ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIRST SEMESTER EXAMINATION, 2020/2021 ACADEMIC SESSION

COURSE TITLE: Power Electronics and Drives

COURSE CODE: EEE 533

EXAMINATION DATE: March, 2021

COURSE LECTURER: Prof Dr. M.J.E. Salami

HOD's SIGNATURE

TIME ALLOWED: 2 HR and 30 minutes

INSTRUCTIONS:

1. ANSWER **ANY FOUR (4) QUESTIONS**
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.
3. YOU ARE **NOT** ALLOWED TO BORROW CALCULATORS AND ANY OTHER WRITING MATERIALS DURING THE EXAMINATION.

Question 1[15 Marks]

a) The current through a diode is shown in Fig. Q1a. Suppose $t_1 = 350\ \mu s, t_2 = 500\ \mu s, f = 200Hz, f_s = 5\ kHz, I_m = 450\ A, and\ I_a = 150\ A$, determine the:

(i) RMS current. (4 marks)

(ii) Average diode current. (2 marks)

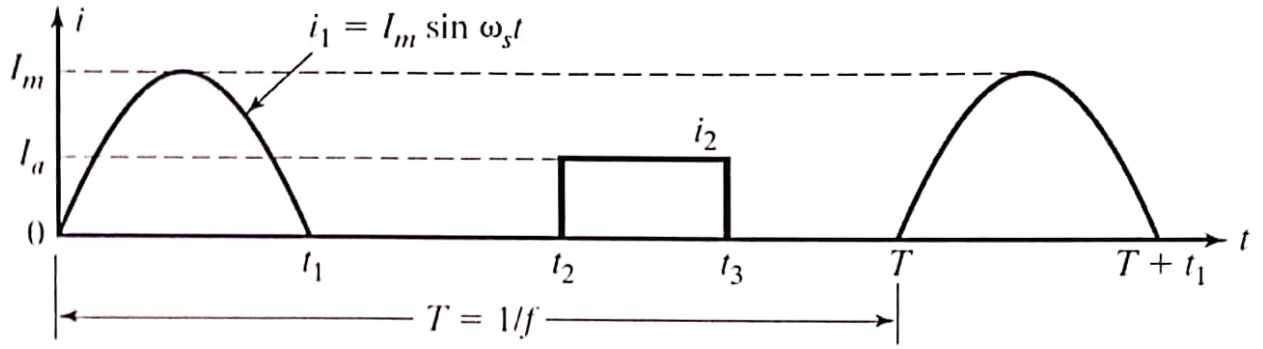

Fig. Q1a

b) Fig. Q1b shows a half-wave rectifier, having a freewheeling diode D_2 and RL load, where $R = 100\ \Omega$ and $L = 25\ mH, V_m = 100\ V$, and the source frequency is 50 Hz.

(i) Sketch the waveforms $v_s(t)$, $i_o(t)$, i_{D1} and i_{D2}. (2 marks)

(ii) Obtain the Fourier series expression for the voltage across the load. (4 marks)

(iii) Determine the average load voltage and current. (3 marks)

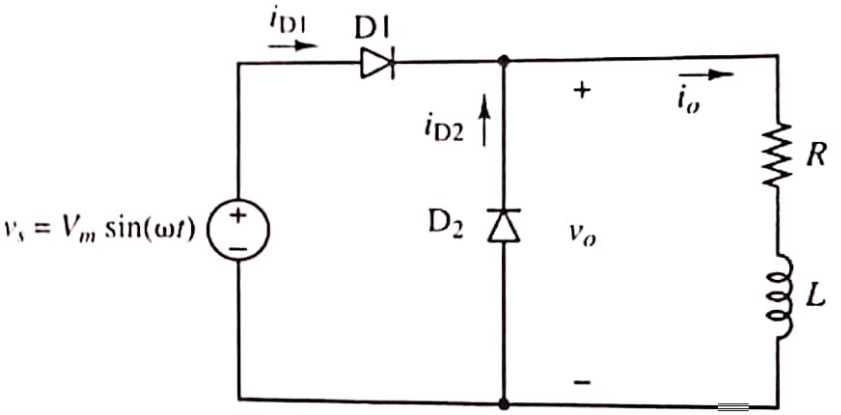

Fig.Q1b

Question 2 [15 Marks]

