of the junction. Once a thyristor fully turns on, the gate input should **-12-** as this may **-13-**. However, If the gate signal is **-14-** before the anode current rises to the **-15-** value, the thyristor reverts to its **-16-** state.

	A	B	C	D	
1	Low cost	High switching frequency	High power capability	Instantaneous turn-on	
2	Turn-on and Turn-off	Turn-on and Conduction	Conduction	Turn-off and Conduction	
3	Turn-on and Turn-off	Turn-on and Conduction	Conduction	Turn-off and Conduction	
4	Inner	Outer	Inner or Outer	Surface	
5	Latching	Holding	Controlling	Reverse	
6	Current	Frequency	Impedance	Wave	
7	Wide	Narrow	Continuous	Discontinuous	
8	Turn-off	Turn-on	Zero	Undefined	
9	$d\omega/dt$	$dv/dt$	$di/dt$	$dp/dt$	
10	Capacitance	Impedance	Voltage	Current density	
11	Undercurrent	Undervoltage	Overvoltage	Overheating	
12	Be removed	Not be removed	Be doubled	Be halved	
13	Turn off the device	Destroy the device	Reverse bias the device	Reduce junction losses	
14	Be removed	Not be removed	Be doubled	Be halved	
15	Maximum	Minimum	Holding	Latching	
16	On	Off	Low impedance	High capacitance	

17. A Single Phase Half Controlled Bridge Rectifier can be obtained from its fully controlled counterpart by replacing two -1- with -2-
- A. Thyristors, transistors  
B. Transistors, thyristors,  
C. Thyristors, diodes  
D. Diodes, thyristors
18. The single phase fully controlled thyristor rectifier is connected to a resistive load of  $20\text{ k}\Omega$ . When the firing angle is  $0^\circ$ , the average dc output voltage of the converter is  $320\text{ V}$ . What will be the output voltage for a firing angle of  $60^\circ$ ?
- A.  $160\text{ V}$                       B.  $180\text{ V}$                       C.  $240\text{ V}$                       D.  $300\text{ V}$
19. In switched mode DC – DC converters, continuous conduction and discontinuous conduction modes are defined with respect to
- A. Inductor current                      C. Capacitor current  
B. Inductor voltage                      D. Capacitor voltage
20. Unlike Thyristors, DIACs and TRIACs are \_\_\_\_ devices
- A. Uncontrolled                      C. Two terminal  
B. Bi-directional                      D. High power
21. The positive part of the inverter output waveform is a mirror copy of the negative part. The waveform is therefore said to be symmetric about the time axis and such a waveform does not contain \_\_\_\_
- A. Harmonics                      C. Even harmonics  
B. Odd harmonics                      D. High order harmonics

Use Figure 1 and the information that follows to answer Questions 22 to 24.

The single-phase diode bridge rectifier shown in Figure 1 is supplying  $50\text{ W}$  power to the load resistor is  $R$ . The source voltage is  $V_s = 230 \sin(\omega t)$ .

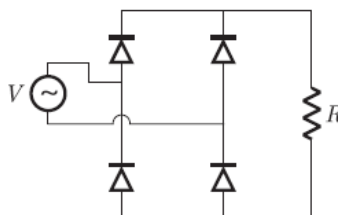


Figure 1 Circuit Diagram for Questions 22 to 24

22. The average output voltage is
- A.  $207.07\text{ V}$                       C.  $146.40\text{ V}$   
B.  $190.20\text{ V}$                       D.  $120.00\text{ V}$
23. In the rectifier above, if the load resistance  $R = 50\ \Omega$ , the output current will be
- A.  $4.14\text{ A}$                       C.  $2.93\text{ A}$   
B.  $3.80\text{ A}$                       D.  $2.40\text{ A}$

24. The converter depicted in Figure 1 can operate in
- A. Quadrant I only  
 B. Quadrant II only  
 C. Quadrants I and II  
 D. Quadrants III and IV
25. The Amplitude modulation ratio of inverter output waveform is defined as the ratio of the peak amplitude of the \_\_\_ voltage to the peak of the \_\_\_ voltage
- A. Carrier; Modulating  
 B. Modulating; Carrier  
 C. Carrier; Sampled  
 D. Sampled; Carrier
26. In sinusoidal PWM, for low values of frequency ratio, the relative harmonic content is
- A. Zero  
 B. Low  
 C. High  
 D. Infinite
27. In a single-phase thyristor rectifier supplying an inductive load, the output voltage waveform will contain negative portions unless
- A. The supply voltage frequency is high  
 B. The load inductance is high  
 C. The load impedance is high  
 D. A free-wheeling diode is connected across the load

Figure 2 shows a forced commutation circuit used to achieve turn-off of thyristor  $T_1$ , which controls the input voltage  $V_s$  to the load resistor  $R_l$ . The components  $C$ ,  $R$  and  $T_2$  are used for turn-off. Use the circuit to answer Questions 28 to 31.

