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.1 A) Attempt any three: **12M**

a) State application if IGBT (any four).

Ans: *Note: [any four points can be considered]*

(1 marks each)

Applications of IGBT:

1. DC and AC motor drives
2. UPS systems
3. Power supplies and drives for solenoids
4. Relays and contactors
5. Power factor correction convertor.
6. Solar inverter
7. Inductive heating cookers
8. High frequency welders
9. Speed control of motors

10. Choppers

b) State any four applications of choppers.

Ans: *Note: [any four points can be considered]*

(1 marks each)

Applications of choppers:

1. Subway cars
2. Trolley buses
3. Battery operated vehicles
4. Battery charging
5. DC motor speed control
6. DC voltage Boosting

c) Compare series and parallel inverters (Any four points).

Ans: *Note: [any four points can be considered, 1marks each.]*

Sr.No.	Series inverter	Parallel inverter
1	Commutating component is connected in series with the load.	Commutating component is connected in parallel with the load.
2	High distortion in the output.	Low distortion in the output.
3	Resonant circuit is necessary.	Resonant circuit is not necessary.
4	Output frequency is not adjustable.	Output frequency is adjustable.
5	Application is induction heating.	In emergency system.

d) Give salient features of the on-line UPS. Why on-line UPS is preferred compared to off-line UPS?

Ans: *Note: [at least four salient features is expected]*

Salient features of on-line UPS: **2M**

1. Mains static switch is normally OFF and UPS static switch is normally ON.
2. In online UPS, the equipment is always connected to the battery; this means there is no lag time in UPS back up when power goes off.
3. Online UPS are also called double conversion UPS. This is because they convert AC, filtering at all fluctuations and surges. This act as a double layer of protection for the equipment.
4. They also have increased battery time and capacity of longer UPS backup.
5. It allows control of output voltage and frequency regardless of input and frequency.
6. Wide input range.
7. High frequency design.
8. Stable output design.
9. Over voltage protection.

Online UPS is preferred over offline UPS because, **2M**

1. Online UPS can provide full isolation of the critical load from a.c. line and also provides power conditioning
2. Its change over time is very less and there is no interruption during from line to battery and vice versa.
3. This system protects the critical load against surges, spikes, line noise, frequency and voltage variation, brownout and outages. All these are not available in the off line UPS.

B) Attempt any one: 8M

a) Give constructional details of IGBT. Draw its symbol. Draw V-I Characteristics of IGBT and label different regions on it.

Ans: Constructional details of IGBT : - **3M**

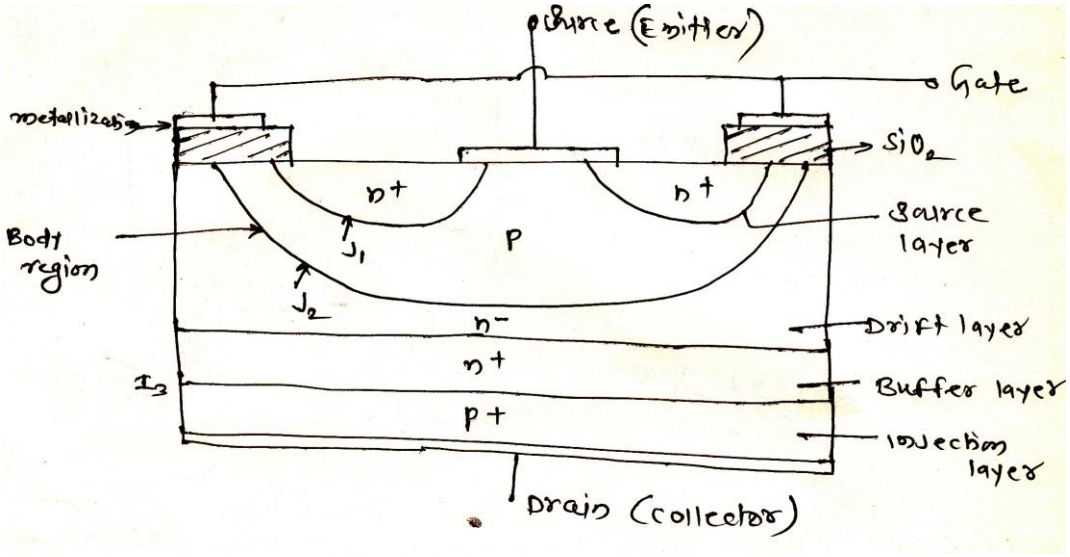
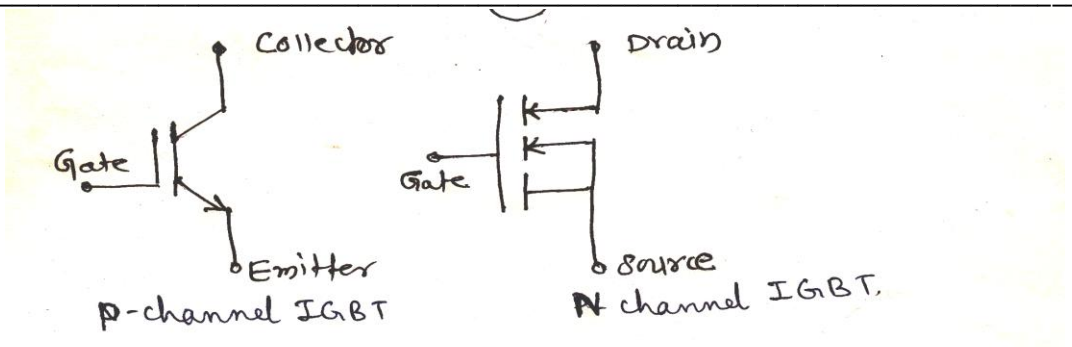
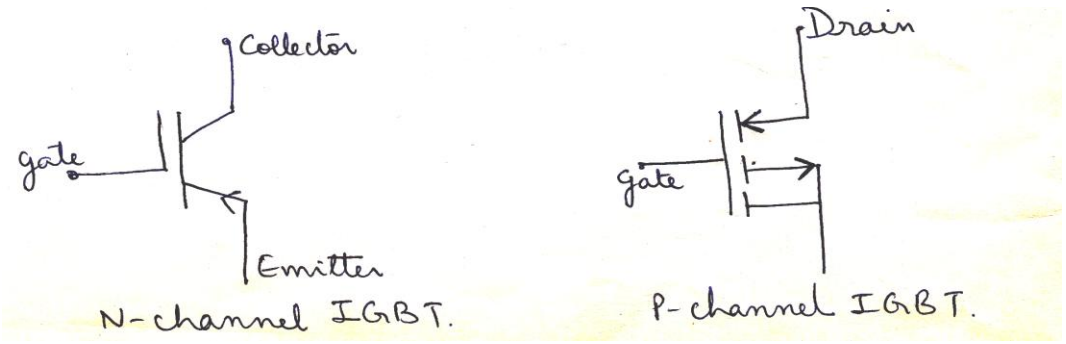


Fig. shows vertical section of n channel IGBT. Having four alternate PNPN layer with three terminals emitter, collector and gate or source, drain and gate.

A heavily doped P^+ substrate, has a lightly doped n type drift region (n^-) grown on to it by the epitaxial process. Then the P type emitter is diffused with two subsequent n type layers over doping windows. Two silicon dioxide layers are then deposited, and deposition of the metal or poly-silicon layer on them forms an interconnected gate as shown in fig.