a) State the merits and demerits of using bridge circuit instead of center-tapped transformer for full wave single-phase rectifier. (3 marks)

b) Derive an expression for the:

i) Average output voltage (3 marks)

ii) Root mean square (RMS) output voltage (3 marks)

for a q-phase uncontrolled rectifier with resistive load and a supply voltage $V_s = V_m \sin \omega t$.

c) A six-phase uncontrolled star rectifier has a purely resistive load of $R = 10\ \Omega$, the peak supply voltage, $V_m = 220\ V$ and the supply frequency $f = 50\ Hz$. Determine the

i) Average output voltage (3 marks)

ii) RMS output voltage (3 marks)

of the rectifier if the source inductance is negligible.

Question 3 [15 Mark]

a) i) Draw and explain the necessity of static and dynamic equalizing circuit for series connected thyristors. (3 marks)

ii) Derive expressions used for determining the values of shunt resistor R and capacitor C in this circuit. (4 marks)

b) The voltage and current rating in a particular circuit are 3 kV and 750 A. Thyristors with rating of 800 V and 175 A are available. The recommended minimum derating factor is 15%. Calculate the
i) Number of series and parallel units required. (4 marks)
ii) Required values of R and C used in the static and dynamic equalizing circuits, if the maximum forward leakage current for the thyristors is 10 mA and $\Delta Q = 20\ \mu C$. (4 marks)

Question 4 [15 Marks]

a) State the advantages and disadvantages of phase-controlled rectifiers over the uncontrolled rectifiers. (2 marks)

b) Derive expression for the
i) Average output voltage (2 marks)
ii) RMS output voltage (3 marks)
for the single-phase, phase-controlled rectifier. Assume the supply voltage is $V_s = V_m \sin \omega t$ and that the firing (delay) angle is α.

c) Fig.Q4c shows a single-phase half-wave converter which is operated from a $220 - V$ 50 Hz supply and the resistive load is $R = 10\ \Omega$. Suppose the average output load is 25% of the maximum possible average output voltage, calculate the
i) Delay angle (2 marks)
ii) RMS and average output currents (2 marks)
iii) Average and RMS thyristors currents (2 marks)
iv) Input power factor. (2 marks)

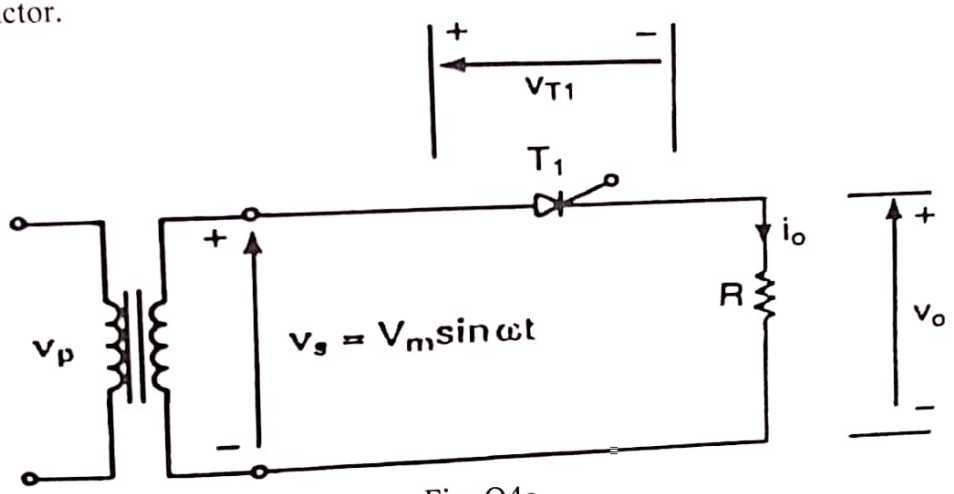

Fig. Q4c

Question 5 [15 Marks]

a) Explain the following terms with respect to phase-control converter;
(i) Semiconverter (1 mark)
(ii) Full converter (1 mark)
(iii) Dual converter (1 mark)
State the applications of each of these converters.

