Important Instructions to examiners:

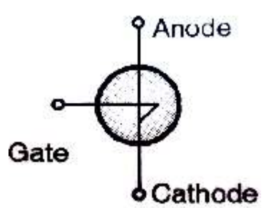
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the Figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any Equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant Values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q1.a) Attempt any SIX of the following : 12M

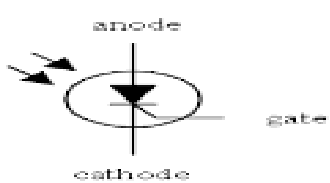
(i) Draw the symbols of –
(1) SUS
(2) LASCR

Ans:- **1M each**

(1) SUS



(2) LASCR



(ii) State any two uses of IGBT.

Ans:- (Any Two) **1M each**

Uses of IGBT: It can be used as a power control device in the following applications

1) SMPS systems
2) UPS systems
3) AC motor controllers
4) Choppers
5) Inverters

(iii) Name any two triggering devices used triggering TRIAC.

Ans:- (Any Two) **1M each**

Triggering devices for TRIACs:

1. UJT
2. PUT
3. SUS
4. SBS
5. DIAC

(iv) Define inverter and state it's any two applications

Ans:- **(Definition 1M, Any two applications ½ M each)**

Definition of inverter:

Inverter is a circuit which converts D.C power into A.C at desired voltage and frequency.

Applications:

1) Variable speed a c motor drivers
2) Induction heating
3) Aircraft power supplies
4) Uninterrupted power supplies (UPS)
5) High voltage d c transmission lines
6) Battery vehicles drive
7) Regulated voltage and frequency power supplies

(v) State difference between forced commutation and natural commutation (Any two points)

Ans: - (Any Two) **1M each**

Parameters	**natural commutation**	**forced commutation**
Need of external commutating components	Not required	required
Type of supply	Source is A.C	Source is D.C
Power dissipation	Less as no power loss takes place in the commutating circuit	More as power loss takes place in the commutating components
Cost	No cost towards commutation	Commutation components are costly

(vi) Define choppers and classify it.

Ans:-

Definition of Chopper: **01M**

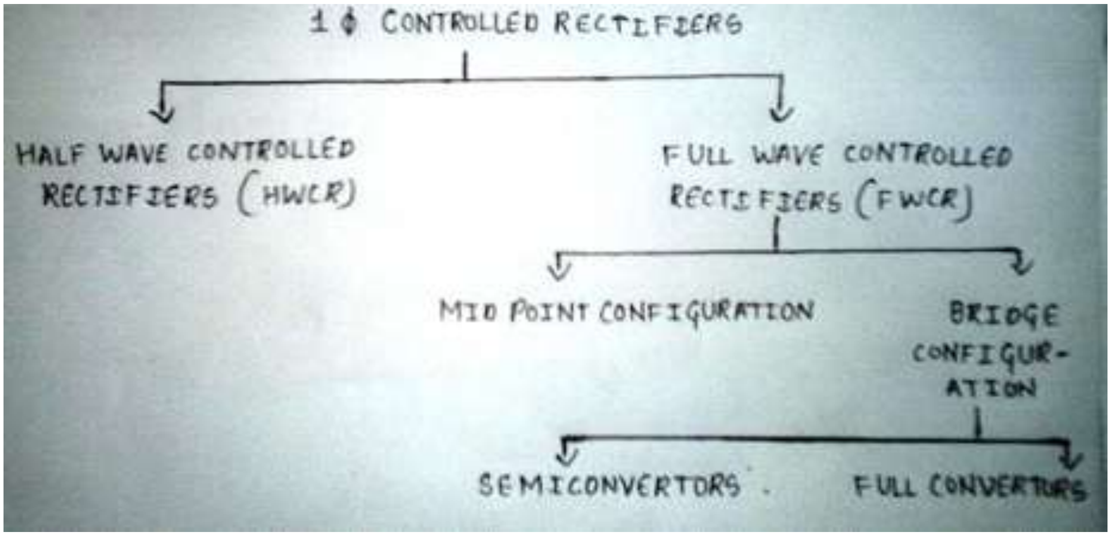
Chopper is a circuit used to obtain variable D.C voltage from a source of fixed D.C

Classification: <u>(Any one classification)</u> **01M**

1) Depending on level of output voltage
   a) Step up chopper
   b) Step down chopper
2) According to the direction of output voltage and current.
   a) Class A (type A)
   b) Class B (type B)
   c) Class C (type C)
   d) Class D (type D)
   e) Class E (type E)
3) According circuit operation
   a) First quadrant chopper
   b) Two quadrant chopper
   c) Four quadrant chopper
4) According to commutation method
   a) Voltage commutated
   b) Current commutated
   c) Load commutated
   d) Impulse commutated

(vii) Give classification of controlled rectifiers.

Ans: - **(½ M for each step)**



(viii) State any two applications of UPS.

Ans: - (Any two applications) **1M each**

Applications of UPS:

UPS systems are used to power critical loads in industrial and commercial applications:-

- PLCs
- Medical equipment
- Computers.
- Used in intensive care units
- Used in EPBAX.

Q1. B Attempt any TWO of the following:- **8M**

i) Compare half wave controlled rectifier and full wave controlled rectifier with respect to the following parameters.

1) Number of SCR's
2) Average load voltage
3) Ripple frequency
4) Application

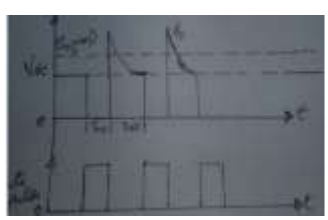
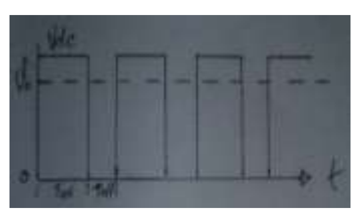
Ans: - **01M each**

Parameter	**Half wave controlled rectifier**	**Full wave controlled rectifier**
No. of SCRs	1	2 or 4
Average load voltage	**Vm/2π * (1+ cosα)** **OR** $\frac{V_m}{\pi}$ volts	**Vm/π * (1+ cosα)** **OR** $\frac{2V_m}{\pi}$ volts
Ripple frequency	50 Hz	100 Hz
applications	In small battery chargers	In DC motor speed control

ii) Compare between step down and step up chopper (any four points).

Ans: - (any 4 point) **01M each**

<u>Note:-</u> (Other relevant point can be considered)

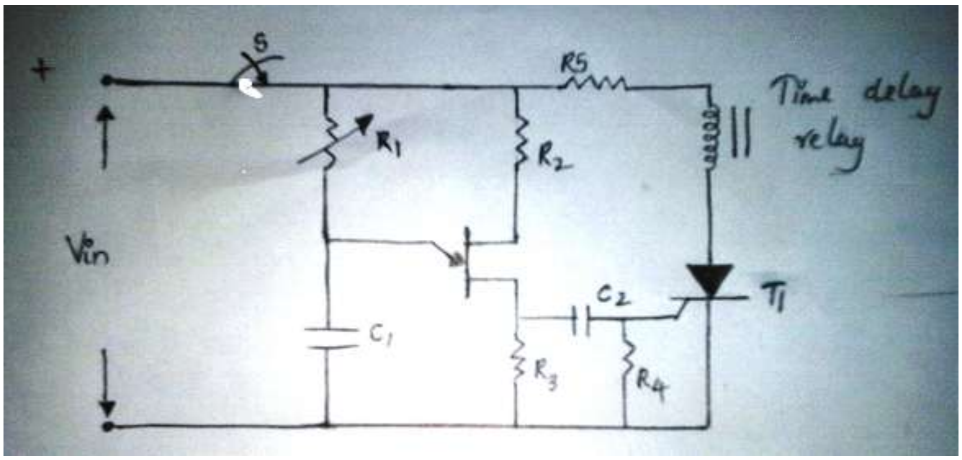
Parameter	**Step-up Chopper**	**Step-down Chopper**
Output voltage equation	**Vo = Vdc / (1-** α) (α- duty cycle)	**Vo = Vdc.** α
Switch position	In parallel with the load	In series with the load
application	Battery charging, voltage booster	Motor speed control
Input-output voltage waveforms		
Quadrant of operation	**second**	**first**

iii) Draw the labeled circuit diagram of DC delay timer using SCR and UJT.

Ans:-

Note:-* *Consider other relevant diagram and give marks accordingly

Diagram:- **04M**



Q2 Attempt any FOUR of the following: 16M

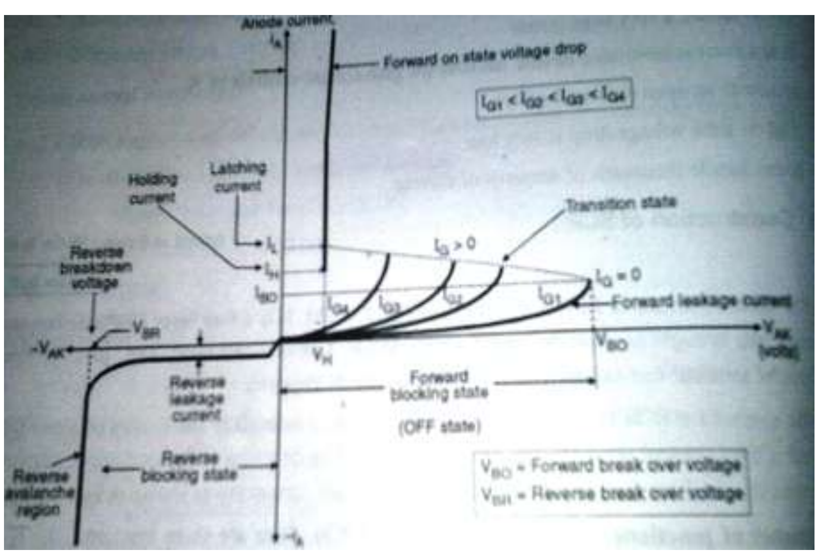
a) Draw V-I characteristic of SCR and define

i) Holding Current

ii) Latching current

Ans:-

V-I characteristics of SCR: **02M**



Holding current: **01M**

It is the minimum value of anode to cathode current below which the device stops conducting and return to its off state.

