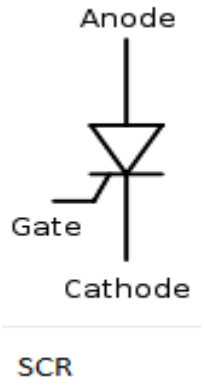
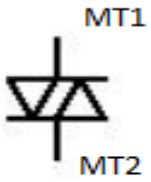
MODEL ANSWER

WINTER– 17 EXAMINATION

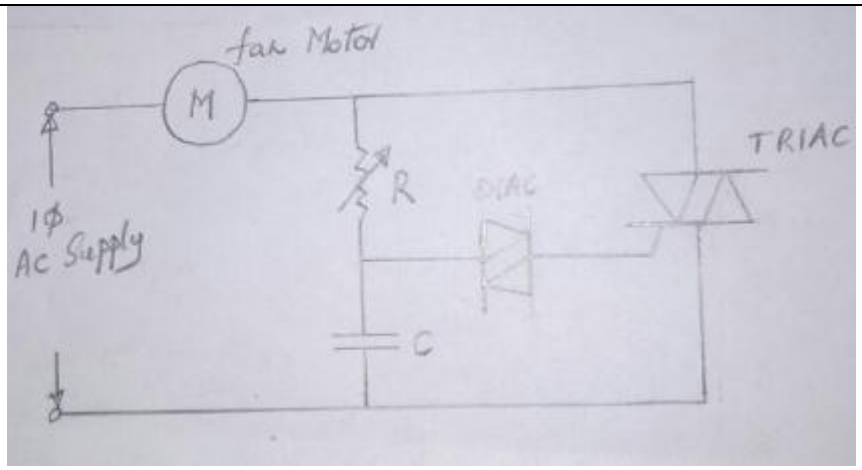
Subject Title: Power Electronics Subject Code: 17444

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 judgement 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.

Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1	(A)	**Attempt any SIX of the following :**	12-Total Marks
	a)	**Draw the symbols of (i) SCR (ii) DIAC**	2M
	Ans:	 SCR  DIAC	1M each
	b)	**State advantages of power transistor (any two)**	2M
	Ans:	1) It is very easy to turn ON and turn OFF the power transistor. 2) It can carry large currents in ON state and block very high voltage in OFF state. 3) It can be operated at switching frequencies in range of 10 to 15 kH_z. 4) ON state voltage drops across power transistor is low.	1M each
	c)	**Define holding and latching current.**	2M

	Ans:	**Holding current(I_H)**: Holding current may be defined as the minimum value of anode to cathode current below which the SCR stops conducting and returns to its OFF- state. **Latching current(I_L)**: latching current may be defined as the minimum ON – state anode to cathode current required to keep the SCR in the ON- state after the triggering pulse has been removed.	**I M each**
	d)	**Define chopper. State its types.**	**2M**
	Ans:	Chopper is a static device (switch) used to obtain variable DC from a source of fixed DC. **Types of chopper**: 1) Step-up chopper 2) Step-down chopper 3) Step up/down chopper	**Definition-1M** **Types-1M**
	e)	**List different turn-on methods of SCR.**	**2M**
	Ans:	**Turn – ON Methods of SCR:** 1) Forward voltage triggering 2) Thermal triggering 3) Illumination triggering 4) dv/dt triggering 5) Gate triggering a) DC voltage triggering b) AC voltage triggering c) Pulse triggering	**2M for correct answer**
	f)	**State the applications of inverter.**	**2M**
	Ans:	**Applications of inverter-** 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 drives 7) Regulated voltage and frequency power supplies	**Any four to be given 2M.**
	g)	**State the use of freewheeling diode in controlled rectifiers.**	**2M**
	Ans:	1) To prevent reversal of load voltage 2) To prevent transfer of reactive power from load to supply and hence to improve power factor of the circuit.	**1M each**
	h)	**Draw the circuit diagram of fan speed regulator using TRIAC.**	**2M**
	Ans:	**Circuit diagram-**	

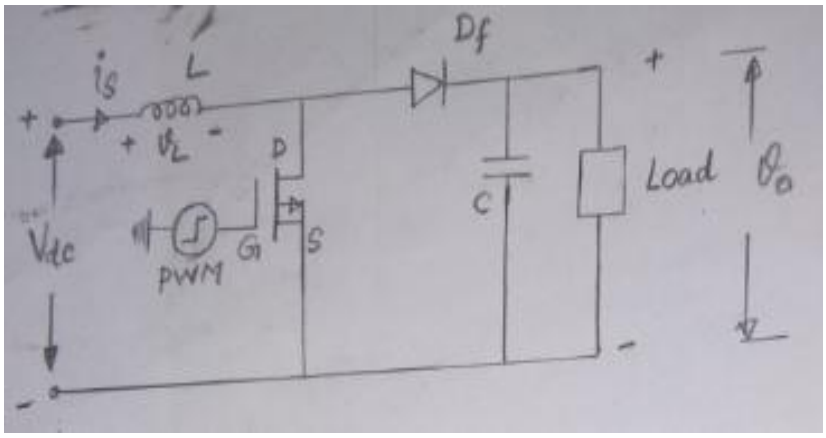


2M

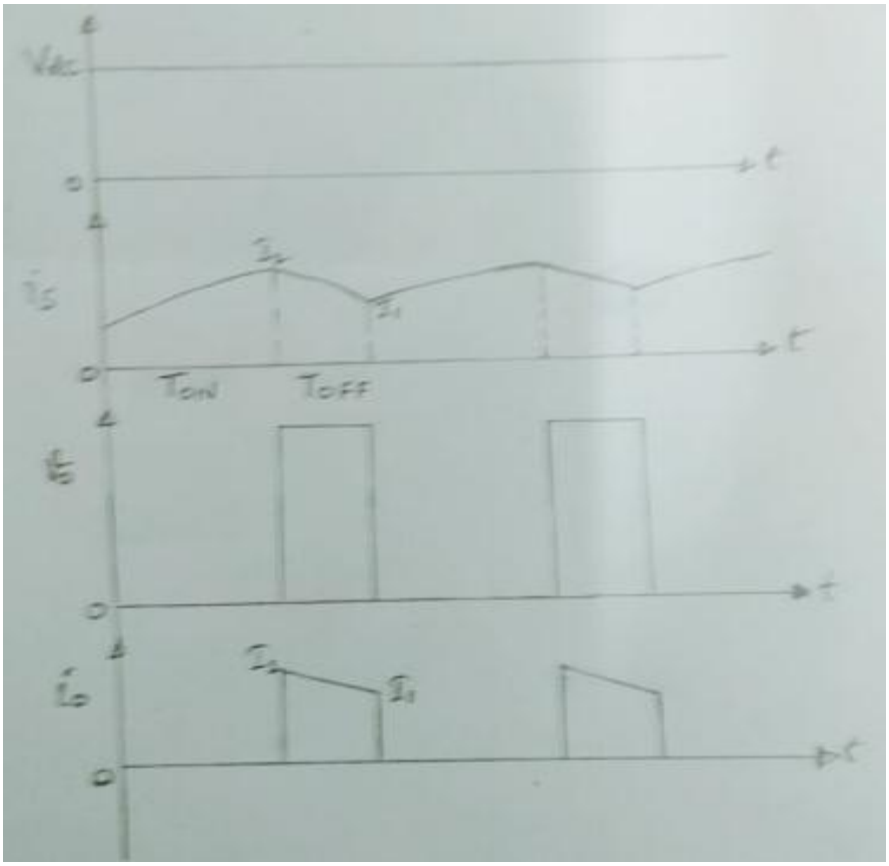
(B)	**Attempt any TWO :**	**8-Total Marks**
a)	**Compare controlled and uncontrolled rectifiers. (any four points)**	**4M**
Ans:		**1M each for any four.**

Parameter	**Controlled Rectifier**	**Uncontrolled Rectifier**
Device used	SCR and Diodes	Only Diodes.
Control of Load Voltage	Load voltage can be controlled.	Load voltage cannot be controlled.
Direction of Power Flow	Source to load and sometimes load to source	Source to load only.
Free Wheeling diode	Required for inductive load	Not necessary
Triggering circuit	Required.	Not required
Applications	DC motor controller, Battery charger.	Power supply

b)	**Draw the circuit diagram and waveforms of step up chopper using MOSFET.**	**4M**
Ans:	**<u>Circuit diagram:</u>**	**2M**

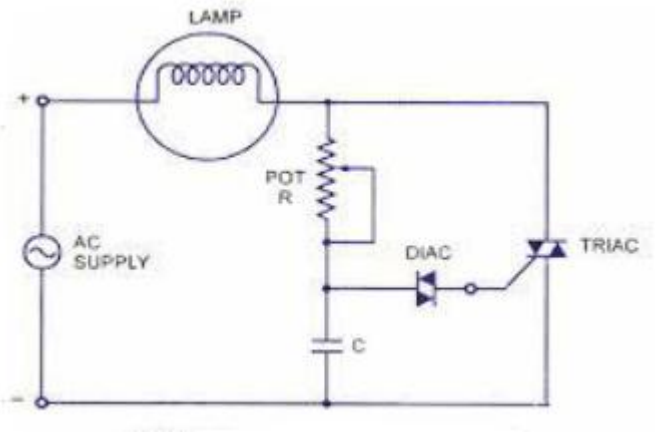
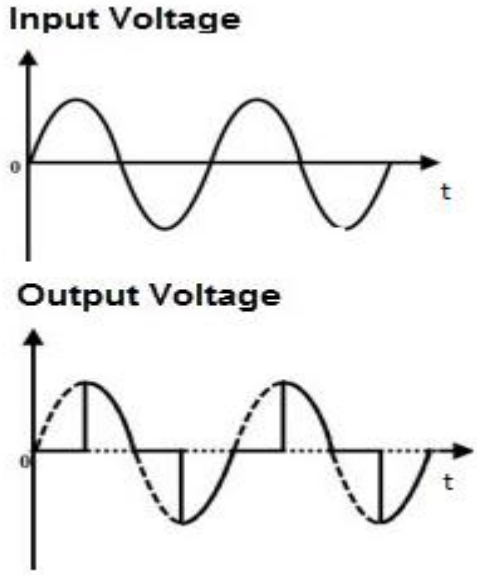
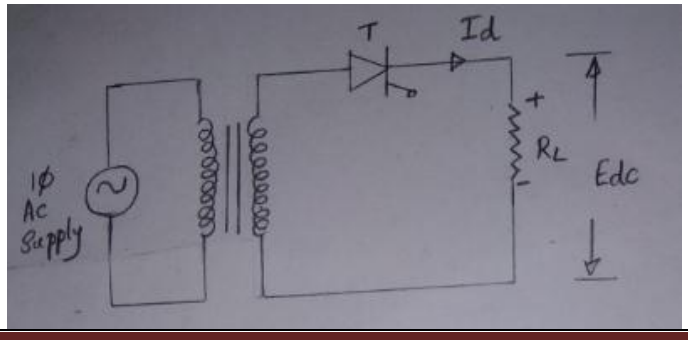


