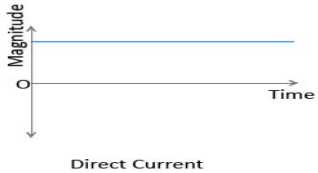
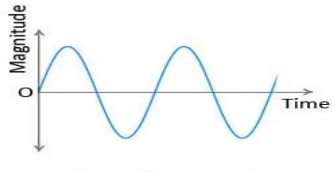
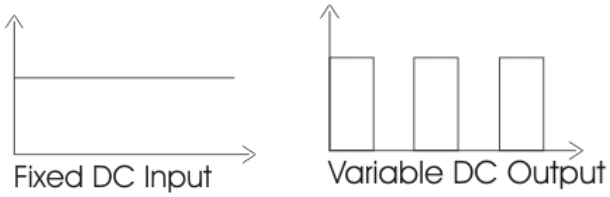
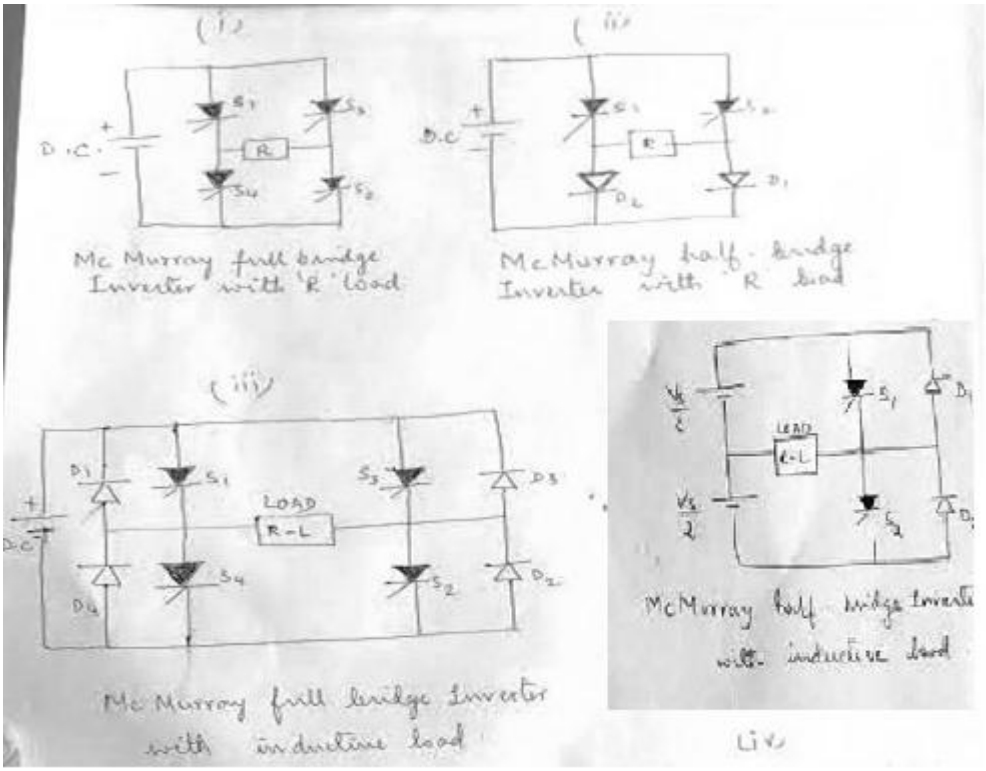
WINTER– 16 EXAMINATION (Subject Code: 17541)

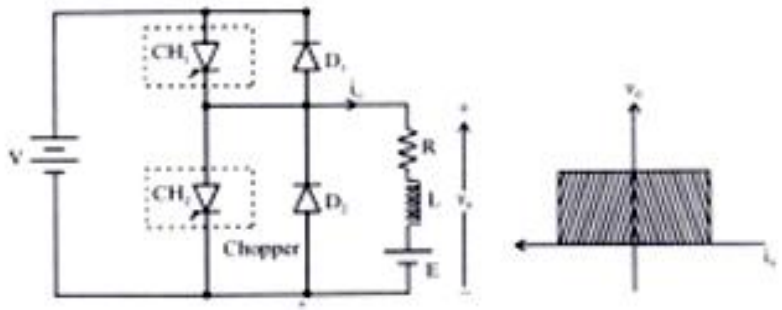
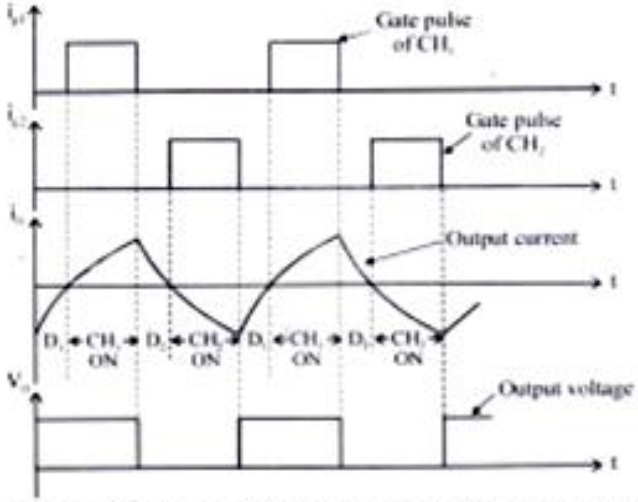
Model Answer

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		**Attempt any three:**	**12-Total Marks**
1	**a)**	**State different types of protections required to ensure safety of power devices.**	**4 M**
	Ans:	Different types of protections required to ensure safety of power devices are: 1. Overcurrent protection 2. Overvoltage protection 3. Snubber circuit 4. Heat sink 5. MOV 6. Sellinum Diode	**Each point 1M- Any Four**
	b)	**Draw the input and output waveform for DC to AC converter and DC to DC converter.**	**4 M**
	Ans:	D.C to A.C converter waveform:  Direct Current  Alternating Current	**1M each waveform**

	D.C to D.C Converter Waveform:  	
c)	**Draw McMurray Bridge Inverter Circuit.**	**4M**
Ans:	 	**Any one circuit can be considered .**
d)	**State advantages, disadvantages and applications of isolated SMPS (any two points for each).**	**4 M**
Ans:	**Advantages of SMPS:** 1. Power dissipation is low **2.** High efficiency **3.** Compact in size **4.** High power handling capacity **Disadvantages of SMPS:** 1. Switching losses are more 2. Cost is more **Applications of SMPS:** 1. Computers 2. Battery chargers 3. Battery vehicles	**Any two Adv- 1 M** **Disadv- 1M each** **Applicatio n2 M**

