TEVETA

Technical Education, Vocational and Entrepreneurship Training Authority

DIPLOMA IN BIOMEDICAL ENGINEERING

LEVEL 6 YEAR III EXAMINATIONS

FINAL INTEGRATED SUMMATIVE EXAMINATIONS

SITTING: NOVEMBER / DECEMBER 2025

SUBJECT: POWER ELECTRONICS III

TIME: THREE (3) HOURS **TOTAL MARKS: 100**

PASS MARK: 50

INSTRUCTIONS TO CANDIDATE

1. Write your Examination number and National Registration Card (NRC) number on the answer booklet provided. Ensure you append your signature in the space provided on the answer booklet.
2. Write the ANSWER SCRIPT SERIAL NUMBER on the examination register and on the entry slip.
3. There are EIGHT (8) questions in this paper. Question one (1) is compulsory, answer FOUR (4) questions from the remaining SEVEN (7) questions.
4. Diagrams may be used where necessary to clarify your answer.
5. Cell phones and programmable calculators are not allowed in the examination room.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

QUESTION 1 (COMPULSORY)

a) State **five (5)** classes of choppers according to the direction of output voltage and current. [5 marks]

b) A type-A DC converter has a load resistance of 20Ω and the input voltage of 220V. During the time the converter switch is on, the voltage drops by 1V, and the chopping frequency is 1 kHz. Given that the duty cycle is 50%, compute the following:

i) Average output voltage V_o [2 marks]
ii) RMS output voltage V_{rms} [3 marks]
iii) Converter efficiency [8 marks]
iv) Effective input resistance [2 marks]

[TOTAL MARKS 20]

QUESTION 2

a) State **two (2)** components in the circuit that affect switching times. [2 Marks]

b) Figure 2 below shows a Shockley diode used to trigger an SCR which upon switching on, in turn, automatically sets on an ignition switch to trigger a firework rocket.

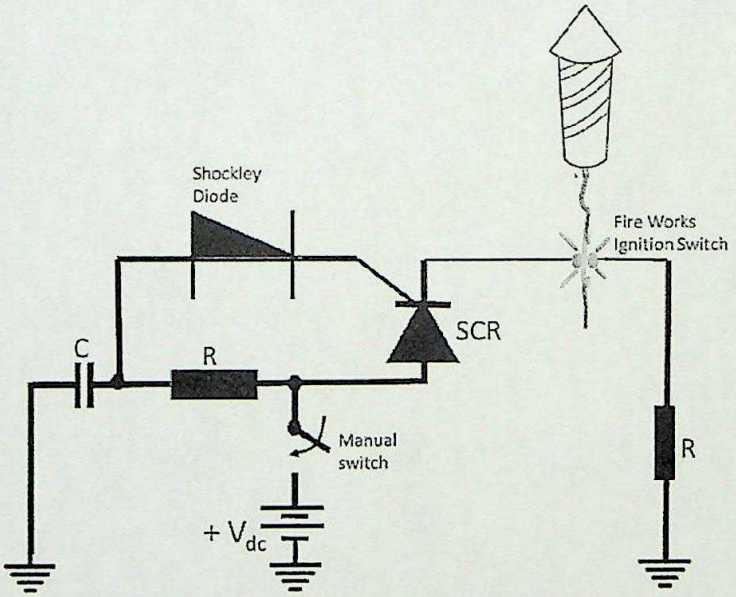


Figure 2: SCR triggered by the Shockley diode

i) Draw the I-V characteristic for the Shockley diode [8 Marks]
ii) Describe the operation of the circuit shown in figure 2 above. [10 Marks]

[TOTAL MARKS 20]

QUESTION 3

Figure 3 below shows a power circuit of a phase-controlled rectifier.