Waveforms:



2M

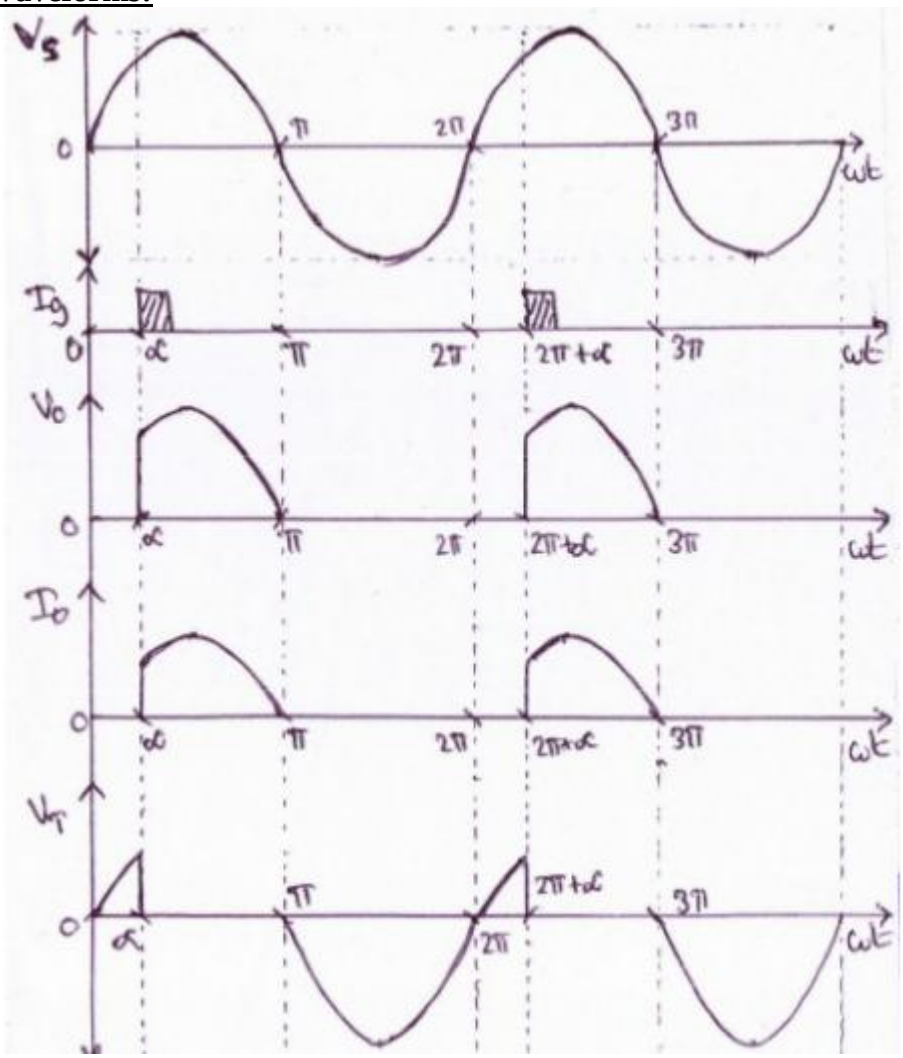
	c)	**Draw the circuit diagram of light dimmer using DIAC and TRIAC and sketch the input-output waveforms.**	**4M**

	Ans:	**Circuit Diagram:**  **Input-output Waveforms:** 	**2M** **2M**
Q 2		**Attempt any FOUR :**	**16-Total Marks**
	a)	**Draw the circuit diagram input-output waveforms and explain the working of single phase half wave controlled rectifier with R load.**	**4M**
	Ans:	**Circuit Diagram:** 	**1M**

Working:

During the positive half cycle of input voltage, the thyristor T is triggered at an angle of ωt = α. Now as the thyristor is ON, the load gets directly connected to the supply. During the negative half cycle, thyristor is reverse biased and is turned OFF. So the load gets voltage only during positive half cycle. The average value of the output voltage may be varied by varying the firing angle "α". As the load is resistive the current waveform will be identical to that of voltage waveform. **1M**

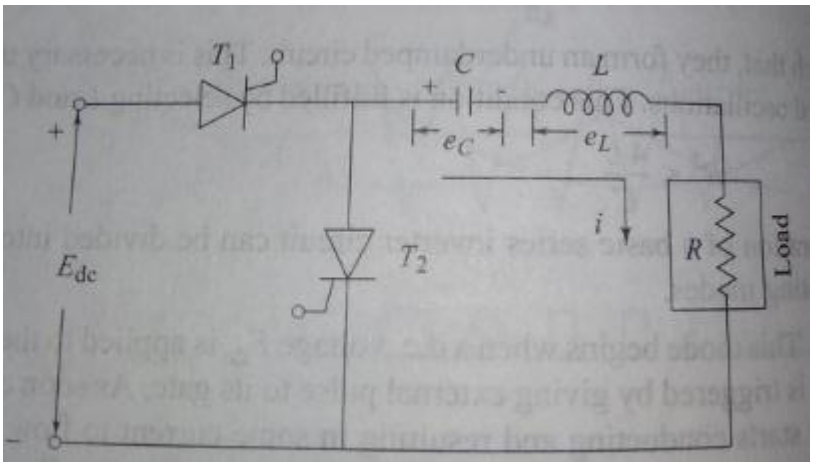
Waveforms:



2M

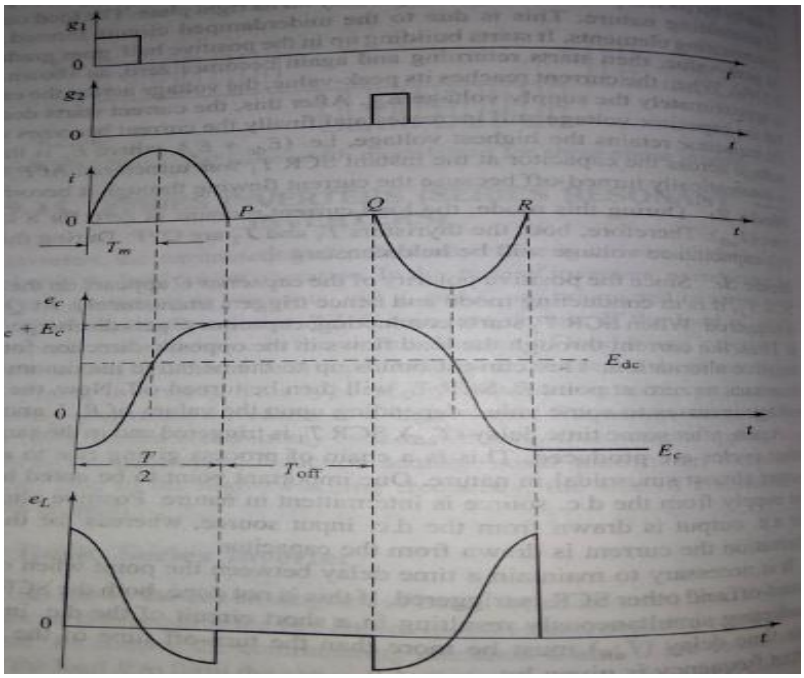
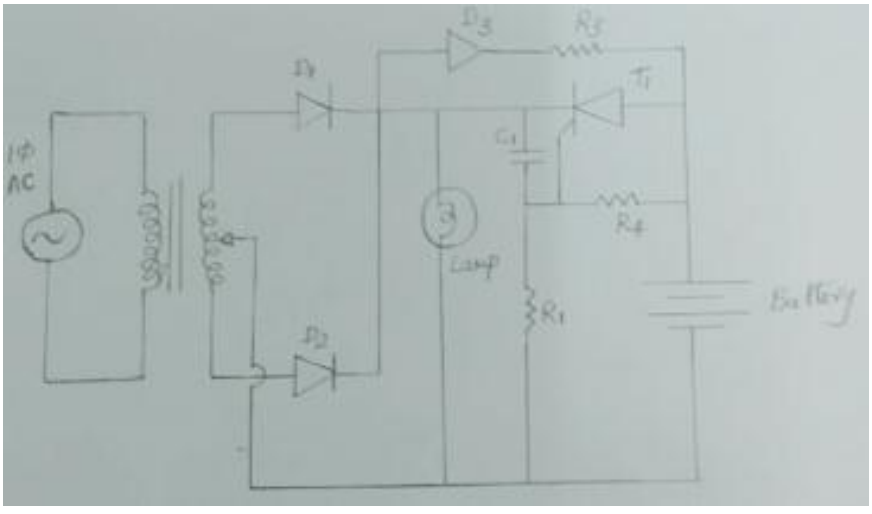
	b)	**Draw and explain the circuit diagram of series inverter with waveforms.**	**4M**
	Ans:		

