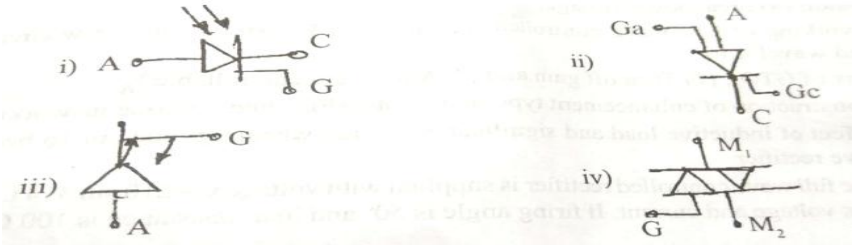
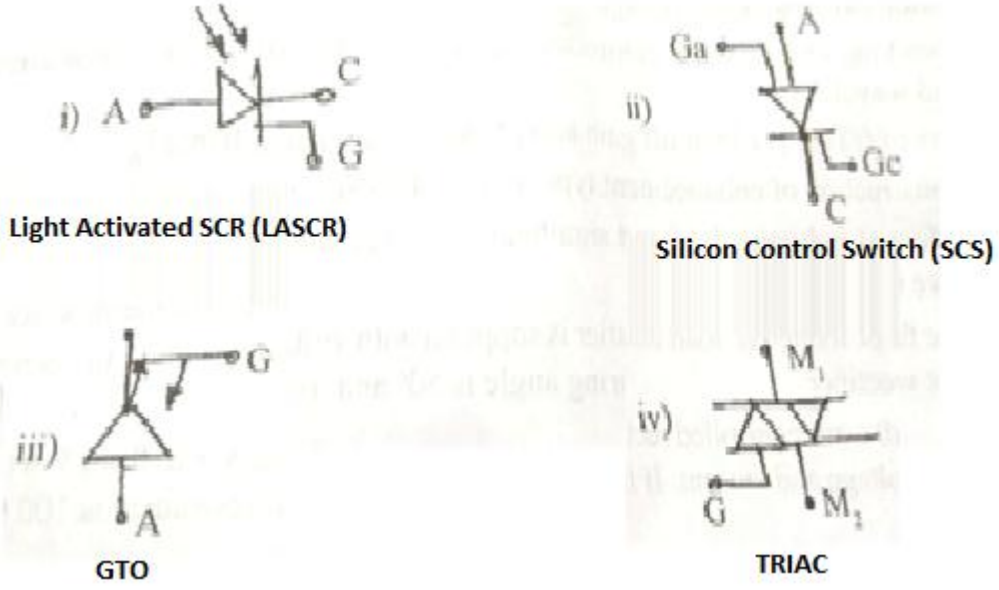
WINTER– 18 EXAMINATION

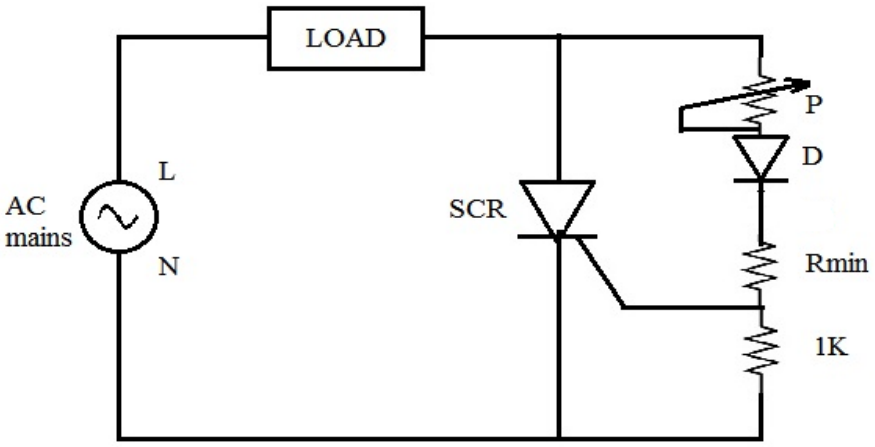
Subject Name: Power electronics **Model Answer** **Subject Code:** 17444

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues 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.

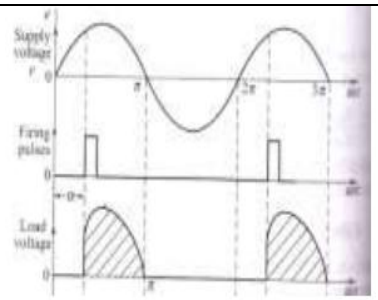
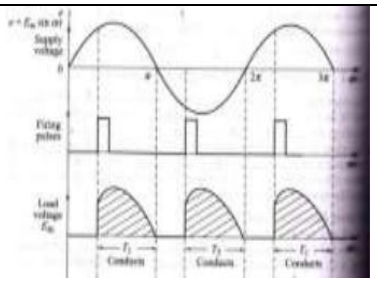
Q. No.	Sub Q. N.	Answers	Marking Scheme
1	**(A)**	**Attempt any SIX of the following:**	**12- Total Marks**
	(a)	**Name four layer Thyristor family devices (Any two devices).**	**2M**
	Ans:	(Consider any two names from following) 1. SCR: Silicon Controlled Rectifier 2. PUT: Programmable Uni-junction Transistor 3. LASCR: Light Activated Silicon Controlled Rectifier 4. SBS: Silicon Bilateral Switch. 5. SUS: Silicon Unilateral Switch. 6. SCS: Silicon Controlled Switch 7. GTO: Gate Turn Off Thyristor	**Each device:** **1M**

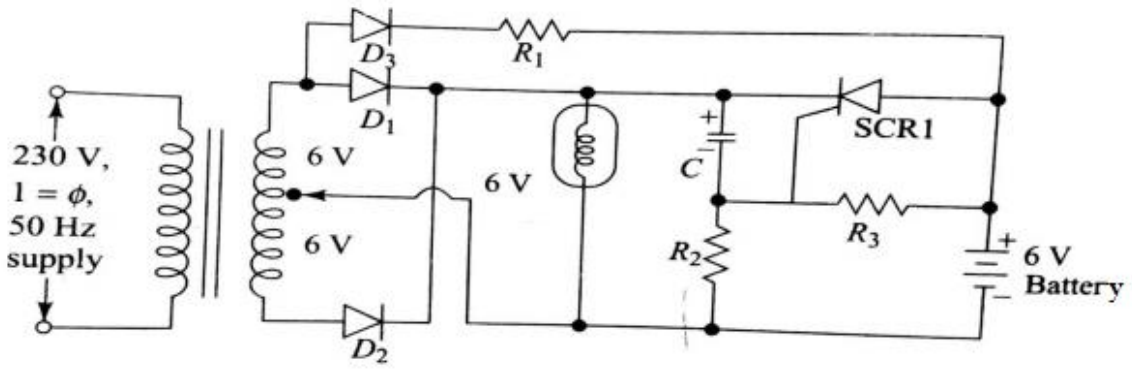
	(b)	**List any two uses of IGBT.**	**2M**
	Ans:	Applications Of IGBT: 1. Inverters. 2. Choppers. 3. SMPS (Switching Mode Power Supply). 4. Un-interrupted Power Supply (UPS). 5. Speed Control of DC and Ac Motors. 6. Resistance welding system.	**Any two applications: 2M** **Each application:1M**
	(c)	**Identify the given symbols of Thyristor family devices:** 	**2M**
	Ans:		**Each symbol Identification: 1/2 M**

	(d)	**List any two applications of inverter.**	**2M**
	Ans:	Applications of inverters 1. Variable speed AC motor drives. 2. Induction heating. 3. Aircraft power supplies. 4. Uninterrupted power supplies (UPS). 5. High voltage DC transmission lines. 6. Battery vehicle drives. 7. Regulated voltage and frequency power supplies	**Any two applications:2M** **Each application:1M**
	e)	**Draw resistance triggering circuit of SCR.**	**2M**
	Ans:	**Resistance triggering circuit of SCR:** 	**Diagram :2M**
	f)	**Define chopper. Classify.**	**2M**
	Ans:	**Definition of Chopper**: Chopper is a circuit used to obtain variable D.C voltage from a source of fixed D.C **Classification:** 1) **Depending on level of output voltage:**	**Definition of Chopper : 01M** **(Any one**

		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	**classification) 01M**
	g)	**State any two applications of controlled rectifiers.**	**2M**
	Ans:	Applications of Controlled Rectifiers: 1. Rectifiers. 2. Regulated Power Supply. 3. Static Switches. 4. Motor Speed Control. 5. Battery Charger and heat control.	**Any two applications:2M** **Each application:1M**
	h)	**List any two advantages of SMPS.**	**2M**