Symbol of IGBT:- **2M**

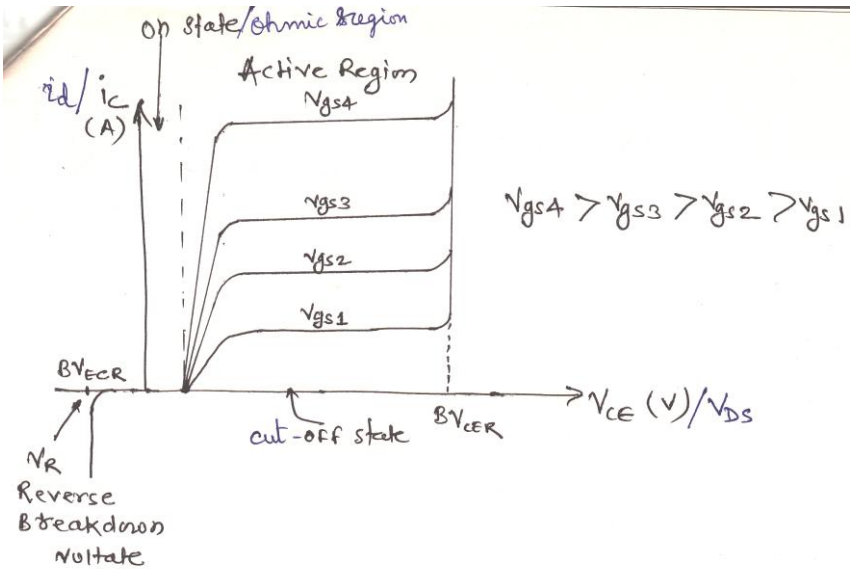




Note: [Either n-channel or p-channel symbol should be considered]

V-I characteristics of IGBT: - **3M**

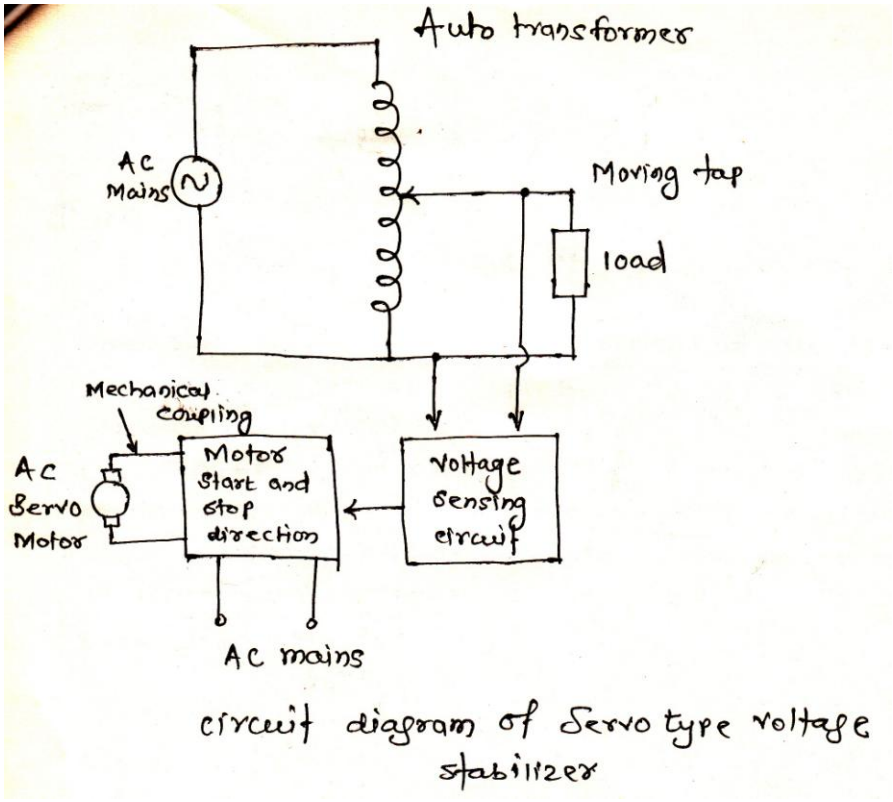
Note: [for drawing characteristics 1 ½ marks and for correct label 1 ½ marks]



b) With neat circuit diagram, explain operating principle of servo-type voltage stabilizer.

State specifications and applications of this stabilizer.

Ans: *Note: [Diagram 2 marks, explanation 2 marks, any 2 specifications- 2 marks, any 2 applications- 2 marks]*



circuit diagram of Servo type voltage stabilizer

The block diagram of servo type voltage regulator as shown,

It uses an ac servo motor which is mechanically coupled to the moving tap of an auto- transformer. The voltage sensing circuit will sense the load voltage and if it is found to be less than or greater than the normal voltage i.e. 230V, the AC servo motor will rotate either in the clockwise or in the anticlockwise direction. Therefore the moving tap of the auto-transformer will also change its position and the necessary corrective action is taken.

Applications: -

1. Mostly for computers, inverters, UPS, refrigerator.

2. Resonant type ac voltage regulators.

Specifications: -

1. Output voltage range

2. Output frequency

3. Voltage regulation

4. Temperature stability.

Q.2 Attempt any four: 16M

a) Explain operating principle of an N-channel MOSFET.

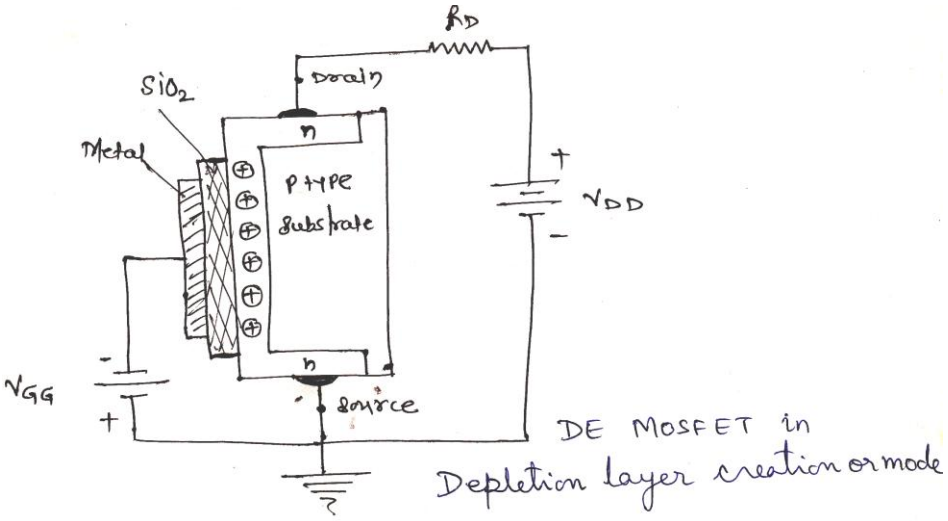
Ans: operating principle of an N channel MOSFET:

Note: [either depletion or enhancement type MOSFET should be considered operating principle 2 marks and diagram 2 marks]

The DE MOSFET can be operated in either of two modes: The depletion mode of the enhancement mode.

The MOSFET operates in the depletion mode when a negative gate to source voltage is applied and in the enhancement mode when a positive gate to source voltage is applied.

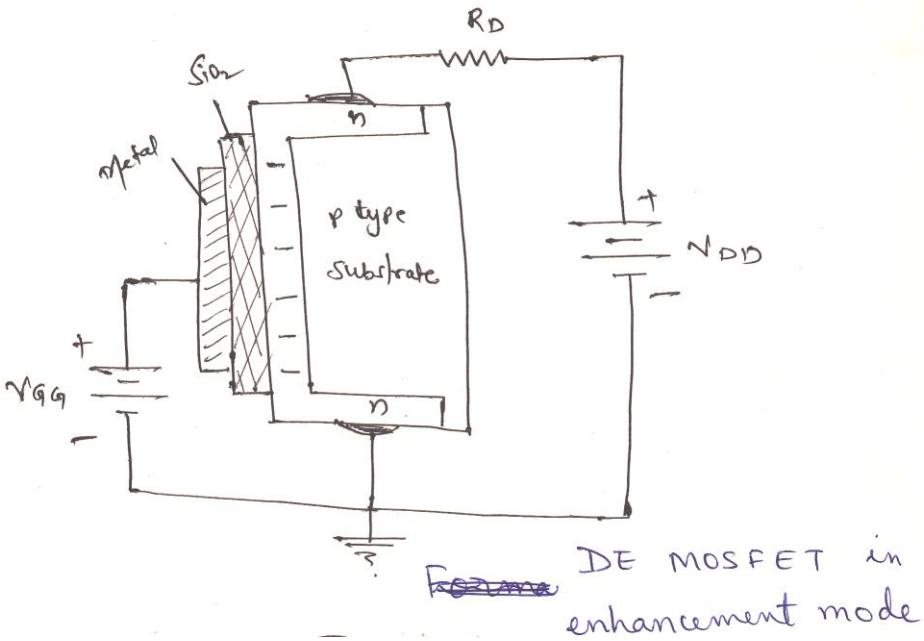
Depletion Mode:



When a negative gate voltage is applied, the negative charges on the gate rippled conduction electrons form the channel, leaving positive ions in their place. Thereby the N- channel is depleted of some of its electrons, thus decreasing the channel conductivity. The greater negative voltage on the gate, greater depletion of N-channel electrons. At sufficiently negative gate to source voltage, V_{GS} (off), the channel is totally depleted and drain current is zero.