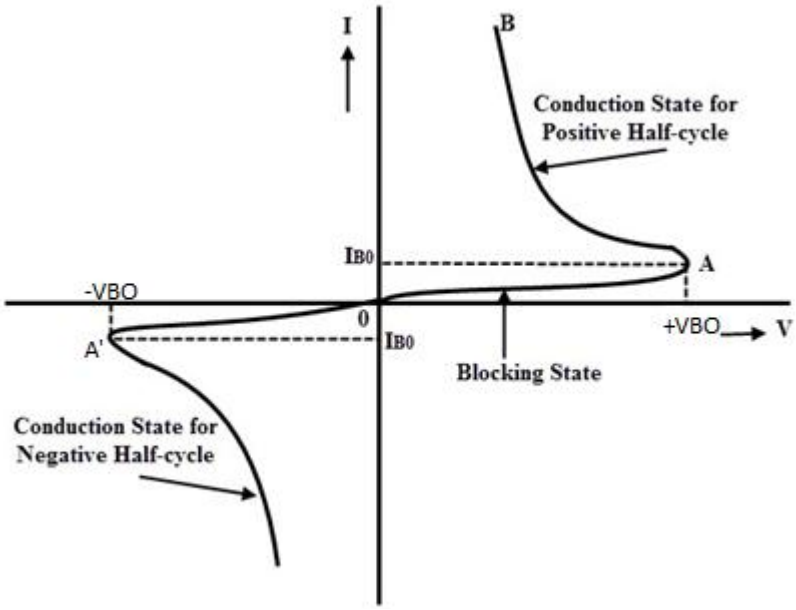
Circuit Diagram: **2M**

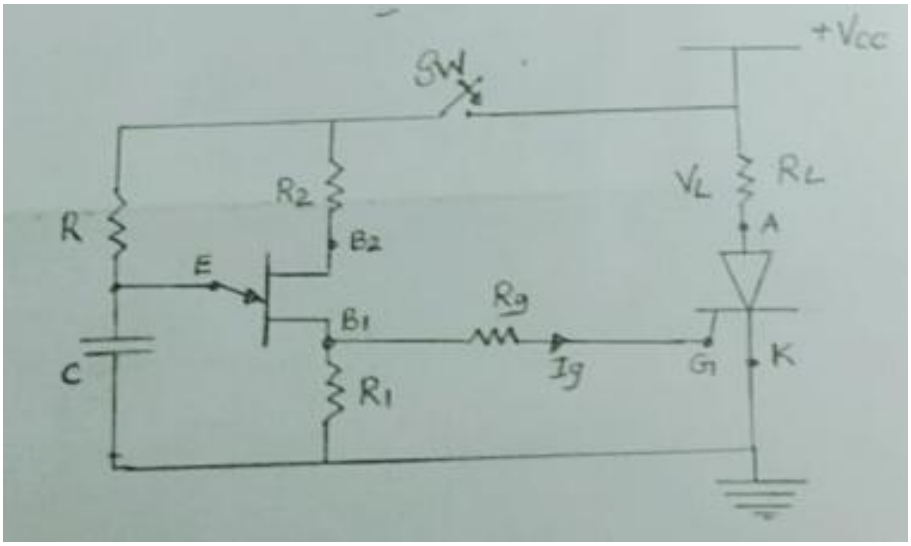


Description: **1M**

Fig. below shows the circuit of a series inverter. The commutating elements L and C are in series with the load forming an R-L-C resonating circuit. The value of L&C are chosen such that, they form an under-damped circuit. This is necessary to produce the required oscillations. This condition is fulfilled by selecting L & C such that, $R^2 < \frac{4L}{C}$. Cycling of output is achieved by alternately switching ON the thyristors T1 & T2. A time delay must be maintained between the point when one SCR is turned OFF and the other is turned ON to avoid a short circuit of the input source. This type of inverter produces an approximately sinusoidal waveform at a high output frequency.

		Waveforms: 	**1M**
	c)	**Draw the circuit diagram of emergency lighting system using SCR and describe its working.**	**4M**
	Ans:	**Circuit diagram:** 	**2M**
		Working: Fig. above shows a single source emergency lighting system. Voltage across C1 affects the ON/OFF control of the SCR. When the supply is ON, bulb is connected to it and will remain ON. Now the battery is charged to a voltage slightly lesser than	**2M**

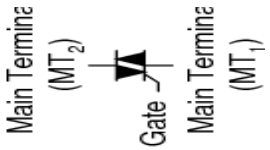
		the supply voltage. This will make T1 to reverse bias and is OFF. When supply fails, capacitor C1 discharges through D3–R3-R4-R1, until the anode becomes sufficient positive than cathode. At the same time the junctionR1 & R4 becomes positive and provide sufficient gate to cathode voltage to trigger SCR. As the SCR is ON the battery gets connected across the bulb making it ON. When the power returns to normal, as the cathode of T1 becomes more positive w. r to anode it reverse biases and get commutated disconnecting the battery.	
	d)	**Draw and explain the VI characteristics of DIAC**	**4M**
	Ans:	**<u>Description:</u>** The figure below shows the V-I characteristics of DIAC which indicates the current flow through the DIAC with respect to the voltage across it. As long as the voltage across the DIAC is within its break-over limits that is from –VBO to +VBO, the resistance offered by the DIAC is very high and only a small leakage current flows through the device (portion OA & OA') as shown in figure. Under these conditions DIAC operates as an open switch. The voltages +VBO and –VBO are the breakdown voltages which are generally in the range of 30 to 50 volts. Once the positive or negative applied voltage is more than the respective breakdown voltages DIAC start conducting. During the positive half cycle, at point A in the figure the DIAC begins to conduct and the voltage drop across the device becomes a few volts. The portion AB represents the conduction of DIAC. Conduction continuous until the device current falls below its holding current level. The holding current and break-over voltage values are identical for reverse and forward region of operation. The first and third quadrant characteristics represent the forward and reverse bias conditions of the DIAC. **<u>V-I characteristics-</u>**  	**2M** **2M**

	e)	**Explain SCR triggering using UJT with neat circuit diagram**	**4M**
	Ans:	**Circuit diagram:** 	**2M**
		Description: Fig. shows the basic circuit of SCR triggering using UJT. When the switch SW is closed at t = 0, capacitor voltage Vc = 0 and the UJT is in the OFF state. Now the capacitor starts charging and at Vc = Vp UJT turns ON. The UJT current I_E supplied by the capacitor flows through R_{B1} & R_1, discharging the capacitor. When Vc falls below the valley voltage Vv of the UJT, it turns OFF. This causes discharging of the capacitor to stop and starts charging again. This cycle continues till the switch SW is closed creating a train of pulses at B_1 and B_2. At B_1 a train positive pulses occur during the discharging of capacitor through UJT emitter. The first pulse occurs at "T" seconds after the switch is closed causing a sufficient gate current and the SCR turns ON. Once the SCR is ON subsequent pulses at its gate have no effect. The circuit may cause premature triggering of SCR if the voltage at B_1 is sufficient with UJT OFF. The requirement to avoid this is by following the below condition. $V_{B1(OFF)} < (I_g . R_g + V_g)$	**2M**
	f)	**Compare step up and step down chopper. (any four points)**	**4M**
	Ans:		**1M each**

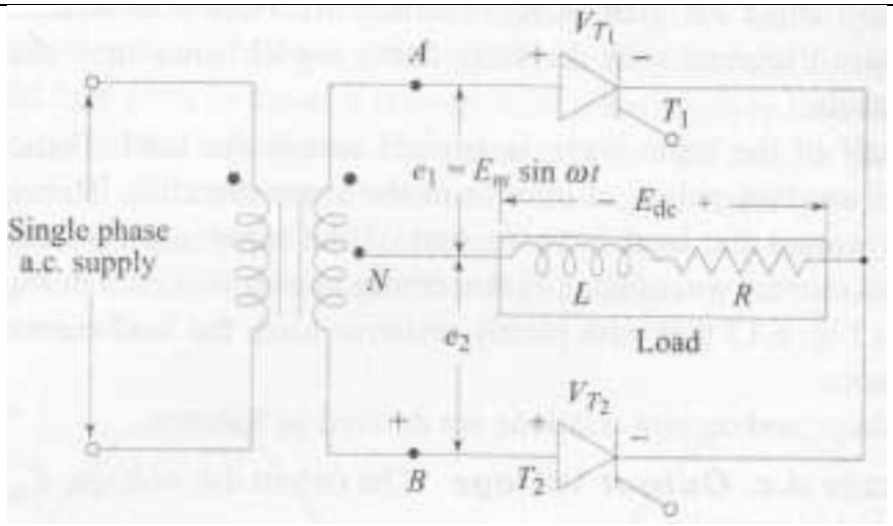
Parameter	**Step up chopper**	**Step down chopper**
Position of chopper switch	In parallel with load	In series with load
Output voltage	More than input voltage	Less than input voltage
Expression of	V_{dc} = Vs/(1-D) Volts	V_{dc} = D.Vs Volts

		output voltage	Where, D= Duty Cycle Vs= Input voltage	Where, D= Duty Cycle Vs= Input voltage
		Application	Battery charging, voltage booster	Motor speed control

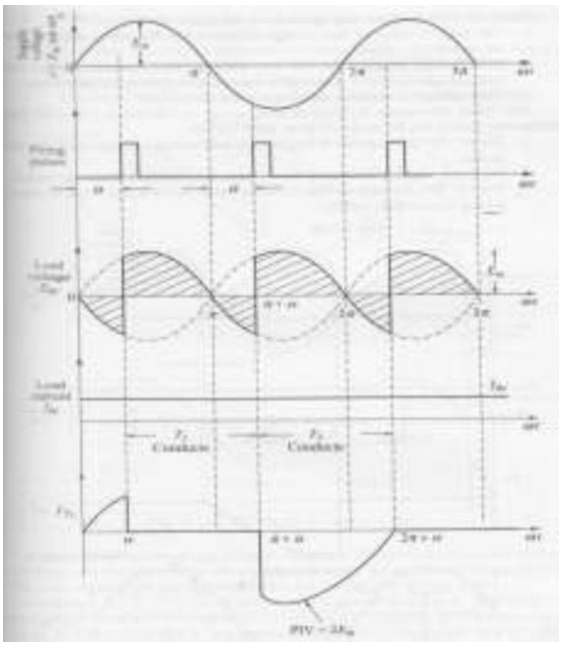
Q. 3		**Attempt any FOUR :**	**16-Total Marks**
	a)	**Compare SCR & TRIAC. (any four points)**	**4M**
	Ans:		**1M Each**

Sr.No.	**SCR**	**TRIAC**
1	 **Symbol**	**Symbol** 
2	It has 4 layers of Semiconductor.	It has 5 layers of semiconductor.
3	It is a unidirectional switch.	It is a bidirectional switch
4	Operates in 1st quadrant only	Operates in 1st and 3rd quadrant.
5	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

	b)	**Draw the neat circuit diagram and waveforms of single phase centre tapped full wave controlled rectifier with RL load.** **4M**
	Ans:	**Circuit Diagram-** **2M**