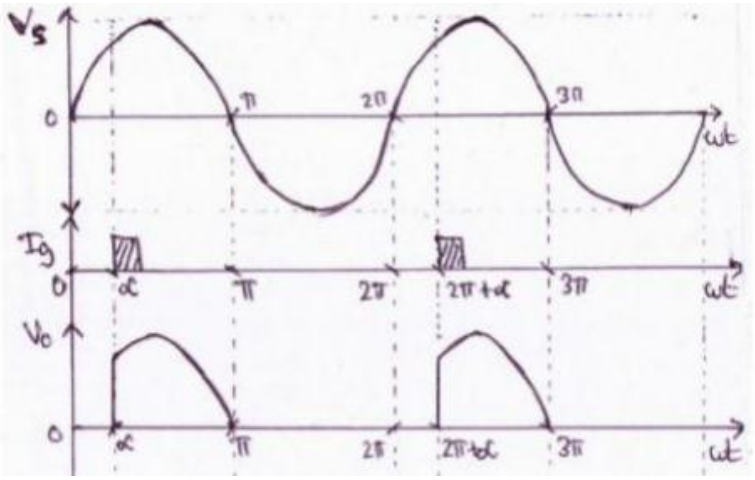
	Ans:	Advantages of SMPS: 1. The switch mode power supply is smaller in size compared to conventional DC supply. 2. It is light weight and compact. 3. Ripples in the output can be easily filtered out using small filter components, reducing the cost and size of filter circuit. 4. Size and cost of the transformer used is less. 5. It has a better power efficiency (typically 60 to 70 percent). 6. Less affected by electromagnetic interferences. 7. SMPS has wide output range. 8. Low heat generation in SMPS.	**Any two advantages:2M** **Each advantage:1M**
	(B)	**Attempt any TWO of the following: :**	**08- Total Marks**
	a)	**Compare single phase halfwave controlled rectifier and single phase full wave controlled rectifier(any four points)**	**4M**
	Ans:		**1M each for any 4 points**

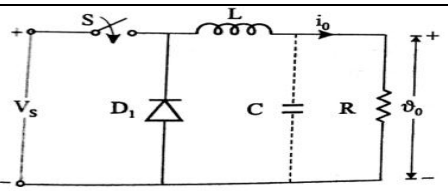
PARAMETER	Single phase half wave controlled rectifier	Single phase full wave controlled rectifier
No. of SCR used	ONE SCR	TWO OR FOUR SCRs
Firing circuit complexity	Easier	Complicated
Application	In small battery chargers	In DC motor speed control
Waveforms		

		Average load voltage	Vm/2π * (1+ cosα)	Vm/π * (1+ cosα)
		Ripple frequency	50 Hz	100 Hz
	b)	**State four performance parameters of inverter.**		**4M**
	Ans:	**Performance parameters of Inverter** 1. Harmonic factor of nth harmonic (HFn) 2. Total harmonic distortion (THD) 3. Distortion factor (DF) 4. Lowest order harmonic(LOH)		**1M each**
	c)	**Draw the neat circuit diagram of emergency light system and write its working.**		**4M**
	Ans:	Circuit diagram of emergency light system: **Note:- (Any other relevant diagram may also be considered)**  **Working:-** • Fig. shows single source emergency lighting circuit .The 230v ac supply is applied as input. This supply is stepped down by a centre- tapped transformer. Transformer secondary voltage is converted to DC by the full wave rectifier circuit using D_1 & D_2.		**Circuit diagram :2M Working : 2M**

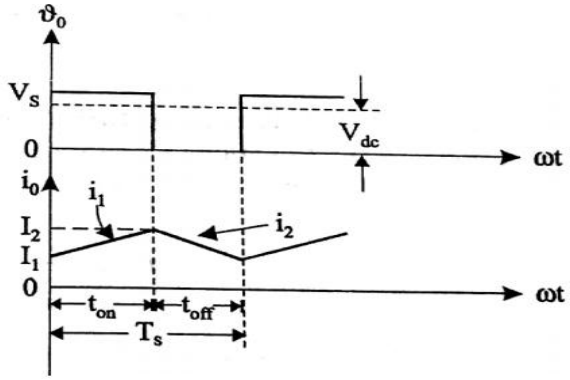
		• When supply is ON, the lamp is connected to rectifier output dc voltage , and will remain ON. • At the same time a pulsating current flows through D3 & R1 charge the battery to a voltage slightly less than the supply voltage. • The capacitor C gets charged with upper plate +VE to some voltage less 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. • When 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 gets connected & commutated and capacitor C recharges again.	

Q. No.	Sub Q. N.	Answers	Marking Scheme
2		**Attempt any FOUR of the following::**	**16- Total Marks**
	a)	**Why the controlled rectifiers are called phase controlled rectifiers? Justify with neat sketch.**	**4M**
	Ans:	**Justification:** Unlike diode rectifiers, phase controlled rectifiers has an advantage of regulating the output voltage. The diode rectifiers are termed as uncontrolled rectifiers. When these diodes are replaced with Thyristors, it becomes a controlled rectifier. Controlled rectifiers use the principle of phase control technique. It is a method of turning ON a thyristor by varying the	**Justification:2M** **waveforms:2M**

		firing angle 'α'. Firing angle is the difference between a positive going zero point of the voltage and the angle at which the gate pulse is applied. The angle from the triggering point to the next negative going zero point is called conduction angle 'β'. The o/p voltage can be regulated by changing the firing angle, i.e, by changing the conduction phase of the supply voltage. Hence they are called phase controlled rectifiers. A small firing angle will give more output whereas a large firing angle will give less output. **Waveforms for controlled rectifier:** Waveforms below shows that output voltage phase can be changed by adjusting firing angle α.  **Note:- Give marks for other relevant diagrams (Waveforms)also**	
	b)	**Describe working of step – down chopper with neat diagram and waveforms.**	**4M**
		Note:- Give marks for any other relevant diagrams also **Circuit Diagram:**	**Circuit Diagram :2M**



Waveforms:



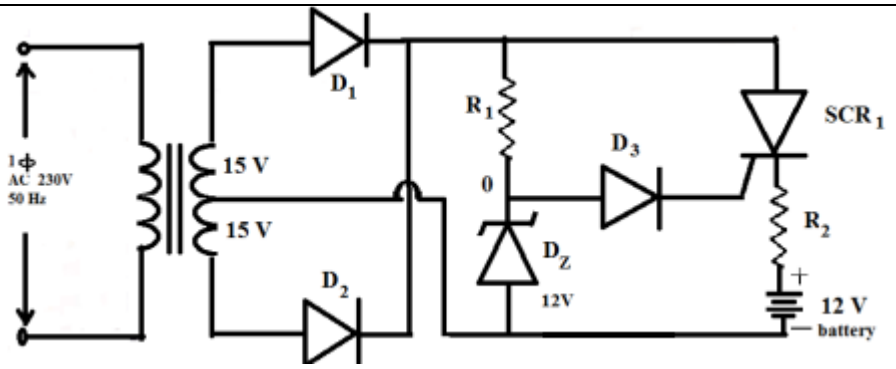
Working:

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 Toff. Equation of the output voltage is, Vo = VS * α, where α is the duty cycle. Freewheeling diode provides path for the load current when the switch is OFF. The inductor filters out the ripples in the load current.

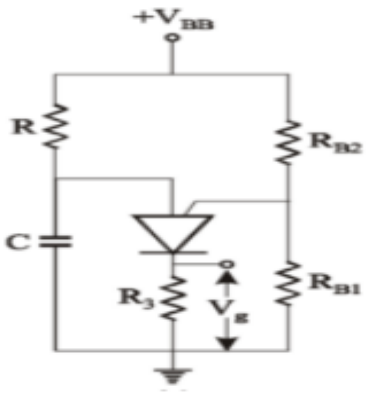
Waveforms:1M

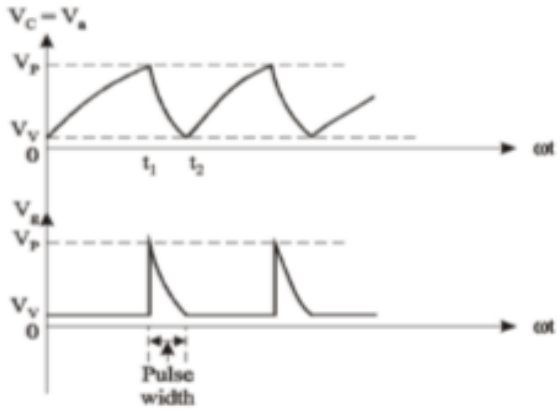
Working :1M

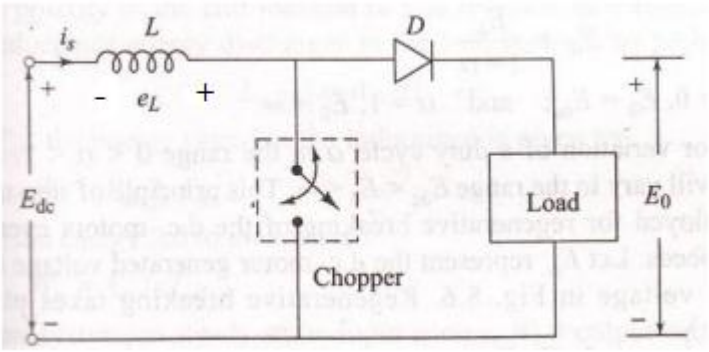
	c)	**Draw the labeled circuit diagram of Battery charger using SCR.**	**4M**
	Ans:	Circuit diagram (Any other relevant diagram may also be considered):	**Circuit diagram :4M**

