



UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

FIRST SEMESTER EXAMINATIONS, NOV/DEC 2018

COURSE NO: EL 379
COURSE NAME: POWER ELECTRONICS
CLASS: EL III

TIME: 3 HOURS

Name: _____ Index Number: _____

SECTION A

The gaps numbered 1 to 13 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 given gap.

The single-phase full-wave, fully controlled bridge rectifier operates in **-1-** quadrant mode when the load is resistive and has an average output voltage of **-2-**. However, when feeding an RL load, the converter operates in **-3-** quadrants because in that case the load **-4-** reverses direction during the negative half cycle. When operated in this mode with a firing angle $\alpha > \pi/2$, the average output voltage is **-5-**. Even so, if a freewheeling diode is connected across the load, the converter reverts to **-6-** quadrant mode of operation, thereby producing an output voltage of **-7-**. When the load is purely inductive, the load current remains flowing throughout the entire negative half cycle. But with a purely resistive load, the thyristors turn off at extinction angle $\beta =$ **-8-** and the load current becomes **-9-** at that point.

A **-10-** is obtained by replacing **-11-** of the thyristors with **-12-**. In the resulting circuit, the output voltage remains **zero** for the duration from **-13-** and a freewheeling diode is not usually needed.

	A	B	C	D
1	one	two	three	four
2	$V_m(1 + \sin \alpha)$	$V_m \sin \alpha$	$(V_m / \pi)(1 + \cos \alpha)$	$(2V_m / \pi) \cos \alpha$
3	one	two	three	four
4	Current	Voltage	Impedance	Reluctance
5	Negative	Positive	Zero	Maximum
6	one	two	three	four
7	$V_m(1 + \sin \alpha)$	$V_m \sin \alpha$	$(V_m / \pi)(1 + \cos \alpha)$	$(2V_m / \pi) \cos \alpha$
8	0	$\pi/2$	π	2π
9	Zero	Negative	Minimum	Maximum
10	Two	Three	Four	Five
11	1	2	3	4
12	Transistor(s)	Resistor(s)	Inductor(s)	Diode(s)
13	$\pi - \alpha$ to 2π	π to $\pi - \alpha$	π to $\pi - \alpha$	$\pi - \alpha$ to 2π

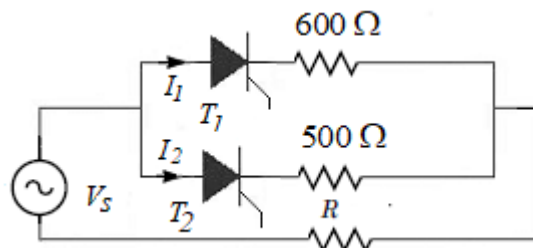


Figure 1 Circuit Diagram for Question 1

14. In the circuit shown in Figure 1, if both thyristors are switched on and the current $I_1 = 100 \text{ mA}$, what is the value of I_2 ?
- A. 80 mA B. 110 mA C. 120 mA D. 140 mA
15. If the duty ratio of a DC chopper is D and the *on-* and *off-times* are respectively t_{on} and t_{off} , then the operating frequency f can be expressed as
- A. t_{on}/D B. t_{off}/D C. D/t_{off} D. D/t_{on}
16. Three DC choppers I, II and III are operated at duty ratios D and switching frequencies f as follows: Converter I: $D = 0.2$, $f = 600 \text{ Hz}$; Converter II: $D = 0.5$, $f = 900 \text{ Hz}$; and Converter III: $D = 0.8$, $f = 1 \text{ kHz}$. The current ripple of converter ___ will be higher than that of converter(s) ____
- A. I; II and III C. III; I and II
B. II; I and III D. I; II
17. A Single-phase half-wave controlled rectifier is delivering power to an R-L load from a source $v_s = 250\sin(112t + 44^\circ) \text{ V}$. If the firing angle α and the extinction angle β are respectively $\pi/3$ and $5\pi/4$, the average output voltage v_o will be
- A. 48.025 V C. 125.322 V
B. 60.450 V D. 154.602 V

Preamble 1: Use the circuit of Figure 2 to answer Questions 18 through 20.