Enhancement mode: -

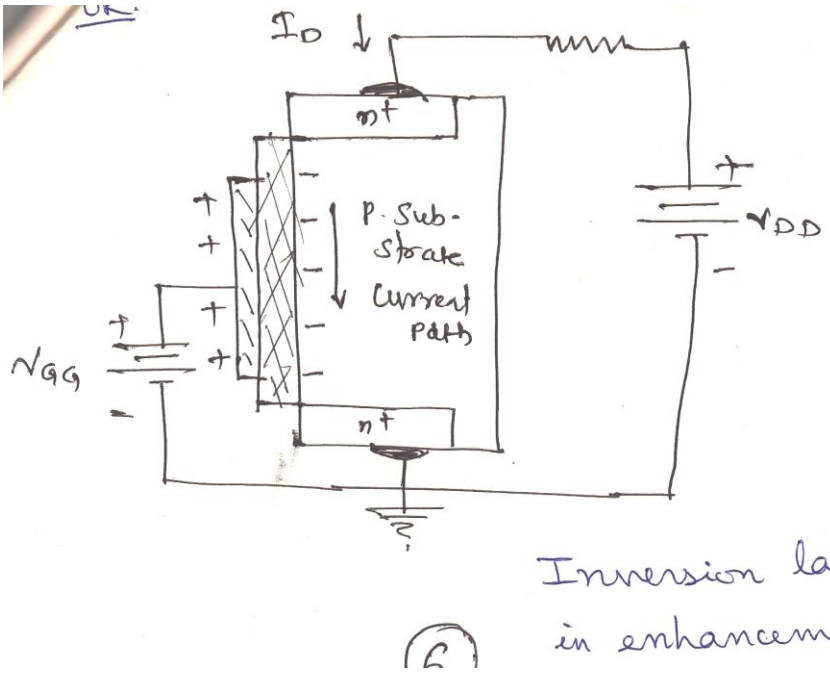
With the positive gate voltage, more conduction electrons are attracted onto the channel, thus increasing the channel conductivity.



OR

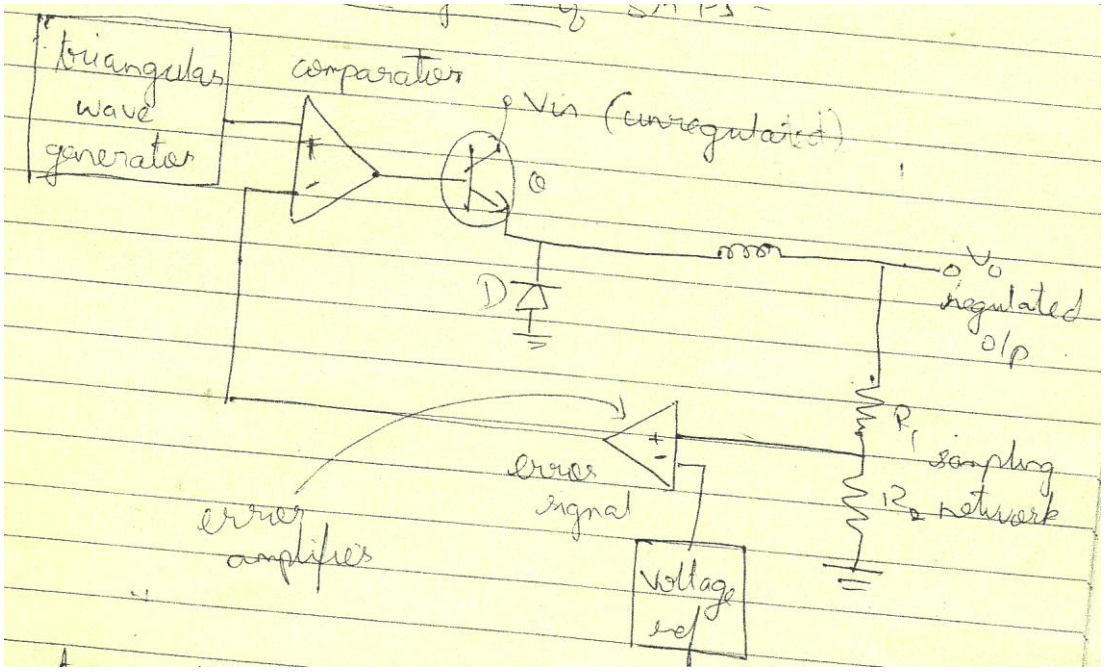
n-Enhancement MOSFET:

it differs in construction from the DE MOSFET in that it has no physical channel. For N- channel, a positive gate voltage above a threshold value induces a channel by creating a thin layer of negative charges in the substrate region adjacent to SiO_2 layer shown in fig. the conductivity of the channel is enhanced by increasing the gate to source voltage and thus pulling more electrons into channel, for any gate voltage below the threshold value, there is no channel.



b) With the help of block- diagram explain the basic principle of operation of SMPS.

Ans: Functional block diagram of SMPS: **2M**



Explaination: **2M**

The transistor Q operates as a switch that is its operates in saturation and cutoff the feedback voltage is given by,

$Vfb = (R_2/R_1 + R_2)\ V_0$.

The feedback voltage is applied at the non-inverting terminal of the errors amplifier.

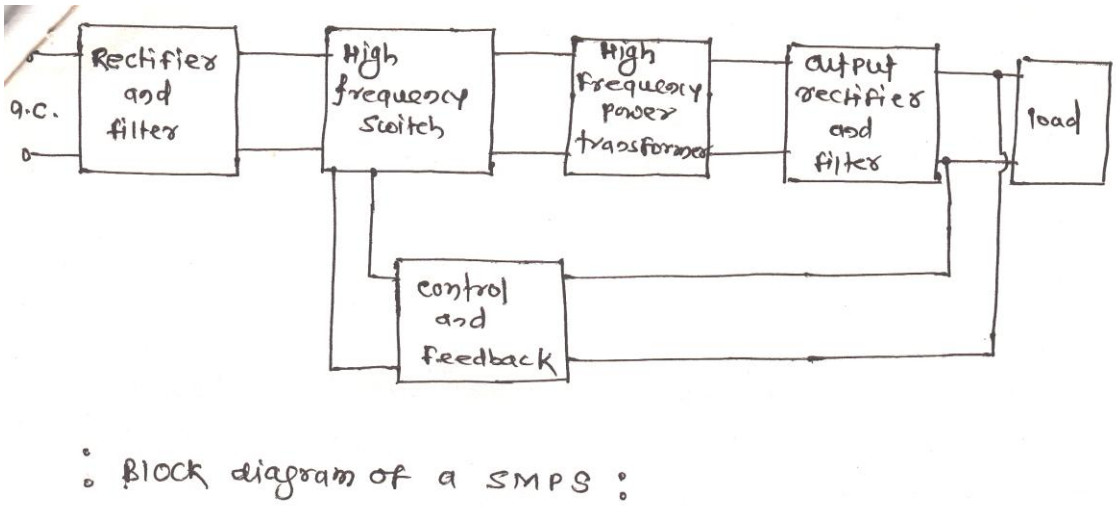
A reference voltage is applied to the inverting terminal of the error amplifier. The difference between the Vfb and reference voltage is called error.

Output voltage of the error amplifier is a control voltage proportional to error. The DC voltage is compare with a triangular wave generated by the triangular wave generator.

The output of the comparator is a rectangular wave which is used to turn on and turn off the transistor. The output of the transistor is filter by the LC filter to produce a pure DC output voltage.