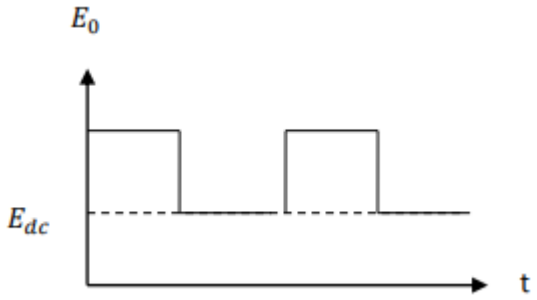


	d)	**Define the following terms with respect to SCR:** (i) Latching current (ii) Holding current (iii) On state voltage(V_{BO}) **(iv)** Reverse breakdown voltage(V_{BR})	**4M**
	Ans:	**(i) Latching current:** Latching current may be defined as the minimum ON – state anode to cathode current required to keep the SCR in the ON- state after the triggering pulse has been removed. **(ii) Holding current:** 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. **(iii) On state voltage (V_{BO}):** It is also called break over voltage. It is the minimum forward voltage applied between Anode and cathode of SCR, at which SCR changes it's forward blocking off state into conduction ON state, with gate terminal left open. **(iv) Reverse breakdown voltage (V_{BR}):** The minimum value of the reverse voltage from cathode to anode at which the device breaks into avalanche region and	**Each Definati on:1M**

		starts conducting heavily in the reverse direction.	
	e)	**Draw the circuit diagram of PUT relaxation oscillator and explain its operation.**	**4M**
	Ans:	PUT relaxation oscillator: **Circuit diagram:**  **Working:** When the supply voltage V_{BB} is applied, the capacitor C starts charging through resistor R. When the voltage across the capacitor exceeds the peak voltage (Vp), PUT goes into negative resistance mode and this creates a low resistance path from anode (A) to cathode (K). The capacitor discharges through this path. When the voltage across the capacitor is below valley point voltage (Vv) the PUT reverts to its initial condition and there will be no more discharge path for the capacitor. The capacitor starts to charge again and the cycle is repeated. This series of charging and discharging results in a saw tooth waveform across the capacitor as shown in the figure below. **Waveform(optional):**	**Circuit diagram :2M** **Operation:2M**



	f)	**Explain the working of step-up chopper with neat diagram.**	**4M**
	Ans:	**Note:- Give marks for any other relevant diagrams also** **Circuit Diagram :**  **Waveform (Optional):**	**Circuit diagram :2M** **Operation:2M**



Working :

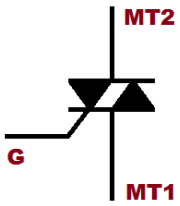
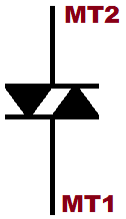
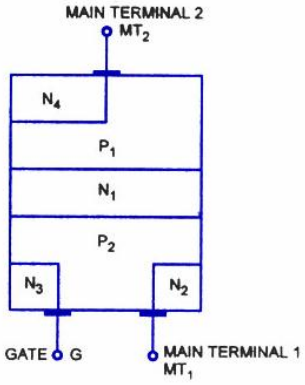
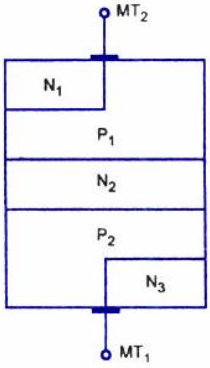
- When the switch is ON for a period T_{ON}, inductor L is connected to the supply Vs and it stores energy. Hence, diode D_F is reverse biased and isolates the output stage.
- When the switch is OFF, the inductor current is forced to flow through the diode and load for a period T_{OFF}. As the current tends to decrease, an emf is induced in the inductor L is reversed to that of shown in the figure and as a result Voltage across the load Vo becomes,

$$\mathbf{E_0 = E_{dc} + L\frac{d_{is}}{d_t}}$$

- The inductor Voltage adds to the source Voltage, thus producing a voltage more than the input voltage.

Q. No.	Sub Q. N.	Answers	Marking Scheme
3		**Attempt any FOUR of the following::**	**16- Total Marks**
	a)	**Differentiate TRIAC and DIAC with respect to (1) symbol (2) layered diagram (3) application (4) breakdown voltage.**	**4M**

Ans:

Parameters	TRIAC	DIAC
Symbol		
Layered diagram		
Application	Fan control, light dimmer	Starter circuits, light dimmer, triggering of TRIAC
Breakdown voltage	Breakdown voltage or Break over voltage can be controlled by adjusting the gate current	Breakdown voltage or Break over voltage cannot be controlled

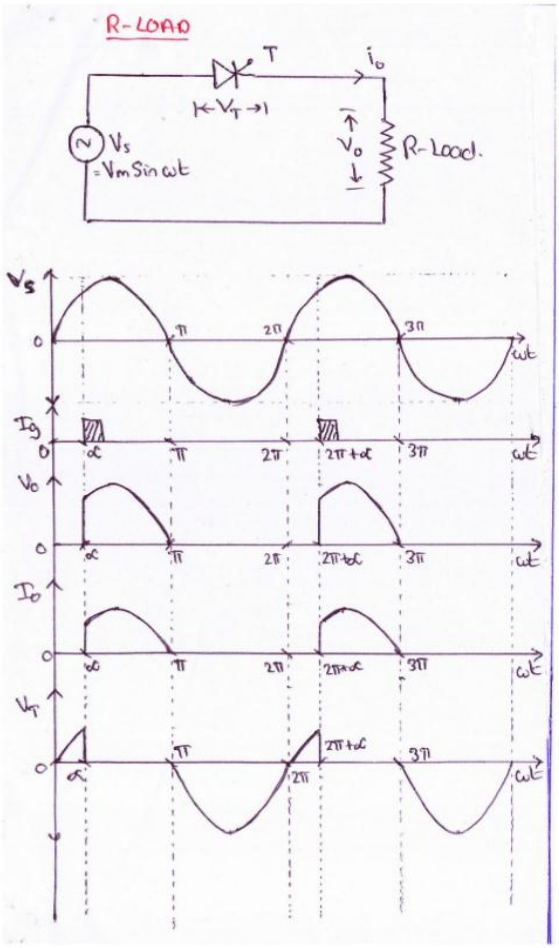
4 points : 4M

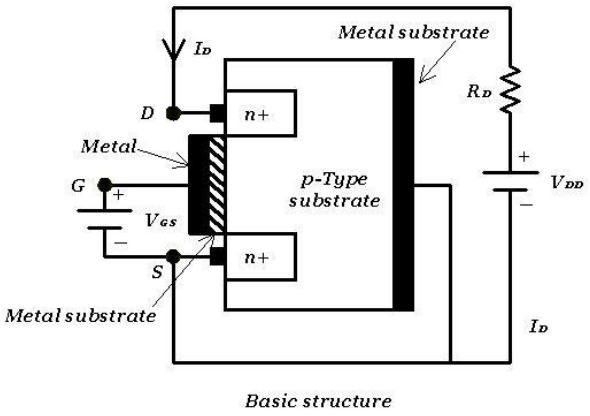
b) Describe working of half wave controlled rectifier with Resistive load. Draw circuit diagram and waveforms. **4M**

Ans:

Circuit Diagram 1M,

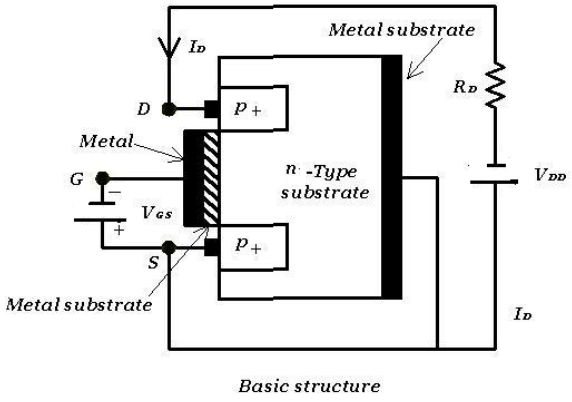
Wavefor

		 . • During positive half cycle of a.c supply, anode of SCR is positive w.r.t cathode. Therefore SCR is forward biased and acts like a closed switch. • Until the SCR is triggered by a gate pulse, it blocks load current i_L .At an angle α, thyristor is triggered and the load current will be identical with the applied input voltage. • During negative half cycle of a.c supply, SCR is reverse biased and it will block the load current and there is no voltage across the load. • Thus by varying firing angle, the output voltage can be varied. Output equation = $\frac{Vm}{\pi}$ (1+ cos α)	**ms : 1M** **Working : 2M**

	c)	**Define terms of GTO : (1) Turn off gain and (2) Maximum controllable I_A.**	**4M**
	Ans:	**(1) Turn off gain** The ratio of anode current I_A to negative gate pulse current $I_g^{(-)}$ needed to turn-off the GTO is called the turn off gain. $$\beta_{off} = \frac{I_A}{I_g^{(-)}} = \frac{\alpha_2}{\alpha_1 + \alpha_2 - 1}$$ Where, α_1, α_2 are the transistor gains. **(2) Maximum controllable I_A** The maximum value of anode current above which no gate current can turn off a conducting GTO is called its maximum controllable anode current (I_A).	**Each definitio n : 2M**
	d)	**Draw the construction of enhancement type power MOSFET and describe its working.**	**4M**
	Ans:	 *Basic structure* **Constructional diagram of N channel enhancement MOSFET** **Working:** Enhancement only MOSFETs have no physical channel. When V_{GS} is equal to zero, and V_{DD} is applied , no current flows through the device.	**Circuit diagram : 2M** **Working :2M**

When positive V_{GS} is applied above the threshold value, electrons in P-region are pulled below the poly silicon gate to form a channel (N-type). Thus source gets connected to drain and a small current I_D flows depending upon the voltage V_{DD}. Below the threshold voltage, there is no channel and the device stops conducting.