B)	**Attempt any ONE**	6 M
a)	**Draw and explain two quadrant chopper.**	**6M**
Ans:	**CLASS C CHOPPER** Class C Chopper is a combination of Class A and Class B Choppers. Figure 2.5 shows a Class C two quadrant Chopper circuit. For first quadrant operation, CH_1 is ON or D_2 conducts and for second quadrant operation, CH_2 is ON or D_1 conducts. When CH_1 is ON, the load current i_o is positive. i.e., i_o flows in the direction as shown in figure 2.5. The output voltage is equal to $V(v_o = V)$ and the load receives power from the source.  **Fig. 2.5: Class C Chopper** When CH_1 is turned OFF, energy stored in inductance L forces current to flow through the diode D_2 and the output voltage $v_o = 0$, but i_o continues to flow in positive direction. When CH_2 is triggered, the voltage forces i_o to flow in opposite direction through L and CH_2. The output voltage $v_o = 0$. On turning OFF CH_2, the energy stored in the inductance drives current through diode D_1 and the supply; output voltage $v_o = V$ the input current becomes negative and power flows from load to source. Thus the average output voltage v_o is positive but the average output current i_o can take both positive and negative values. Choppers CH_1 and CH_2 should not be turned ON simultaneously as it would result in short circuiting the supply. Class C Chopper can be used both for dc motor control and regenerative braking of dc motor. Figure 2.6 shows the output voltage and current waveforms.  **Fig. 2.6: Class C Chopper - Output Voltage and Current Waveforms**	**(Diagram: 3 M & Explanation :3M) Waveform Optional (Any 1 chopper can be consider)**

CLASS D CHOPPER

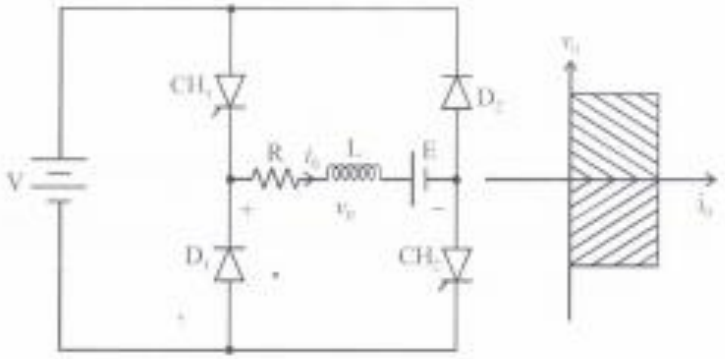


Fig. 2.7: Class D Chopper

Figure 2.7 shows a class D two quadrant chopper circuit. When both CH_1 and CH_2 are triggered simultaneously, the output voltage $v_0 = V$ and output current i_0 flows through the load in the direction shown in figure 2.7. When CH_1 and CH_2 are turned OFF, the load current i_0 continues to flow in the same direction through load, D_1 and D_2, due to the energy stored in the inductor L, but output voltage $v_0 = -V$. The average load voltage v_0 is positive if chopper ON-time (t_{ON}) is more than their OFF-time (t_{OFF}) and average output voltage becomes negative if $t_{ON} < t_{OFF}$. Hence the direction of load current is always positive but load voltage can be positive or negative. Waveforms are shown in figures 2.8 and 2.9.

