ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE
FACULTY OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

**FIRST SEMESTER EXAMINATION, 2019/2020 ACADEMIC SESSION**

**COURSE TITLE: Power Electronics and Drives**

**COURSE CODE: EEE 533**

**EXAMINATION DATE: February14, 2020**

**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.

**Question1 [15 Marks]**

a) Compare, in tabular form, the performance of the following uncontrolled rectifiers: (3 Marks)

i) Half-wave single-phase
ii) Full-wave single phase
iii) Star Three-phase

by considering the following parameters

1. Rectification efficiency
2. Ripple factor
3. Total utilization factor

b) Fig. Q1b shows a half-wave rectifier which is used as a battery charger. The batteryvoltage $E = 12\ V$ andits capacity is $100\ W-h$. The average charging current should be $I_{dc} = 5\ A$. The primary input supply voltage is $V_s = 240\ V, 50\ Hz$ and the transformer has a turns ratio of $N = 4:1$. Compute the

i) Conduction angle, δ of the diode (2 Marks)
ii) Current-limiting resistance $R$. (3 Marks)
iii) RMS battery current (3 Marks)
iv) Rectifier efficiency (2 Marks)
v) Charging time, $h_0$ in hours. (1 Mark))
vi) Peak inverse voltage, PIV of the diode. (1 Mark)

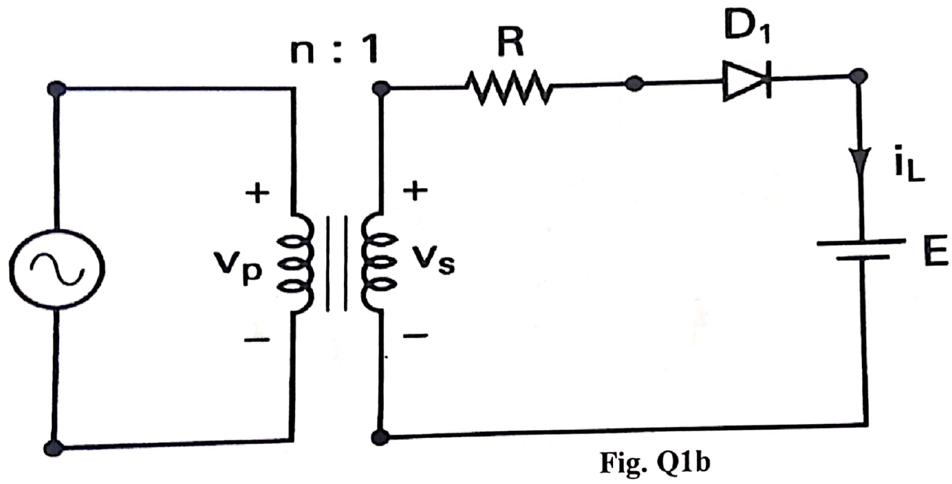


**Fig. Q1b**

**Question 2 [15 Marks]**

a) State the main advantages and disadvantages of three-phase uncontrolled rectifier over its single-phase counterpart. (2 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 (4 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 the shunt resistor $R$and capacitor $C$ in this circuit. (4 Marks)

b) Draw and explain the simultaneous triggering circuit for

i) Series connected thyristors. (2 Marks)
ii) Parallel connected thyristors. (1 Mark)

c) 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. (2 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 $\Delta Q = 20\ \mu C$. (3 Marks)

**Question 4[15 Marks]**

a) State the advantages 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 andthe 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)

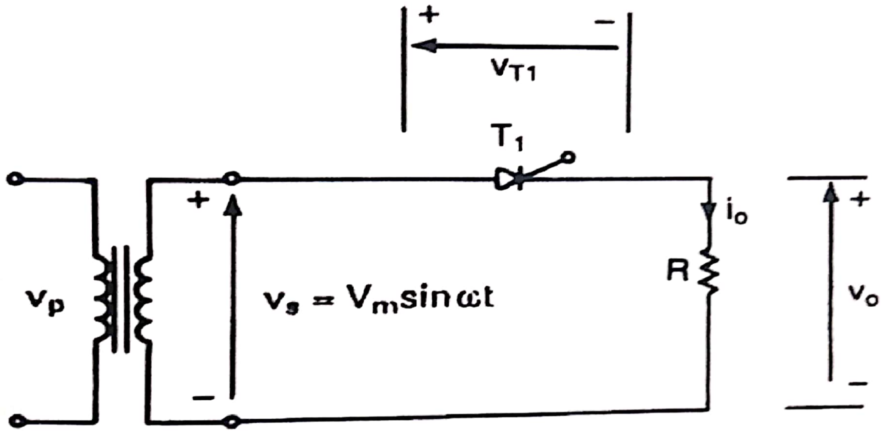


Fig. Q4c

**Question 5 [15 Marks]**

a) Why are three-phase phase-controlled converters extensively used for high-power variable-speed drives? (2 Marks)