(OR)



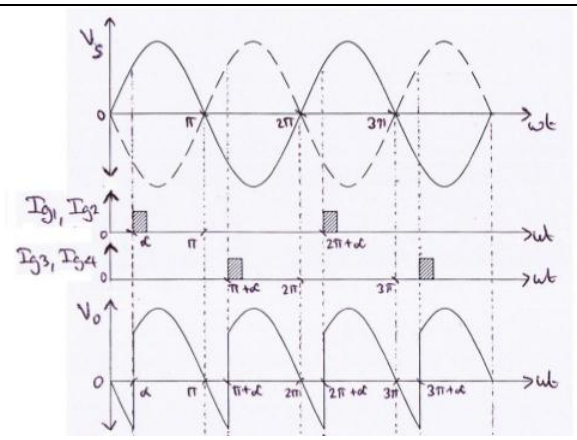
Basic structure

Constructional diagram of P channel enhancement MOSFET

Enhancement only MOSFETs have no physical channel. When V_{GS} is equal to zero, and V_{DD} is applied , no current flows through the device.

When negative V_{GS} is applied above the threshold value, holes in N-region are pulled below the poly silicon gate to form a channel (P-type). Thus source gets connected to drain and a small current I_D flows depending upon the voltage V_{DD}. Below the threshold voltage, there is no channel and the device stops conducting.

	e)	**Write the effect of inductive load and significance of free wheeling diode in 1ϕ bridge type full wave rectifier.**	**4M**
	Ans:	**Effect of inductive load:**	**Effect of load : 2M** **Significance of**



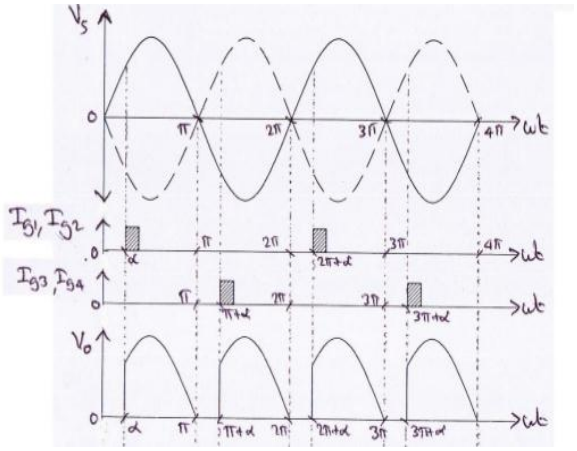
Waveforms for 1ϕ bridge type full wave rectifier for inductive load without freewheeling diode

In single phase bridge type full wave rectifier, when one set of SCRs are triggered at an angle α, the load current increase slowly, since the inductance in the load forces the current to lag the voltage. During the positive conduction cycle, inductor stores energy. At $\omega t = 180^0$, the load voltage reverses along with the supply voltage as current through the inductor cannot be stopped instantly. Therefore during negative cycle, the current continues to flow till some part of the energy stored in the inductor is dissipated in the load resistor and the remaining fed back to the supply itself. Thus by controlling the firing angle from 0-180^0 the average DC output voltage can be varied continuously positive maximum to negative maximum. Because the output DC voltage is reversible even though the current flow is unidirectional, the power flow in the converter can be in either direction. Hence two modes of operation (rectifying mode & inverting mode) are available with 1Ø bridge rectifier.

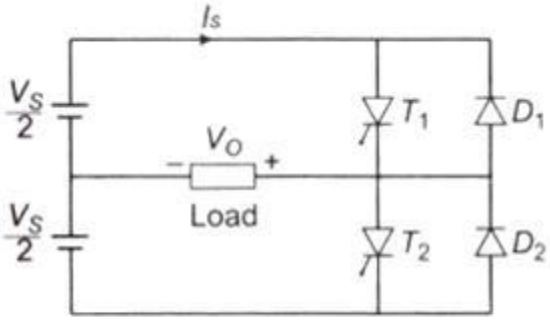
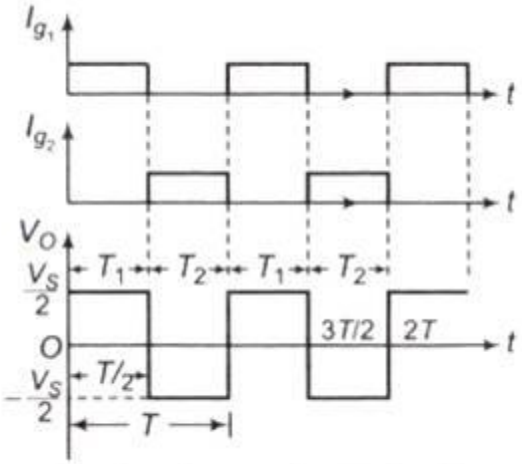
Significance of freewheeling diode:

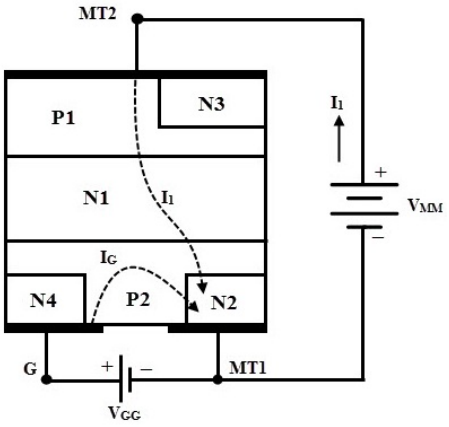
To cutoff the negative portion of the instantaneous output voltage and reduce the output current ripple, a freewheeling diode is used. When the load voltage tends to reverse, the freewheeling diode becomes forward biased and turns on. Thus, the load voltage is clamped to zero volts at $\omega t = 180^0$. At the same time a nearly constant load current is maintained by the

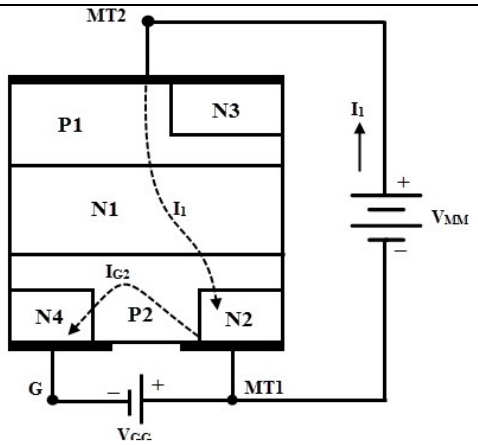
freewheeling diode : 2M

		freewheeling diode. Hence it behaves like a converter connected with resistive load only and gives only rectifying operation. Thus the function of the freewheeling diode is to, 1) Prevent the reversal of load voltage. 2) Prevent transfer of reactive power from load to supply, thus improve the power factor of the circuit.  **Waveforms for 1ϕ bridge type full wave rectifier for inductive load with freewheeling diode** **(Note: waveforms optional)**	
	f)	**A single phase full wave controlled rectifier is supplied with voltage v= 210 sin 314 t. Find average output voltage and current. If firing angle is 50^0 and load resistance is 100 Ω.**	**4M**
	Ans:	Given: v= 210 sin 314 t $\alpha = 50^0$ $R_L = 100\ \Omega$ Required: Vdc = ?	**Average output voltage : 2M** **Load current : 2M**

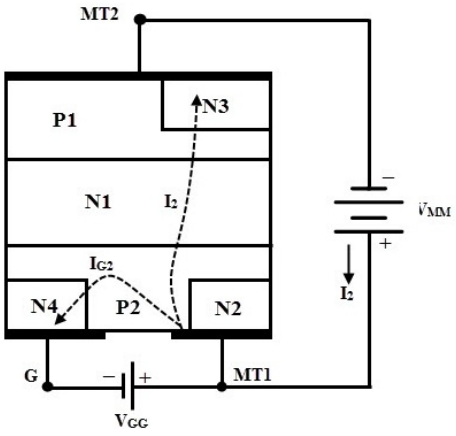
		I_L = ? Solution: Average output voltage = $\frac{Vm}{\pi}$ (1 + cos α) = $\frac{210}{\pi}$ (1 + cos 50) = 66.84 * 1.642 = 109.75 V Load current I_L = $\frac{Vdc}{RL}$ = $\frac{109.75}{100}$ = 1.0975 A	

Q. No.	Sub Q. N.	Answers	Marking Scheme
4		**Attempt any FOUR of the following::**	**16- Total Marks**
	(a)	**Describe working of 1-ϕ half bridge inverter with neat sketch.**	**4M**
	Ans:	 1-ϕ half bridge inverter  Waveforms of gate pulses and output voltage **Working:** • The DC power supply has been divided into two halves each having a voltage of Vs/2. • The thyristor T1 is turned on for a time T/2, which makes the instantaneous voltage across the load, Vo = Vs/2.	**Circuit Diagram : 1M** **Waveforms : 1M** **Working : 2M**