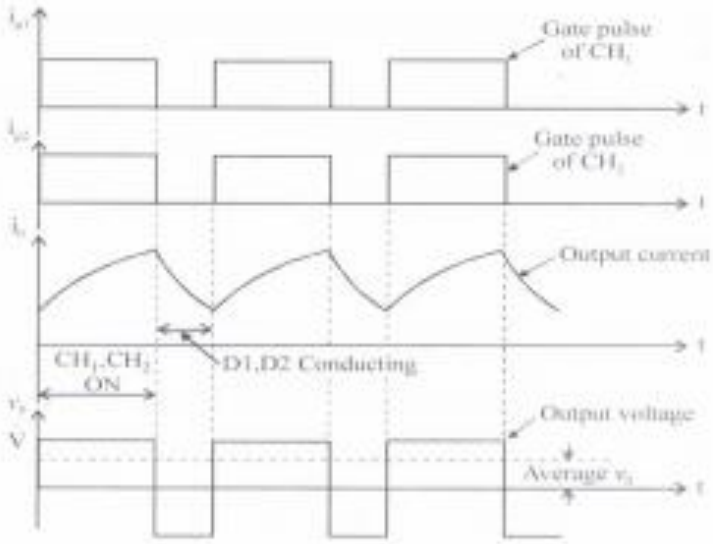


Fig. 2.8: Output Voltage and Current Waveforms for $t_{ON} > t_{OFF}$

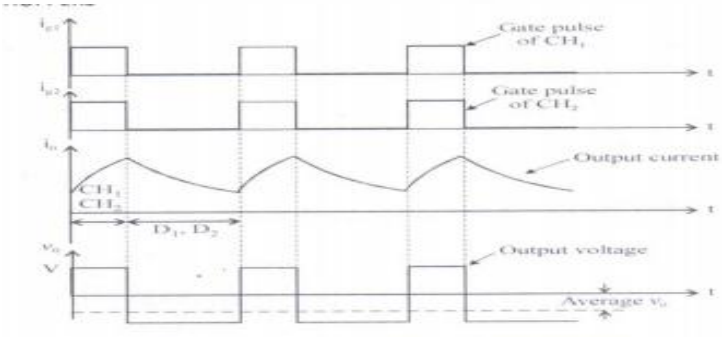
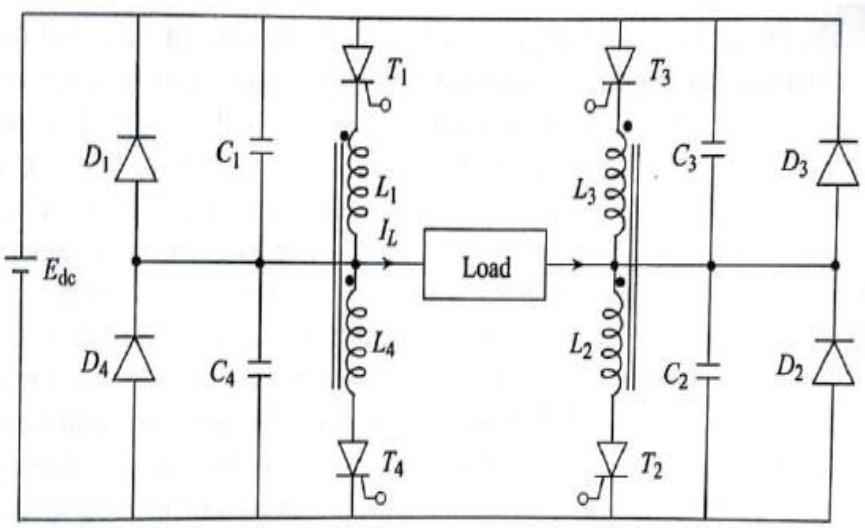
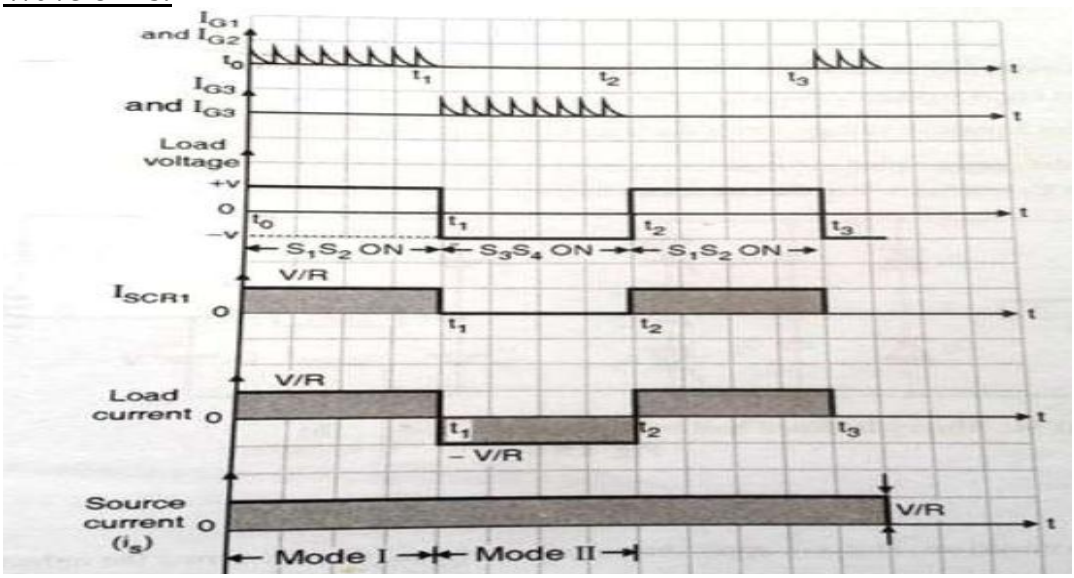
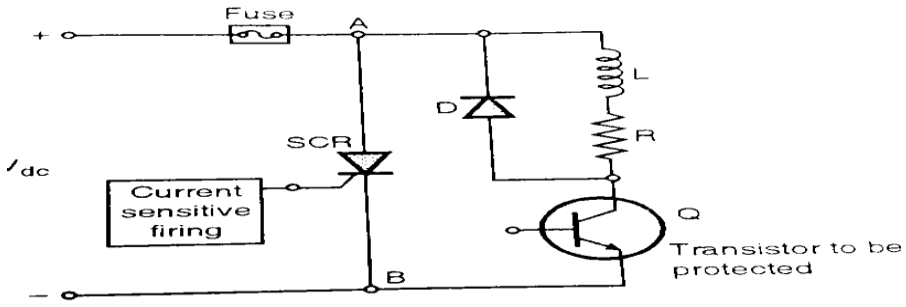
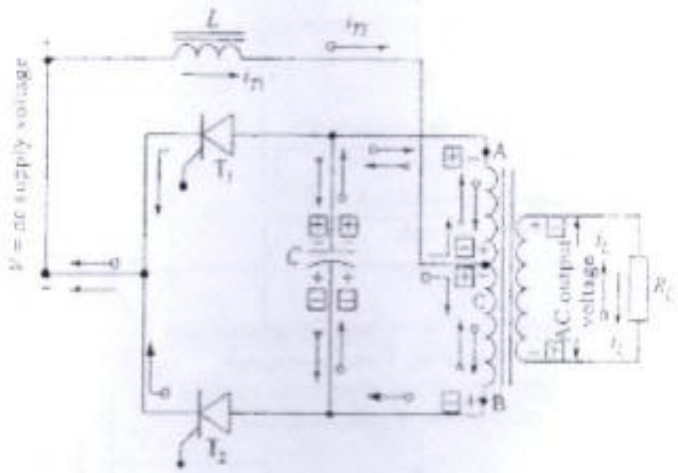
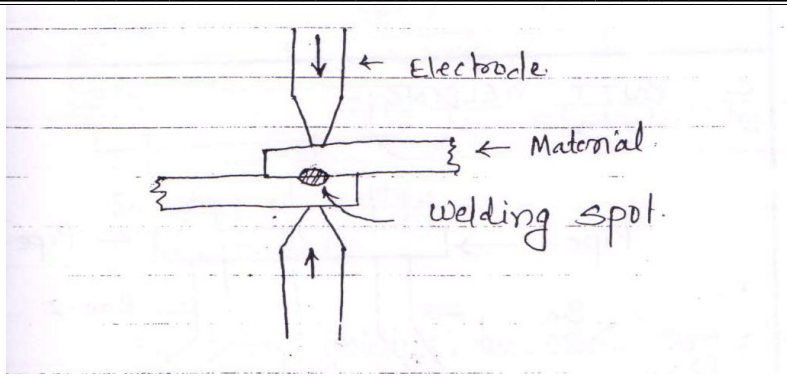


Fig. 2.9: Output Voltage and Current Waveforms for $t_{ON} < t_{OFF}$

b)	**Draw the circuit diagram of McMurray Bedford bridge inverter. Describe the operation of it with output voltage waveforms.**	**6 M**
Ans:		**2M full bridge Bedford can also be consider**
	Operation: • It uses 4 SCRS and 4 diodes. • When T1 and T2 are turned ON, the direction of load current is from left to right and the inductor stores energy. • When T1 and T2 are turned OFF, inductor reverses its polarity. • D3 and D4 becomes forward biased. • When T3 and T4 are turned ON, the direction of load current is from right to left and the inductor stores energy. • When T3 and T4 are turned OFF, inductor reverses its polarity. • D1 and D2 become forward biased.	**2M**
	Waveforms: 	**2M**