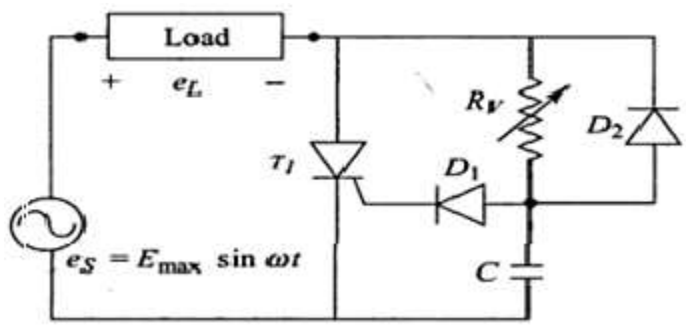
Latching current: **01M**

It is the minimum anode to cathode current required to keep the device in the on state after the trigger pulse has been removed.

b) Describe RC gate triggering method of SCR with neat diagram and waveforms.

Ans:-

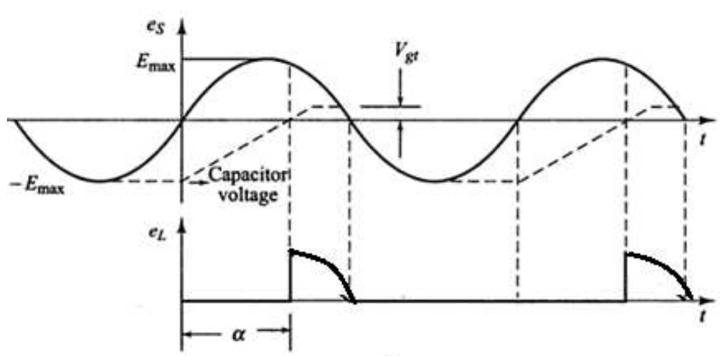
Diagram: **1 ½ M**



Description: **1 ½ M**

A large value of firing angle (more than 90°) can be obtained from above circuit usually in 0-180° range . In the positive half cycle the capacitor is charged through the variable resistance R up to the peak value of applied voltage. The charging rate of the capacitor can be controlled by the variable resistance R. Depending upon the voltage across the capacitor and with sufficient gate current, the thyristor triggers. In negative half cycle the capacitor C is charged up to the negative peak value through the diode D2. Diode D1 is used as a safe guard against the reverse breakdown of the gate – cathode junction during the negative half cycle.

Waveform:- **1 M**

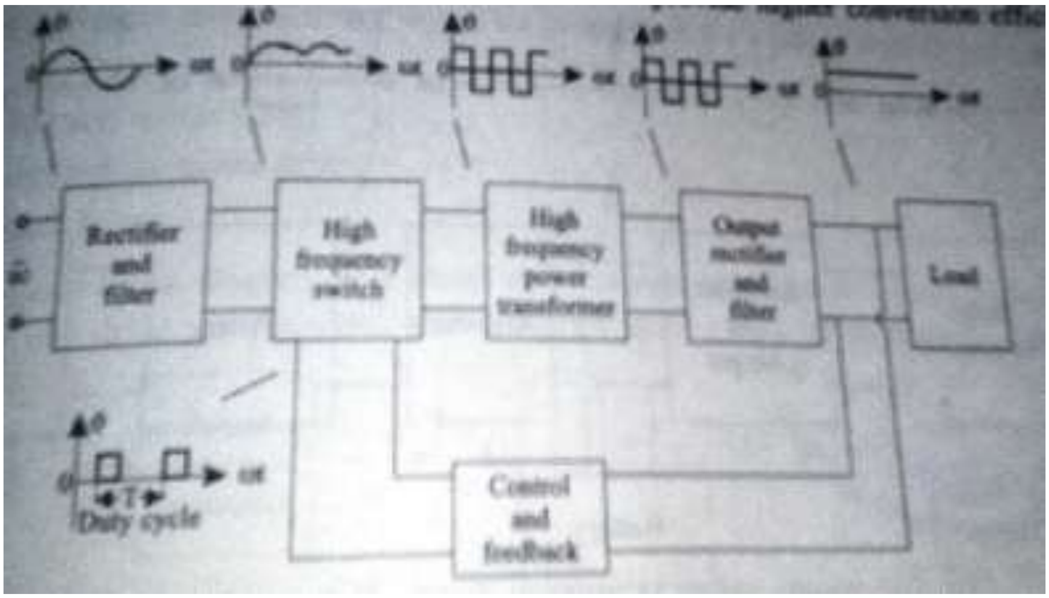


c) Draw block diagram of SMPS and describe it's working.

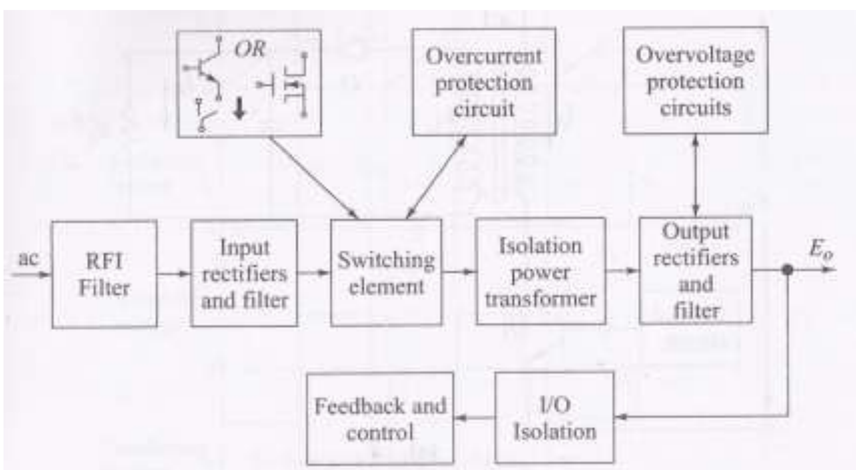
Ans:- **(Diagram 02M, Description 02M)**

***Note:-* Any relevant Diagram and explanation can be considered**

Diagram:-



OR



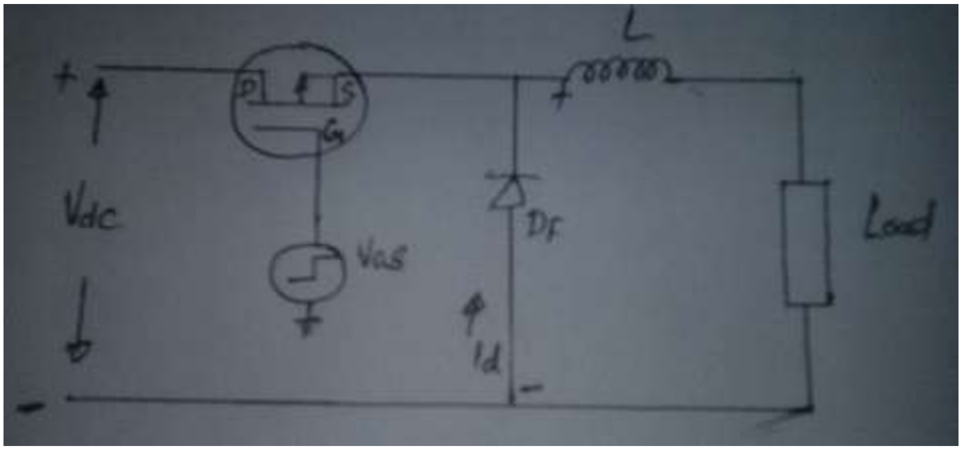
Description of working:

SMPS converts unregulated AC or DC voltage into a regulated voltage. In case of AC it first converted into unregulated DC. This is fed to a high frequency step-up chopper. It uses a high frequency AC conversion stage to facilitate the use of a high frequency transformer for voltage scaling and isolation. The output of transformer is then rectified and filtered, to get a regulated output for the load. The output is fed back to the chopper to control which is used to control the switching frequency.

d) Draw circuit diagram of step down chopper and explain its working with neat waveforms.

Ans:-

Diagram: - **(give marks for diagram using SCR and resistive load also)** **1 ½ M**

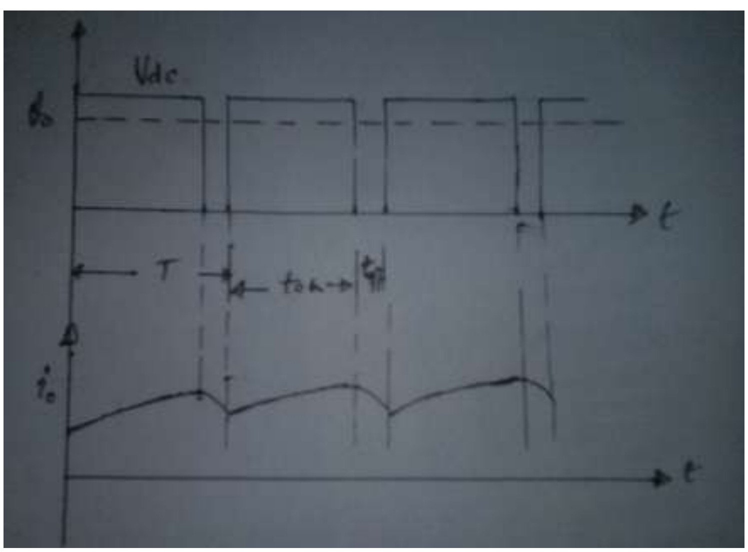


Description of working: **1 ½ M**

When the switch (Power MOSFET) is closed, the supply voltage Vs appears across the load and when it is open the load is disconnected from the supply. Thus the average DC output voltage is controlled by controlling the switching on period t_{on} and switching off period t_{off}. Equation of the output voltage is,

$V_o = V_{dc} \cdot \alpha$, where α is the duty cycle.