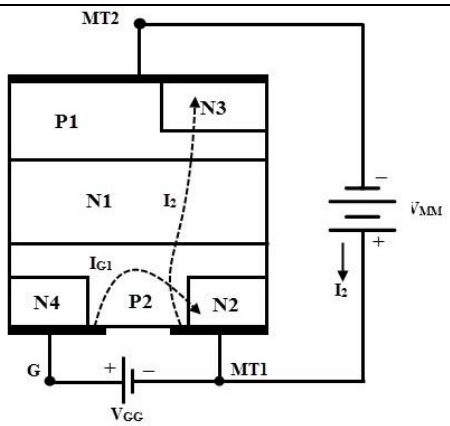
		• If thyristor T2 is turned on at instant T/2 by turning T1 off, the load current will now flow in reverse and –Vs/2 voltage appears across the load. • Thus by turning on T1 & T2 alternatively, a square wave A.C output may be produced across the load. The frequency of output, $\omega = \frac{2\pi}{T}\frac{rad}{sec}$ • During the switching of T_1 and T_2, path for the reactive current back to the supply from inductor stored energy is provided by D1 and D2 respectively and hence called feed back diodes.	
	(b)	**Explain four modes of operation of a TRIAC.**	**4M**
	Ans:	There are four different operating modes of TRIAC: **1) MT2 and gate are positive with respect to terminal MT1(Mode1)** : Here terminal MT2 is positive with respect to terminal MT1 current flows through path P1-N1-P2-N2.The two junctions P1-N1 and P2-N2 are forward biased whereas junction N1-P2 is blocked. The TRIAC is now said to be positively biased. A positive gate with respect to terminal MT1 forward biases the junction P2-N2 and the breakdown occurs as in a normal SCR.  **2) MT2 is positive but gate is negative with respect to terminal MT1(Mode2)**: Though the flow path of current remains the same as in mode 1 but now junction P2-N3 is forward biased and current carriers injected into P2 turn on the TRIAC.	**Each mode : 1M**



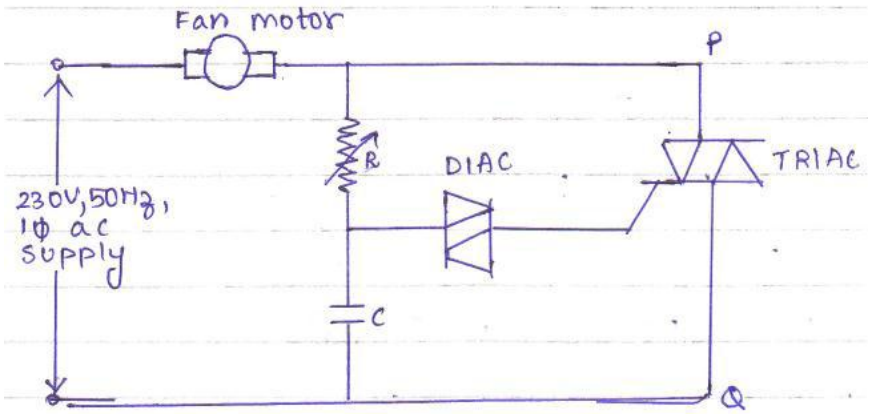
3) MT2 and gate are negative with respect to terminal MT1(Mode4) : When terminal MT2 is negative with respect to terminal MT1, the current flow path is P2-N1-P1-N4. The two junctions P2-N1 and P1 – N4 are forward biased whereas junction N1-P1 is blocked. The TRIAC is now said to be negatively biased. A negative gate with respect to terminal MT1 injects current carriers by forward biasing junction P2-N3 and thus initiates the conduction.

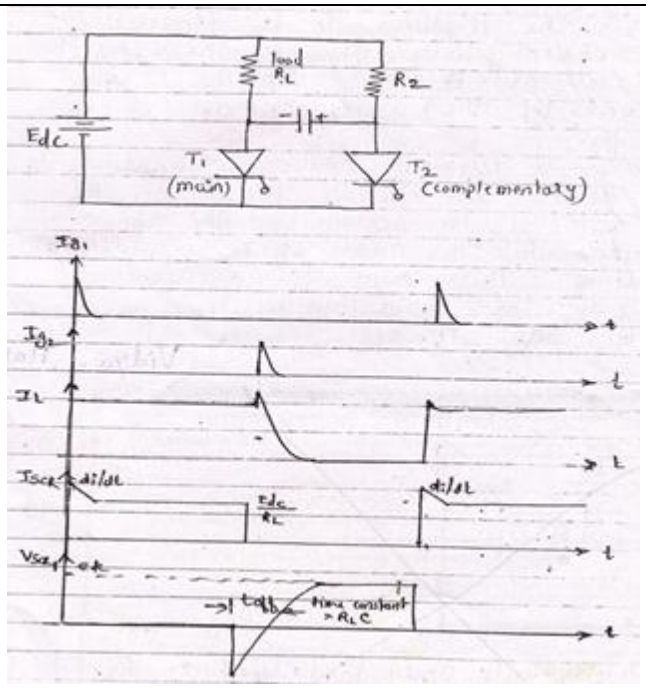


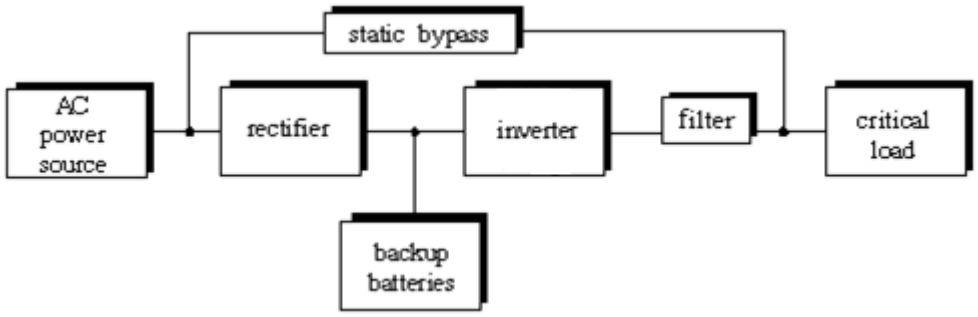
4) MT2 is negative but gate is positive with respect to terminal MT1(Mode3) : Though the flow path of current remains the same as in mode 3 but now junction P2-N2 is forward biased, current carriers are injected and therefore, the TRIAC is turned on.



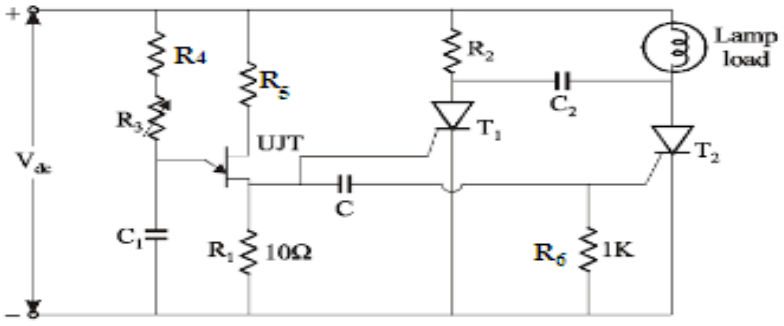
(Diagram is optional)

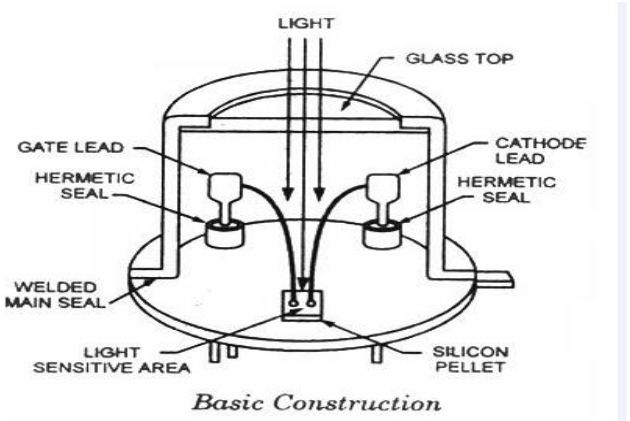
	(c)	**With the help of circuit diagram explain speed control of fan using TRIAC-DIAC.**	**4M**
	Ans:	 In the above circuit DIAC is used to trigger TRIAC. During the positive half cycle (when P is positive) the TRIAC requires a positive gate signal for turning it ON. This is provided by the capacitor C. When the voltage across capacitor is above the break over voltage of the DIAC, DIAC turns ON & the capacitor discharges through the TRIAC gate i.e. positive gate signal is given to the TRIAC & thus TRIAC turns ON. So current starts flowing through load. A similar operation takes place in the negative half cycle. In the above circuit DIAC is used to trigger TRIAC.	**Circuit Diagram : 2M** **Working : 2M**