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 $V_m$. (5 Marks)

c) Fig.Q5c shows a three-phase half-wave phase-controlled 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)

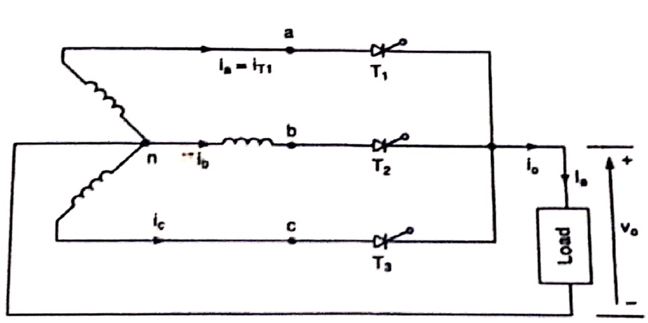


**Fig. Q5c**

**Question 6 [15 Marks]**

a) For the following applications, select with justification an integral cycle control or a phase angle control: (3 Marks)

1. Lighting control
2. Motor speed control
3. Heating loads.

b) Fig. Q6b depicts a single-phase ac voltage controller which has a resistive load of $R = 10\ \Omega$ and an input voltage of $220\ V, 50\ Hz$. The delay angle of thyristor $T_1$ is $\alpha = \pi/2$. Compute the

i) RMS value of the output voltage, $V_o$. (2 Marks)

ii) Input power factor. (3 marks)

iii) Average input current. (2 Marks)

c) The DC chopper shown in Fig. Q6c has a resistive load of $R = 10\Omega$ and the input voltage is $V_s = 220\ V$. When the chopper switch remains on, its voltage drop is $V_{ch} = 2\ V$ and the chopping frequency is $f = 1\ kHz$. If the duty cycle is 50%, determine the

i) Average and RMS values of the output voltage $V_o$. (2 Marks)

ii) Chopper efficiency (2 Marks)

iii) Effective input resistance $R_i$ of the chopper. (1 Mark)

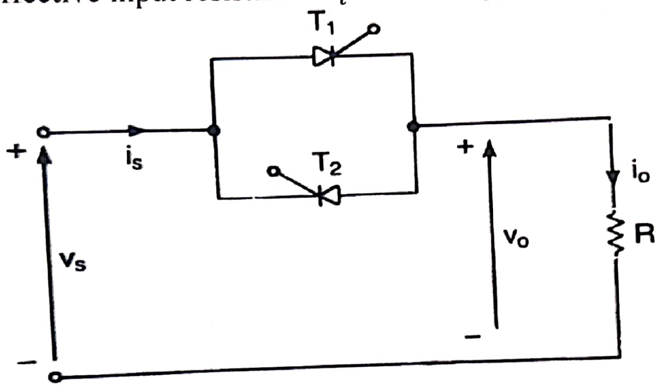


Fig.Q6b

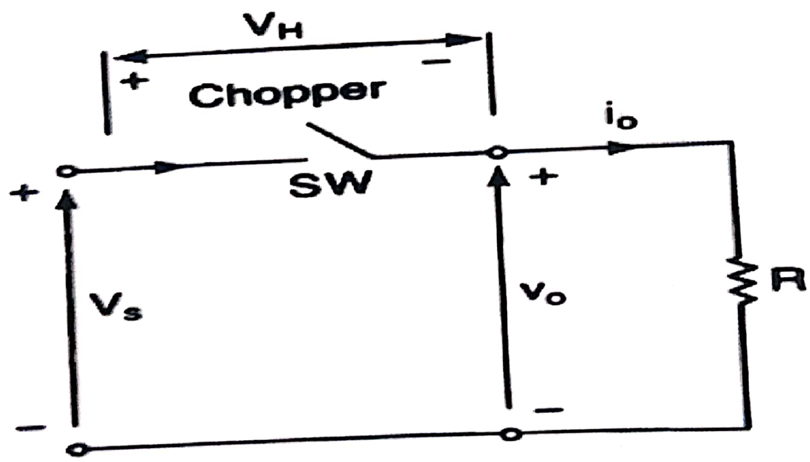


Fig. Q6c