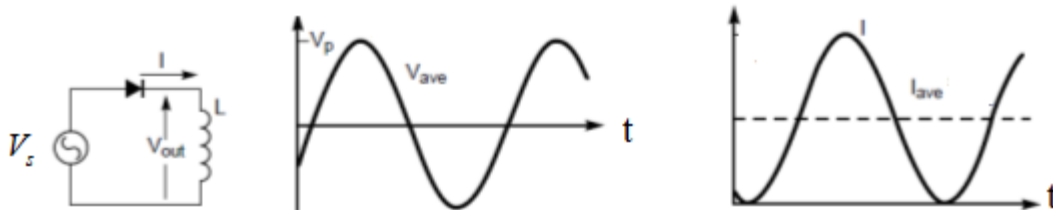


Figure 2 Circuit Diagram for Questions 18 to 20

18. The half-wave rectifier shown in Figure 1 is supplying a purely inductive load $L = 280 \text{ mH}$ from a source $V_s = 140 \sin(200t + 4) \text{ V}$. The average current delivered to the load is
- A. 0 A B. 39.2 A C. 159.1 A D. 2.5 A
19. The average load voltage is
- A. 0 V B. 39.2 V C. 159.1 V D. 2.5 V
20. The average power delivered to the load is
- A. 0 W B. 39.2 W C. 159.1 W D. 2.5 W
21. The switching frequency of a buck converter is 2 kHz. If the converter features an inductor of 250 mH and supplies a load of 5 k Ω , what is the minimum duty ratio needed to ensure that the converter operates in Continuous Conduction Mode CCM.
- A. 0.1 B. 0.6 C. 0.8 D. 0.9
21. A DC chopper operates at constant frequency. If $t_{on} = T/5$ and the converter operates at frequency $f = 4 \text{ kHz}$, what will be the value of t_{off} ?

- A. 20 ms B. 50 ms C. 200 μ s D. 120 μ s

22. The average _____ of an inductor is zero

- A. Voltage and Current C. Current
 B. Voltage D. Impedance

23. An H-Bridge is a typical example of a(n)

- A. Frequency Changer C. Phase shifter
 B. Output filter D. Switching matrix

24. The switching frequency of a DC chopper is 250 Hz. If its *on-time* is 2 ms, the duty ratio is

- A. 0.25 B. 0.50 C. 0.80 D. 0.88

Preamble 2: Figure 3 shows the waveform for a DC-AC converter. Use the switching scheme shown in the Figure to answer Questions 25 through 27.

25. If the supply voltage $V_s = 120$ V, $t_{on} = 2$ ms and the switching period $T = 8$ ms, then the average output load voltage is

- A. 24 V B. 30 V C. 60 V D. 192 V

26. If the supply voltage $V_s = 120$ V, $t_{on} = 2$ ms and the switching frequency $f = 200$ Hz, then the average output load voltage is

- A. 0 V B. 48 V C. 96 V D. 112 V

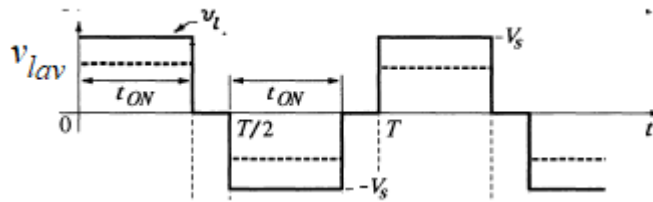


Figure 3 Circuit Diagram for Questions 25 to 27

27. The average output voltage can be *decreased* by decreasing _____ relative to _____

- A. T, t_{on} B. t_{on}, T C. t_{on}, f D. f, t_{on}

28. In the full bridge inverter circuit shown in Figure 4(a), transistors Q_1 and Q_3 were on and carrying load current. At time t , these pair of transistors are switched off while Q_2 and Q_4 are turned on. Current will immediately begin to flow through