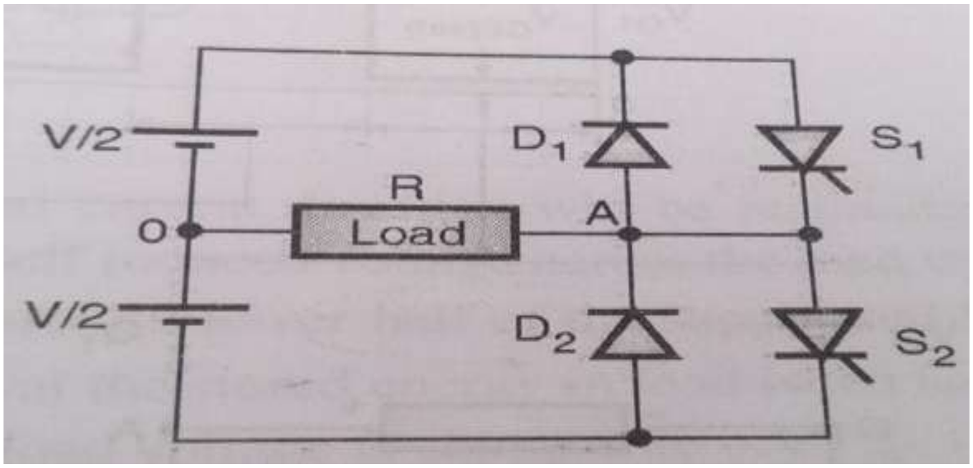
Waveform: - **1 M**



e) Draw the circuit diagram of single phase half bridge inverter. Explain its working with neat waveforms.

Ans:-

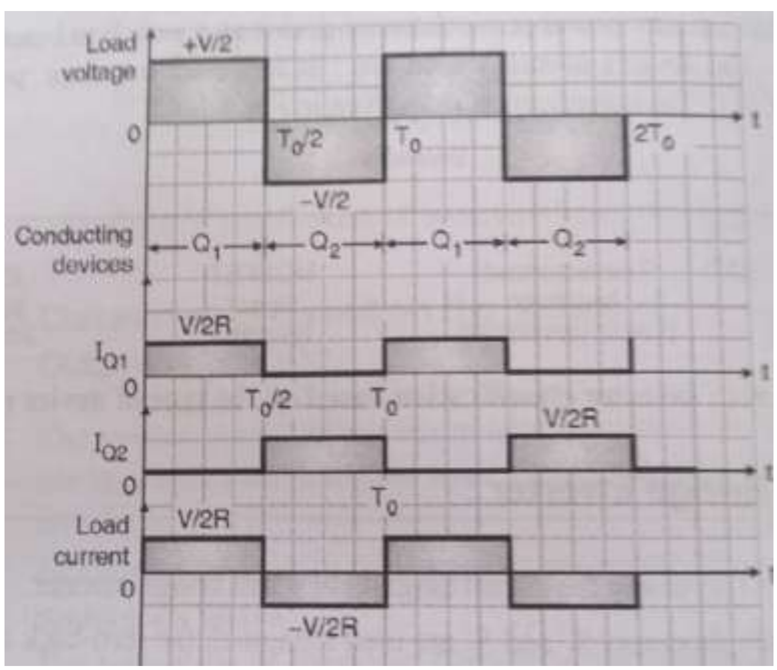
Diagram: - **1 ½ M**



Description of working: **1 ½ M**

The thyristor S1 is turned on for a time T/2, which makes the instantaneous voltage across the load, Vo= V/2. If thyristor S2 is turned on at instant T/2 by turning S1 off, the load current will now flow in reverse and –V/2 voltage appears across the load. Thus a square wave is produced across the load. Necessary precaution must be taken while designing the triggering circuits so that both the thyristor are not switched on simultaneously, as this will short circuit the source and may damage the thyristor.

Waveform:- **1 M**

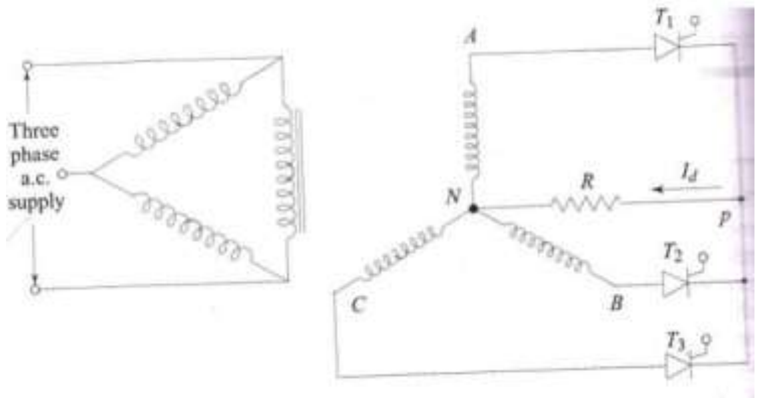


f) Draw circuit diagram and input, output voltage waveforms of three phase half wave rectifier with resistive load.

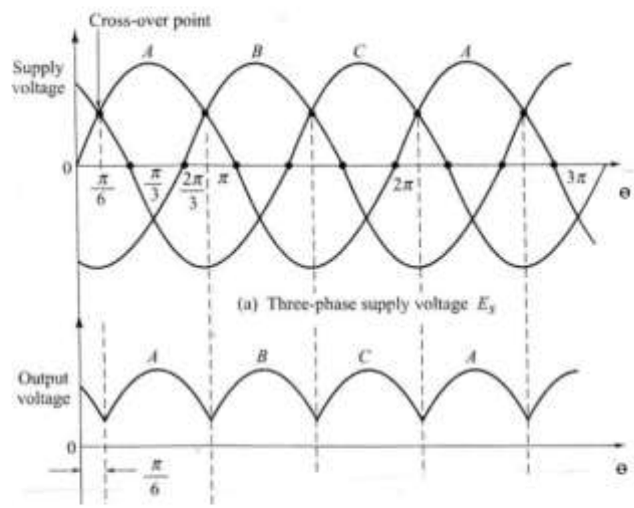
Ans:-

***Note:-* : Uncontrolled rectifier may also considered**

Diagram:- **02M**



Input and Output waveform:- **02M**

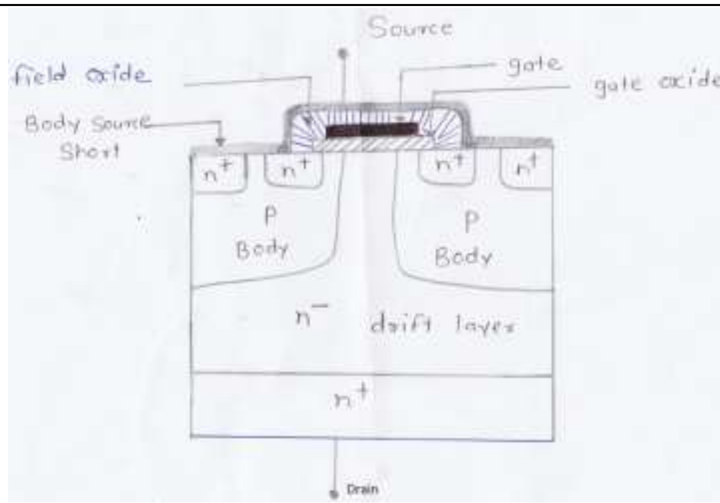


Q3 Attempt any FOUR of the following: - **16M**

a) Draw structure of a power MOSFET. State any two application of it.

Ans:-

Structure **2M**



Applications: - (Any two) **(1M each application)**

i) It is used in analog & digital signal Processing circuits, both in discrete & IC forms

ii) It can be used as static switch

iii) It can be used in SMPS, solid state DC relay, brushless DC motor drivers & automobile application.

b) Differentiate SCR And TRAIC with respect to:-

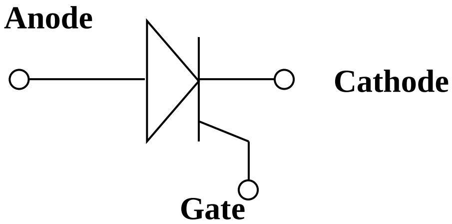
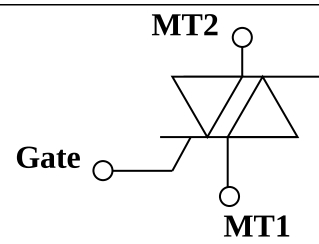
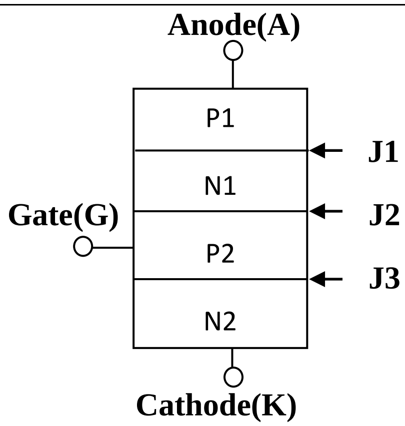
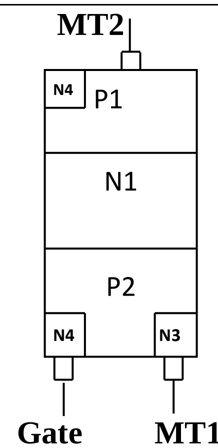
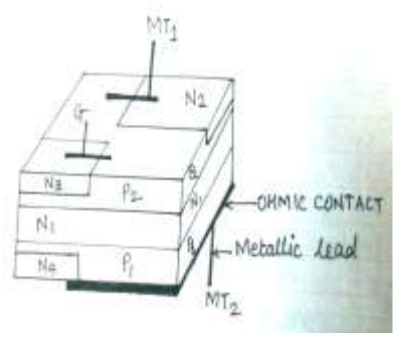
i) Symbol

ii) Layered diagram

iii) Operating quadrant

iv) Application

Ans: - **(01M each point)**

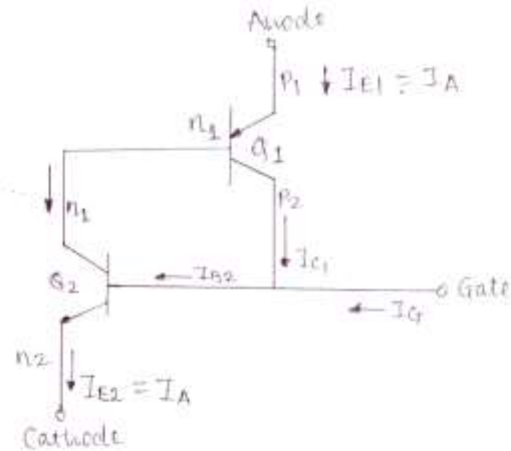
Parameters	SCR	TRAIC
1) Symbol		
2) Layered Diode		 **OR** 
3) Operating quadrant	1^{st}	1^{st} & 3^{rd}
4) Application	Used for temperature control Used in light dimmer, phase control, power control, inverters, choppers, static switch	It is used in static switch, phase control, speed control of AC motor, light dimmer ,heater control, liquid level control, AC power control, , flasher

c) Draw two transistor analogy circuit of SCR. Write equation for ID and describe its working.