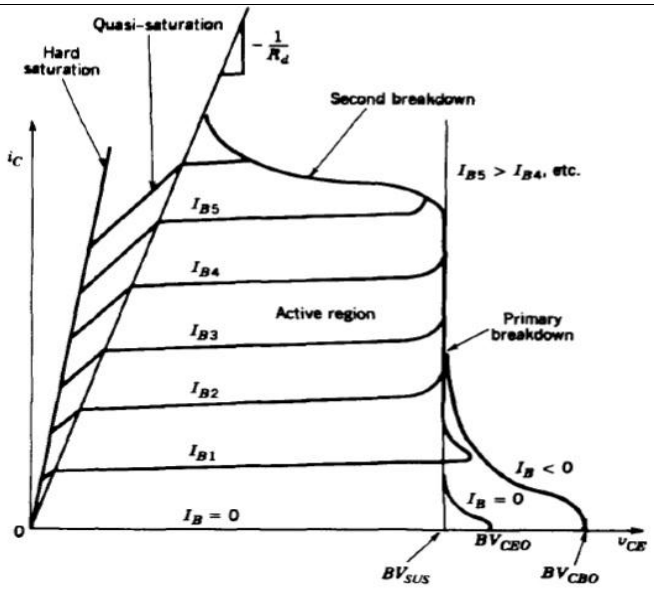
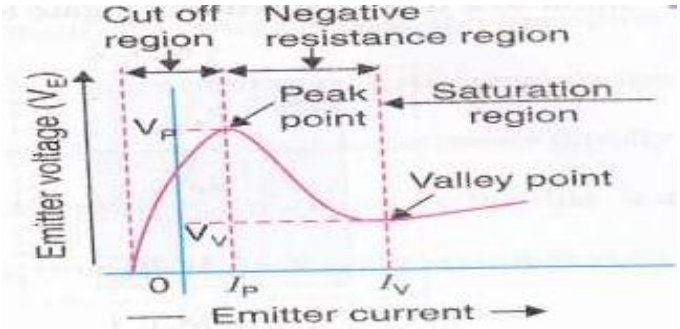


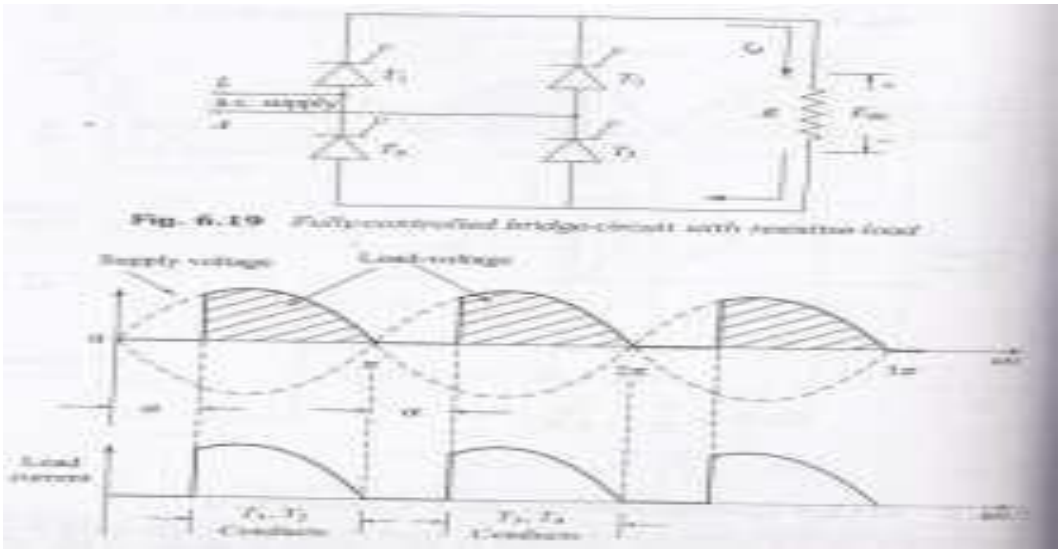
Waveform-

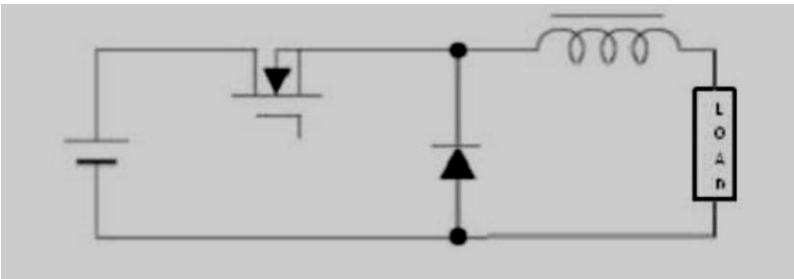
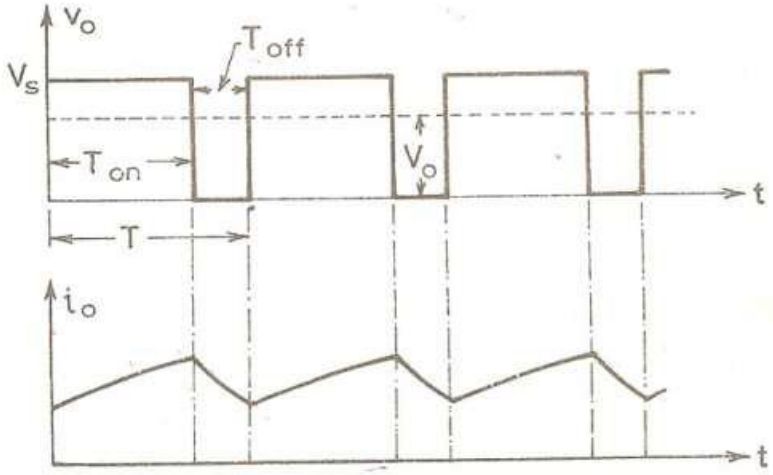


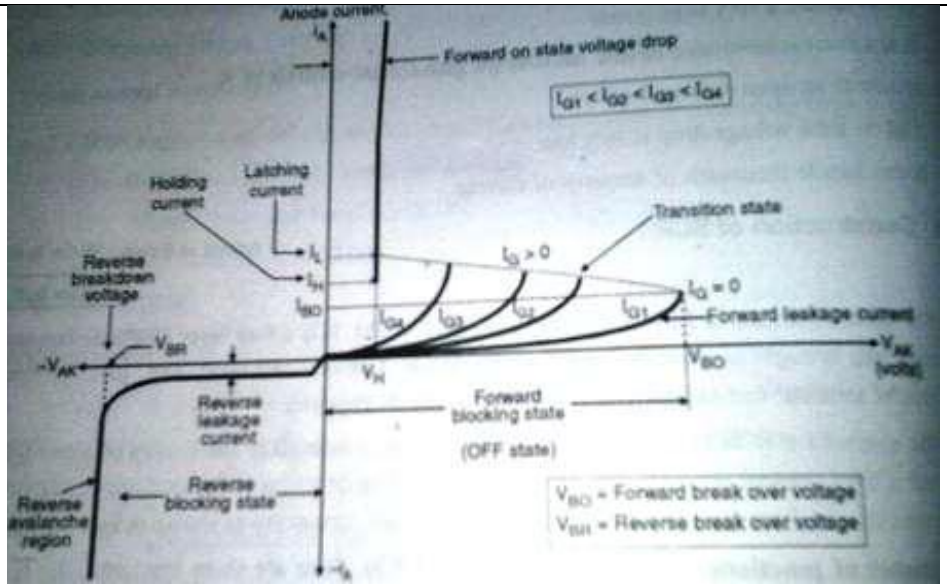
2M

	c)	**Draw and explain the VI characteristics of power transistor.**	**4M**
	Ans:		

		 There are four regions Cutoff region, Active region, quasi saturation and hard saturation. The cutoff region is the area where base current is almost zero. Hence no collector current flows and transistor is off. In the quasi saturation and hard saturation, the base drive is applied and transistor is said to be on. Hence collector current flows depending upon the load. The power BJT is never operated in the active region (i.e. as an amplifier) it is always operated between cutoff and saturation . The primary breakdown shown takes place because of avalanche breakdown of collector base junction. Large power dissipation normally leads to primary breakdown. The second breakdown shown is due to localized thermal runaway.	**2M** **2M**
	d)	**Draw and explain the VI characteristics of UJT.**	**4M**
	Ans:	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. **<u>Diagram-</u>** 	**2M**

		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.	**2M**
	e)	**Draw the circuit diagram of single phase fully controlled bridge rectifier with R load. Draw the waveforms of input and output voltage.**	**4M**
	Ans:		**2M** **2M**
	f)	**Describe the need of polyphase rectifier.**	**4M**
	Ans:	**Polyphase Rectifier:** 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. Ripple factor decreases rapidly with an increase in the number of phase. Poly phase rectifier gives smooth direct current. Low harmonics in the input supply current .Number of phases are more due to that average output can be more & hence output power is also more. High ripple frequency therefore small filters can be used.	**4M**
Q. 4	**A)**	**Attempt any FOUR :**	**16-Total Marks**

	a)	**Draw the circuit diagram and waveforms of step down chopper and explain it.**	**4M**
	Ans:	**Diagram:** 	**1M**
		Working: 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 ton and switching off period t off . Equation of the output voltage is, Vo = Vdc. α, where α is the duty cycle.	**2M**
		Waveform: - 	**1M**
	b)	**Draw and explain the VI characteristics of SCR.**	**4M**
	Ans:	**Diagram-**	**2M**



Explanation-

Forward Blocking mode:

When anode is at a higher potential than cathode, thyristor is said to be forward biased, It is seen from the figure that when the gate circuit is open J1 and J3 are forward biased and junction J2 is reverse bias.

In this mode a small current, called forward leakage current flows from anode to cathode.

Forward Conduction mode:

When anode to cathode forward voltage is increased with gate circuit open, reverse biased junction J2 will have an avalanche breakdown at a voltage called forward breakover voltage VBO .

After this breakdown, thyristor gets turned ON.

Reverse Blocking mode:

When cathode is made high potential with respect to anode with gate open, then the SCR is said to be reverse biased.

J1 and J3 are reverse biased and J2 is forward biased.