OR

Block diagram of SMPS: **2M**



: Block diagram of a SMPS :

Explaination: **2M**

Block diagram of SMPS is shown –

The first block is rectifier and filter that converts the AC supply voltage to a pulsating DC which is then filtered out to reduce the amount of ripple content.

The second block is the high frequency switching and it uses either MOSFET and BJT to convert the DC voltage to high frequency AC square wave. This high frequency AC square wave ranges from 20KHz to 100KHz.

The next block of the SMPS is high frequency power transformer that isolates the circuit and steps up or steps down the voltage to the desired voltage layer. The output of the transformer is the input of the second rectifier section, called output rectifier section. The last section of the SMPS is the control and the feedback block, which contents circuitry that provides a pulse width modulation output signal, duty circle that varies pulse by pulse to provide accurate DC output voltage.

c) With neat circuit diagram. Explain simple bridge inverter with R-load.

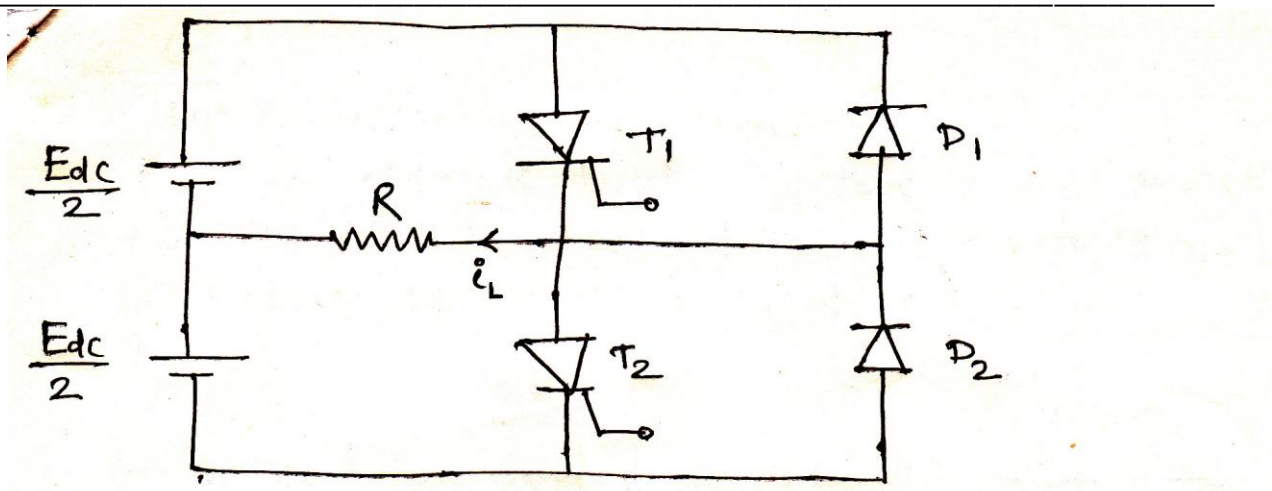
Ans: *Note: [since the question is not specific, any one type of (half bridge inverter, full bridge inverter using any type of switching device can be considered)]*

Bridge inverter with R-load: (Single phase half bridge inverter) **2M**

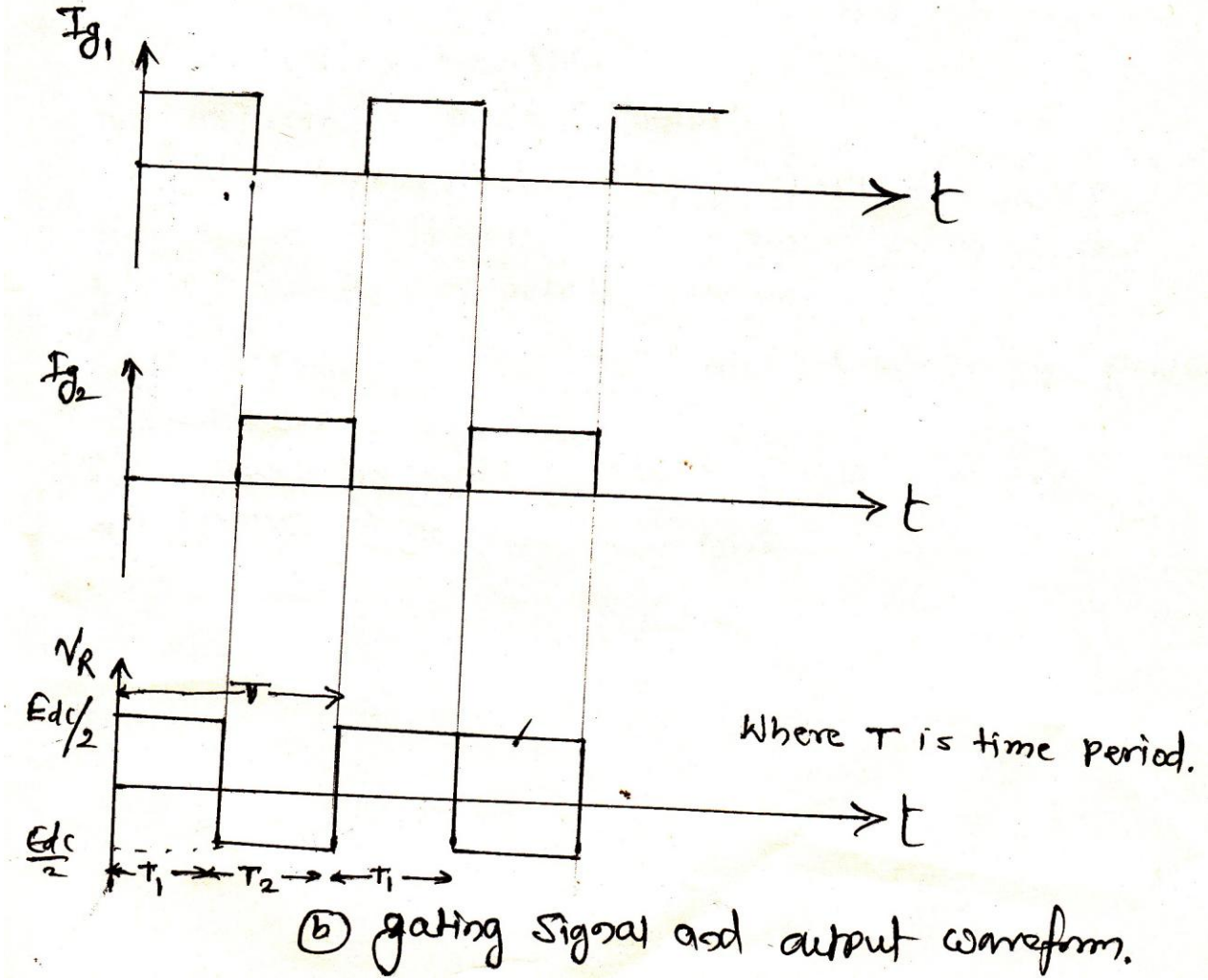
Single phase half bridge inverter shown, consist of 2 SCR and 2 Diodes. It is seen from fig b.

That $0<t\leq T/2$, thiristor T_1 conduct and the load is subjected to a voltage E_{dc} /2 due to upper voltage source $E_{dc}/2$. At t=T/2, thiristor T_1 is commutated and T2 is gated on. During the period $T/2 < t \leq T$ thiristor T2 conducts and the load is subjected to $-E_{dc}/2$ due to lower voltage source $E_{dc}/2$. From fig b. it is seen that voltage is an alternating voltage waveform of amplitude $E_{dc}/ 2$ and a frequency 1/T Hz.

Circuit Diagram: **2M**



ⓐ Single phase half bridge inverter



Where T is time period.

ⓑ gating signal and output waveform.

d) Define inverter. State four applications of inverters.

Ans: Invertor: **2M**

a device that converts DC power into AC power at desired output voltage and frequency is called inverter.