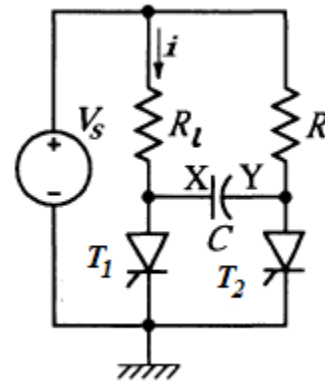


Figure 2 Circuit Diagram for Questions 28 to 31

28. Both thyristors  $T_1$  and  $T_2$  are initially off. Thyristor. But when  $T_1$  is turned on, load current  $i$  flows and at the same time, the capacitor  $C$  charges to \_\_\_ on plate Y
- A.  $+V_s$   
 B.  $-V_s$   
 C.  $V_{T1}$   
 D. 0 V
29. When it is desired to turn off  $T_1$ ,
- A. thyristor  $T_2$  is turned on  
 B. thyristor  $T_2$  is turned off  
 C. The polarity of  $V_s$  is reversed  
 D. The resistance  $R$  is increased
30. For  $T_1$  to regain gate control, the capacitor charges to \_\_\_ when  $T_2$  is switched on (at which time  $T_1$  is off)
- A. The same polarity  
 B. Opposite polarity  
 C. Zero voltage  
 D. half voltage

31. Neither  $T_1$  nor  $T_2$  can be switched off if
- Both thyristors conduct at the same time
  - The source voltage reverses polarity
  - The load current  $i$  is greater than the holding current of  $T_1$
  - The load current  $i$  is less than the holding current of  $T_1$
32. A buck-boost converter operating at duty ratio 0.6 will \_\_\_\_ input voltage
- Step down
  - Step up
  - Not alter
  - Reverse
33. At what duty ratio must a buck-boost converter operate at in order to give an output of 96 V for an input of 24 V?
- 0.25
  - 0.40
  - 0.50
  - 0.80
34. For a single phase full wave controlled rectifier supplying a resistive load from a 400 V rms source, find the firing angle at which the output voltage is 300 V.
- $22.46^\circ$
  - $30.02^\circ$
  - $48.24^\circ$
  - $60.67^\circ$
35. For a three phase full wave controlled rectifier supplying a resistive load from a three phase 380 V<sub>peak</sub> line-to-line mains source, find the average output voltage if the thyristor switches are operated at  $65^\circ$ .
- 320.41 V
  - 265.62 V
  - 200 V
  - 190 V
36. Unlike a rectifier, a dc motor can operate in
- Only one quadrant
  - Only two quadrants
  - Only three quadrants
  - All four quadrants
37. Unlike \_\_\_\_, \_\_\_\_ can produce any output voltage frequency regardless of the input frequency
- Inverters, Rectifiers
  - Inverters, Cycloconverters
  - Cycloconverters, Inverters
  - Cycloconverters, Choppers
38. The 7<sup>th</sup> harmonic component of the inverter output waveform has amplitude equal to
- $7E_{dc}/2$
  - $7E_{dc}/2\pi$
  - $2E_{dc}/7\pi$
  - $7\pi E_{dc}/2$
39. The output ripple frequency of a three-phase full wave rectifier is \_\_\_\_ the input source frequency.
- Equal to
  - Two times
  - Three times
  - Six times
40. In a typical boost converter, output voltage will increase with increased \_\_\_\_ but is unaffected by \_\_\_\_
- Duty ratio, Input voltage
  - Input Voltage, Duty ratio
  - Input Voltage, Switching frequency
  - Switching frequency, Duty ratio

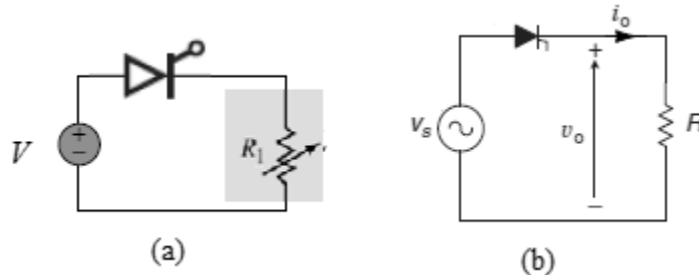
## SECTION B

Attempt *BOTH* questions in this section. Each question carries 20 marks. Answer the questions in your answer booklet.

### Question 1 (20 marks)

Use the circuit below to explain the following phenomenon:

- a) The thyristor in Figure 1 (a) is to be switched off by adjusting the variable resistor  $R_1$  to its maximum resistance value. But when the ambient temperature increases significantly, this maximum resistance no longer turns off the thyristor **[4 marks]**



**Figure 1 Circuit Diagram for (a) Question 1 (b) Question 2**

- b) Given that the voltage of the source  $V_s$  in Figure 1 (b) is given by  $245\sin(37t - 2.3)$ , and the resistance  $R$  is  $80 \Omega$ , calculate
- the average output voltage **[7 marks]**
  - The average output current of the half wave rectifier of Figure 1 (b) if the firing angle is  $65^\circ$ . **[3 marks]**
- c) Draw the current and voltage waveforms of the half bridge DC-AC converter with capacitive elements. **[6 marks]**

### Question 2 (20 marks)

- What are the modes of operation of a DC Motor and a rectifier **[7 marks]**
- Why is the 2-Quadrant Rectifier incapable of exploiting all operation modes of the DC motor? **[7 marks]**
- State how the incompatibility between the DC motor and the rectifier can be resolved. **[2 Marks]**
- Under what circumstances will
  - Thyristors be preferred to BJT transistors in DC choppers? **[2 Marks]**
  - MOSFETs be preferred to thyristors in inverter circuits? **[2 Marks]**

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