Ans: - **(Diagram 02 M, Equation 01M, Working 01M)**

(NOTE:- Give marks for describing the below model and writing the eqn. of $I_A = \alpha_2 I_G + I_{CBO1} + I_{CBO2} / 1- (\alpha_1 + \alpha_2)$)

Diagram:-



Working:-

As shown, SCR can be considered to be 2 transistor Q1 (P-N-P) & Q2 (N-P-N) connected as shown. Let I_{C1}, I_{B1}, I_{E1} & I_{C2}, I_{B2}, I_{E2} be the current of 2 transistors. By using external DC supply anode of SCR is made positive with respect to its cathode. No I_G is given to SCR. The junctions J1 & J3 are forward biased while J2 is reverse biased.

Let 'I' be the current drawn from the supply. Hence from the circuit diagram, $I = I_{E1} = I_{E2} = I_E$. For transistor Q1 the relation between the current can be written as $I_{C1} = \alpha_1 I_{E1} + I_{CO1}$ & for Q2 can be written as $I_{C2} = \alpha_2 I_{E2} + I_{CO2}$ are the reverse leakage currents of 2 transistors.

For transistor Q1 :- $I_{E1} = I_{C1} + I_{B1}$

But from the diagram, $I_{B1} = I_{C2}$

Therefore $I_{E1} = I_{C1} + I_{C2} = \alpha_1 I_{E1} + I_{CO1} + \alpha_2 I_{E2} + I_{CO2}$

But $I_{E1} = I_{E2} = I_E$

Therefore $I_E = (\alpha_1 + \alpha_2) I_E + I_{CO1} + I_{CO2}$

Therefore $I_E \{1-(\alpha 1 + \alpha_2)\} = I_{CO1} + I_{CO2}$

Therefore $I_E = I = \frac{I_{CO1}+I_{CO2}}{1-(\alpha 1 + \alpha 2)}$……….……(1)

Initially $I_G = 0$ that is $I_{B2} = 0$ and hence Q2 is off . Hence $I_2 \approx I_{CO2}$ reverse leakage current which is too small. Since $I_{C2} = I_{B1}$, this small current is not sufficient for Q1 to turn on. Thus both Q1 & Q2 are off due to which $\alpha_1 + \alpha_2 \approx 0$ & hence from equation (1)

$I_E = I = I_{CO1} + I_{CO2}$ & SCR remain off.

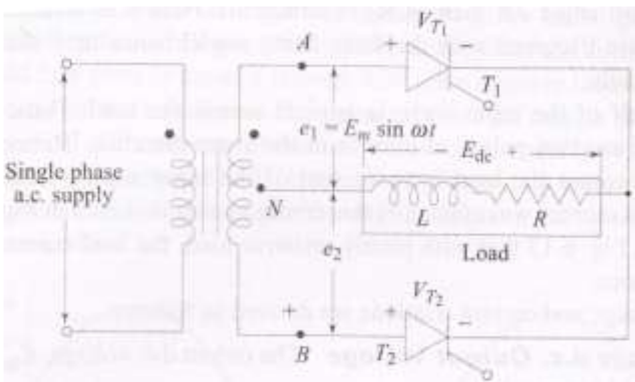
When I_G is supplied to the gate now $I_{B2} = I_{G2}$ starts flowing in Q2. This increases the collector current I_{C2} which is equal to I_{B1}. When I_{B1} increases it increases I_{C1} which is equal to I_{B2}. Hence once again I_{B2} increases.. This action is cumulative & hence both I_{C1} & I_{C2} go on increasing till Q1 & Q2 saturate. In this case $\alpha_1 + \alpha 2 \approx 1$ & hence from equation (1) $I = I_E \approx \infty$ un less limited by external series resistor R.

Thus the turn on of SCR can be controlled by using gate terminal as control terminal & giving required small I_G to it. In this way a large SCR current I_A can be controlled by a small gate current I_G .

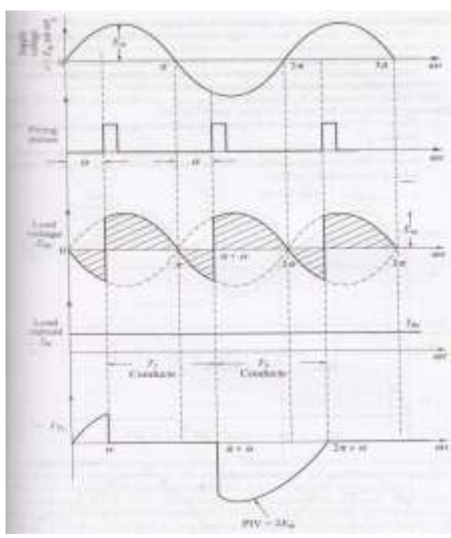
d) Draw single phase centre tapped controlled rectifier with RL load and its load voltage waveform.

Ans:- **(Diagram 02M, Waveform 02M)**

Diagram:-



Waveform:-

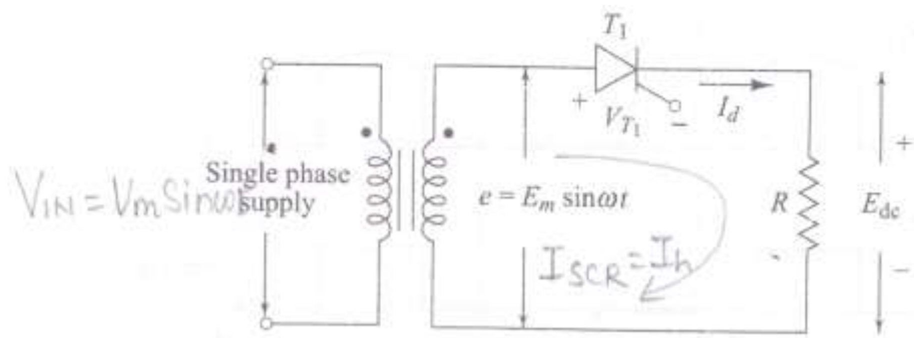


e) Draw the neat diagram of single phase half wave controlled rectifier with resistive load and describe its working.

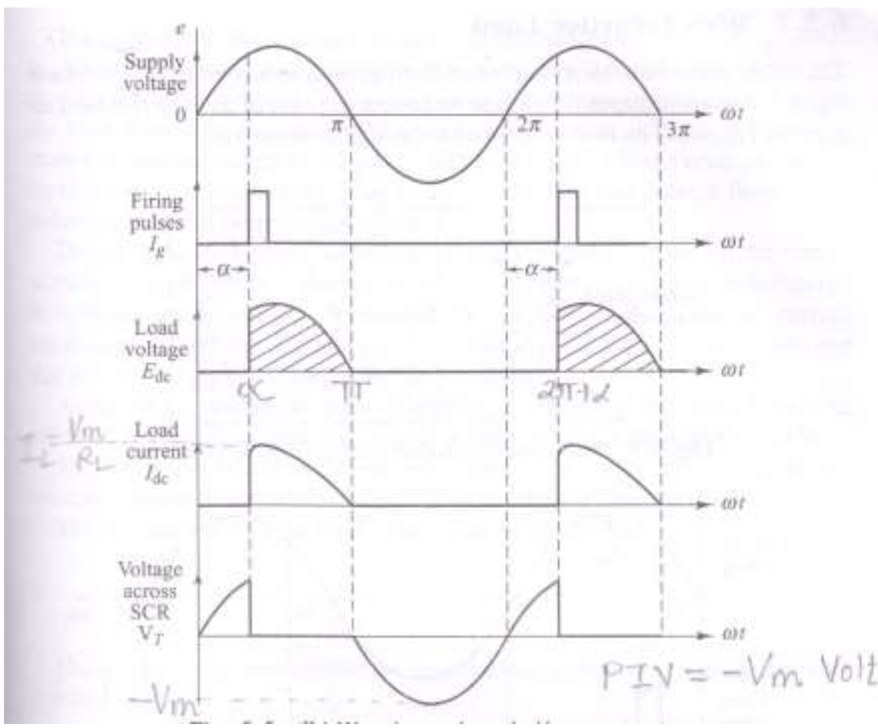
Ans:- **(Diagram 02M, Working 02M)**

Note:- Give marks for relevant explanation also

Diagram:-



Waveform:-



Working:-

Positive half cycle:- Point B is positive w.r.t A hence SCR is forward bias since $V_m < V_{BO}$ and gate current is not given, SCR remains off. At Q=α sufficient gate current is given to trigger the SCR. Since voltage drop across on SCR can be neglected all the input AC voltage appears across R_L as output voltage V_0. Hence at Q=α V_O suddenly jumps from 0 to the instantaneous value of AC input voltage at Q=α.

For entire positive half cycle SCR is forward biased & hence remains ON . Hence output voltage V_O is exactly same as the input voltage for the remaining positive cycle from α to π. At Q = π negative half cycle starts due to which SCR is reverse biased and remains off for entire negative half cycle. It will also remain off in the next positive half cycle unless it is once again triggered by gate current at 2π+α.\

Output voltage V_O, SCR is not conducting from 0 to α. Hence I_L = 0 therefore $V_O = I_L R_L = 0$. From α to π SCR is ON and allow I_L to flow hence output voltage will be produces which is identical in shape with the input waveform. Since the load is resistive I_L & V_O are in phase w.r.t each other. Hence the waveform for I_L is identical to that of V_O.