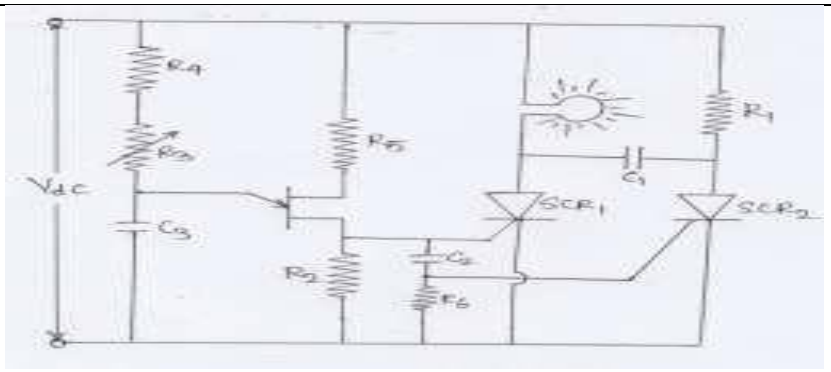
A small current flows through the SCR this is called as reverse leakage current.

This is reverse blocking mode, called the OFF state of the SCR.

If the reverse voltage increased, then at reverse breakdown voltage VBR, an avalanche breakdown occurs at J1 and J3 and the reverse current increases rapidly

2M

	c)	**Describe the working of DC flasher circuit using SCR with neat diagram.**	**4M**
	Ans:	**Diagram-**	**2M**

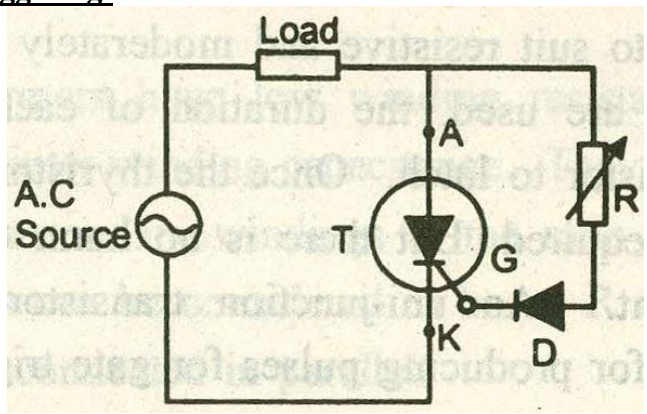


Working:-

- 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.

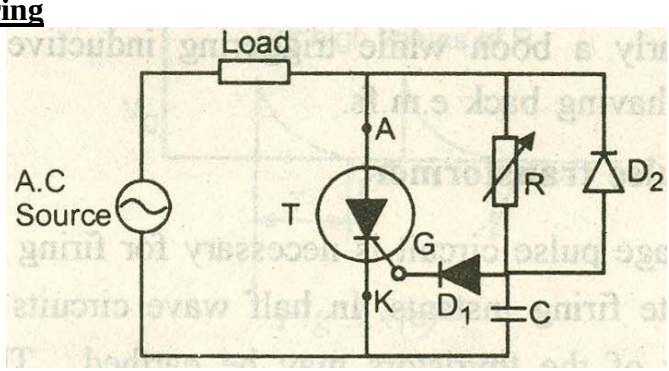
2M

	d)	**Draw the neat block diagram of gate triggering. State the advantages of gate triggering.**	**4M**
	Ans:	**(i)Resistance triggering:**	**2M**

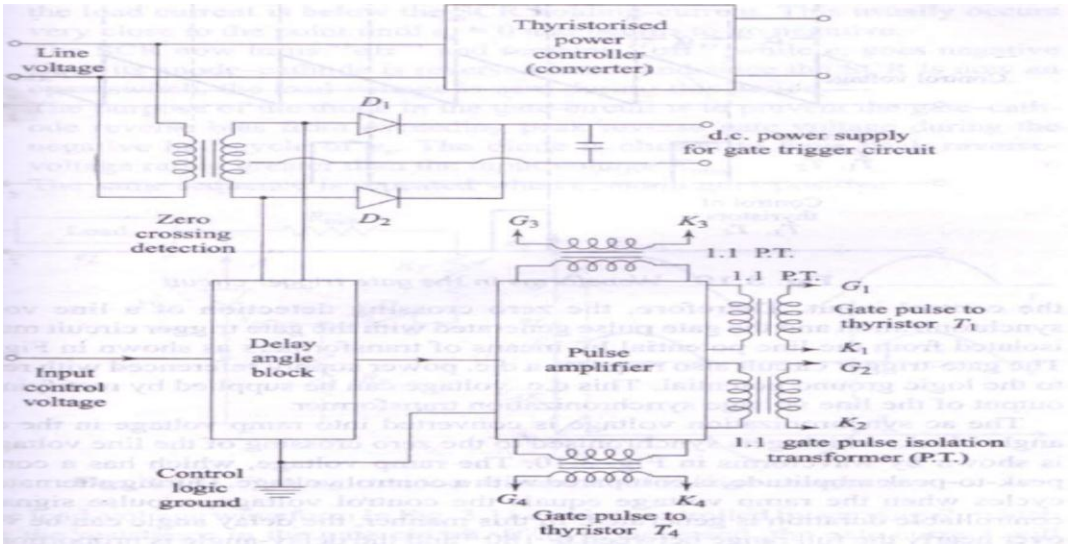


OR

(ii) RC Triggering



OR

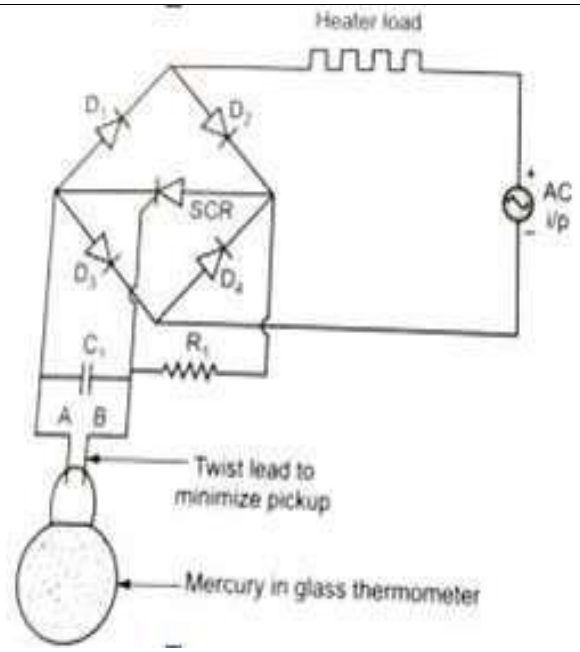


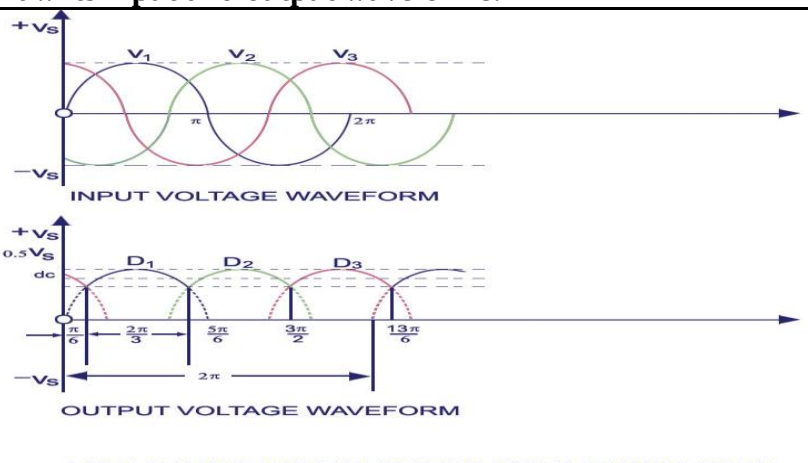
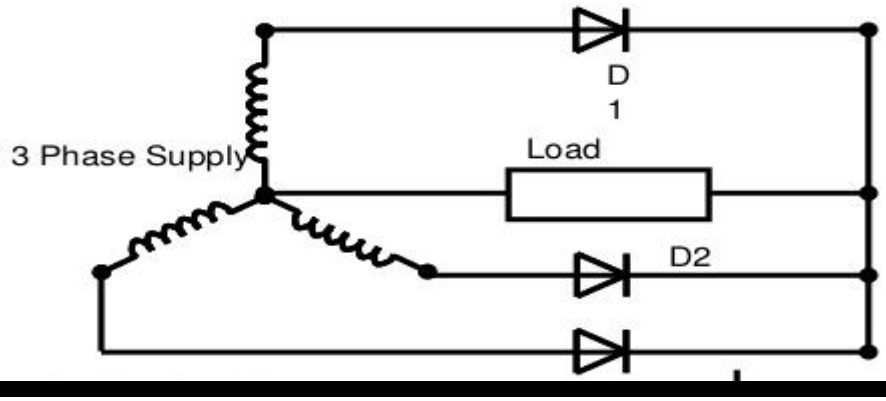
Advantages-

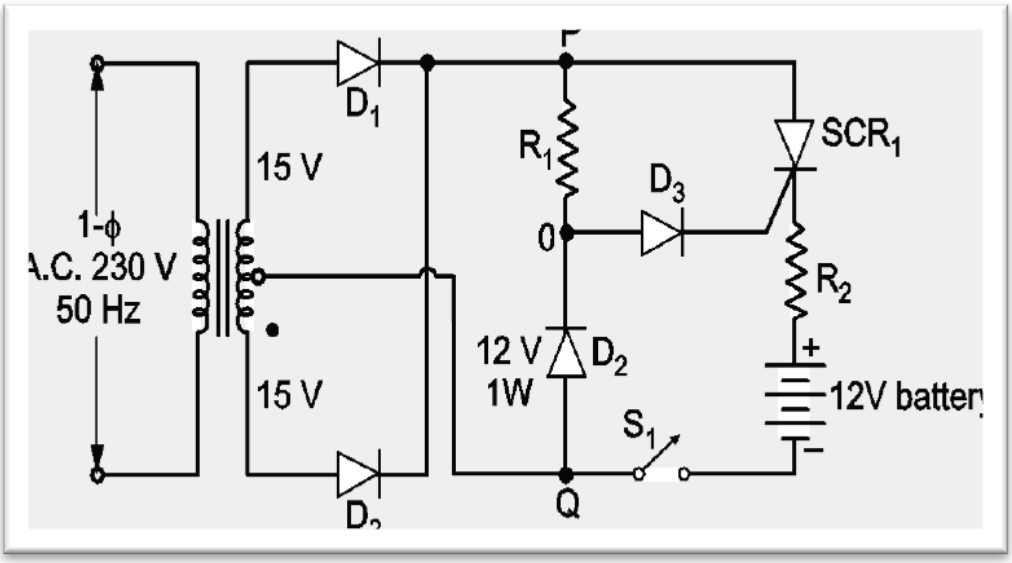
- Positive gate voltage or gate current
- Maximum Permissible gate power dissipation P_{GM}
- There are maximum and minimum limits for gate voltage and gate current to prevent the permanent destruction of junction J3 and to provide the realizable triggering.
- The gate signal can be ac or dc or a sequence of high frequency pulses.