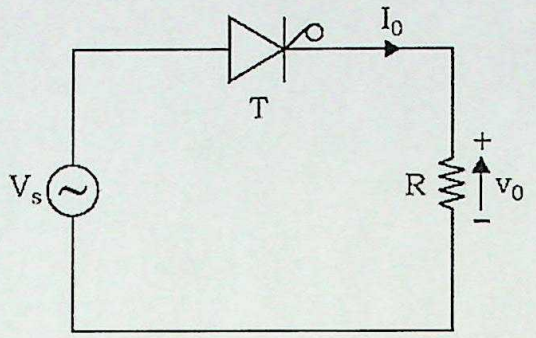


Figure 3: Single-phase controlled rectifier

a) For a trigger angle α less than 30°, draw the current and voltage waveforms for the resistive load R over 3π. [10 marks]

b) Explain the operation of the circuit in Figure 3 above [10 marks]

[TOTAL MARKS 20]

QUESTION 4

a) Define a cycloconverter [2 marks]

b) State:

i) **two (2)** types of cycloconverters [2 marks]

ii) **four (4)** uses of cycloconverters [4 marks]

c) A three-phase to single -phase cycloconverter employs three-phase-positive and negative-group converters. Each converter is supplied from a delta/star transformer with a per phase turn ratio of 2:1. The supply voltage is 400V, 50Hz. The RL load has R = 2Ω and at low output frequency, ω0L = 1.5Ω. To account for communication overlap and thyristor turn-off time, the firing angle in the inversion mode should not exceed 160°. Calculate:

i) Value of the fundamental RMS output voltage [5 Marks]

ii) RMS output current [4 Marks]

iii) Output power [3 Marks]

[TOTAL MARKS 20]

QUESTION 5

Figure 5 below shows a SCR commutation.

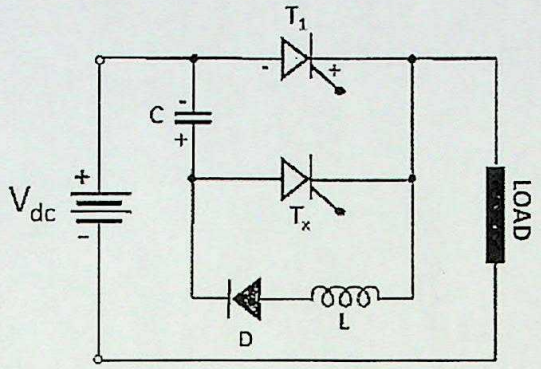


Figure 5: SCR Commutation Circuitry

a) Identify the type of commutation [1 Mark]
b) State the main application of this type of commutator [1 Mark]
c) Explain the operation of a SCR commutation [10 Marks]
d) Sketch its characteristic waveforms [8 Marks]

[TOTAL MARKS 20]

QUESTION 6

a) State the:

i) meaning of the acronym IGBT. [1 Mark]

ii) **two (2)** types of IGBT in existence today. [2 Marks]

b) Draw an electronic symbol of IGBT [2 Marks]
c) Using illustrations where necessary, explain construction and working of IGBT. [15 Marks]

[TOTAL MARKS 20]

QUESTION 7

a) State the acronyms of the following transistor family denotations:

i) DIAC [1 Mark]
ii) TRIAC [1 Mark]
iii) SIS [1 Mark]
iv) SIT [1 Mark]
v) LASCS [1 Mark]
vi) LASCR [1 Mark]
vii) PUT [1 Mark]
viii) GTO [1 Mark]

b) The SCR of figure 7 has gate trigger voltage V_T = 0.7V, gate trigger current I_T = 7mA and holding current I_H = 6mA. Calculate the:

i) Output voltage when the SCR is off [3 Marks]
ii) Input voltage that triggers the SCR [4 Marks]
iii) Value of V_{CC}, If V_{CC} is decreased until the SCR opens [5 Marks]

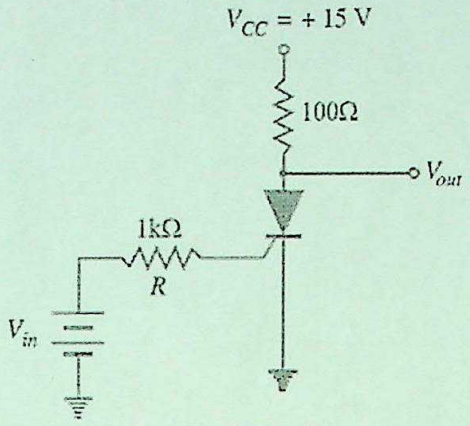


Figure 7: SCR Circuit

[TOTAL MARKS 20]

QUESTION 8

a) Describe static V-I characteristics and switching characteristics of the following:

i) SCR [5 Marks]
ii) IGBT [5 Marks]
iii) MOSFET [5 Marks]

b) Differentiate a simple diode from power diode [5 Marks]

[TOTAL MARKS 20]