Application: **2M**

Note:[2 marks for any four application]

1. Variable speed AC motor Drives .
2. Induction heating
3. Aircraft power supply
4. Uninterruptible power supplies (UPS)
5. High voltage DC transmission lines
6. Battery vehicle drives
7. Regulated voltage and frequency power supplies.
8. Standby aircraft power supply
9. HVDC transmission lines

e) What are the different welding controls used in resistance welding. 4M

Ans: 1. Line contactor: it connects and disconnects the primary windings of welding transformer across the ac mains supply, it is like a switch controlled by control signal coming from control circuit.

2. Heat control circuit: It controls the amount of heat transferred to the load.

3. Sequence Timer: It has

- Squeeze timer- It provides time for pressure to build up before the line contactor is closed.
- Weld timer: It provides time for welding.
- Timer (Hold time): provide time for material to cool before releasing the pressure.
- Timer (Off time): Provides the time for unenergising welding electrodes before the next welding cycle begins

4. Pulsation timer: It decides the number of cycles for which the welding current flow

Q.3 Attempt any four: **16M**

a) List diffrent voltage control and PWM technique used in inverter.

Ans: There are various technique to control this output voltage – **2M**

- Controlling the DC input voltage
- Controlling AC output voltage
- Internal control of inverter

Internal control of inverter: there are two possible ways of doing this,

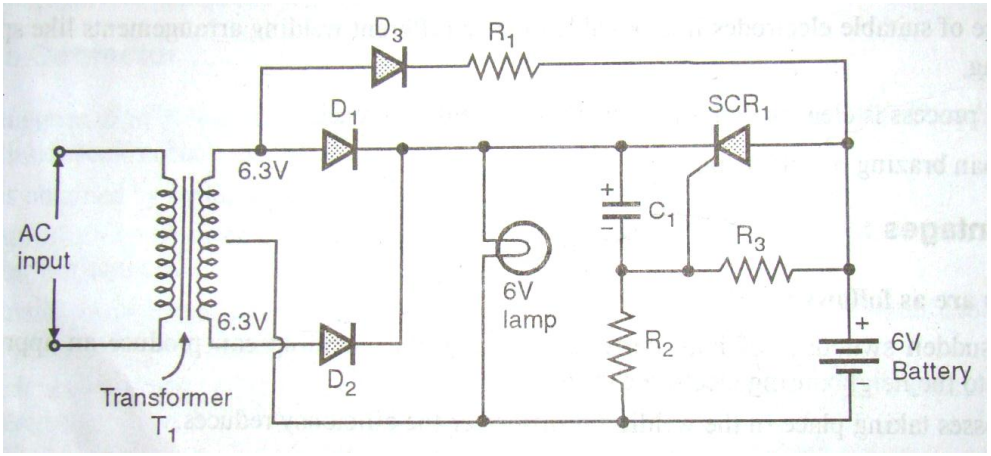
1. Series Inverter control
2. Pulse Width modulation control

Different PWM techniques used in inverter are : **2M**

i) Single PWM (SPWM)
ii) Multiple PWM (MPWM)
iii) Sinusoidal PWM (Sine PWM)
iv) Modified sinusoidal PWM

b) With neat block diagram, explain emergency light system.

Ans: Emergency light system diagram: **2M**



Explanation: **2M**

[Note: Additional points can be considered]

1. Diode D1 and D2 form full wave rectifier along with centre –tap transformer.

2. They supply DC voltage for the lamp when AC supply is ON.

3. Diode D3 and R1 supply the battery charging current.

4. The cathode of SCR1 is kept at a higher potential by C1.

5. When AC supply is interrupted the o/p of rectifier is zero.

6. cathode potential of SCR1 falls below battery voltage the gate current is supply to SCR1 through R3 and SCR is trigger, this connect battery across the lamp. When again AC input reappear SCR1 is turned OFF automatically and battery start charging.

c) State specifications of Isolation transformer and also write its core properties.

Ans: (Any two points 2 marks)

Core properties of isolation transformer:

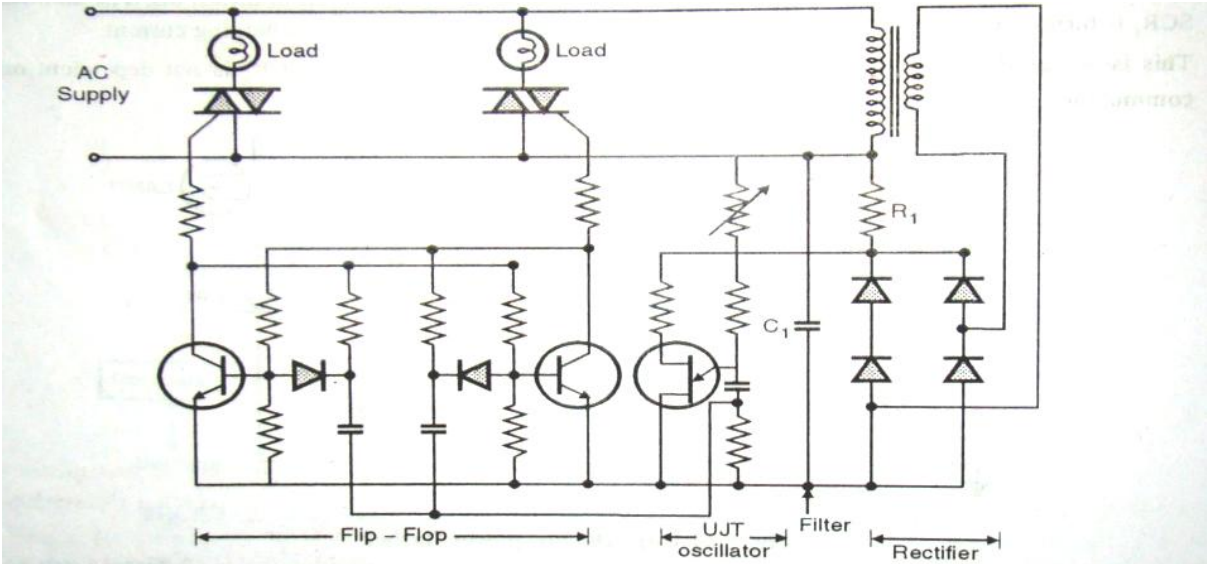
1) To provide complete isolation
2) Operating at high frequencies
3) Power loss should be minimum
4) Multiple secondary windings / DC output voltages
5) Core should not saturated

Specifications: **(any 2 points 2 marks)**

Type of isolation provided, operating frequency, power rating

d) With neat circuit diagram explain AC flasher circuit.

Ans: Diagram of AC flasher circuit: **2M**



Note: [circuit diagram consisting of Astable multivibrator with resistance & diode arrangement can also be considered]

Explanation**:** **2M**

AC flasher is economically used for high power requirement applications.

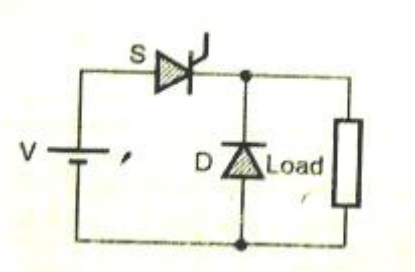
A power flip-flop can handled two loads independently, each up to 2.5 KW.

The circuit consists of a bistable multivibrator using transistor, free running uni-junction Oscillator, bridge rectifier, capacitor with a filter to provide DC supply and two triacs to

Control the loads.

e) With neat circuit diagram explain operation of step-down chopper.

