



MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION
TECHNOLOGY)

EEE 405: POWER ELECTRONICS

DATE:

TIME:

INSTRUCTIONS

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Question **ONE** is **compulsory**. Attempt any other two questions.

Do not write on the question paper

QUESTION ONE

- a) State any four desirable characteristic of a controllable switch (4marks)
- b) A half wave rectifier circuit employing an SCR is adjusted to have a gate current of 1mA. The forward break down voltage of the SCR is 100 volts. If a sinusoidal voltage of 200volts is applied, determine:
- (i) Firing angle
 - (ii) Conduction angle
 - (iii) Average current. (6marks)

- c) An 80 volts battery supplies R-L load through a D.C chopper. The load has a free wheeling diode across it, which is composed of 0.4H in series with 5Ω resistor. Load current due to improper selection of chopping frequency varies widely between 9A and 10.2A . determine:
- (i) Average load voltage
 - (ii) Average load current
 - (iii) Duty cycle of the chopper
 - (iv) Operating frequency
 - (v) The ripple current to maximum current ratio. (10marks)

- d) A single phase full bridge inverter of Fig Q 1 (d) has a resistive load of 2.4Ω and a D.C input voltage of 48 volts. Draw the output waveform of the inverter hence determine
- (i) Rms out put voltage at fundamental frequency
 - (ii) Output power
 - (iii) Total harmonic distortion
 - (iv) Distortion factor
 - (v) Harmonic factor of the lowest order of harmonic (10marks)

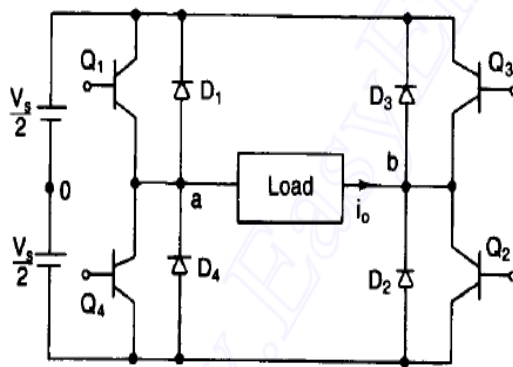


Fig Q 1(d)

QUESTION TWO

- a) A D.C buck converter operates at a frequency of 1 KHZ from 100 volts d.c source supplying a 10Ω resistive load. The inductive component of the load is 50mH. For an output of 50 volts, determine:
- (i) The duty cycle
 - (ii) The turn ON time
 - (iii) The RMS value of the output current
 - (iv) The average value of the output current
 - (v) The maximum current
 - (vi) The input power (12marks)

- b) With an aid of two transistor analogy for a silicon controlled rectifier, show that the anode current is given by:

$$I_a = \frac{\alpha_2 I_g + I_{CB01} + I_{CB02}}{1 - (\alpha_1 + \alpha_2)}$$

Where α_1 = common base current gain for transistor 1

α_2 = common base current gain for transistor

I_{CB01} = Common base leakage current for transistor 1

I_{CB02} = Common base leakage current for transistor 2

(8marks)

QUESTION THREE

- a) With an aid of a circuit diagram of three phase semi controlled rectifier with inductive load and free wheeling diode, draw output waveforms, hence show that;

$$V_{d.c} = \frac{3\sqrt{3}}{2\pi} V_{max} (1 + \cos \alpha) \quad (8marks)$$

- b) A three phase half wave controlled rectifier with a three phase 208 volts, 60HZ a.c source, supplies power to 10Ω resistive load. If its required to obtain an average output voltage of 50% of the maximum possible output. Determine:
- (i) The delay angle
 - (ii) The rms output current

- (iii) Average output current
 - (iv) Average SCR current
 - (v) Rms SCR current
 - (vi) The rectification efficiency.
- (12marks)

QUESTION FOUR

A three phase inverter in Fig Q 4 has a star connected load of 10Ω . The inverter frequency is 60HZ and dc input voltage is 220 volts. Express the instantaneous line to line voltage hence determine:

- i. Rms line voltage
- ii. Rms phase voltage
- iii. Rms line voltage at the fundamental frequency
- iv. Total harmonic distortion
- v. Distortion factor
- vi. Distortion factor of the lowest order of harmonic
- vii. Load power
- viii. Average transistor current
- ix. Rms transistor current

(20marks)

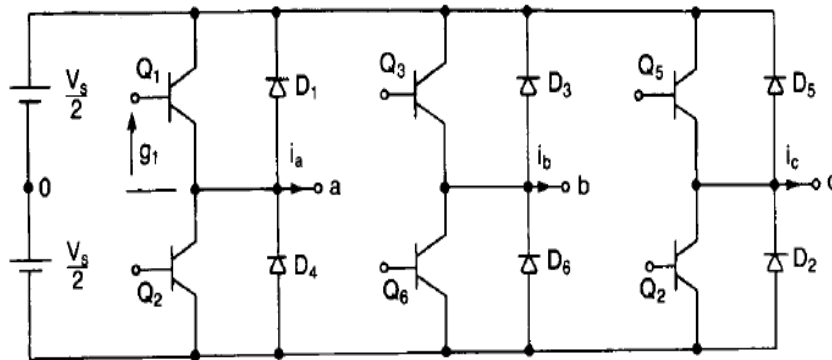


Fig Q 4.

QUESTION FIVE

a) Define the following terms as applied in inverters:

i. Distortion factor

ii. Total harmonic distortion (2marks)

b) With an aid of a circuit diagram of single phase half bridge inverter and waveforms, show that the instantaneous output voltage is given by:

$$\begin{aligned} v_o &= \sum_{n=1,3,5,\dots}^{\infty} \frac{2V_s}{n\pi} \sin n\omega t \\ &= 0 \quad \text{for } n = 2, 4, \dots \end{aligned}$$

(12marks)

c) Power of a 100w, 110 volts tungsten lamp is to be varied by controlling the firing angle of SCR in half wave rectifier circuit supplied with 110 V A.C. Determine the RMS voltage and current developed in the lamp at a firing angle of 60° . (6marks)