Q 2		Attempt any two.	16
	a)	**State the necessity of protection circuits. With neat diagram explain current fold back crowbar protection.**	**8M**
	Ans:	**Need:** To provide protection against over voltage, over current, di/dt, dV/dt, and over temperature. In the converter circuit voltage transient get generated due to reverse recovery process of the power devices and switching take place in presence of supply and load inductance. The short circuit fault condition or the cross conduction taking place in convertor circuit will result in heavy fault current flowing through the devices. So we require protection circuit.	**3M**
			**2M**
		Crowbar protection: It is used to protect device where a large current or power is involved. 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	
		Explanation: SCR is used which is normally in off state. There are a voltages or current sensitive firing circuit. If the current through transistor Q goes above a predecided value, then the current sensitive firing circuit will turn ON the SCR. The SCR will act as a closed switch and will short circuit points A and B. So in fault condition, SCR turns ON and creates a virtual short circuit to blow the fuse and the transistor is protected	**3M**
	b)	**Explain with neat diagram parallel inverter with resistive load. Explain which commutation method is used in circuit.**	**8M**

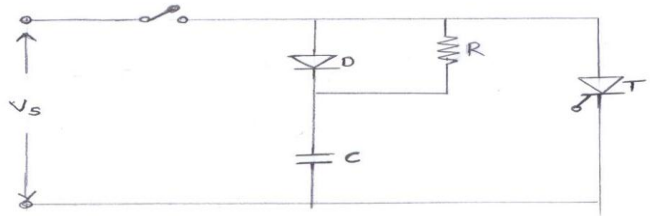
	Ans:	**Parallel Inverter** 05/C In parallel inverter the commutating component are connected in parallel with the load, where a capacitor connected in parallel with the load is used to commutate a conducting thyristor by applying reverse voltage across the thyristor. An inductor L is required in series with the dc source to prevent the instant discharging of capacitor C via the source when thyristor switching occurs. Figure show the basic parallel inverter circuit. This circuit can produce ac square wave output from dc source.	**3M**
		 	**3M**
		When T1 is fired and current flows through the inductance L and the thyristor T1, the d.c. source voltage Edc appears across half the transformer primary which means the total primary voltage is 2Edc hence the capacitor is charged to 2Edc with the polarity shown in figure. When T2 is turn on the commutating capacitor applies a voltage -2Edc to appear across T1. When this reverse voltage is applied for a sufficient time across T1, it will be turn off. Scr T2 will now be conducting and a voltage of 2Edc will appear across the transformer primary and the commutating capacitor, but with a reverse polarity. When T1is turned on the commutating capacitor applies a voltage -2Edc to appear across T2, hence it will be turn off. Thus, if trigger pulses are periodically applied to the alternate thyristors, an approximately rectangular voltage waveform will be obtained at the transformer output terminals. **Class C commutation Method is used.**	**2M**
	c)	**State types of resistance welding. Explain spot welding.**	**8M**
		Types of resistance welding: 1. Butt welding 2. Spot welding 3. Projection welding 4. Seam welding	**2M**
		SPOT WELDING:	**3M**



Explanation: **3M**

Spot welding is done by clamping two or more pieces of metal in the form of sheets together between two pointed electrodes. The electrode tips are made of copper or copper alloy and are water cooled. The welding current depending on the thickness and the composition of the plates are adjusted.

Q. 3		Attempt any four.	16M
	a)	**Explain any one Snubber circuit for protecting SCR against dv/dt.**	4M
	Ans:	**dv/dt Snubber circuit:**	2M

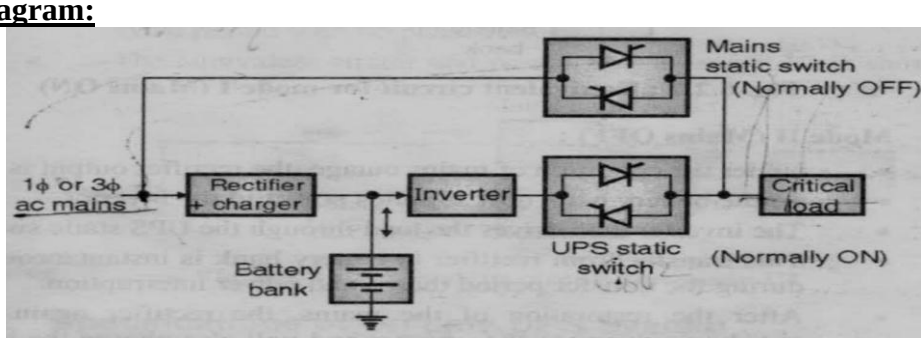
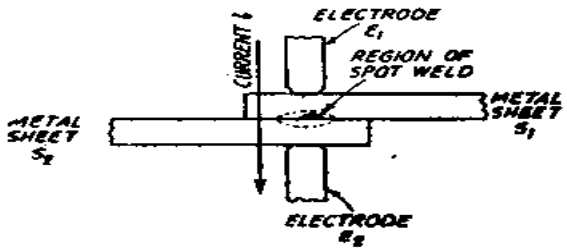


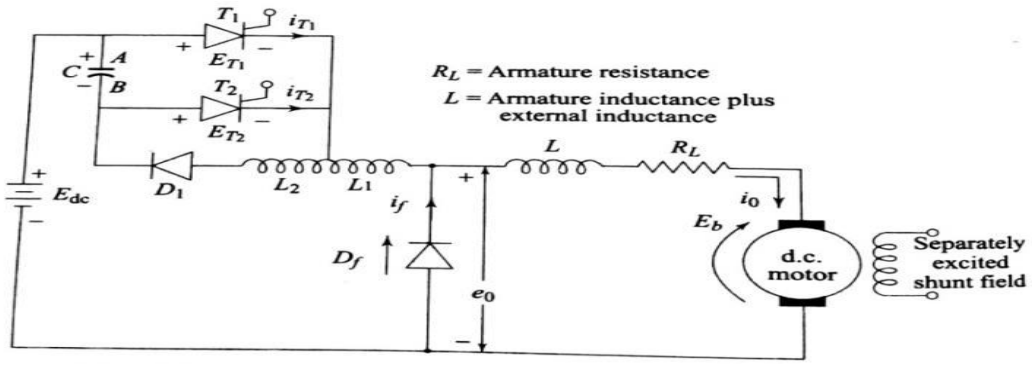
Explanation: **2M**

If switch is ON, voltage is applied to SCR but to high rise in rate of change of supply voltage SCR may turn ON, to avoid this we have to reduce rate increase of voltage across SCR' snubber Ckt is used for this protection.
When SCR is off SW is closed, the capacitor charges to supply voltage Vs through diode. Due to low forward resistance offered by diode, this diode is same as commented across SCR, thus the rate of rise of voltage is controlled.
When capacitor is fully charged, diode is reverse biased .SCR ' is turn On ,thus the capacitor will discharge through R and SCR.Thus this R limits the discharge current.