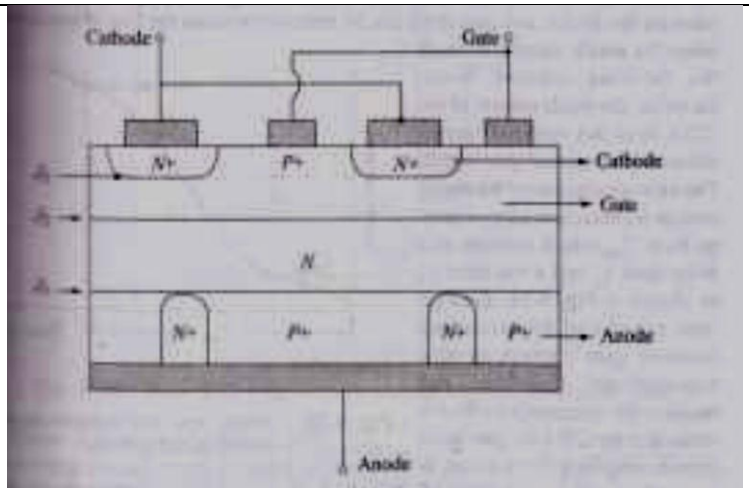
2M

	e)	**Draw the circuit diagram of temperature controller using SCR with neat circuit diagram.**	**4M**
	Ans:		**4M**



	f)	**Draw the circuit diagram of three phases half wave uncontrolled rectifier. Draw its input and output waveforms.**	**4M**
	Ans:	 3-PHASE HALF-WAVE RECTIFIER VOLTAGE WAVEFORM 	**2M** **2M**

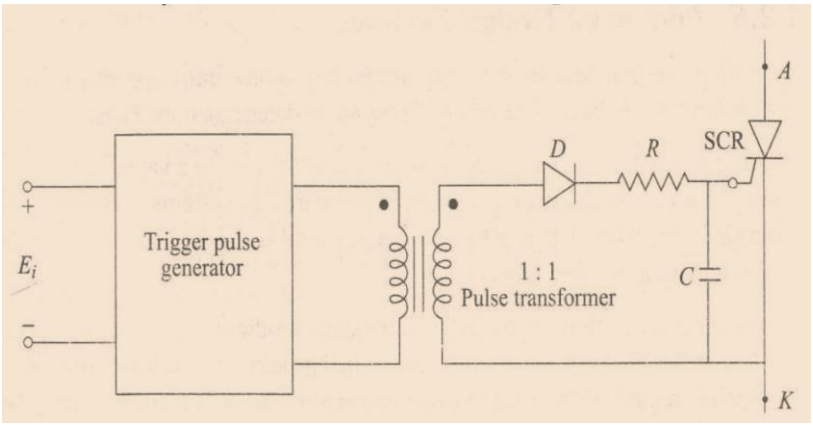
Q.5		**Attempt any FOUR :**	**16-Total Marks**
	a)	**Draw and explain the battery charger using SCR.**	**4M**
	Ans:		**2M**
		Explanation : **Automatic battery charging circuit using SCR is shown in figure** A 12 V discharged battery is connected in the circuit. The single-phase 230 V supply is stepped down to (15-0-15) V by a centre-tapped transformer. Diodes D1 and D2 form full-wave rectifier. Due to this, the pulsating d.c. supply appears across the terminals P and Q. 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 O rises to sufficient level so as to forward bias diode D_3 & gate – cathode junction of SCR1 , the gate pulse is provided to SCR1 and it is turned ON. When SCR1 is turned ON, the charging current flows through the battery. Thus, during each positive half-cycle of pulsating d.c. supply, voltage across P-Q, SCR1 is triggered and charging current is passed till the end of that half-cycle. Due to the zener diode Dz, the maximum voltage of point O is held at 12 V. Due to the charging process, the battery voltage rises and finally attains full value of 12 V. Thus, when the battery is fully charged, the cathode of SCR1 is held at 12 V. Therefore diode D3 anode voltage & cathode voltage becomes 12 V & hence D3 and gate-cathode junction of SCR1 cannot be forward biased, since the potential of point O can reach upto 12 V. Hence, no gate-current is supplied and SCR1 is not triggered. In this way, after charging further charging is automatically stopped.	**2M**
	b)	**Draw the construction of GTO & explain the working principle.**	**4M**
	Ans:	**Diagram: -**	**2M**

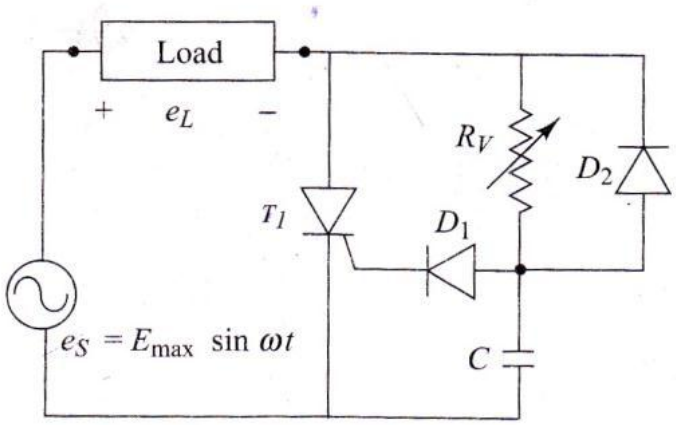


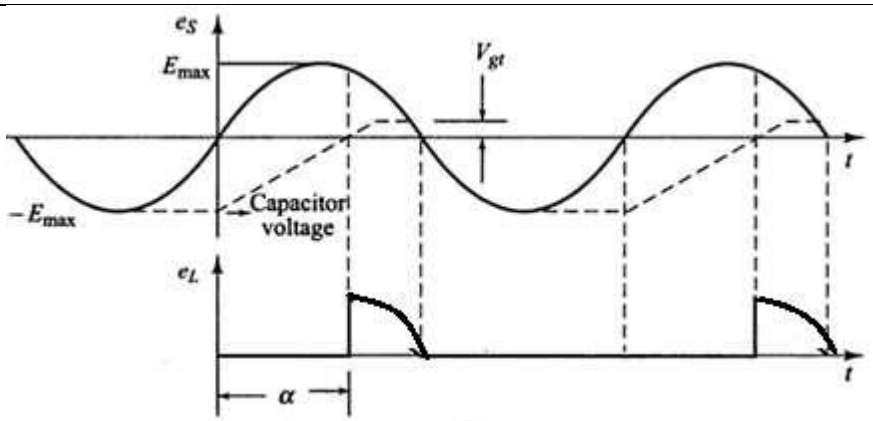
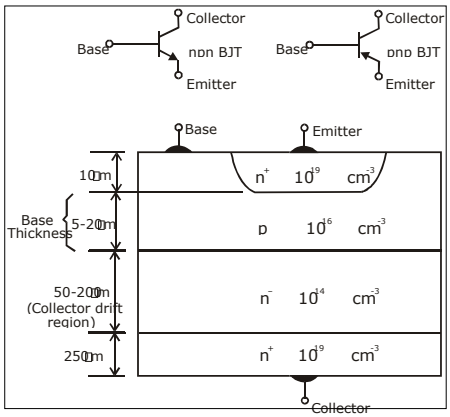
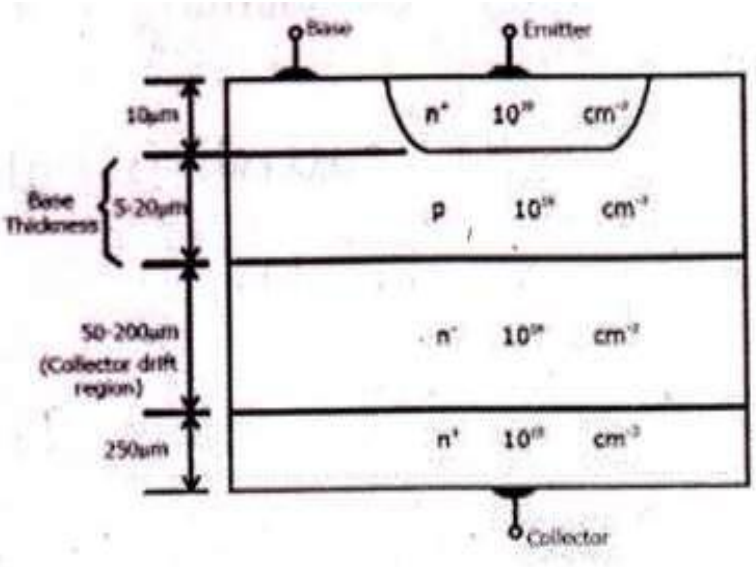
Working :

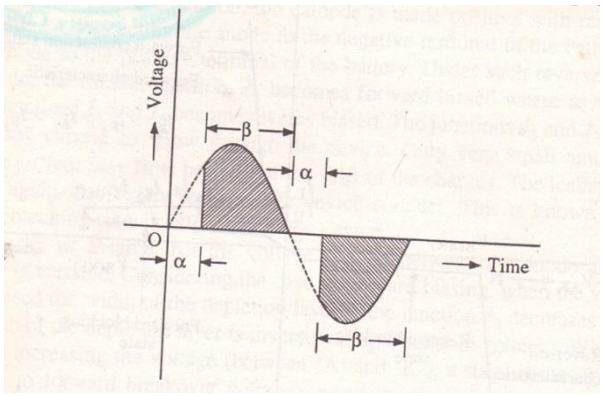
- The turn ON operation of GTO is similar to a conventional thyristor. When the anode terminal is made positive with respect to cathode by applying a positive gate current, the hole current injection from gate forward bias the cathode p-base junction.
- This results in the emission of electrons from the cathode towards the anode terminal. This induces the hole injection from the anode terminal into the base region. This injection of holes and electrons continuous till the GTO comes into the conduction state.
- To turn OFF a conducting GTO, a reverse bias is applied at the gate by making the gate negative with respect to cathode. A part of the holes from the P base layer is extracted through the gate which suppresses the injection of electrons from the cathode.
- In response to this, more hole current is extracted through the gate results more suppression of electrons from the cathode. Eventually, the voltage drop across the p base junction causes to reverse bias the gate cathode junction and hence the GTO is turned OFF.