Ans: Step down chopper diagram: **2M**



Explanation: **2M**

Output voltage is less than input voltage. When the SCR is on, voltage is available to the load. When the SCR is off, voltage is not available to the load. Freewheeling diode is used for inductive load

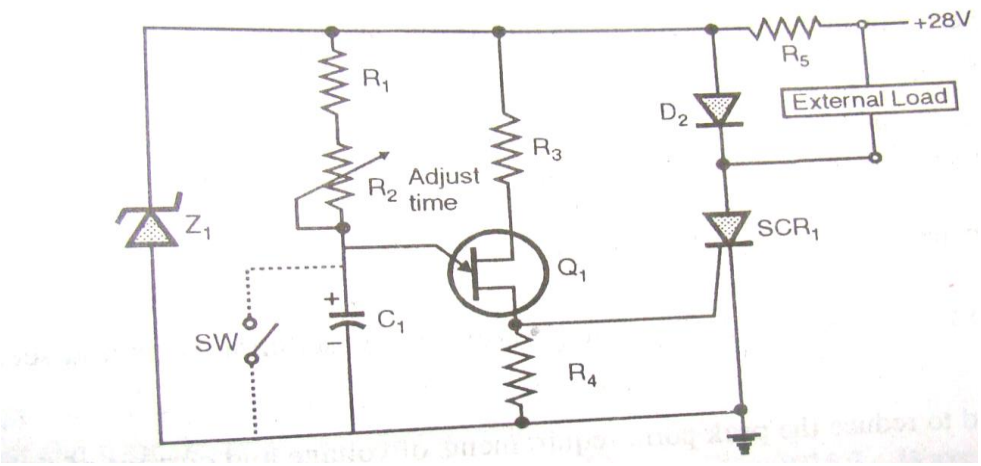
Output voltage Vo = D x V

D is the duty cycle.

Q.4 A) Attempt any two: **8M**

a) Explain the working of dc time delay relay with a suitable circuit diagram.

Ans: Diagram: **2M**



Explanation: **2M**

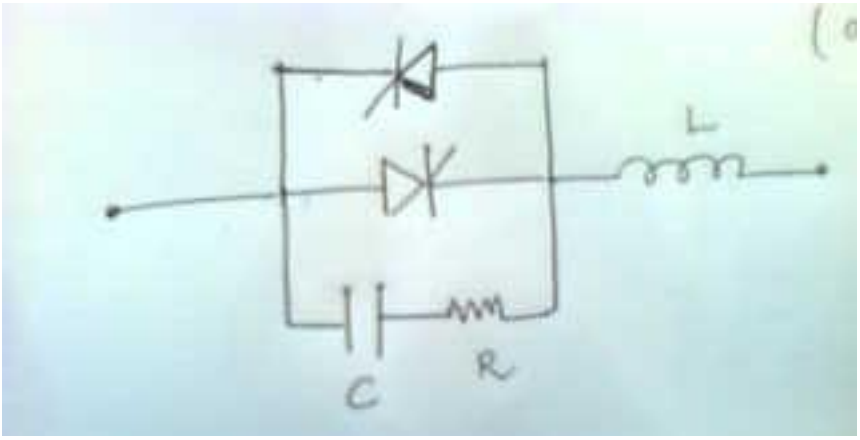
1. Initially SCR1 is OFF and there is no voltage to the load.

2. By opening or shorting contact SW across C1 timing is initiated.

3. C1 is charged through R1 and R2 and C1 reaches peak point voltage of UJT and UJT triggers generating a pulse across R4 which triggers SCR1.

b) With neat circuit diagram, explain operating principle of unpolarised RC snubber circuit.

Ans: Diagram of unpolarised snubber circuit: **2M**



Explanation: **2M**

An unpolarised RC snubber circuit is used for di/dt protection. It is used when pair of SCR's are connected in antiparallel.

c) Compare on-line and off-line UPS.

Ans: (any 4 points can be considered 4 marks)

ON line UPS	**OFF line UPS**
Inverter preferred	Line preferred
Main static switch is normally OFF	Main static switch is normally ON.
UPS static switch is normally ON	UPS static switch is normally OFF.
Total harmonic distortion is low	Total harmonic distortion is high
Operation is continuous	Operation is only during the absence of mains.
Critical load	General purpose load
Very reliable	Not so reliable.

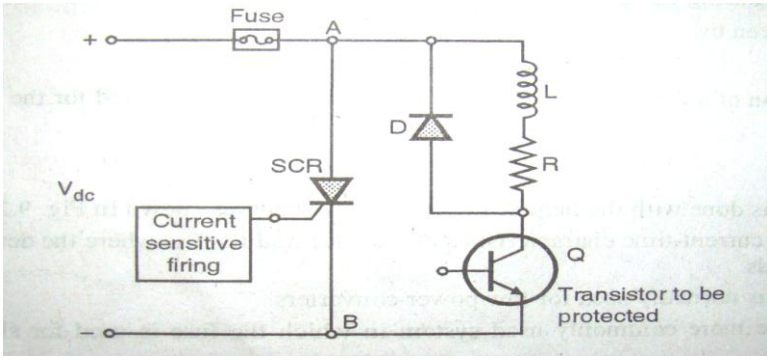
B) Attempt any one: **8M**

a) State necessity of protection circuit for an SCR? Explain crowbar protection with neat diagram.

Ans: Necessity of Crowbar protection **2M**

In power converters, fault may take place which result in large fault currents. This fault current must be cleared quickly in order to protect the power devices from getting damaged.

Crowbar protection diagram: **3M**



Explanation: **3M**

1. SCR is used which is normally in off state.
2. There are a voltages or current sensitive firing circuit.
3. If the current through Q goes above a preset value, then the SCR will be turn ON.
4. The SCR will act as a closed switch and will short circuit points A and B.
5. So in fault condition, SCR turns ON and will below the fuse and the transistor is protected.

b) What are the different chopper configurations? Explain them with neat diagram.

Ans: *[Note: Atleast any four type expected, 1 marks for diagram and 1 marks for Explaination]*

Single quadrant : Type A and Type B

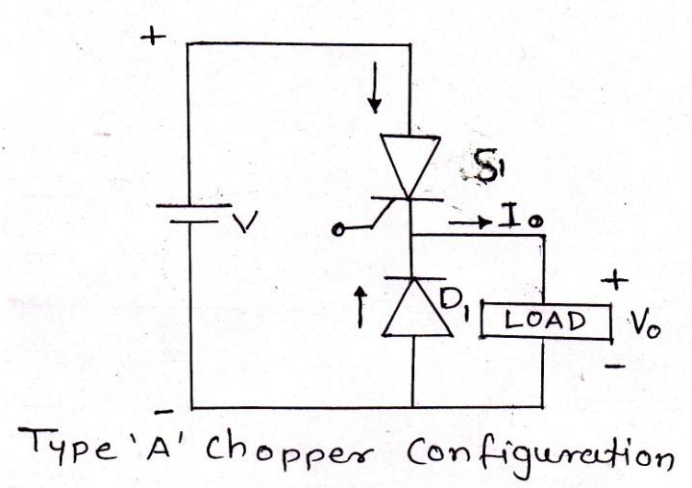
Two quadrant : Type C and Type D

Four quadrant : Type E

Type A chopper:

When thiristor S1 triggers Vo = V and Current Io flows as shown

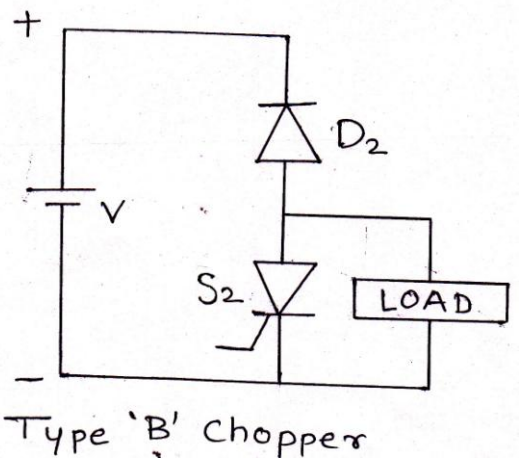
when thiristor turn off Vo = 0 but Io in the load contineous to flow in the same direction due to inductive load through diode D1. Thus the average values of load voltage and current are always positive and power flows from source to load.



Type 'A' Chopper Configuration

Type B chopper :

When thyristor S2 triggers Vo = 0 and Current Io flows through the load and thyristor S2 when thyristor S2 turn off the energy stored in the inductive load is return to the source through D2. The load current Io flows in the opposite direction hence the average values of load voltage is positive and the average current is negative this meanse power flows from load to source.