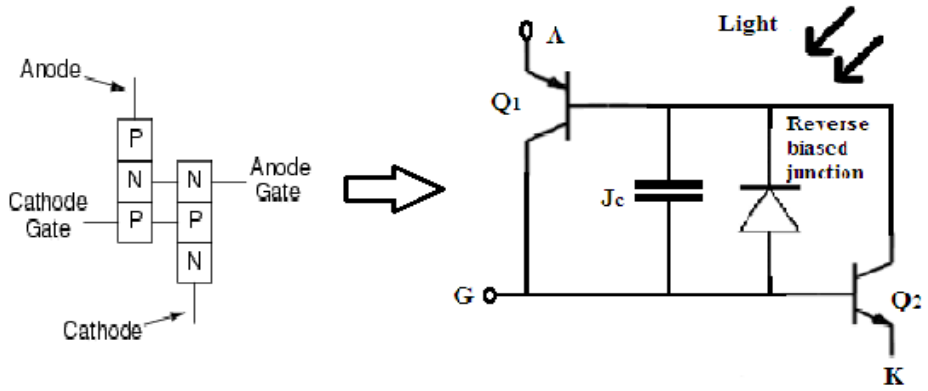
		So current starts flowing through load. A similar operation takes place in the negative half cycle, & a negative gate pulse will be applied when the DIAC breaks down in the reverse direction. The charging rate of capacitor C can be changed by varying the resistance R and, hence the firing angle can be controlled. Thus if firing angle is less speed of fan motor is more & if firing angle is more speed. Fan motor is less. Thus by controlling the firing angle of TRIAC, we can control speed of fan using TRIAC.	
	(d)	**Describe working of complementary symmetry commutation circuit with neat diagram.**	**4M**
	Ans:	 **Explanation:** • Here complementary thyristor T_2 is connected in parallel with the main thyristor. • Initially, both the thyristors are OFF, when a triggering pulse is applied to the gate of T_1, thyristor $T_1$is triggerd. Therefore current starts flowing through the	**Circuit diagram : 2M** **Working : 2M**

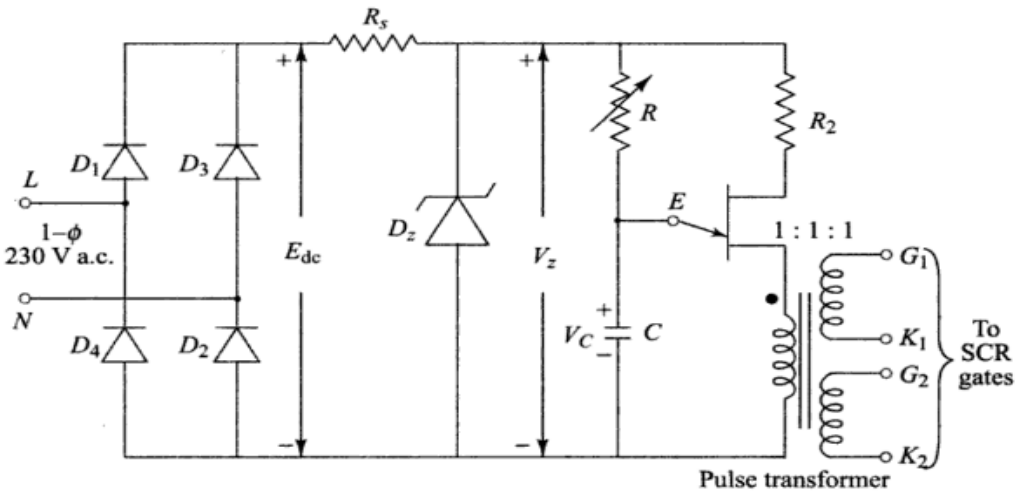
		load as well as R_2& C. Capacitor C will get charged by the supply voltage Edc. • When a triggering pulse is applied to the gate of T_2, T_2 will be turned on. As soon as T_2 is ON, the negative polarity of capacitor C is applied to the anode of T1 and positive to the cathode. This causes the reverse bias voltage to get applied across the main thyristor T1 turning it OFF.	
	(e)	**Draw the block diagram of UPS and explain function of each block.**	**4M**
	Ans:	 Power source: A 3Ø or 1Ø AC supply which supplies the rectifier. Rectifier& battery charger: Converts 3Ø or 1Ø AC. Rectifier supplies power to the inverter and the charger feeds the backup battery bank. Backup battery: When the supply is ON, the battery starts charging. A static switch will connect or disconnect the battery form the input of the inverter depending on the status of a.c mains. Inverter: It gets d c input voltage from the rectifier when the ac main is ON, and from the battery bank when the a.c mains is OFF. Inverter converts this d.c voltage into a.c voltage and through a suitable filter applies it to the load. Filter: It filters out the harmonics present in the output of the inverter and provides a perfect sinusoidal voltage to the load.	**Block diagram : 2M** **Function : 2M**

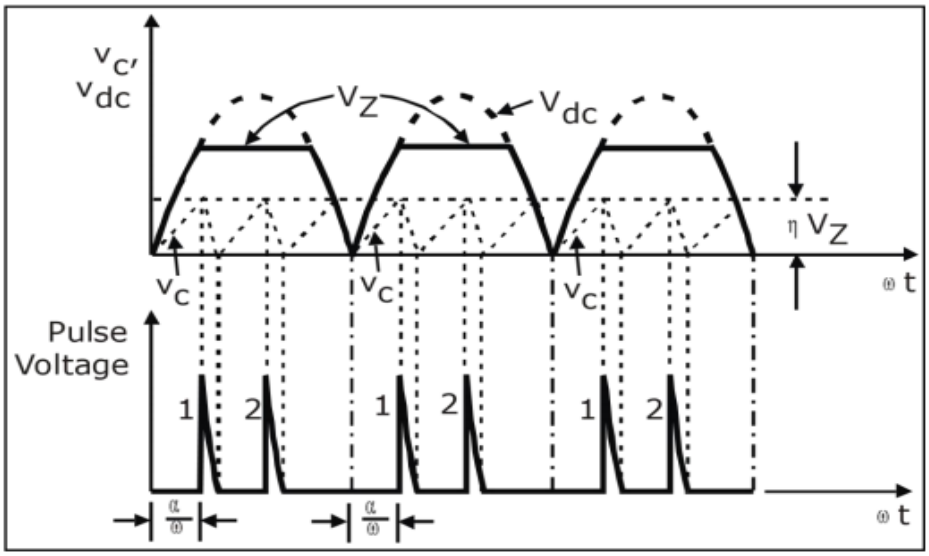
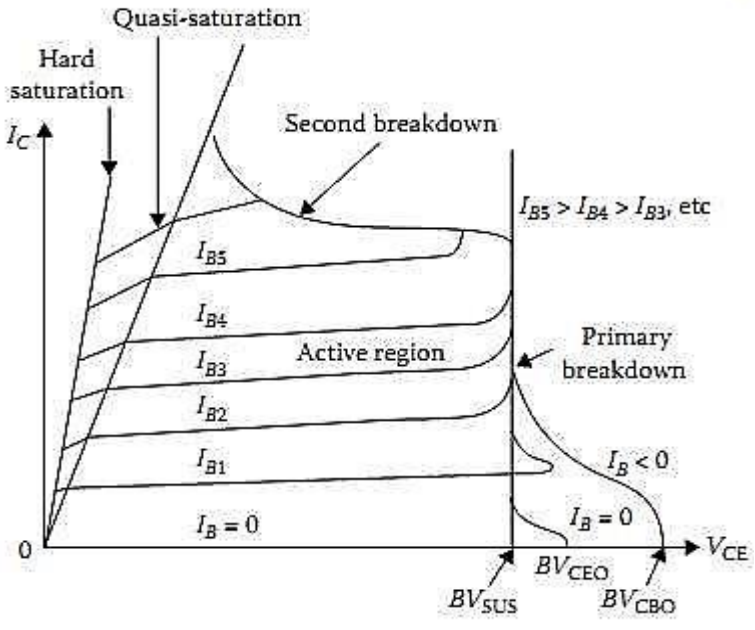
		Critical load: Computer systems for signaling systems, control systems, medical and lab testing equipment are some of the critical loads that use UPS. Static bypass switch: Connects the AC Power mains directly to the load.	
	f)	**Compare step-up chopper and step-down chopper (any four points).**	**4M**
	Ans :	<table><tr><th>Parameter</th><th>Step – up chopper</th><th>Step – down chopper</th></tr><tr><td>Switch position</td><td>In parallel with load</td><td>In series with load</td></tr><tr><td>Quadrant of operation</td><td>Second</td><td>First</td></tr><tr><td>Output voltage equation</td><td>Vo = V / (1- α)</td><td>Vo = V * α</td></tr><tr><td>Applications</td><td>Battery charging, voltage booster</td><td>Motor speed control</td></tr></table>	**4 points : 4M** **(Other relevant point can be considered)**