	b)	**State the advantages of SMPS over linear regulators (two points). Give four applications.**	4M
	Ans:	**Advantages of isolated SMPS:**	2M

1. Electrical isolation is provided between the load and source
2. Good regulation
3. high power handling capacity
4. switching frequency is very high

		Applications : 1) Personal computers 2) Printers 3) Cable TV networks 4) Video games 5) Television receiver **6)** Voltage boosters and battery chargers.	**2M**
	c)	**Explain the operating principle of ON line UPS with block diagram.**	**4M**
	Ans:	**Block Diagram:**  **Explanation :** In ON line UPS the rectifier is used to convert a. c. supply to DC supply which supplies power to the inverter as well as the battery bank to keep it charged. Inverter is used to convert DC to AC supply. In this, UPS Static Switch is normally ON. Mains static switch is Normally OFF and used only when UPS is to be bypassed. When UPS fails the UPS Static switch which is normally ON is made OFF and Mains static switch is made ON to connect AC supply directly to load.	**2M** **2M**
	d)	**Explain operating principle of resistance welding with neat diagram.**	**4M**
	Ans:	**Diagram:**  **Principle:** Fig shows the basic arrangement for making a weld. The two overlapping metal sheets S1 and S2to welded are tightly clamped and kept in position between two electrodes E1 and E2 to which is supplied short duration low voltage high current supply. As a result of this current, the temperature of the common surfaces of sheets in region shown by dotted curves increases until the two pieces of the metal fuse together under the pressure of the electrodes.	**2M** **2M**
	e)	**Draw circuit of Jone's Chopper and explain its working.**	**4M**

	Ans:	**Diagram:**  **Explaination:** Let us assume, that initially capacitor C is charged to a voltage Edc with the polarity shown in the fig. **SCR T1 is triggered;** a load current flows through T1, L1 and the load. Simultaneously current flows through the path CA-T1 - L2 - D1 - CB and capacitor C discharges and reverses its polarity i.e. plate B is positive and plate A is negative. Diode D1 prevents the reverse discharge. Hence, capacitor C holds its charge until SCR T2 is triggered. When **SCR T2 is triggered** current flows through the path CB - T2 - T1 - CA. The capacitor voltage with reverse polarity is applied across the thyristor T1which reverse biases SCR T1 and turns it OFF. The capacitor again charges up through supply, C, SCR T2, L1, load with the plate A positive and SCR T2 turns OFF because the current through it falls below the rated holding current value when capacitor C is recharged. The load current flows through the freewheeling diode Df until the thyristor T1 is turned ON again, and thus, the cycle repeats itself.	**2M** **2M**
Q. 4		**Attempt any THREE of following:**	**12 M**
	a)	**Give classification of chopper. Also list its applications (any four).**	**4 M**
	Ans:	**Classification of choppers:** 1. Depending upon the quadrant of operation(or direction of load voltage and load current) • Single quadrant • Two quadrant • Four quadrant 2. Single quadrant • Type A chopper • Type B chopper 3. Two quadrant • Type C chopper • Type D chopper 4. Four quadrant • Type E chopper	**2M**

2. Depending on the output voltage:
- Step up chopper
- Step-down chopper

Applications of chopper:
1. Used in speed control of DC motor.
2.Used in reversible motor drives
3.Used in SMPS
4. Battery chargers
5. D.C. voltage boosting
6.Battery-operated electric cars
7.Battery-operated appliances

Applications: Any four -½ M each

b) State the need of AC voltage regulator (stabiliser). Give its classification. 4 M

Ans:

Need of AC voltage regulator: **2M**

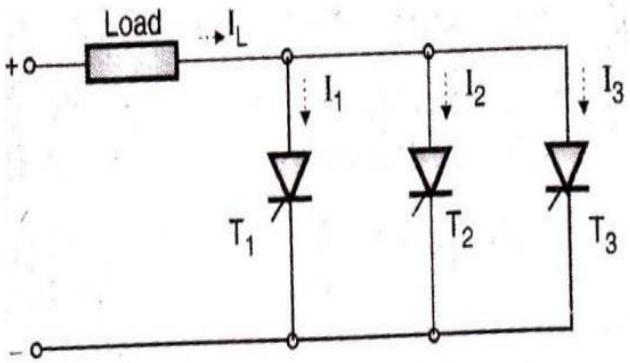
The input voltage is subjected to transients, over voltages, under voltages and fluctuations. This voltage has to be maintained constant. Otherwise it affects the load which is connected to it. A voltage stabilizer maintains a constant output voltage irrespective of changes in the input or load. Over voltages damage the load and under voltage cause heating and subsequent heating.

Classification of AC voltage regulators: **2M**
1.Relay type
2.Solid State
3.Servo voltage stabilizer
4.Resonant type or constant voltage transformer

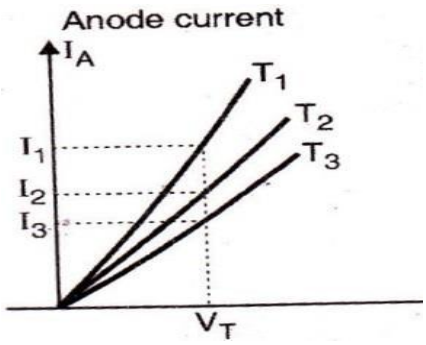
c) Draw the circuit diagram of parallel connections of three thyristors and describe with forward characteristics. 4 M

Ans:

Circuit Diagram:

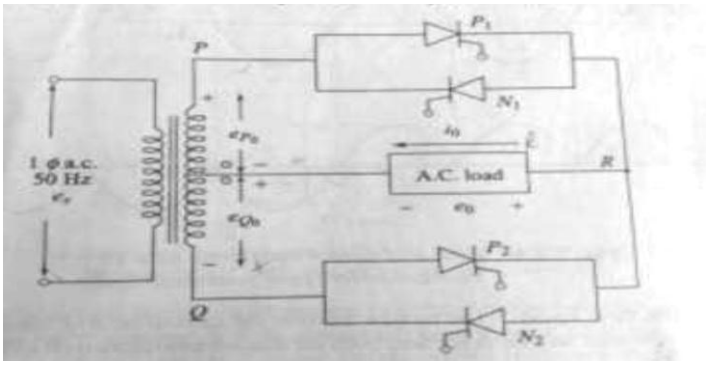
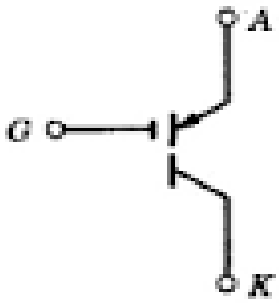
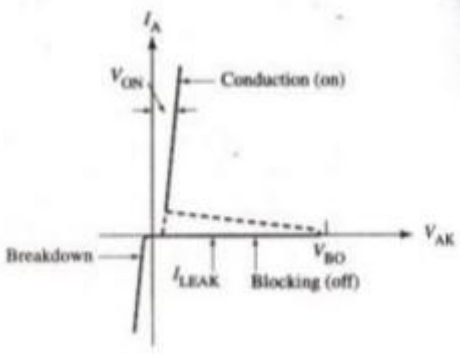


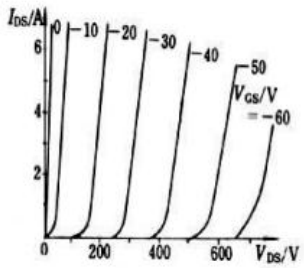
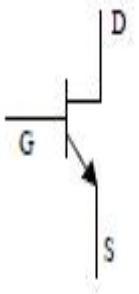
Characteristics:

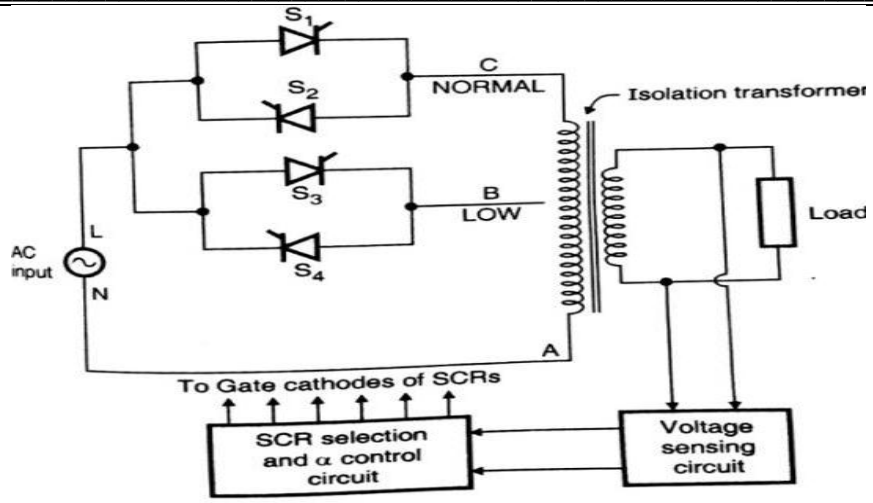


Circuit Diagram 1M Characteristics 1M Explanation 2M

Explanation:
- Figure shows the dynamic characteristics of SCR connected in parallel. Since the voltage drop across the devices must be same, the SCR with lower forward resistance will share more current.
- This unequal sharing of voltages and currents can be corrected by external equalizing circuits. SCRs are connected in parallel to improve the current rating. Due to unequal resistance the sharing of current will not be equal which causes heating of the SCRs and thermal runaway. Hence, all the SCRs operated in parallel

	should be at the same temperature by having a common heat sink.	
d)	**Draw circuit of single phase cyclo converter and explain.**	**4 M**
Ans:	**Circuit diagram:**  **Explanation:** • Cyclo Converter reduces the input frequency. • Depending upon firing sequence of the SCRs that particular SCR conducts. • For example, in the diagram shown, SCRs firing sequence is P1, P2, P1. This forms the single • Positive half cycle. • For the negative half cycle, firing sequence is NI, N2, and N1. • The output frequency is reduced to 1/3.	**2M** **2M** **Waveform is optional**
B)	**Attempt any ONE of following:**	**6 M**
a)	**Draw symbols of modern power devices SIT and MCT. Describe VI characteristic of any one.**	**6M**
Ans:	**Symbol of MCT**  **Characteristics of MCT**  **Characteristics of SIT** **Symbol of SIT**	**Symbol :1 M each**

		  **MCT charecteristics:** In the static condition, the VI characteristics of the MCT are similar to those of thyristor and GTOs. The MCT, like GTO has negligible reverse voltage blocking capability. For proper triggering, a pedestal voltage level must be maintained. MCT behaves like theyristor in the on-state because the OFF-MOSFET has a high impedance in this operating condition (negative voltage at the gate-terminal). However, the on-state voltage drop of an actual MCT device has been observed to exceed those for the thyristor. **SIT characteristics:** SIT can operate both in switching and linear modes, the higher the negative voltage Vgs at the gate the higher voltage can SIT handle in off state.	**Any one characteristics :2 M**
	b)	**Describe importance of PWM inverter. How can you reduce Harmonics with the help of this inverter?**	**6M**
	Ans:	**Importance of PWM inverter**: PWM inverter is used to reduce the harmonics present in the sinusoidal output of the inverter. Pure sine wave is obtained. Reduction of harmonics with the help of inverter: **Methods:** **1) Single Pulse-Width Modulation:-** In single -pulse-width modulation control, there is only one pulse per half-cycle and the width of the pulse is varied to control the inverter output voltage. The gating signals are generated by comparing a rectangular reference signal of amplitude Ar with a triangular carrier wave of amplitude Ac. **2)Multiple Pulse-Width Modulation:-** In this method of pulse-width modulation, the harmonic content can be reduced using several pulses in each in each half-cycle of output voltage. By comparing a reference signal with a triangular carrier wave, the gating signals are generated for turning-on and turning-off of a thyristor. **3) Sinusoidal Pulse-Width Modulation:-** The gating signals are generated by comparing a sinusoidal reference signal with a triangular carrier wave of frequency fc.	**2 M** **4 M Waveform is optional**
Q.5		**Attempt any TWO of following:**	**16 M**
	a)	**Draw the circuit diagram of phase control method used in AC voltage stabilizer. Describe its operation. List two advantages, disadvantages and applications**	**8 M**
	Ans:	**Circuit diagram:**	**2M**



3M

Explanation:

The circuit consists of a tapped transformer along with back to back connected SCRs in pair for each tap.