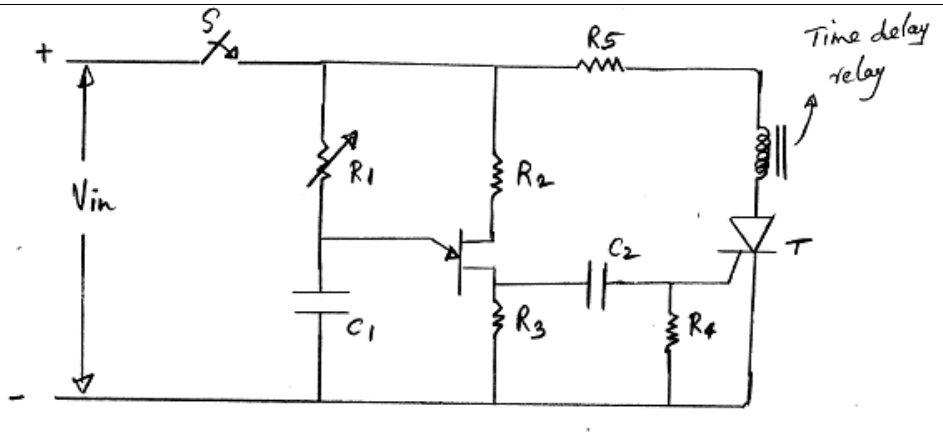
2M

c)	**Describe the operation of pulse transformer used in triggering circuits.**	**4M**
Ans:	 Pulse transformers are often used to couple a trigger pulse generator to a thyristor in	**2M**

		order to obtain electrical isolation between the two circuits. The transformers commonly used for thyristor control are either 1:1 two winding or 1:1:1 three winding types. Figure shows a complete output circuit to fire a thyristor correctly. The series resistor R either reduces the SCR holding current or balances gate current in a three winding transformer connected to two SCRs. The series diode D prevents reverse gate current in the case of ringing or reversal of the pulse transformer output voltage. The diodes also reduce holding current of the SCR. In some cases where high noise levels are present it may be necessary to load the secondary of the transformer with a resistor to prevent false triggering.	**2M**
	d)	**Explain RC triggering circuit with neat circuit diagram & waveforms.**	**4M**
	Ans:	**Circuit diagram-**  **Description:** The triggering angle control limitation of the resistance triggering circuit (R triggering) can be overcome by the -resistance-capacitance (RC) triggering circuit. The figure shows the RC-half wave trigger circuit. The conduction period can be controlled over the full 180° range. By varying the value of Rv, the trigger can be controlled from 0 to Π 1. During the positive half cycle, the capacitor C charges to the trigger voltage of the thyristor in a time determined by the RC time constant and the applied anode voltage. 2**.** During the negative half cycle, the capacitor charges to the peak supply voltage at t = (-Π/2). After this period, the supply voltage decreases and reaches zero at t = 0.During this period the capacitor voltage becomes positive during the positive half cycle of the ac input, the capacitor begins to charge through the variable resistance Rv, in the opposite direction and as soon as it charges to a positive voltage equal to the gate trigger voltage, the thyristor turns ON. Here the diode D1 is used to prevent the negative voltage between the gate and the cathode through the diode D2 during the negative half-cycle **Waveform:-**	**1 ½ M** **1 ½ M**

			**1M**
e)	**Draw the symbol & vertical structure of power transistor and explain.**		**4M**
Ans:	**Symbol-**   **Explanation-** 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	**Symbol-1M, vertical structure-1.5 M**

		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.	**1.5M**
	f)	**Define firing angle and conduction angle. What is the effect of firing angle on average output voltage?**	**4M**
	Ans:	**Firing angle (α) -** The angle of sine wave at which SCR is turned ON is called as firing angle . It is denoted by **α** & it varies from 0 to 180^0 **Conduction angle (β) –** The angle at which SCR remains in conduction state is known as its conduction angle. . It is denoted by **β** **β =π-α** ***Note: waveform optional***  **Effect of changing α** : Output voltage of controlled rectifier is inversely proportional to firing angle . As α is 0° then output voltage of rectifier is maximum and when α is 180° then output voltage of rectifier is minimum. As firing angle α increases output DC voltage of rectifier decreases.	**Each definition 1M,Effect 2M**
Q.6		**Attempt any FOUR :**	**16-Total Marks**
	a)	**Draw and explain the C of electronic timer using SCR.**	**4M**
	Ans:	**Diagram-**	**2M**



Explanation-

Electronic timer are actually a time delay relay , which provide a delayed switching action between the time an event is initiated and the time the event is actually performed. **2M**

Fig. shows the basic electronic timer circuit using UJT & thyristor to switch a control relay ON and OFF.

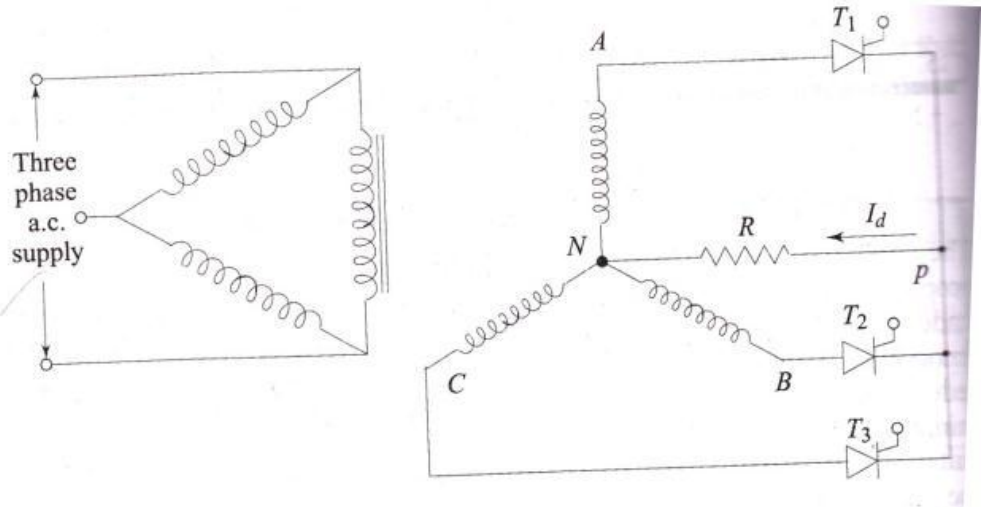
R1 & C1 = RC network

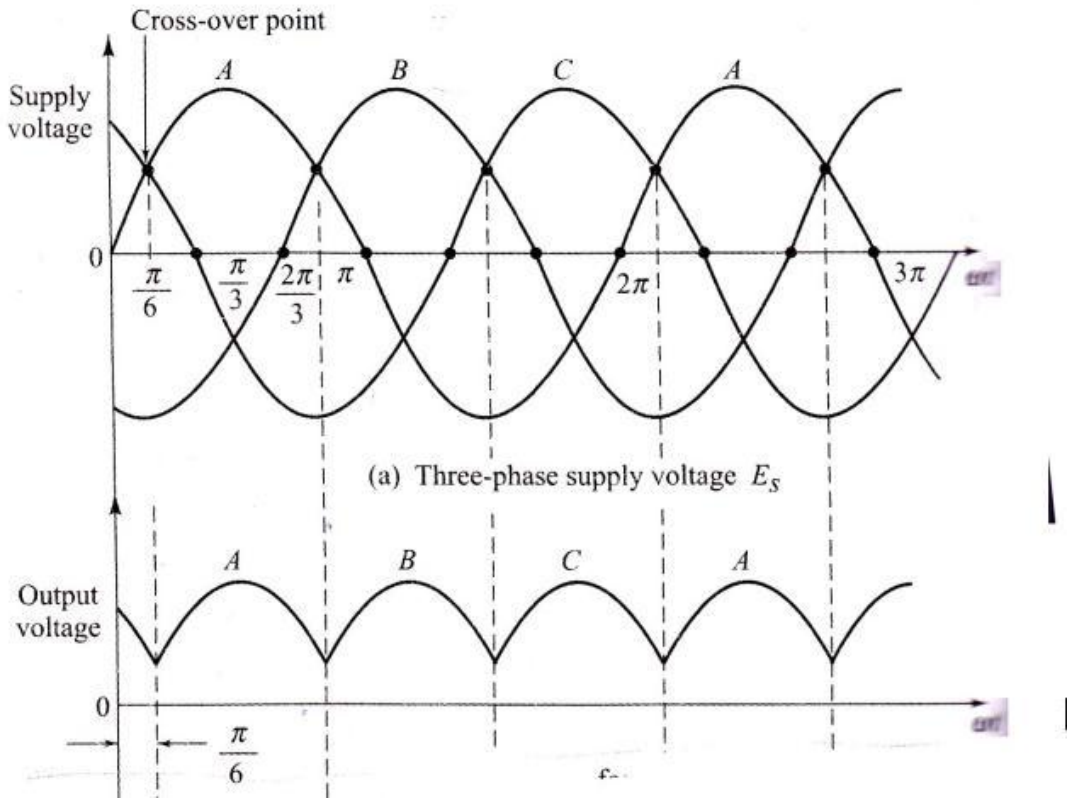
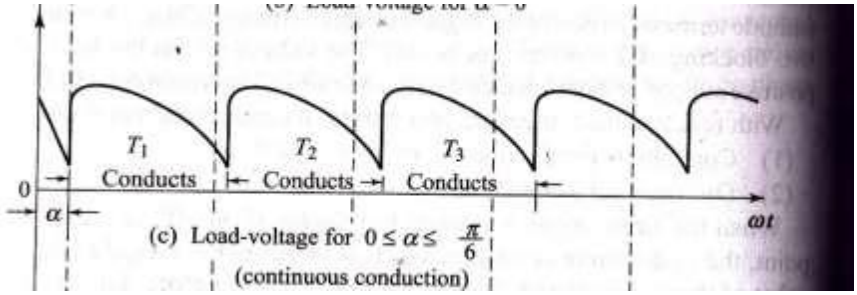
When the switch s is closed, the capacitor C1 begins to charge until the current at the emitter of the UJT is sufficient to switch the UJT on. This produces a trigger pulse to the thyristor T1 and latches the control relay.[i.e relay is energized]