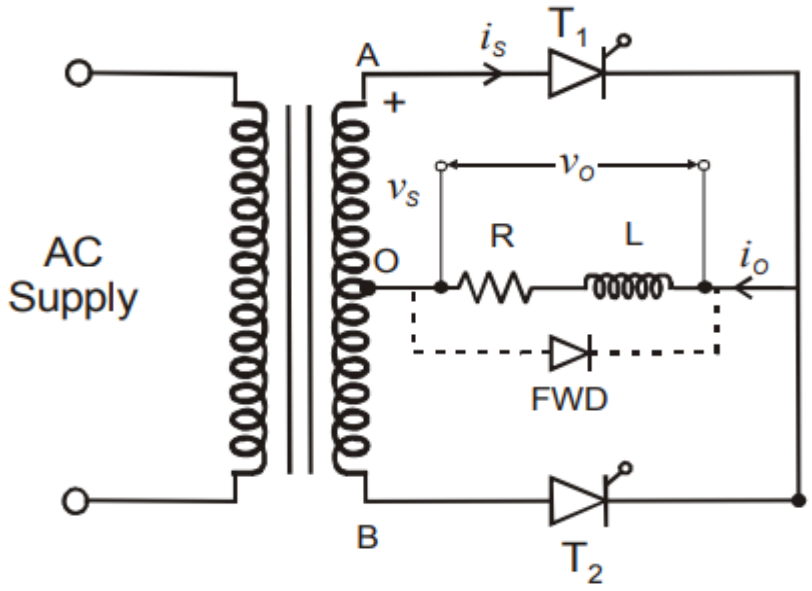
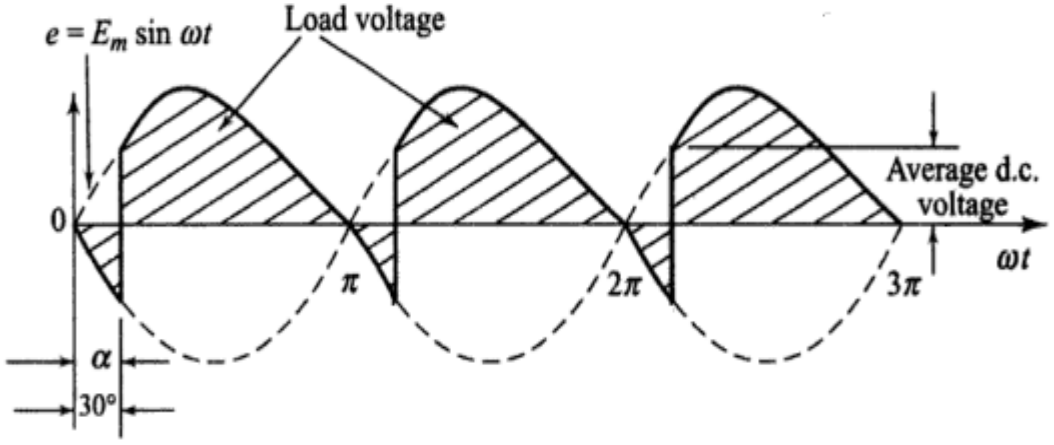
Q. No.	Sub Q. N.	Answers	Marking Scheme
5.		**Attempt any FOUR of the following:**	**16- Total Marks**
	a)	**Draw the neat circuit diagram of low power dc flasher and describe its working.**	**4M**
	Ans:	**Circuit diagram of low power dc flasher:** 	**2M - circuit diagram**

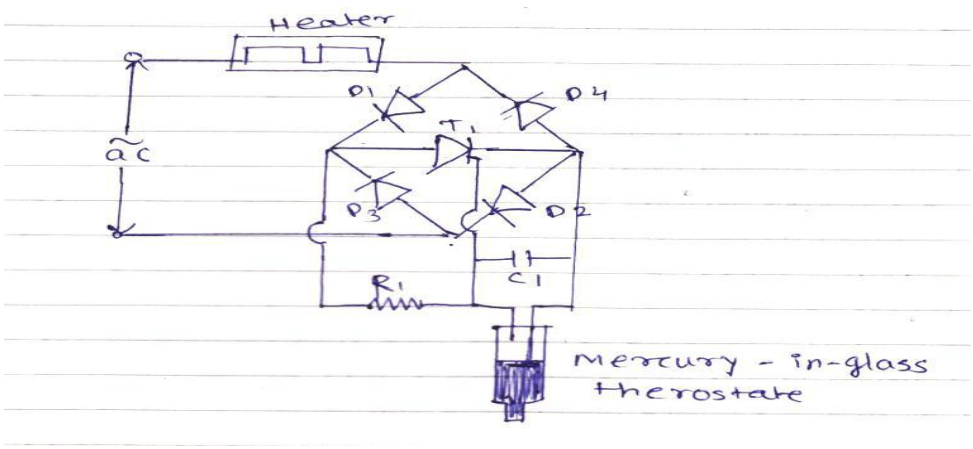
		Working:- ▪ The circuit consists of UJT relaxation oscillator and Class C commutation circuit. ▪ UJT relaxation oscillator produces a train of pulses which is directly applied to SCR1 which is delayed & applied to SCR2 where the delay is decided by C & R6. ▪ Let SCR 1 and lamp be ON initially. Capacitor C1 charges through R & SCR1 to supply voltage Vdc .With the next trigger pulse SCR2 will be turned ON. ▪ Now voltage across C1 reverse biases SCR1 & turns it OFF. ▪ Capacitor discharges through SCR2 & charges in opposite direction. ▪ Since SCR1 is reversed biased, it will not turn ON even if the gate pulse arrives. ▪ When the current through SCR2 reduces below holding current, SCR2 turns OFF. A large R1 reduces the current through SCR 2. ▪ When next trigger pulse comes SCR1 is turned ON, lamp glows again and capacitor C1 gets charged though R1 to develop commutating voltage for SCR1. ▪ Switching of SCR1 gives flashes from lamp. ▪ The flash rate depends on firing pulse frequency of UJT relaxation oscillator. Therefore by adjustingR3, the required flash rate can be obtained.	**2M – working**
	b)	**With the help of construction and equivalent circuit explain working of LASCR.**	**4M**
	Ans:	**Constructional diagram:**  *Basic Construction*	**1.5M – Construc tional diagram**

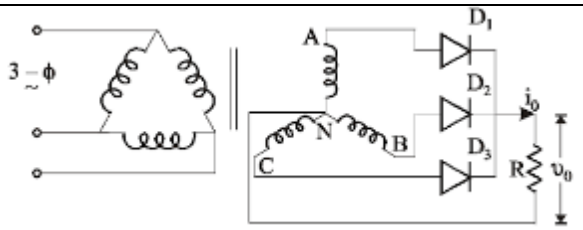
		Equivalent circuit:  **Working:** ▪ LASCR is turned on by direct radiation of light on the silicon wafer. ▪ Electron hole pairs created due to radiation produce triggering gate current under the influence of electric field. ▪ The gate structure is designed to provide sufficient gate sensitivity for triggering from practical sources (e.g. LED). ▪ Once the LASCR is triggered to ON state, it behaves like a normal SCR. ▪ LASCR will stay ON even if the light disappears, it will turn OFF only if its anode current is decreased below I_H.	**1.5M – Equivalent circuit** **1M - working**
	c)	**State the need of polyphase rectifier.**	**4M**
	Ans:	**Need of polyphase Rectifier:** ▪ The capacity of 1Ø rectifiers is limited (normally upto 2kW), as the size and cost increases with increase in output requirement. ▪ This is because, a single phase rectifier produces relatively high a.c ripple voltage at its ouput as compared to 3Ø rectifier. ▪ Hence it require large smoothing reactors to filter out the ripples, increasing the cost. ▪ Polyphase rectifier has 3 or more phases at input which utilizes three or more diodes each	**4M**

		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. ▪ As number of pulses are more (high ripple frequency) 3Ø rectifier produces a smoother output, reducing the cost of filtering. ▪ Thus a 3Ø rectifier become more suitable for large power applications.	
	d)	**Draw the circuit diagram of synchronized UJT triggering circuit and explain its working.**	**4M**
	Ans:	 *Synchronized UJT trigger-circuit* **Working:** ▪ The diode bridge D1 – D4 rectifies a.c. to d.c. ▪ Resistor Rs lowers V_{dc} to a suitable value for the Zener diode and UJT. ▪ The zener diode 'Z' functions to clip the rectified voltage to a standard level V_Z which remains constant except near V_{dc} 0. ▪ This voltage V_Z charges capacitor 'C' at a rate determined by the RC time constant. ▪ When the capacitor reaches the peak point V_P the UJT starts conducting and capacitor discharges through the primary of the pulse transformer. ▪ As the current through the primary is in the form of a pulse the secondary windings have pulse voltages at the output. The pulses at the two secondary's feed SCRs in phase.	**2M – circuit diagram** **2M - Working**

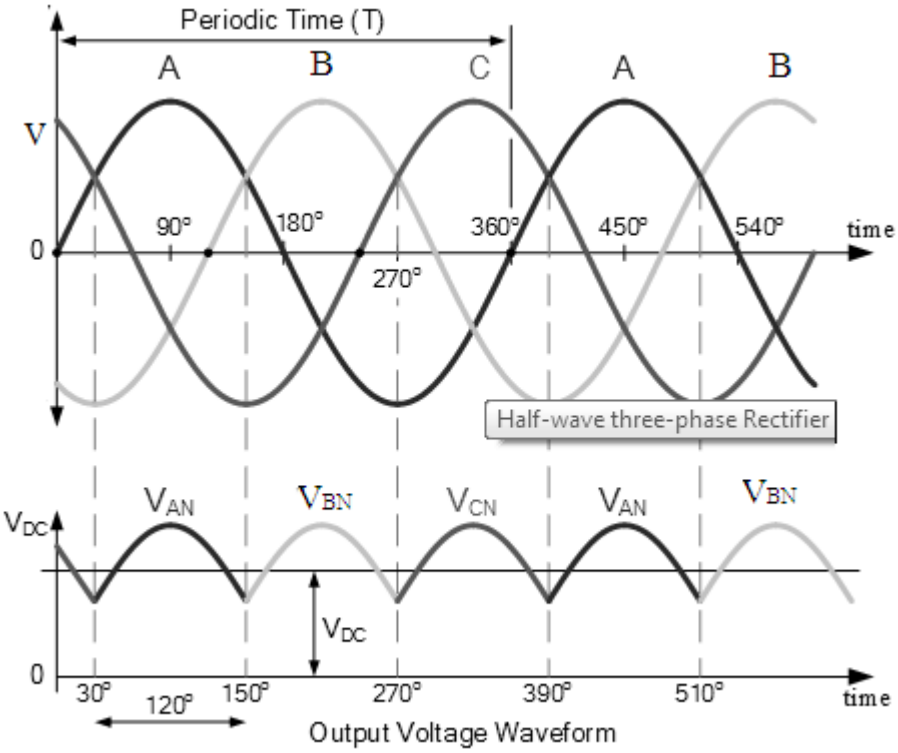
		▪ As the zener voltage V_Z goes to zero at the end of each half cycle the synchronization of the trigger circuit with the supply voltage across the SCRs is achieved. **Note: Waveform is optional.** 	
	e)	**Draw neat labeled VI characteristics of power transistor.**	**4M**
	Ans:	 (a)	**2M – charteristics** **2M - Labelling**