Waveform for V_{SCR} can be explained as follows from 0 to α SCR is off hence all the input AC voltage appears across SCR from α to π. SCR conducts hence V_{SCR} = +1 to 1.5V which is shown by horizontal line which is very near to X-axis. For entire negative cycle & also for time period of 2π to 2π+α. SCR is off, hence V_{SCR} = AC input voltage

Hence when firing angle α is varied from 0 to π output voltage goes on reducing. Due to this by adjusting value of α required DC output voltage can be obtained which can be vary by changing α. If firing angle α advances i.e reduces DC voltage increases. If firing angle α retarded i.e. increases V_O decreases.

f) A single phase full wave controlled rectifier is supplied with a voltage V = 200 sin(314t). Find average output DC voltage and current if firing angle is 30^o and total resistance is 100Ω.

Ans:- **04M**

Solution:-

$V = 200 \sin(314t)$

compare with $V = V_m \sin(\omega t)$

$\therefore V_m = 200$

Average dc o/p voltage =

$$V_{dc} = \frac{V_m}{\pi}\left[1 + \cos\alpha\right]$$

$$= \frac{200}{\pi}\left[1 + \cos 30\right]$$

$$\boxed{V_{dc} = 118.79V}$$

Average DC output current

$$I_{dc} = \frac{V_m}{\pi \cdot R}\left[1 + \cos\alpha\right]$$

$$= \frac{V_{dc}}{R}$$

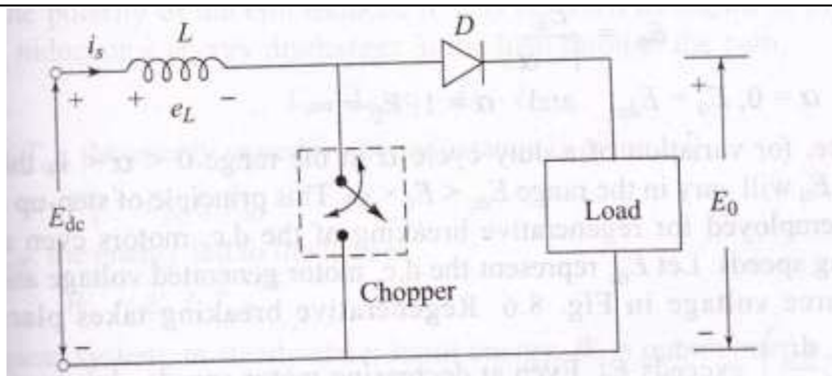
$$\boxed{I_{dc} = 1.188\ A}$$

Q4) Attempt any FOUR of the following: **16M**

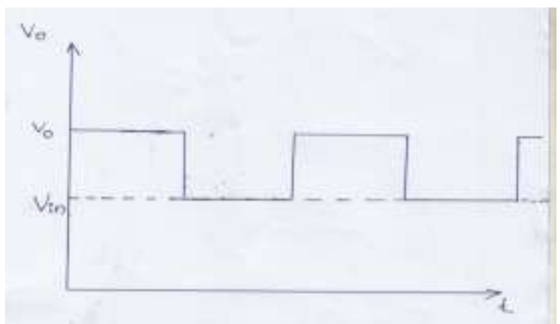
(a) **Draw the neat circuit diagram of step-up chopper and draw its input and output voltage waveforms.**

Ans:-

Diagram of step up chopper **2M**



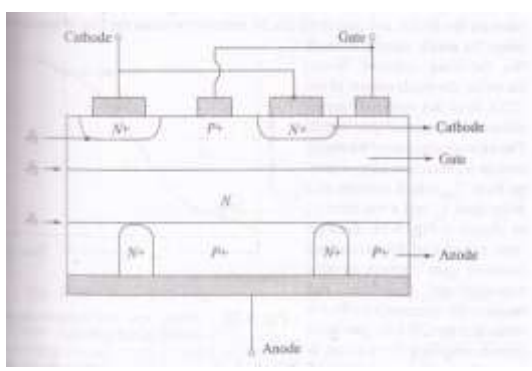
Waveform:- **2M**



b) Draw constructional diagram of GTO and state two differences between GTO and SCR.

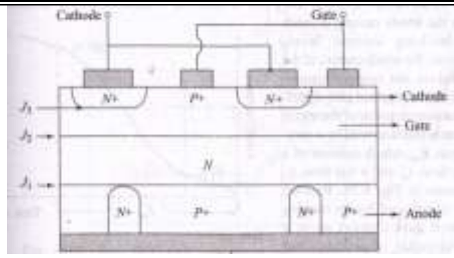
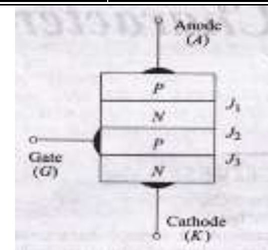
Ans:-

Diagram: - **2M**



(Any two differences) **1M each**

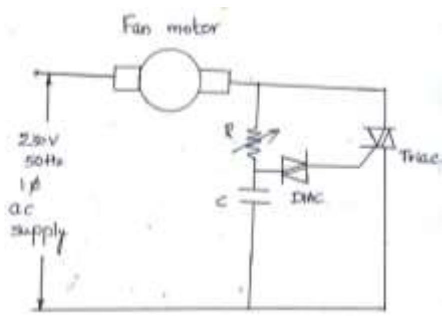
GTO	SCR
1. Diagram:-	**Diagram: -**

	
2. GTO can turn off by application of negative pulse of gate terminal.	SCR cannot turn off by application of pulse at gate input.
3. Gate cathode structure of GTO is interdigitated.	Gate cathode structure SCR is not interdigitated.
4. Reverse blocking capacity is less than SCR.	Reverse blocking capacity of SCR is more than GTO.
5. Turn off time is less than SCR turn off time.	Turn off time is More than GTO turn off time

c) Draw fan speed regulator circuit using DIAC and TRAIC.

Ans:- **4M**

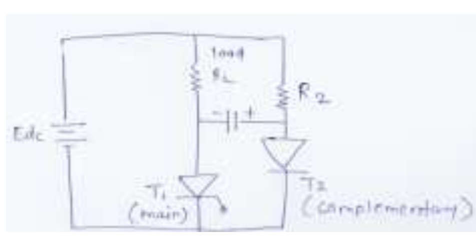
Diagram:-



d) Draw circuits diagram of class C commutation and explain its working.

Ans: - **Diagram 02M, Working 02M**

Diagram:-



Working:-

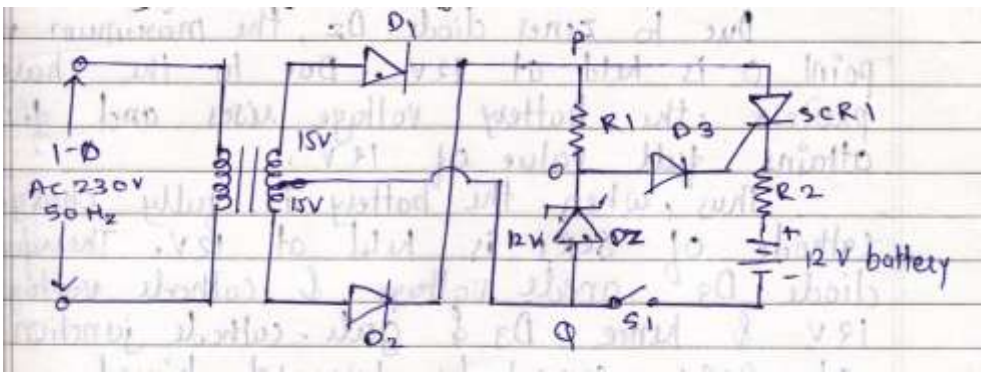
Initially, both the thyristors are OFF when a triggering pulse is applied to the gate of T, the thyristors T_1 is triggered, Therefore current starts following through the load as well as R_2 & C. Capacitor C will get charged by the supply voltage E_{dc} as shown in fig. When a triggering pulse is applied to the gate of

T_2, T_2 will be turned on. As soon as T_2 is ON, the negative polarity of capacitor C is applied to the anode of T_1 positive to the CATHODE . This main thysistor T_1 & immediately turns it off.

e) Draw circuit diagram of simple battery charger and explain its working.

Ans:- **Diagram 02M, Working 02M**

Diagram:



Working:-

Automatic battery charging circuit using circuit using SCR is shown in figure.

- A 12v discharged battery is connected in the circuit.
- The single-phase 230 v supply is stepped down to (15*0*15) v by a center tapped transformer.
- Diodes D1 & D2 forms full wave rectifier.
- When switch s1 is closed , the pulsating DC voltage appears across terminals P&Q
- When SCR1 is Off, its cathode is held at the potential of discharged battery. During each positive half cycle when the potential of point 0 rises to sufficient level so as to forwarded bias diode D3 & gate – cathode junction of SCR1, the gate pulse is provided to SCR1 & it is turned ON.
- When SCR1 is turned ON, then charging current flows through battery. Thus during each positive half cycle of pulsating dc voltage across P-Q, SCR1 is triggered and charging current is passed till the end of that half cycle .
- Due to Zener diode D_z , the maximum voltage point 0 is held at 12v. Due to the charging process, the battery voltage rises and finally attains fall value of 12v.
- Thus, when the battery is fully charged, cathode of SCR1 is held at 12v. Therefore, diode D3 anode voltage & cathode voltage become12v & SCr1 cannot be forward biased.
- Hence no gate current is supplied and SCR1 is not triggered.
- In this way, after full charging further is automatically stopped.

f) Define harmonic factor and total harmonic distortion with respect to inverters.

Ans:-

Harmonic Factor: - **02M**

Harmonic Factor of n^{th} harmonic (HF_n) The harmonic factor is a measure of the individual harmonic contribution on the output voltage of an inverter. It is defined as the ratio of the rms voltage of a particular harmonic component to the rms value of fundamental component.