- A. Q_2 and Q_4 B. D_1 and D_3 C. D_2 and D_4 D. D_1 and D_2

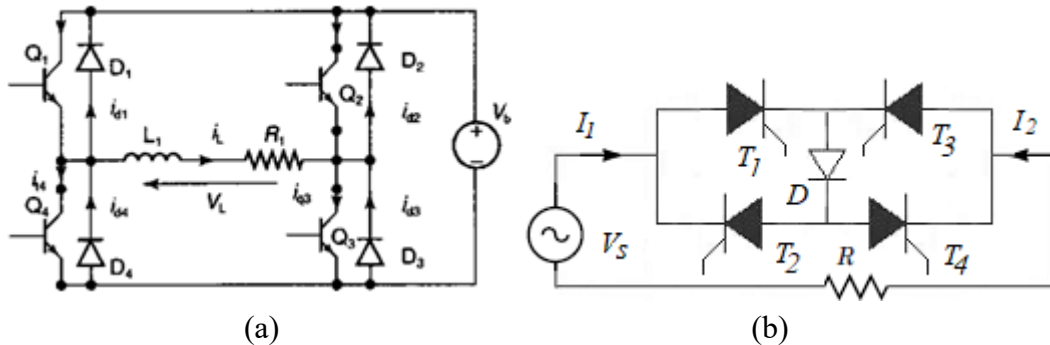


Figure 4 (a) Circuit for Question 28 (b) Circuit for Question 29

29. The circuit in Figure 4(b) will
- Allow current only in the direction indicated by I_1
 - Allow current only in the direction indicated by I_2
 - Allow current in the directions indicated by both I_1 and I_2
 - Not allow current in either direction
30. The junction temperature of a power semiconductor device may rise above the safe limit if ____ is too ____
- di/dt ; high
 - di/dt ; low
 - dv/dt ; high
 - dv/dt ; low
31. The output voltage frequency of the _____ is limited to values which are integer factors of the input frequency.
- Phase controlled regulator
 - Cycloconverter
 - Half-bridge inverter
 - Full-bridge inverter
32. If the input to the circuit shown in Figure 5 is a sinusoidal AC voltage, which of the following waveforms represents a possible output of the circuit?

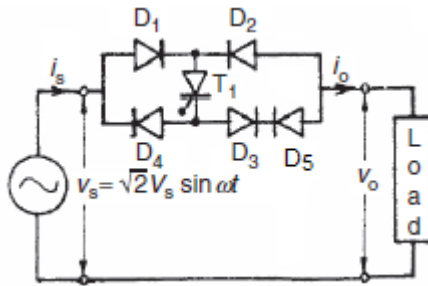
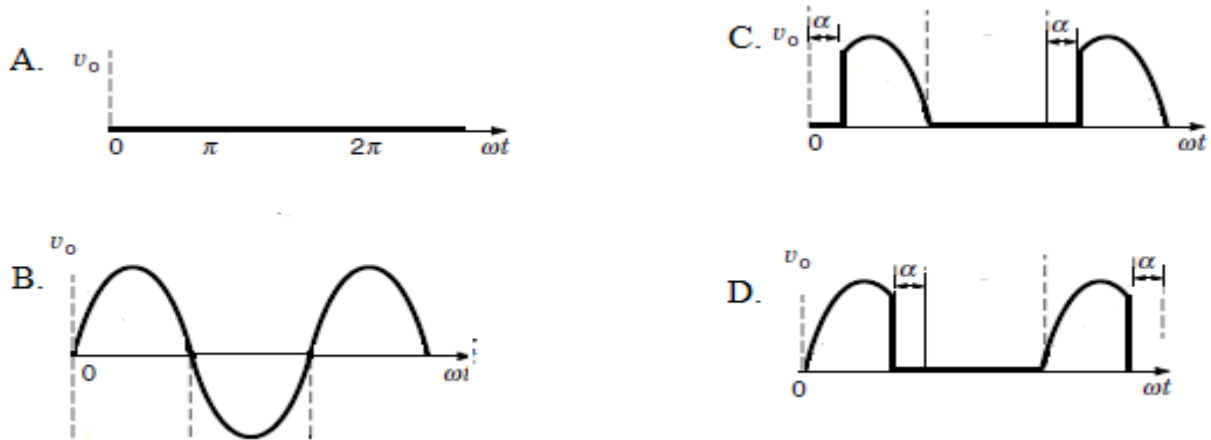


Figure 5 Circuit Diagram for Questions 32



33. ON state voltage drop across a thyristor is approximately
- 0 V
 - 0 - 0.5 V
 - 0.5 - 1 V
 - 1 - 1.5 V
34. In the DC-DC boost converter when the switch is *off*, the inductor current ____ while its voltage is equal to ____
- rises; $-V_o$
 - decreases; $-V_o$
 - decreases; $V_s - V_o$
 - rises; $V_s - V_o$
35. High dV/dt may result in ____ of a thyristor
- Reverse bias
 - Normal conduction
 - Maximum efficiency
 - Accidental triggering

36. A buck-boost converter operating at a duty ratio of 0.75 gives an output of ____ when the input voltage is 170 V.
- A. 127.50 V B. 226.67 V C. 456 V D. 510 V
37. By doubling both the *on* and *off* times of a boost converter, the
- A. Duty ratio is doubled while the frequency is halved
B. Frequency is doubled while the duty ratio is halved
C. Frequency is halved while the duty ratio remains the same
D. Duty ratio is halved while the frequency remains the same
38. For a boost converter to convert an input voltage of 120 V to an output voltage of 200 V, it must be operated at a duty ratio of
- A. 0.2 B. 0.4 C. 0.6 D. 0.8
39. Load commutation of a single-phase full-bridge rectifier is possible if the load is
- A. Resistive C. Unknown
B. Inductive D. Negligible
40. A single-phase *half-wave* fully controlled rectifier is supplying an RL load from a 380 V source. If the firing angle $\alpha = 60^\circ$ and the extinction angle $\beta = 220^\circ$, find the value of average output voltage.
- A. 64.56 V C. 108.27 V
B. 80.28 V D. 126.53