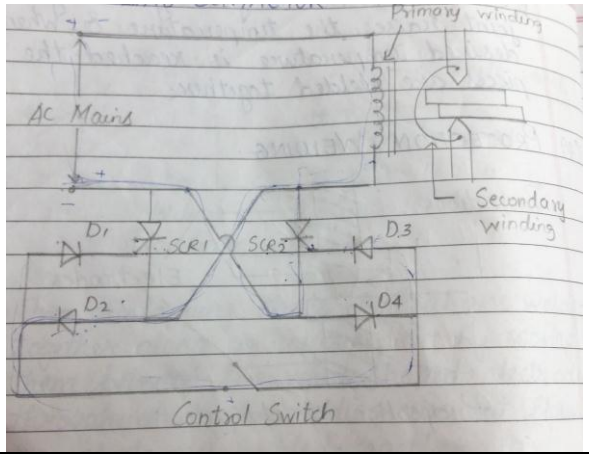
- The sensing circuit senses the output voltage and selects a particular tap by triggering the corresponding pair of SCRs. e.g. if the voltage required is 230V then SCR1 and 2 will be triggered.
- The smooth adjustment in the output voltage is then obtained by automatic adjustment of firing angle of the selected pairs of SCRs.
- Thus the output voltage can now be adjusted in step less manner.
- If the load voltage required is less, than other pair of SCRs is triggered.

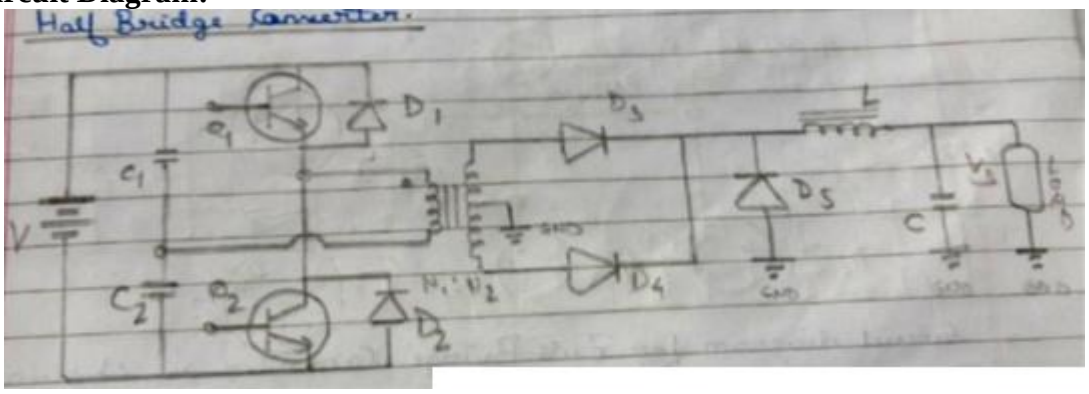
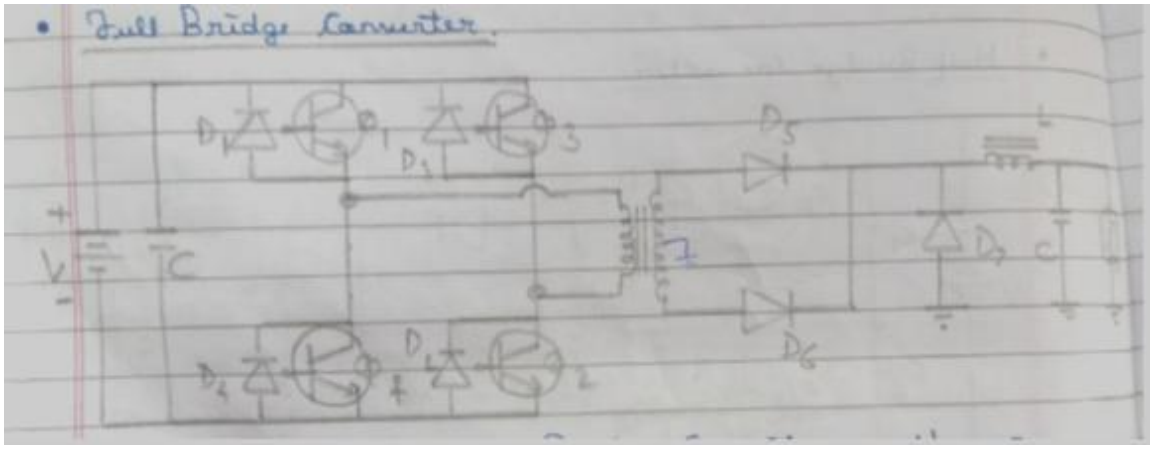
Advantage	Disadvantage	Application
1.Better output voltage regulation	1.Poor input power factor	1.TVs
2.Fast dynamic response	2.Need of filters due to distorted waveforms	2.Refrigerators
	3.Costly	

