



**UGANDA INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
END OF SEMESTER ONE EXAMINATIONS**

ACADEMIC YEAR 2024/2025

DEPARTMENT: ICT

SEMESTER: ONE

PROGRAMME(S): DIPLOMA IN ELECTRICAL AND ELECTRONICS ENGINEERING (DEEE)

YEAR OF STUDY: TWO

COURSE: POWER ELECTRONICS

COURSE CODE : EET2102

DATE: MONDAY 16TH, DECEMBER 2024

TIME: 2:00 PM – 5:00 PM

DURATION: 3 HOURS

INSTRUCTIONS:

- (i) This paper contains two Sections: A (40 marks) & B (60 marks).**
- (ii) Attempt ALL questions in Section A, and ONLY THREE questions in Section B.**
- (iii) All questions in Section B carry equal marks.**
- (iv) Credit will be given for use of relevant examples and illustrations.**
- (v) Begin each number in Section B on a new page of the answer sheet.**
- (vi) DO NOT write on this question paper.**

SECTION A [40 MARKS]

Attempt **ALL** the Questions in this Section.

Section A I [20 Marks]

Write the correct alternative in the answer booklet provided (1 mark @)

1. Which of the following devices is most commonly used in a controlled rectifier circuit?
(a) Diode (b) SCR (c) Transistor (d) Triac.
2. What is the main function of a power electronic converter?
(a) To reduce the current (b) To convert AC to DC or DC to AC
(c) To stabilize the voltage (d) To increase the load current
3. In a full-wave bridge rectifier, how many diodes conduct at any given time?
(a) One (b) Two (c) Three (d) Four
4. What does PWM stand for in power electronics?
(a) Power Wave Modulation (b) Pulse Width Modulation
(c) Phase Width Modulation (d) Pulse Width Measurement
5. The efficiency of a power electronic converter primarily depends on:
(a) The power factor (b) The input voltage
(c) The switching losses (d) converter size
6. In a buck converter, what happens to the output voltage compared to the input voltage?
(a) It is lower than the input voltage
(b) It is equal to the input voltage
(c) It is higher than the input voltage
(d) It is inverted with respect to the input voltage
7. In a phase-controlled rectifier, the output DC voltage depends on:
(a) The frequency of the AC input (b) The load resistance
(c) The triggering angle of the SCRs (d) The input DC voltage
8. What is the main purpose of a flyback transformer in a power electronics circuit?
(a) To increase the input voltage (b) To provide galvanic isolation
(c) To filter high-frequency noise (d) To reduce switching losses
9. The term "duty cycle" in a PWM signal refers to:
(a) The number of switching cycles per second
(b) The ratio of t_{on} to T of the signal
(c) The frequency of the carrier wave
(d) The peak voltage of the waveform
10. Which of the following devices is used to protect circuits from overcurrent in power electronics?

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- (a) Diode (b) Fuse (c) Capacitor (d) Inductor

11. In an inverter, the output AC voltage is typically:
(a) Constant DC (b) Pulsating DC (c) A sine wave (d) A square wave

12. Which of the following is a key feature of an ideal switch in power electronics?
(a) Zero ON resistance (b) Zero OFF resistance
(c) Zero switching time (d) Zero forward voltage drop

13. The output voltage of a boost converter is:
(a) Lower than the input voltage (b) Equal to the input voltage
(c) Inverted with respect to the input voltage (d) Higher than the input voltage

14. In a thyristor, the gate current is used to:
(a) Maintain the conduction state (b) Turn the device off
(c) Turn the device on (d) Regulate the voltage

15. In a controlled rectifier with inductive load, the output voltage waveform is typically:
(a) A pure DC waveform (b) A smooth sinusoidal waveform
(c) A chopped DC waveform (d) A pulsating DC waveform

16. In a buck-boost converter, the output voltage can be:
(a) Always positive (b) Always negative
(c) Either positive or negative (d) Equal to the input voltage

17. What is the main disadvantage of using a diode in a rectifier circuit?
(a) It has no current-carrying capability (b) It is slow in switching
(c) It allows only unidirectional current flow (d) It has a high forward voltage drop

18. Which of the following is a common application of a controlled rectifier?
(a) DC motor control (b) Power factor correction
(c) Voltage regulation (d) All of the above

19. Which of the following statements is true for an ideal transformer in power electronics?
(a) The efficiency is always 100%
(b) The output voltage is always greater than the input voltage
(c) The power loss is proportional to the current
(d) The transformer has no leakage inductance

20. In a three-phase rectifier circuit, the output DC voltage is determined by:
(a) The peak of the input AC voltage (b) The average of the input AC voltage
(c) The number of phases (d) The load resistance

Section A II [20 Marks]

- a) Describe the various types of SCR commutation techniques commonly used in power electronics. For each technique:
 - b) Explain the working principle.
 - c) Highlight its advantages and disadvantages. **(6 marks)**
 - d) Illustrate with a suitable circuit diagram."
- e) List and explain at least two key applications of SCR commutation circuits in practical power electronics systems. **(4 marks)**
- f) Explain the operation of a TRIAC. Include its characteristics, working principle, how it differs from an SCR, and provide a suitable circuit diagram. **(5 marks)**
- g) Discuss the various control techniques used for TRIACs in AC power control applications. Provide circuit diagrams and explain the working principle of each technique. **(3 marks)**
- h) List and explain at least **two** practical applications of TRIACs in power electronics. Provide examples and describe their importance in industry or consumer electronics. **(2 marks)**

SECTION B [60 MARKS]

Attempt **ONLY THREE** Questions in this Section.