Equation: - (optional)

$$\boxed{HF_n = \frac{E_{n\,rms}}{E_{1\,rms}}}$$

Total Harmonic Distortion:- **02M**

Total Harmonic Distortion (THD):- A total harmonic distortion is a measure of closeness in a shape between the output voltage waveform and its fundamental components. It is defined as the ratio of the rms value of its total harmonic component of the output voltage and the rms value of the fundamental component. Mathematically,

Equation: - (optional)

$$THD = \sqrt{\sum_{n=2,3}^{\infty} E_{n\,rms}^2} \Big/ E_{1\,rms}$$

$$= \frac{\sqrt{E_{0\,rms}^2 - E_1^2}}{E_1}$$

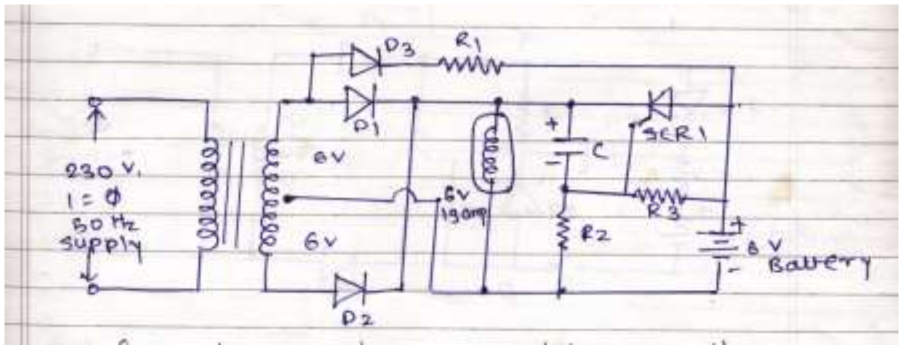
Q5) Attempt any <u>FOUR</u> of the following: **16M**

a) Draw the neat circuit diagram of emergency lighting system using SCR and describes its working.

Ans*:*

Note:- ***Give marks for other relevant diagrams also***

Diagram:- **02M**



Working:- **02M**

- Fig. shows simple emergency lighting circuit .The 230v ac supply is applied as input. This supply is stepped down by tapped transformer. The supply is stepped down full wave rectifier & converts ac to dc volt.
- When ac supply is available, ac supply appears across lamp and it glows.
- Pulsating current also flows through D3 & R1 to charge the battery. Thus battery charging is carried out.
- The capacitor c gets charged with upper plate +VE to some voltage less than secondary voltage of transformer. Due to capacitor voltage, gate cathode junction of SCR1 gets reverse biased. The anode is at battery voltage & cathode is at rectifier output voltage, which is slightly higher, hence SCR1 is reverse biased & cannot conduct. The lamp glows due to rectifier output dc voltage.
- If power fails, the capacitor C discharges through D3 R1 & R3 until the cathode of SCR, is less positive than anode. At the same time the junction of R2 & R3 becomes +VE & establishes a sufficient gate to cathode voltage to trigger the thyristor. Once the thyristor turns ON, the battery discharges through it, & turns the lamp ON when power is restored, the thyristor is connected & commutated & capacitor C is recharged again.

b) What is polyphase rectifier? State its advantages.

Ans:

Polyphase Rectifier: - **02M**

Polyphase rectifier has 3 or more phases at input. A rectifier which utilizes two or more diodes (usually three), each of which operates during an equal fraction of an alternating current cycle to achieve an output current which varies less than that in an ordinary half-wave or full wave rectifier.

Advantages: - (Any two) **01M each**

1) Ripple factor decreases rapidly with an increase in the number of phase

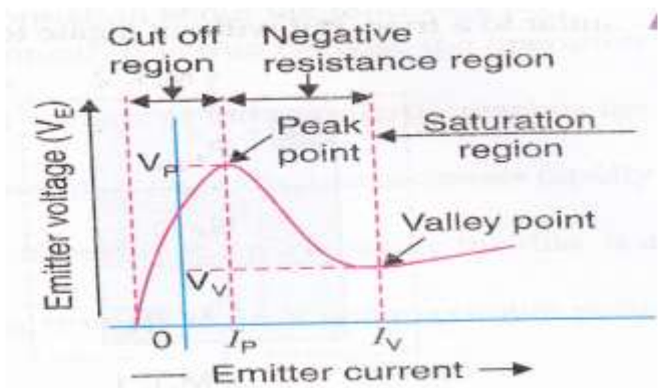
2) Poly phase rectifier gives smooth direct current
3) Low harmonics in the input supply current
4) Number of phases are more due to that average output can be more & hence output power is also more
5) High ripple frequency therefore small filters can be used.

c) Draw V-I characteristics of UJT and describe its different operating regions.

Ans:- **Diagram 02M,Descrition 02M**

Fig shows the V-I characteristic of UJT. There are two important points on the characteristic curve namely the peak-point and the valley- point. These points divide the curve into three important regions i.e , cut off region , negative resistance region and saturation region . these regions are explained below:

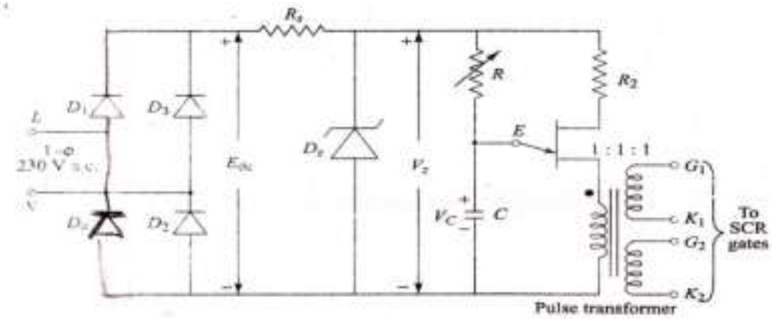
Diagram:-



1) Cut-off region: The region, to the left peak-point, is called cut-off region. In the region, the emitter voltage is below the peak-point voltage (Vp) and the emitter current is approximately zero. The UJT is in its OFF position in this region.
2) Negative resistance region: The region, between the peak –point and the valley-point called negative –resistance region. In this region, the emitter voltage decreases from Vp to Vv and the emitter current increases from Ip to Iv. The increase in emitter current is due to the decrease in resistance rb1. It is because of this fact that this region is called negative-resistance region. It is the most important region from the application point of view.
3) Saturation region: the region, beyond the valley point, is called saturation region. In this region, the device is in its ON position. The emitter voltage (Ve) remains almost constant with the increasing emitter current.

d) Draw the circuit of synchronized UJT gate triggering of SCR and explain its working.
Ans

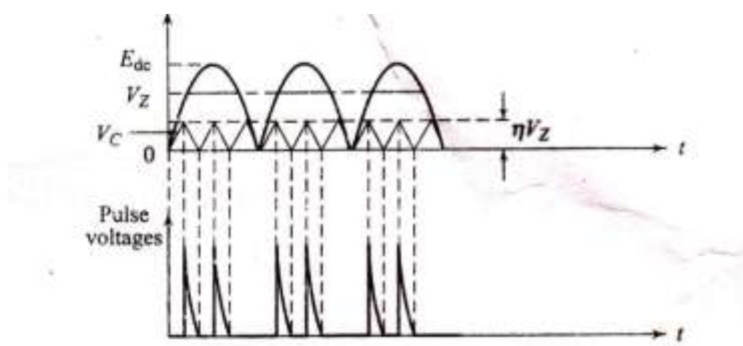
Diagram: - **02M**



Working:- **02M**

Synchronized UJT triggering circuit is shown in fig. The diode bridge D1-D4 rectifies A.C to D.C. Resistor R_s lowers E_{dc} to a suitable value for the zener diode and UJT. The zener diode D_z is used to clip the rectified – voltage to a fixed voltage V_z. This voltage V_z is applied to the charging circuit RC. Capacitor C charger through R until it reaches the UJT trigger voltage V_p. The UJT then turns "ON" and C discharge through the UJT emitter and primary of the pulse transformer. The windings of the pulse transformer have pulse voltage at their secondary terminals. Pulse at the two secondary windings feed the same in phase pulse to two SCDs of a full wave circuit. SCR with positive anode voltage would turn ON. Rate of rise of capacitor voltage can be controlled by varying R. The firing angle can be controlled up to about 150◦. This method of controlling the output power by varying charging resistor R is called as ramp control, open loop control or manual control.

Waveform:-

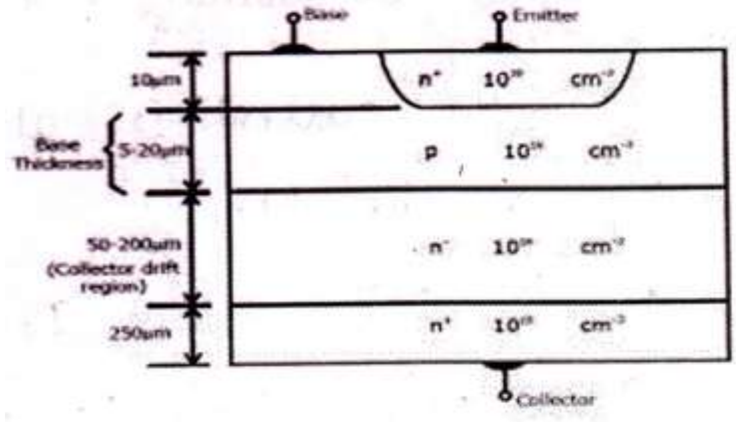


As the zener diode voltage V_z goes to zero at the end each half cycle, the synchronization of the trigger with supply voltage across SCRs is achieved. Thus the time t, equal to α/w. when the pulse is applied to SCR for the first time, will remain constant for the same value of R. The various voltage waveforms are shown in fig.

(e) Draw the labeled constructional diagram of NPN bipolar power transistor. State functions of various layers.

Ans:

Diagram:- **02M**



Function of Layers:- **02M**

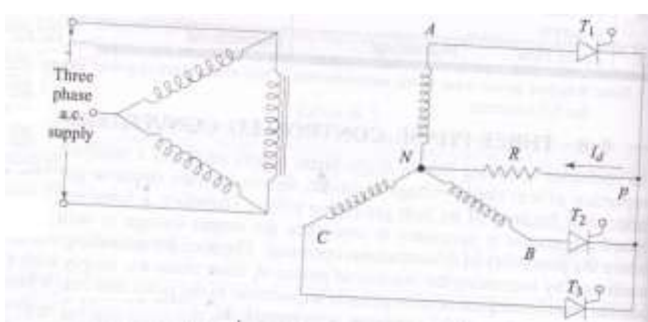
Fig. shows the doping level in each layer. The thickness of the different layer will have a significant effect on the characteristics of the device.