b) Derive expression for the average output voltage and RMS output voltage for a three-phase phase-controlled half-wave converter in terms of delay angle α and peak supply voltage V_m. (4 marks)

c) Fig.Q5c shows a three-phase half-wave phase-control converter which is operated from a three-phase Y=connected $440 - V$ 50 Hz supply. Suppose it is required to obtain an average output voltage of 50% of the maximum possible output voltage, calculate the
i) Delay angle, α. (2 marks)
ii) Average and RMS output currents. (2 marks)
iii) Average and RMS thyristors currents (2 marks)
iv) Rectification efficiency (2 marks)

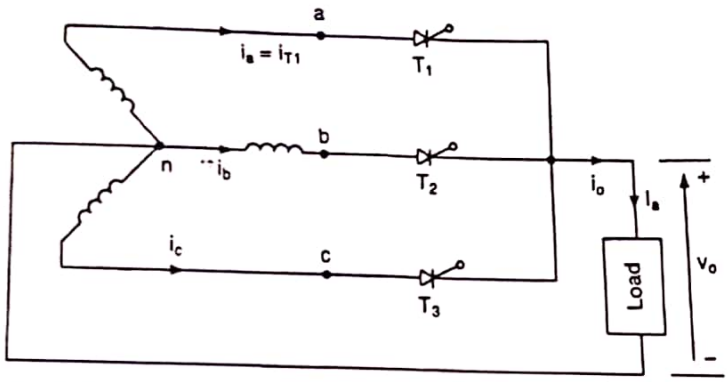

Fig. Q5c

Question 6 [15 Marks]

a) Design the triggering circuit of Fig. Q6a in which the parameters of the Unijunction Transistor (UJT) are $V_s = 30\ V, \eta = 0.51, I_p = 10\ \mu A, V_v = 3.5\ V$, and $I_v = 10\ mA$. The frequency of oscillation is $f - 50\ Hz$ and the width of the triggering pulse is $tg = 50\ \mu s$. Assume $V_D = 0.5\ V$. (5 marks)

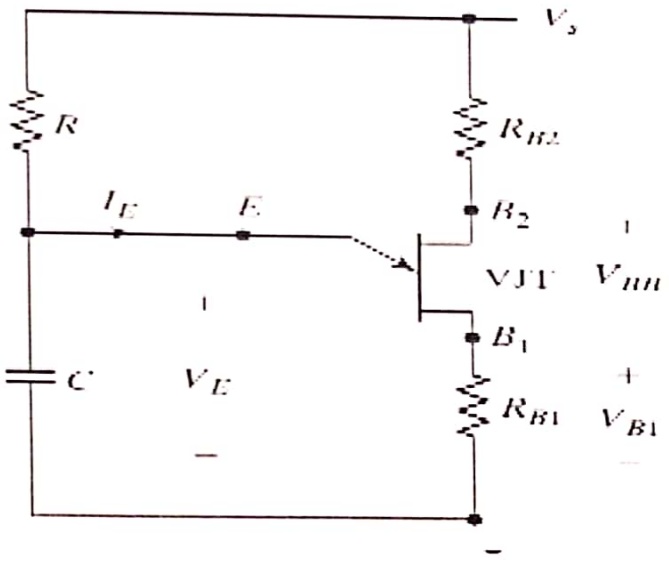

Fig. Q6a

b) Use appropriate well-labelled diagram, highlighting the essential components, to explain the operation of

(i) Uninterruptive power supply (UPS) (3 marks)

(ii) High voltage direct current (HVDC) transmission system (4 marks)

c) An HVDC transmission system is rated as $500\ MW, \pm 250\ kV$, determine the RMS current and peak reverse voltage of each thyristor. (3 marks)