Question 1

- a) Briefly describe the following types of power supplies commonly used to power electronic equipment:
 - i) Linear Power Supply. **(2 marks)**
 - ii) Switched-Mode Power Supply. **(2 marks)**
- b) You are recruited as a technician in an electrical or electronic company. The company has various electronic equipment that needs to be repaired. Before starting to repair, you realize that a DC power supply is needed to power the electronic equipment. However, the company doesn't have any DC power supplies at the moment.
In the workshop, you find the following components:
 - 24V batteries.
 - MOSFETs.
 - Power diodes.
 - Electrolytic capacitors.The electronic equipment requires different DC input voltages, such as 3V, 5V, 9V, 12V, and 50V.
As a technician with a background in power electronics, design appropriate circuits to achieve the following:
- c) Design a circuit to step down the 24V DC from the battery to power a 9V electronic device. Clearly explain the working principle and identify the key components used in the design. **(4 marks)**
- d) Design a circuit to step up the 24V DC from the battery to power a 50V electronic device. Clearly explain the working principle and identify the key components used in the design. **(4 marks)**

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- e) Explain how the duty cycle of the MOSFET's switching affects the output voltage in both the buck and boost converters. **(2 marks)**
- f) The input to a step-up chopper is 200 V, and the required output voltage is 600 V. The conducting time of the thyristor is $t_{on}=200\mu s$. Calculate the following:
- i) Calculate the frequency of the chopper. **(3 marks)**
 - ii) If the pulse width (t_{on}) is halved while maintaining a constant operating frequency, compute the new output voltage. **(3 marks)**

Question 2

- a) Differentiate between controlled and uncontrolled rectifiers based on the following criteria:
- Control over output voltage.
 - Components used. **(4 marks)**
 - Output waveform characteristics.
- b) Define the following terms
- i) Rectification. **(2 marks)**
 - ii) Phase Control. **(1 mark)**
 - iii) Firing Angle. **(1 mark)**
- c) With the aid of a circuit diagram, explain the operation of a single-phase half-wave-controlled rectifier feeding an R load. Also, draw the waveforms for the output load voltage and output load current. **(6 marks)**
- d) A 220-V, 50-Hz, one-pulse SCR-controlled converter is gated at a firing angle of 60° , and the load current extinguishes at an angle of 220° . Determine the following:
- i) The turn-off time of the circuit. **(2 marks)**
 - ii) The average output voltage of the converter. **(2 marks)**
 - iii) For a load with resistance $R=7\Omega$ and inductance $L=3mH$, calculate the average load current. **(2 marks)**

Question 3

- a) Alternating Current (AC) is characterized by a periodic reversal in the direction of charge flow, resulting in a corresponding reversal of voltage. AC is widely used for power delivery in residential, commercial, and industrial settings.
- i) Write a mathematical expression for AC voltage of a periodic waveform, clearly defining all the parameters. **(2 marks)**
 - ii) Sketch the waveform of an AC periodic voltage. **(2 marks)**
 - iii) Prove mathematically that the average voltage of a purely AC waveform over a complete time period is zero. **(4 marks)**
- b) Write the mathematical expression for the output voltage of a half-wave rectifier, defining all the parameters involved. **(2 marks)**
- c) Half-wave rectifiers, though less efficient compared to full-wave or bridge rectifiers, are used in specific scenarios based on requirements.
- i) List four practical applications of half-wave rectifiers. **(4 marks)**
 - ii) State any **two** disadvantages of half-wave rectifiers. **(2 marks)**
 - iii) Compare half-wave rectifiers with full-wave rectifiers in terms of efficiency, ripple factor, output voltage, and diode requirements. **(4 marks)**

Question 4

Many industrial applications require the conversion of a DC voltage from one level to another. A device that performs this conversion is called a DC-DC Converter or DC Chopper. These converters regulate voltage by adjusting the ON-OFF time or duty cycle of the switching element, utilizing a control technique called Pulse Width Modulation (PWM).

- a) Mention **four** key functions of DC-DC Converters. **(2 marks)**
- b) List the essential characteristics of DC-DC Converters. **(4 marks)**
- c) Besides linear converters, name the other types of DC-DC Converters. **(6 marks)**
- d) Draw the circuit diagram of a linear DC-DC converter and briefly explain its operation. **(5 marks)**
- e) Name and explain any **one** method of chopper control with the relevant diagram. **(3 marks)**

Question 5

- a) Define Power Electronics and explain the role of power electronic devices in energy conversion systems. **(7 marks)**
- b) List four applications of power electronics. **(4 marks)**
- c) Draw the block diagrams for the following modes of operation of a Silicon Controlled Rectifier (SCR): **(1 mark @)**
 - i) Reverse Blocking Mode
 - ii) Forward Blocking Mode
 - iii) Forward Conduction Mode
- d) Mention **five** methods used to trigger or turn on the SCR. **(2 marks)**
- e) Draw the symbols for the following power electronics devices. **(1 mark @)**
 - i) Zenor diode.
 - ii) SCR.
 - iii) GTO.
 - iv) Triac.