	f)	**Draw circuit diagram of centre tapped full wave controlled rectifier with RL load. Draw load voltage waveform for firing angle α = 30^0.**	**4M**
	Ans:	**Circuit Diagram:**  **Load voltage waveform for firing angle α = 30^0**  The shaded portion represents load voltage waveform for $\alpha = 30^0$	**2M - Circuit Diagram** **2M - load voltage waveform**

Q. No.	Sub Q. N.	Answers	Marking Scheme
6.		**Attempt any FOUR of the following::**	**16- Total Marks**
	a)	**Describe working of Temperature Controller with neat diagram.**	**4M**
	Ans:	**Circuit Diagram:**  **Working:** ▪ When the thermostat is open, the voltage across the capacitor C_1 triggers the thyristor T_1 in each half cycle of the input cycle and the current flows through the heater. ▪ The charging time constant depends on the product of R_1 and C_1 network. ▪ As the temperature increases beyond a set point temperature, thermostat short circuits the capacitor. ▪ As there is no gate supply the SCR turns OFF for a zero anode to cathode voltage and the heater current becomes zero maintaining the temperature. ▪ When the temperature drops below the set point thermostat will regain its initial position making the capacitor to charge and to turn ON the SCR and then heater.	**2M - Circuit Diagram** **2M - Working**
	b)	**Draw circuit diagram input and output waveforms of 3-ϕ half wave uncontrolled rectifier.**	**4M**
	Ans:	**Circuit Diagram:**	**2 M - Circuit**



Input and output waveforms:



Diagram

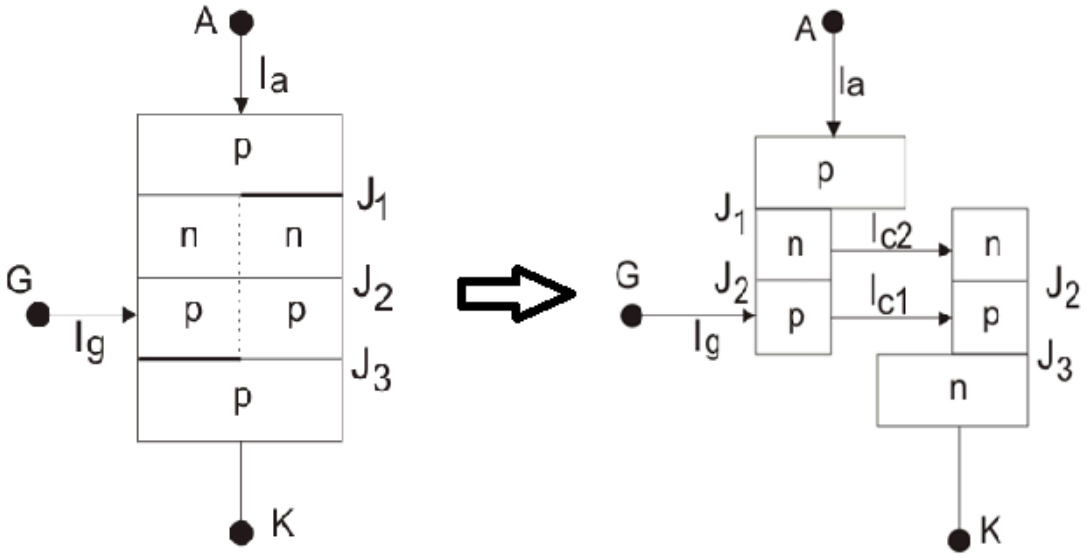
1M - input waveform and 1M - output waveform

c) Compare natural commutation and forced commutation (any 4 points). **4M**

Ans:

Sr No.	Parameter	Natural commutation	Forced commutation
1	Source	AC	DC
2	External commutating components	Not required	Required
3	Cost of commutation circuit	Nil	More

1M each point (Any relevant point should be considered)

			4	Power loss in commutation components	Nil	Some power loss takes place.	
			5	Applications	Controlled rectifiers, AC Controllers.	Choppers, inverters.	
	d)	**Draw constructional details of SCR. Why silicon is used as the intrinsic semiconductor for manufacturing the SCR?**					**4M**
	Ans:	**Constructional diagram of SCR:**  **Silicon is used as the intrinsic semiconductor for manufacturing the SCR for following reasons:** **1) Smaller ICBO:** At room temperature, Silicon crystal has fewer free electrons than Germanium crystal. This implies that silicon will have much smaller **Collector cut off current** than Germanium. **2) Smaller variation of ICBO with temperature:** The variation of **Collector cut off**					**2M - Constructional diagram** **2M - Reasoning**

current with temperature is less in Silicon compared to Germanium.

3) Greater operating range of temperature: The structure of Germanium crystals will be destroyed at higher temperature. However, Silicon crystals are not easily damaged by excess heat.

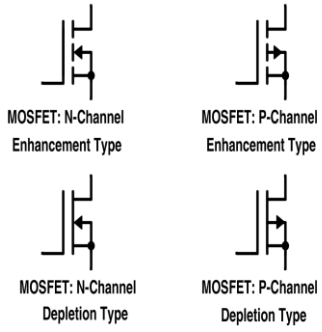
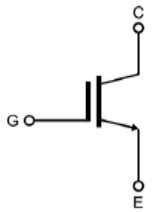
4) Higher PIV rating: Peak Inverse Voltage ratings of Silicon diodes are greater than Germanium diodes.

5) Si is less expensive due to the greater abundance of the element. The major raw material for Si wafer fabrication is sand which is readily available in nature.

But the potential Barrier of Silicon is more compared to Germanium. But if we consider the advantages listed above, it can be concluded that Silicon is the best element for the Semiconductor Devices and Applications.

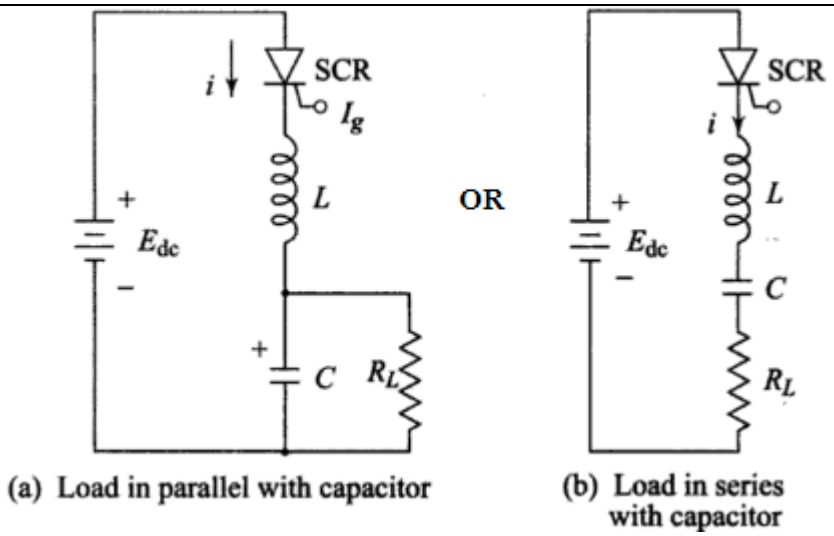
e) Compare between power MOSFET and IGBT (any four points). **4M**

Ans:

Sr No.	Parameter	Power MOSFET	IGBT
1	Switching frequency	Upto 100 KHz	10 KHz
2	ON state conduction drop	4 – 6 volts	3.3 volts
3	V-I rating	500 V/ 200 A	1200 V/ 400 A
4	Symbol		
5	Turn ON time	$100ns$	$< 1\mu s$

1M each point (Any relevant point should be considered)

			6	Turn OFF time	150-200ns	2 μs	
			7	Applications	Motor drives, UPS, static VAR compensators, induction heatng.	SMPS, Brush less DC motor drives, electronic d.c relay	
	f)	**Classify the commutation methods of Thyristor. Draw class A commutation circuit.**					**4M**
	Ans:	**Various methods of thyristor commutation:** 1) Natural commutation 2) 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 iv) Class D- Impulse or auxiliary commutation v) Class E- External pulse commutation vi) Class F- AC line commutation **Class A commutation:**					**2M – Classification** **2M – Circuit Diagram**



(a) Load in parallel with capacitor (b) Load in series with capacitor