SECTION B

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

Question 1 (20 marks)

- a) State four characteristics of an ideal switch. **[4 Marks]**
- b) Explain why ideal Power Electronics switches are lossless. **[4 Marks]**
- c) On the left of Figure 6 shows power converter circuits with various loads. Against each circuit is a four-quadrant Cartesian plane. Show by ticking in the appropriate boxes the quadrants in which the given converters can operate. **[4 marks]**

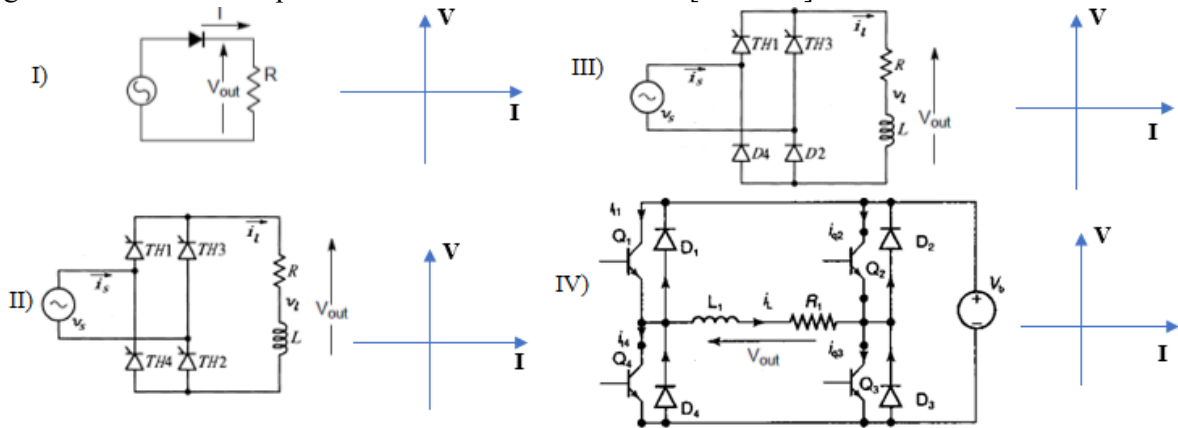


Figure 6 Circuit Diagram for Question 1(c)

- d) A buck-boost converter gives an output of 150 V when the input voltage is 100 V.
 - I. What is the value of the output current if the load is purely resistive with resistance $R = 240 \Omega$? **[1 mark]**
 - II. Find the value of the operating duty ratio D . **[3 marks]**
- e) Figure 7 shows waveforms for an inverter which converts a DC voltage $V_s = 480$ V to AC. If the on-time $t_{on} = 12$ ms and the off-time $t_{off} = 4$ ms, find the average output load voltage. **[4 marks]**

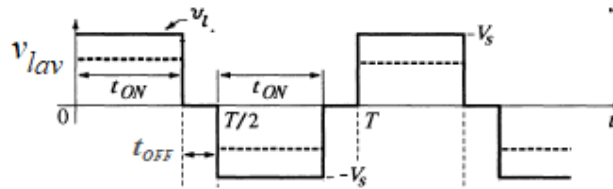


Figure 7 Circuit Diagram for Question 1(e)

Question 2 (20 marks)

- a) A single-phase full-wave fully controlled bridge rectifier is supplying an RL load from AC source given by $V_s = 350 \sin(35t + 2)$ V. If the average output voltage is 270 V:
 - I. Find the firing angle α_1 at which the thyristors are operated. **[3 marks]**
 - II. Determine the firing angle α_2 needed to obtain the same output voltage in a) above if a freewheeling diode is now connected across the load. **[3 marks]**

- b) Draw the (i) circuit diagram and (ii) waveforms for the boost converter. **[6 marks]**
- c) Derive an expression for the output voltage V_o in terms of the input voltage V_s of the boost converter. **[4 Marks]**
- d) The critical inductance L_b needed for a boost converter switching at frequency $f = 50$ kHz and feeding a load of resistance $R = 80$ k Ω to operate in Continuous Conduction Mode (CCM) is 480 mH. Determine the duty ratio D needed to ensure this mode of operation. **[4 Marks]**

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