1) The emitter layer is heavily doped the base is moderately doped. The n region is known as the collector drift region and it is lightly doped. The n region is known as the collector drift region and it is lightly doped then n+ that terminates. The drift region has doping level similar to that of emitter. This n+ region serves as collector contact.
2) Due to the doping level the n drift layer will increase the voltage blocking capacity of the transistor. The width of this layer decides the breakdown voltage of power transistor.
3) The current gain β of a transistor depends on the base thickness. As the base thickness reduces the gain increases but the breakdown voltage of transistor will decrease. In power transistor high breakdown voltage is more important than high current gain. Therefore the base thickness much larger than that in the logic level transistor.

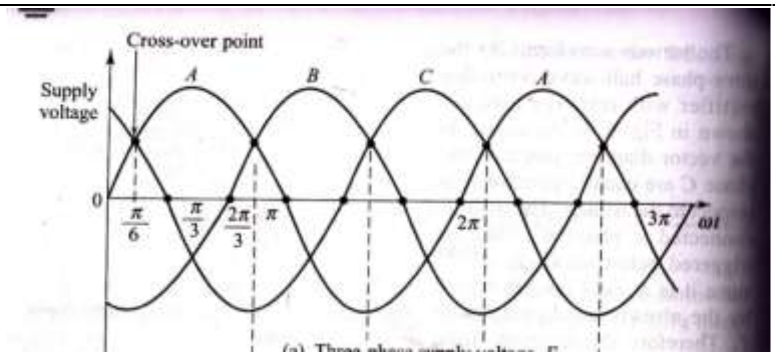
f) Draw the circuit of 3 – phase half wave controlled rectifier and draw its input and output voltages waveforms.

Ans:

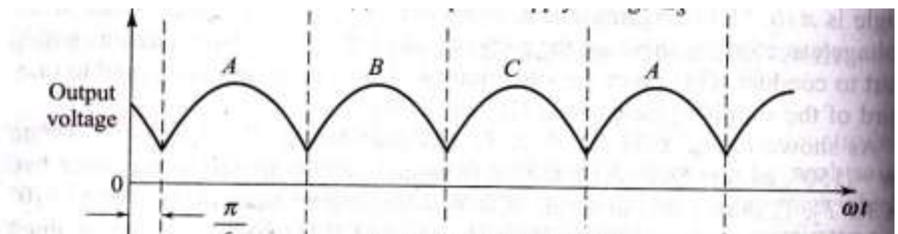
Diagram: - **02M**



Input waveform:- **01M**

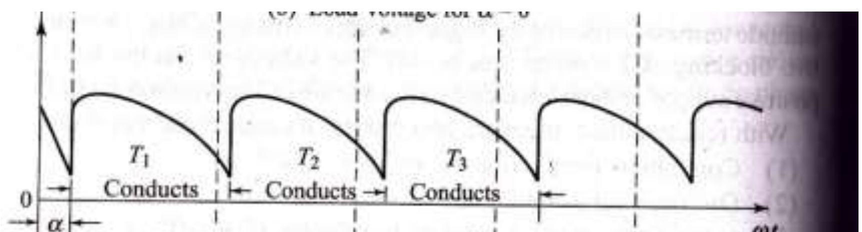


Output waveform:- **01M**



(b) Load-voltage for $\alpha = 0°$

OR



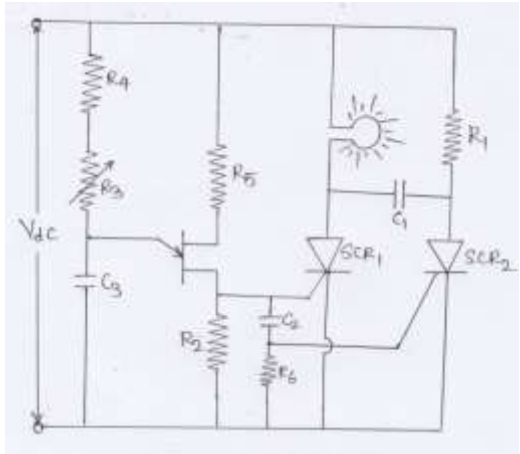
(c) Load-voltage for $0 \leq \alpha \leq \frac{\pi}{6}$ (continuous conduction)

Q6 Attempt any FOUR of the following: 16M

a) Describe the working of DC flasher circuit using SCR with neat diagram.

Ans: - **(Diagram 02M, Working 02M)**

Diagram:-



Working:-

The circuit consists of UJT relaxation oscillator and Class 'C' commutation circuit. UJT relaxation oscillator produces a train of pulses. It is directly applied to SCR_1 and it is delayed & applied to SCR_2. The delayed is decided by C & R_6.

Initially let SCR $_1$ is ON and lamp is On. Capacitor C_1 charges through R & SCR_1 to supply voltage V_{dc} .With the next trigger pulse SCR_2 will be turned ON. Now voltage across C_1 reverse biases SCR_1 & turns it off. Capacitor discharges through SCR_2 & charges in opposite direction. Since SCR_1 is reversed biased, it will not turn ON even if the gate pulse arrives. When the current through SCR_2 reduces below holding current, SCR_2 turns Off. A large R_1 reduces the current through $SCR_{2.}$

When next trigger pulse comes SCR_1 is turned On lamp glows again and capacitor C_1 gets charged though R_1 to develop commutating voltage for SCR_1.

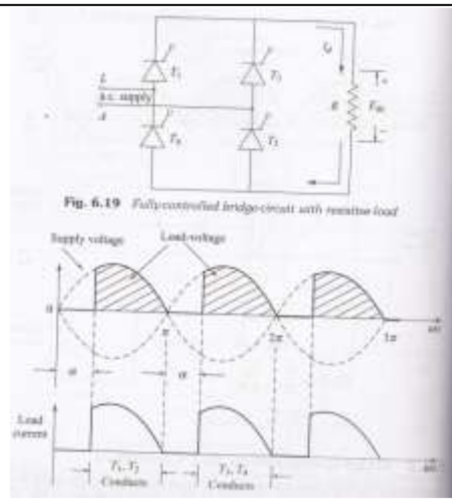
Switching of SCR_1 gives flashes from lamp. The flash rate depends on firing pulse frequency of UJT relaxation oscillator. Therefore by adjusting R_3, the required flash rate can be obtained.

b) Draw the circuit of single phase bridge controlled rectifier and explain its working with neat waveform.

Ans:- **(Diagram 02M, Waveform 01M, Working 01M)**

Note: - (Diagram and waveforms with any load e.g. R, RL can be considered also considered fully controlled or half controlled bridge rectifier)

Diagram:-



Working:-

During Positive Half:- When AC supply is applied during the positive half cycle the pair of SCRs i.e. T_1 & T_2 are forward biased and conduct. When triggered at an angle θ = α. This will continue till θ = α to θ = π.

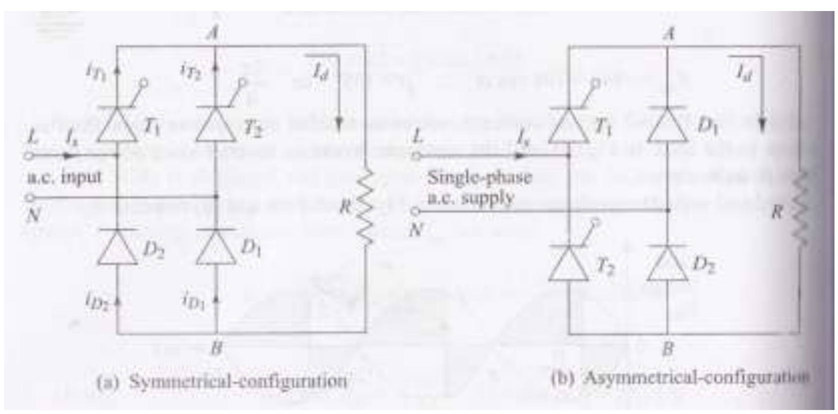
During Positive Half:-During negative half cycle T_3 & T_4 conduct simultaneously.

Average DC voltage is given by

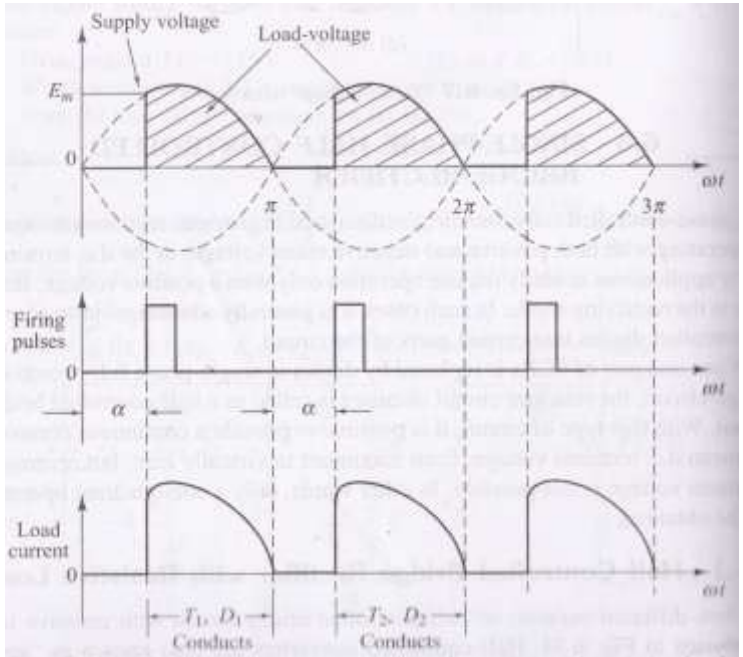
$$V_{dc}(avg) = \frac{V_m(1+cos\alpha)}{\pi}$$