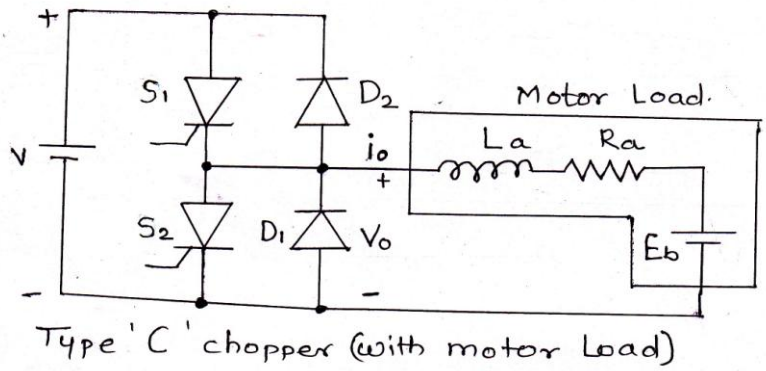


Type 'B' Chopper

Type C chopper :

Thyristor S1 and diode D1 operates as a type A chopper and Thyristor S2 and Diode D2 works as a type B chopper.

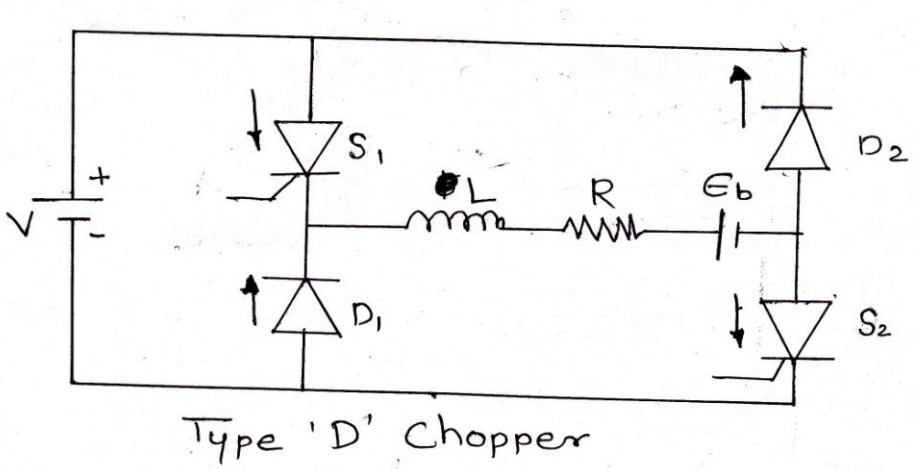
In this load current is positive when Thyristor S1 is trigger or diode D1 conducts and its value is negative when thiristor S2 is ON and Diode D2 conducts.



Type 'C' chopper (with motor Load)

Type D chopper :

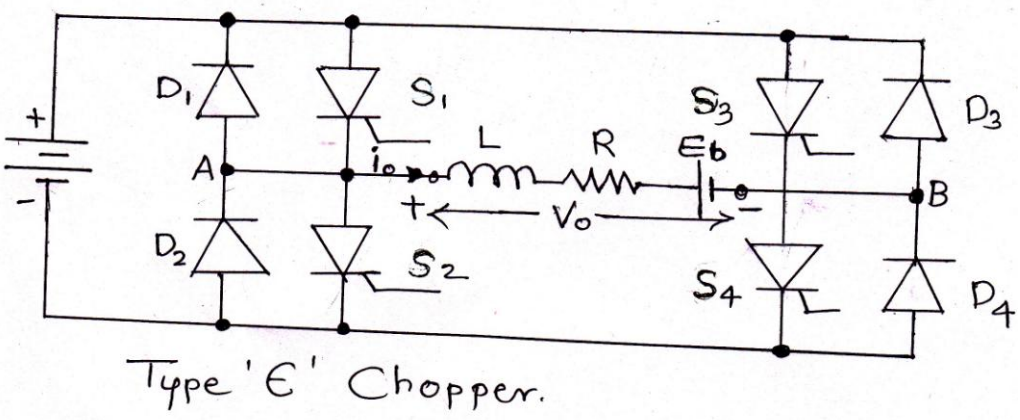
Type D chopper is also two Quadrant chopper, the load current is positive and the load voltage is either positive or negative, this type of chopper may be used for motoring and regenerating breaking of DC motor



Type 'D' Chopper

Type E chopper :

A type E chopper is four quadrant chopper in which the load current and load voltage are either positive or negative



Type 'E' Chopper.

Q.5 Attempt any four: 16M

a) Explain the method adopted for the protection of SCR against over current.

Ans: Over current protection of SCR: **4M**

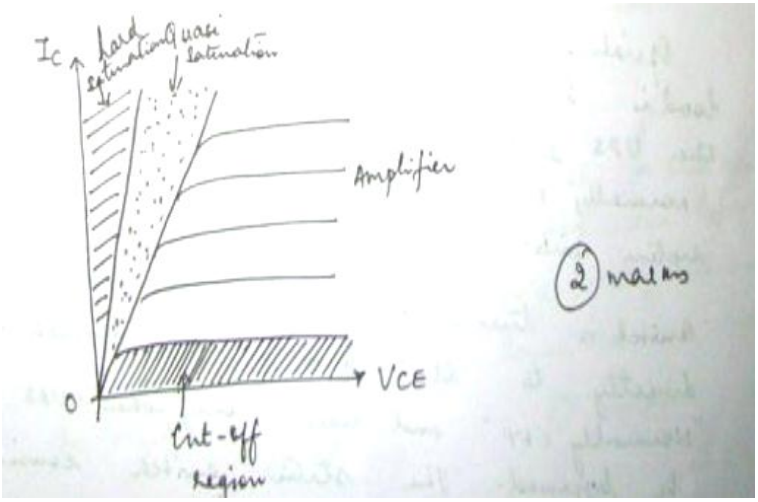
Fuse may be used .In case of over current or short circuit due to a fault, the fuse blows and protects the semiconductor devices.

Crowbar circuit can also be used for overcurrent protection.

Current fold back protection can also be used for overcurrent protection.

b) Explain how power transistor is turned on. Draw V-I characteristics of power transistor.

Ans: Diagram: **2M**

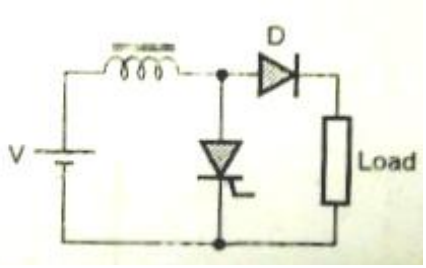


Explanation: **2M**

When the base current is applied transistor does not turn ON instantly because of the presence of internal capacitances when positive input voltage is applied to the base, Base current(Ib) rises and base to emitter voltage begins to rise gradually Current Ic begins to rise from zero and collector to emitter voltage starts falling from its initial value Vcc and this way the transistor turn ON

c) Explain the operation of a step-up chopper. Obtain the expression for output voltage.

Ans: Diagram of step up chopper: **2M**



Explanation: **2M**

Output voltage is more than the input voltage.

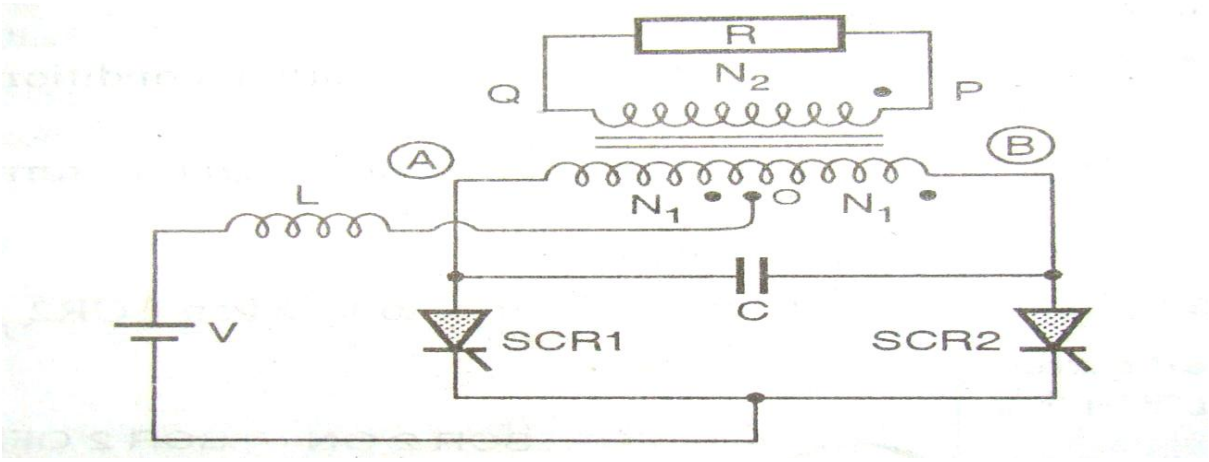
When SCR is on, current through the inductor rises and voltage developed across the inductor is Ldi/dt. When SCR is turned off, the energy stored in the inductor is transferred to the load.