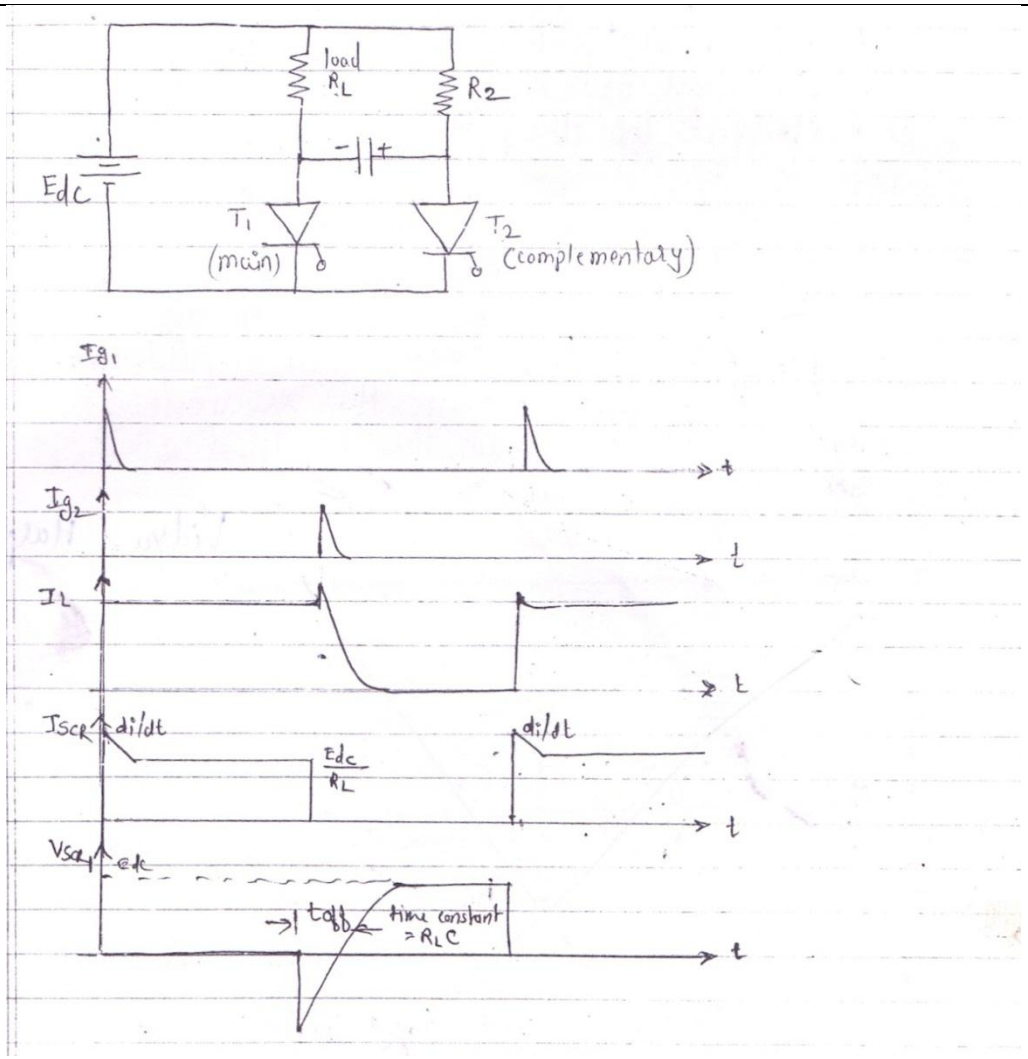
By varying the value of the resistor R1 and the Capacitor C1 , the time delay of the relay can be delayed or advanced .

This is the simplest type of electronic timer that uses a charging rate characteristics of a capacitor whose charging / discharging depends on the size of the capacitor and resistor.

b)	**Draw the circuit diagram of three phase controlled half wave rectifier with R load. Draw its input and output waveforms.**	**4M**
Ans:	**Circuit diagram-**	**2M**



		Waveform-  **OR** **Output waveform-**  	**2M**
	c)	**Draw & explain the class C commutation with neat circuit diagram and waveforms.**	**4M**
	Ans:	**Circuit diagram-**	**2M**



1M

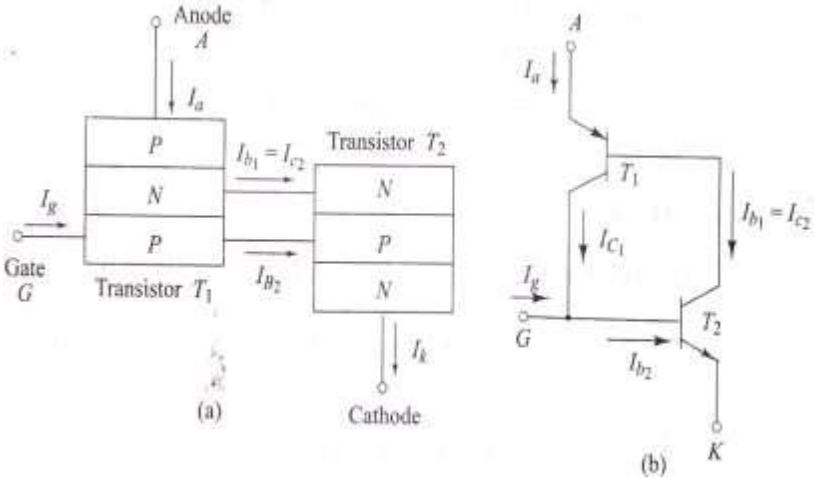
Description:

Here complementary thysistor T_2 is connected in parallel with the main thysistor. Initially both the thysistors are OFF when a trigerring pulse is applied to the gate T1,the transistor T1 is trigerred .therefore current starts flowing 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 troerring 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 causes reverse bias voltage across the main thyristor T_1 & immediately turns it off.

1M

d)	**Draw and explain the two transistor analogy of SCR.**	**4M**
Ans:	**Diagram:-**	**2M**



Working:- **2M**

The operation of an SCR can be explained in a very simple way by considering it in terms of two transistors.

The SCR can be considered as an npn & pnp transistor, where the collector of one transistor is attached to the base of the other & vice versa. This gives net gain of loop circuit as β1xβ2 are where β1xβ2 are current gains of two transistors respectively.

The collector current of transistor T1 becomes the base of transistor T2 & vice versa &

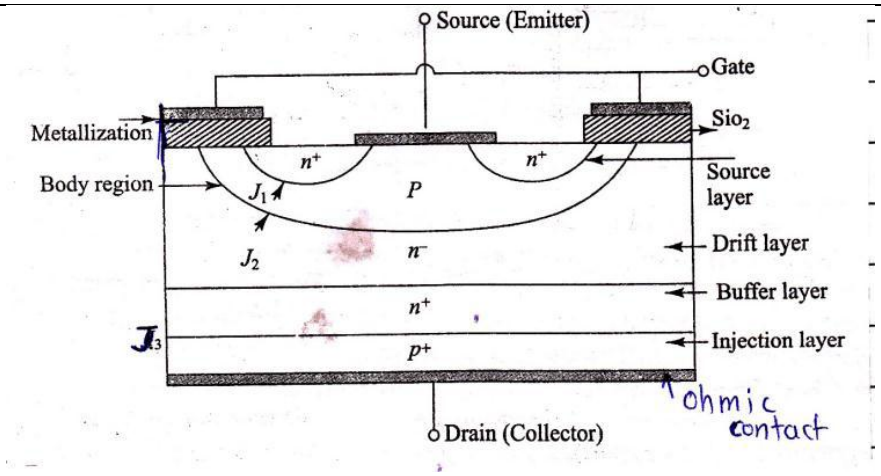
Ic1= Ib2

Ib1=Ic2

When the gate current is zero or the gate terminal is open , the only current in circulation is the leakage current , which is very small. Under these conditions P-N-P-N device is said to be in its forward blocking or high impedance off state .

As soon as a small amount of gate current is given of transistor T2 by applying forward bias to its base emitter junction it generates the collector current as β2 times the base current. This collector current of T2 is fed as input base current toT1 which is futher multiplied by β1 times the base current i.e collector current of transistor T2 In this way both transistors feedback each other and the collector current of each goes multiplying . This process is very quick & soon both the transistors drive each other into saturation. Now the device is said to be in on-state from the OFF-state. This characteristic of the device is known as its regenerative action.

e)	**Describe the construction of IGBT.**	**4M**
Ans:	**Constructional diagram-**	**2M**



Explanation-

Basic structure of IGBT:- **2M**

- Vertical cross section of n channel IGBT is Shown in the figure.
- Vertically oriented structure is used to maximize the area available for the current flow. This will reduce the resistance offered to the current flow and hence the on-state power loss taking place in the device.
- These IGBT uses highly inter digitated gate source structure in the order to reduce the possibility of source / emitter current crowding.
- The vertical cross- section of IGBTis shown in the figure.
- IGBT have 4 alternate p-n-p-n layers with three terminals, ex. Emitter, collector & gate or source, drain & gate.
- A heavily doped p+ substrate (injection layer) has a lightly doped n-type drift region grown on to it by the epitaxial process.
- Then the p type emitter is diffused with 2 subsequent n-type layers over doping n-type layers over doping windows .
- Two SIO2 layers are then deposited & deposition of the metal or polysilicon layer on them forms an interconnected gate
- From this, figure , it is clear that the emitter to collector path is basically a p-n-p bipolar structure, therefore , these performance of an IGBT is closer to that of a BJT rather than a MOSFET.

f)	**Define commutation. List various types of commutation.**	**4M**
Ans:	**Definition-** Commutation: The process to turn off conducting SCR is called commutation.	**1M**
	Types of commutation:- (natural commutation and forced commutation) i) Class A- Self commutation by resonating the load ii) Class B- Self commutation by an LC circuit iii) Class C- Complementary commutation	**3M**

		iv) Class D- Impulse or auxiliary commutation v) Class E- External pulse commutation vi) Class F- AC line commutation	