OR

Diagram:-



Waveform:-

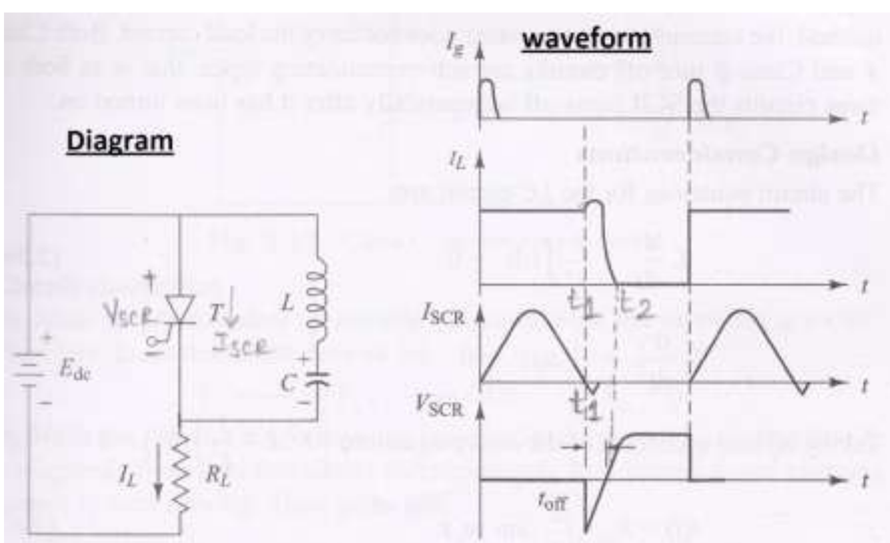


During positive half cycle Thyristor T_1 and diode D_1 are forward biased. Hence current flows through the path L-T_1-R-D_1-N. When SCR T_1 is triggered

During Negative half cycle thyristor T_2 and diode D_2 are forward biased. Hence current flows through N-T_2-A-R-B-D_2-L when SCR_2 is triggered

c) Draw circuit diagram of class B commutation of SCR and describe its working.

Ans:- **(Diagram 02M, Working 02M)**



Working:-

At $t < t_0$ **:-**

Since triggering pulse is not given SCR remains off and act like open switch but current still flows through C_L and R_L due to dc voltage +vin. This current charges the capacitor and V_c increases in positive direction i.e. top plate positive V_C opposes applied voltage V_{in} hence V_c becomes equal to V_{in} i.e. capacitor is fully charged this charging current automatically stops . Since SCR is off there is no path to capacitor to discharge. Hence this DC voltage across the capacitor is retrained by it.

At $t = t_0$ triggering pulse is given to the gate of SCR hence SCR becomes ON and voltage drop across it reduces to 1 to 1.5 V which can be neglected. At the applied voltage V_{IN} now appears across R_L and hence a constant dc current $I_R = V_{IN}/R_L$ flows through it. This is shown in the waveform. Now when SCR becomes on it act as a close switch and provides a path for capacitor to discharge. Hence energy from the capacitor is transferred to inductor L through On SCR. But because commutating circuit LC is under damped this is sinusoidal AC current. In the SCR both the current are flowing in same direction from top to bottom hence they are added and current flowing through SCR is given by $I_{SCR} = I_R + I_C$ as shown in the waveform of I_{SCR}.

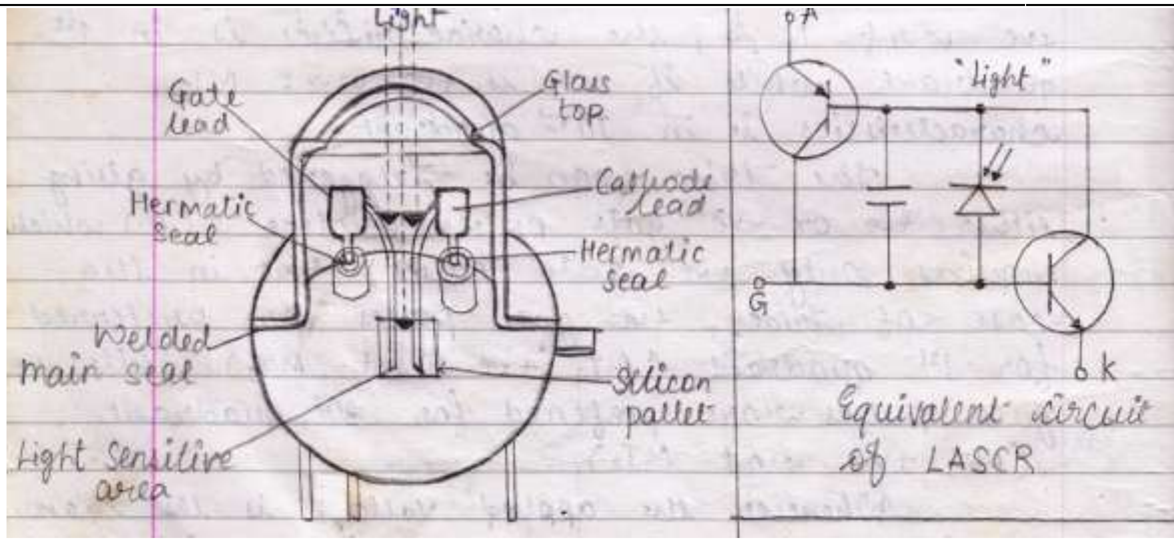
When all the energy of capacitor gets transferred to inductor the polarity of back emf on it changes with top end of inductor positive due to this current I_C still flows in the same anticlockwise direction. This still flows in the same anticlockwise direction. This current now charges the capacitor in reverse direction with its bottom plate positive. This voltage V_C is now more than V_{in} because energy from inductor is also given to it. When all the energy of inductor is transferred I_C now reverses its direction because charged capacitor acts like dc voltage I_C now starts flowing in clockwise direction due to which in SCR two current I_R & I_C are flowing in opposite direction. Hence as shown above I_{SCR} goes on reducing and become zero at $t = t_1$. Since $I_{SCR} < I_H$ SCR automatically goes off at $t = t_1$. Since $V_C > V_{in}$ SCR is reversed biased at this instant, which is shown in the waveform of V_{SCR}. At the same time at $t = t_1$ a small part of I_C is diverted to R_L. Hence there is a positive kink in the I_R at $t = t_1$.

Since SCR is now off the charged capacitor discharges through R_L. Hence reduces exponentially and become zero at $t = t_2$. As V_C reduces voltage across SCR goes on increasing in positive direction. The instant at which it become zero is shown on the waveform of V_{SCR} also commutation time T_C for which SCR is reverse biased is shown in the waveform for proper commutation to take place $T_C > T_{OFF}$ (off time for SCR) condition must be satisfied. When capacitor is fully discharged voltage across SCR now becomes $+V_{IN}$. This voltage remains $t = t_3$ when another triggering pulse is given to SCR and then all the waveform repeats themselves.

d) Draw constructional diagram of LASCR and describe its working principle.

Ans:- **(Diagram 02M,Working 02M)**

Diagram:-



Working:-

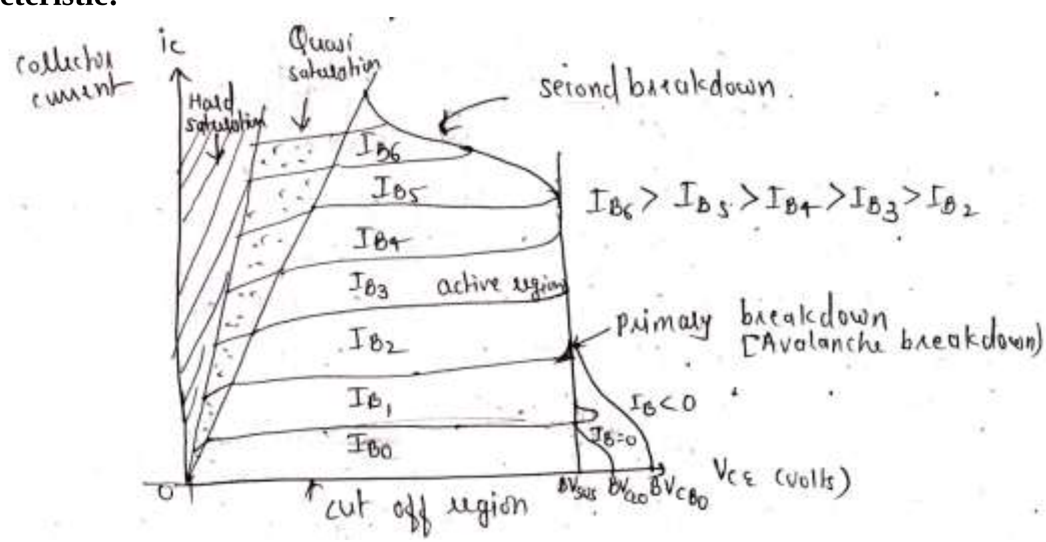
As shown in the transistor equivalent circuit, when the light energy increases the current in the reverse biased photo diode increases. Due to this current gain of both the transistor increases. When the net current gain exceed unity, SCR is automatically turned On. In this device also G can be used for turning On but it cannot be used for turning off. Thus even though light source is completely removed, once LASCR is ON, it cannot turn off LASCR.

The high sensitivity of LASCR causes it to respond to other effects, such as temperature, applied voltage and rate of change of applied voltage. It has a longer turn off time as compared to normal SCR.

e) Draw V-I characteristic power transistor. What is primary and secondary breakdown?

Ans:- **(V-I characteristic 02, primary break down 01M, secondary breakdown 01M)**

V-I Characteristic:-



Primary Break down:-

The breakdown due to the conventional avalanche break down of the collector base junction is known as primary break down.

Secondary Break down:-

As a large values of collector current the collector emitter voltage decrease. Therefore the collector current increases and there is a rise in power dissipation. Thus at higher levels of collector currents the allowable active region is further restricted by a potential failure mode called secondary break down.

f) List various commutation methods of SCR and draw class D commutation circuit.

Ans:- **(List commutation 02M, Diagram 02M)**

List of commutation:- (natural commutation and forced commutation)

i) Class A
ii) Class B
iii) Class C
iv) Class D
v) Class E
vi) Class F

Diagram:-