Expression for output voltage:

Output voltage Vo = V/ (1-D)

d) With neat circuit diagram, explain the operation of parallel inverter.

Ans: Parallel inverter **2M**



Explanation: **2M**

1. SCRs, SCR1 and SCR2 are switched alternately to connect the input DC source V across the half of the transformer primary. C is commutating capacitor.

2. When SCR 1is turned ON the DC voltage appears across the left half of primary OA.

3. Due to transformer action voltage across AB is 2V. Hence the capacitor is changed to 2V. The load voltage and current is positive.

4. The firing of SCR2 turns off SCR1. The input voltage gets connected across OB .

5. The load voltage changes polarity and direction of load current is reversed.

6. Square o/p waveform is observed.

e) Write a short note on circuit breaker.

Ans: Circuit breaker: **4M**

Circuit breakers disconnect the load from the mains in the event of overload or fault.

Are used for low voltage motors of high ratings.

They are used for overload protection, short circuit protection, under voltage, over temperature and unbalanced supply voltage in motors.

Q.6 Attempt any four: 16M

a) State application of MOSFET and IGBT. (Any two of each).

Ans: (2 marks each)

Applications of MOSFET: ac motor control, SMPS

Applications of IGBT: ac motor control, SMPS, drives, UPS (any 2 points)

Note: [Any other application may be considered.]

b) Explain resonant type regulators.

Ans: *Note: [Marks to be considered without diagram]*

Resonant type voltage regulator

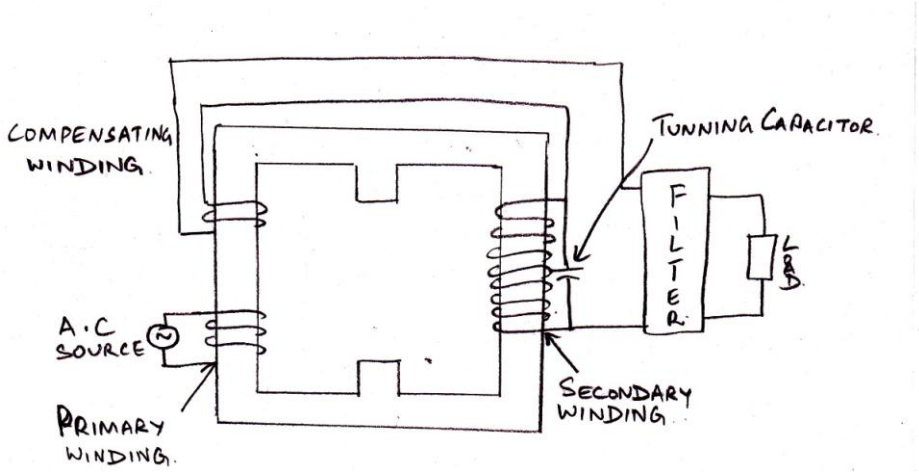


fig. RESONANT TYPE VOLTAGE REGULATOR

Constructional details of Resonant type regulators: **2M**

Primary winding is unsaturated inductor

Secondary winding is saturated inductor

Capacitor is used for tunning.

Compensated winding for voltage regulation

Working: **2M**

Primary winding is given ac supply. Output is taken across secondary winding. For any change in the input voltage, the output voltage remains constant.

c) State specifications of UPS.

Ans: various specifications of UPS: **4M**

Note: [any 4 points can be considered]

i) Power rating

ii) Output voltage

iii) Output frequency

iv) Output waveform

v) Input voltage

vi) Backup time

vii) Transfer time

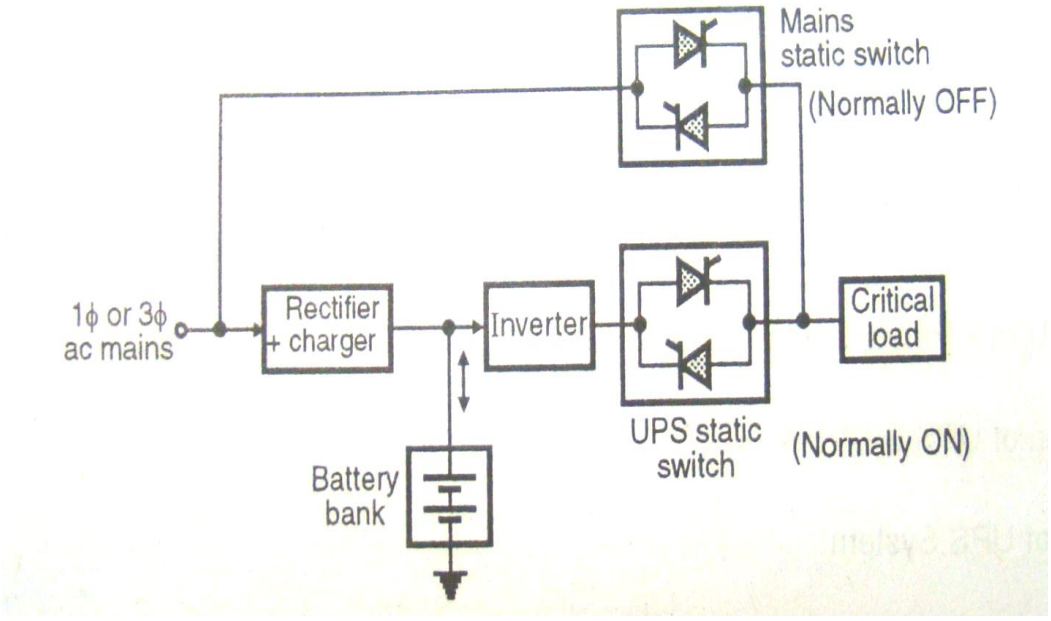
viii) Efficiency of the current

ix) Protection provide

x) Load power factor

d) Draw block diagram of on-line function of each block.

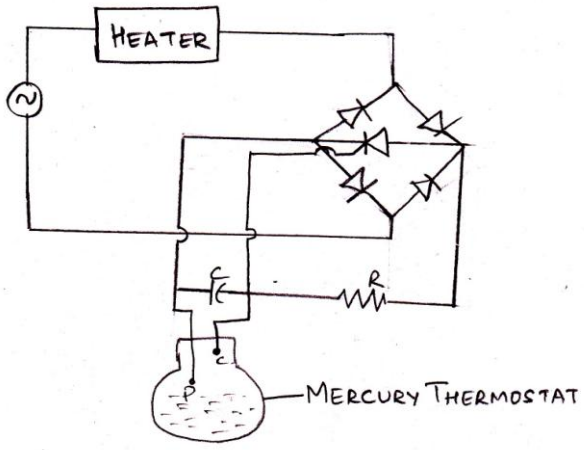
Ans: On-line UPS diagram: **4M**



e) Explain the circuit of temperature controller using SCR.

Ans: Temperature controller using SCR

Diagram: **2M**



Explanation: **2M**

When the temperature is less than the set temperature, the mercury in the glass is unable to expand and cannot short the terminals A and B. Therefore, the SCR receives the gate signal through the RC network and the heater will be turned ON.

When the temperature slightly increases above the set value, the mercury in the glass will expand and short the terminals A & B. This will short circuit the gate supply to the SCR. Hence, the SCR will not get the trigger pulse and goes to OFF state and the heater will be turned OFF.