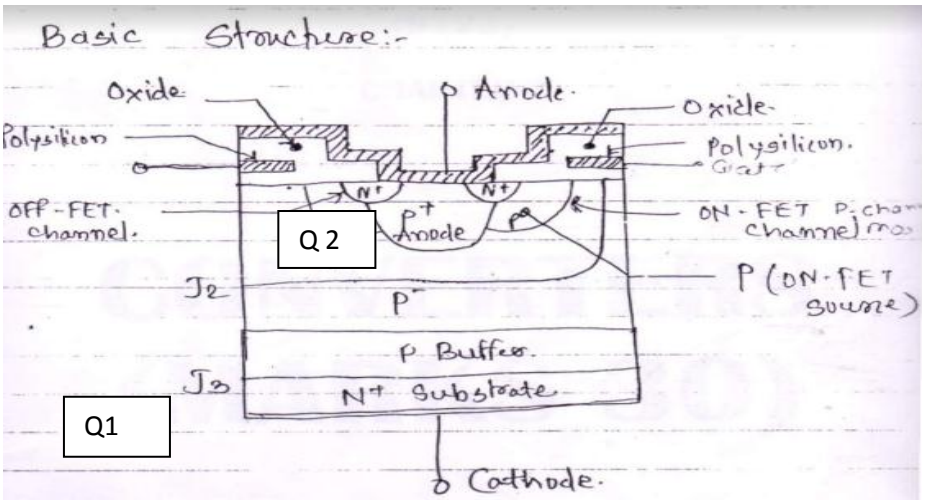
1M each

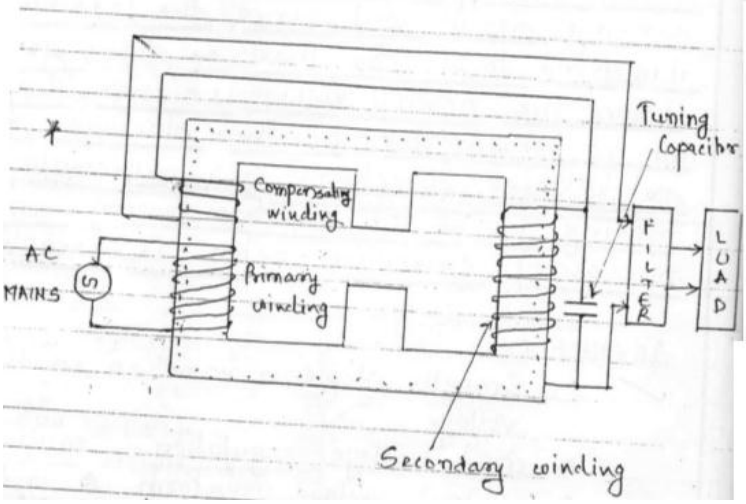
b) Draw neat labeled diagram of line contactor using SCR and explain its working. **8M**

Ans: **Circuit diagram:** **4M**



		Explanation: During the positive half cycle the current flows through primary of the transformer, SCR2 and back to the supply. Diodes D2 and D3 provide the positive trigger to the gate of SCR2. During the negative half cycle the current flows through primary of the transformer, SCR1 and back to the supply. Diodes D1 and D4 provide the positive trigger to the gate of SCR1. The control switch controls the opening and closing of the primary winding.	**4M**
c)		**Draw diagram of isolated SMPS describe its operation. Give any two advantages and disadvantages.**	**8 M**
Ans:		**(Note: Any one type can be considered)** Isolated SMPS can be half-bridge converter or full bridge converter. **Circuit Diagram:**  **Explanation:** This output is rectified and filtered by the LC filter. When Q1 is turned ON, voltage across C1 i.e. V/2 appears across the primary of the transformer. D3 is forward biased and D4 is reverse biased. When Q2 is turned ON, voltage across C2 i.e. V/2 appears across the primary of the transformer. D4 is forward biased and D3 is reverse biased. **OR**  **Explanation:** This output is rectified and filtered by the LC filter. When Q1 and Q2 are turned ON simultaneously, voltage appears across the primary of the transformer. D5 is forward biased and D6 is reverse biased. When Q3 and Q4 are turned ON, voltage appears across the primary of the transformer. D6 is forward biased and D5 is reverse biased.	**3M** **[Note: Flyback or forword convertor also can be consider]** **3M**

		Advantages of Isolated SMPS: 1.Complete isolation between input load 2. High efficiency **Disadvantages of SMPS:** 1.Use of transformer 2.Complicated circuit	**(Adv :1 M each** **Disadv: 1 M each)**
Q.6		**Attempt any FOUR of following:**	**16 M**
	a)	**Draw the constructional diagram of MCT and explain its operation.**	**4 M**
	Ans:	**Constructional diagram:** **Diagram:**  **Explanation:** **MCT turn ON:** If the gate of the MCT is negative with respect to anode a p-channel MOSFET M1is turned ON which causes the forward biasing of n-p-n transistor. This also forward biases the p-n-p transistor Q2 and regenerative action starts. **MCT turn OFF :** If the gate of MCT is positive with respect to anode, N-channel MOSFET M2will turn ON and short circuit the base emitter junction of Q2.This will break the regenerative action and the device will turn off.	**2M** **2M**
	b)	**Explain the operations of resonant type AC voltage stabilizer.**	**4 M**
	Ans:	**Diagram:**	**2M**



2M

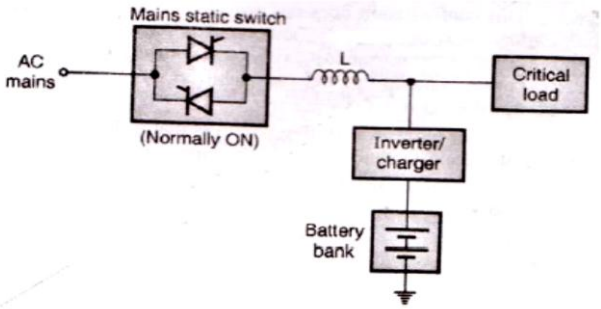
Operation:

As the name suggest a constant voltage transformer maintains a constant output voltage for a wide range of input voltage variation and load fluctuation.

The primary winding of is an unsaturated inductor. The secondary winding is a saturated inductor. Capacitor C is connected across secondary winding to tune the CVT to get a 50Hz O/P.

This capacitor also helps to saturate the secondary flux by drawing an additional current from the secondary winding. The compensating winding is included in order to improve the voltage regulation of CVT. The CVT provides a spikeless constant voltage at its output over a wide
current fluctuation.

c)	**Draw block diagram of Line Interactive UPS and explain function of each block.**	**4 M**
Ans:	**Diagram:**The function of each block can be explained with different modes:	**2M**



2M

Explanation:

Mode 1:

The static switch is closed and the load gets connected directly to the ac mains. The inverter /charger block acts as a charger and charges the battery.

Mode 2:

When the mains fail the static switch opens, the inverter /charger block acts as an inverter and the battery supplies power to the load through the inverter**.**

d)	**List advantages and disadvantages of resistance welding any two points each.**	**4 M**
Ans:	**Advantages of Resistance welding:** 1.Welding time is extremely short ,few milliseconds	**1M each** **Any two**

		2. Heat control is possible 3. Quality of welding is improved 4. No surface deformities at the region of weld 5. Better than brazing or soldering **Dis-Advantages of Resistance welding:** 1.Complex process 2.Effeciency is less due to losses taking place in welding transformer 3. Cost is high	**points can be considered**
	e)	**Define i) backup time ii) power rating iii) transfer time with respect to battery**	**4 M**
	Ans:	**Back up time:** It is the time period for which the UPS system can supply power to the load, after mains failure has taken place. Back up time depends upon capacity of battery and efficiency of inverter. **Transfer time:** It is the time taken by the UPS system to Switch from mains to battery is known as the transfer time. Ideally transfer time should be zero but practically it is above 4-5 milliseconds. **Power rating**: It is the product of rated voltage which the battery can supply at rated current. It is expressed in Volt-Amp(VA).	**1.5M** **1.5M** **1M**