



MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 405: POWER ELECTRONICS

DATE: 16/8/2021

TIME: 2:00 – 4:00 PM

Instructions to Candidates

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 (COMPULSORY) (30 MARKS)

- a) State any four desirable characteristic of a controllable switch (4 marks)
- 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

(8 marks)

- c) 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:
- Firing angle
 - Conduction angle
 - Average current. (9 marks)
- 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
- Rms out put voltage at fundamental frequency
 - Output power
 - Total harmonic distortion (9 marks)

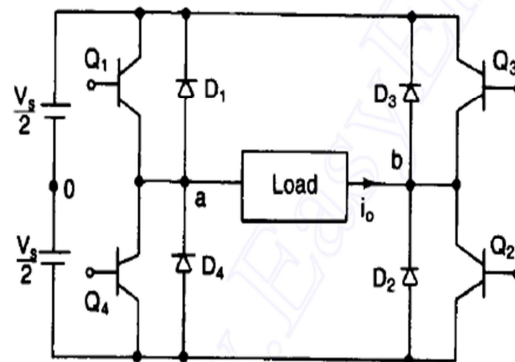


Fig Q 1(d)

QUESTION TWO (20 MARKS)

- 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:
- The duty cycle
 - The turn ON time
 - The RMS value of the output current
 - The average value of the output current
 - The maximum current
 - The input power
 - The peak to peak ripple current (14 marks)

- b) With an aid of a diagram and waveforms, describe the operation of a Buck –boost converter . (6 marks)

QUESTION THREE (20 MARKS)

- 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;

$$V_{d.c} = \frac{3\sqrt{3}}{2\pi} V_{max} (1 + \cos \alpha) \quad (12 \text{ marks})$$

- b) A three phase half wave controlled rectifier with a three phase 208 v0lts, 60HZ a.c source, supplies power to 100Ω resistive load. If the delay angle is 20°. Determine:

- (i) The maximum output current
- (ii) The average output voltage
- (iii) The maximum SCR current
- (iv) The maximum reverse voltage rating (8 marks)

QUESTION FOUR (20 MARKS)

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:

- (a) Rms line voltage
- (b) Rms phase voltage
- (c) Rms line voltage at the fundamental frequency
- (d) Total harmonic distortion
- (e) Distortion factor
- (f) Distortion factor of the lowest order of harmonic
- (g) Load power
- (h) Average transistor current
- (i) Rms transistor current

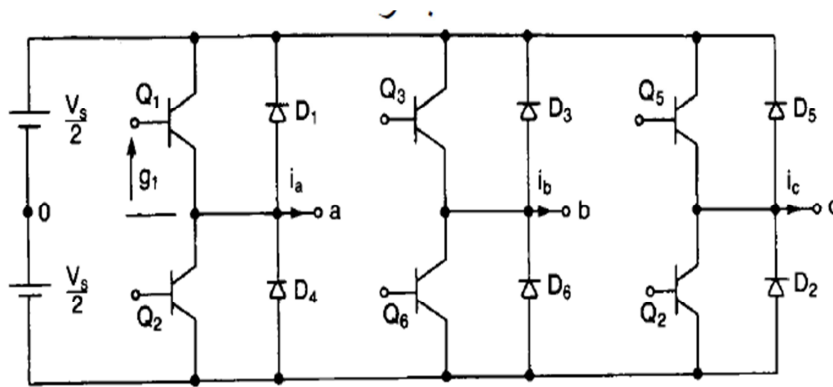


Fig Q 4.

QUESTION FIVE (20 MARKS)

- a) Define the following terms as applied in inverters:
- (j) Distortion factor
 - (ii) Total harmonic distortion (2 marks)
- 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:
- $$v_o = \sum_{n=1,3,5,\dots}^{\infty} \frac{2V_s}{n\pi} \sin n\omega t$$
- $$= 0 \quad \text{for } n = 2, 4, \dots$$
- (12 marks)
- 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° . (6 marks)