Sl NO. 1/Sem 4/I

Model Question Paper I

POWER ELECTRONICS DEVICES AND CIRCUITS

Time: 3 Hour *Max.Marks: 75*

PART A

I. Answer **all** questions in one word or one sentence. Each question carries 1 mark.
*(9*1=9 Marks)*

1	Define Latching current of SCR	M1.02	R
2	SCR is a ……layer ……junction …….terminal device.	M1.02	R
3	Draw the symbol of UJT.	M1.01	R
4	Define Firing angle of SCR	M2.01	R
5	The single phase semi- controlled rectifiers have ……..number of SCRs	M2.03	R
6	Define Chopper.	M3.01	R
7	Define Cycloconverters.	M3.04	R
8	Define Pulse Width Modulated inverter.	M4.02	R
9	Define a Voltage Source Inverter (VSI).	M4.01	R

PART B

II. Answer any **eight** questions from the following, each question carries 3 marks.
*(8*3=24 marks)*

1	Define Commutation of SCR and also list out different commutation techniques for SCR.	M1.03	R
2	Draw a Snubber Circuit and state its need.	M1.03	U
3	List out any six applications of UJT.	M1.01	R
4	Illustrate the operation of a half wave controlled rectifier with R load.	M2.01	U
5	List different roles of a freewheeling diode in a controlled rectifier circuit.	M2.01	R
6	A step up chopper has input voltage of 220V and output voltage of 660V. If the total time period of thyristor-chopper is 300μs, then compute its duty cycle (α) and turn ON time (T_{ON})	M3.01	A
7	List any three comparisons between buck and boost converters.	M3.03	R
8	Summarize the working of a static Servo Voltage stabilizer with block diagram.	M4.03	U
9	List any six requirements of a practical inverter.	M4.01	R
10	Explain SMPS with the help of a block diagram.	M4.03	U

PART C

Answer ***ALL*** questions. Each question carries 7 marks.

*(6*7=42 Marks)*

III	Explain any two turn on methods of SCR	M1.03	U
	OR		
IV	Illustrate the working of TRIAC with a neat diagram	M1.01	U
V	Explain V-I characteristics of SCR.	M1.02	U
	OR		
VI	Illustrate the working of N channel enhancement type MOSFET.	M1.01	U
VII	Explain the single phase full wave bridge controlled rectifier with RL load and freewheeling diode.	M2.02	U
	OR		
VIII	Explain single phase half wave controlled rectifiers with RL load and freewheeling diode.	M2.01	U
IX	Summarize the different control methods of a DC Chopper	M3.01	U
	OR		
X	Explain the working of a DC chopper with a neat circuit diagram and waveforms. Also list out different types of DC chopper.	M3.02	U

XI	Explain the working of a half bridge inverter with RL load and feedback diodes.	M4.02	U
	OR		
XII	Explain the different types of UPS with block diagram.	M4.03	U
XIII	Illustrate the working of a series inverter with a neat diagram.	M4.01	U
	OR		
XIV	Explain the 180^0 conduction mode of three phase bridge inverter with R load only.	M4.02	U

BLUE PRINT

Mark Distribution

Module	Hr / Module	(hi / ∑Hi) * 123	TYPE OF QUESTIONS							
			PART A		PART B		PART C		TOTAL	
			No of Questions	Marks	No of Questions	Marks	No of Questions	Marks	No of Questions	Marks
I	16		3		3		4		**10**	
		33.93		3		9		28		**40**
II	14		2		2		2		**6**	
		29.69		2		6		14		**22**
III	12		2		2		2		**6**	
		25.45		2		6		14		**22**
IV	16		2		3		4		**9**	
		33.93		2		9		28		**39**
Total	**58**		**9**		**10**		**12**		**31**	
		123		**9**		**30**		**84**		**123**

Cognitive Level Wise Question Analysis

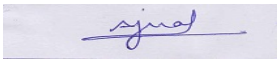
Mark Distribution

Cognitive Level	% Marks	Marks	TYPE OF QUESTIONS							
			PART A		PART B		PART C		TOTAL	
			No of Questions	Marks	No of Questions	Marks	No of Questions	Marks	No of Questions	Marks
R	30		9		5		0		**14**	
		36.9		9		15		0		**24**
U	50		0		4		12		**16**	
		61.5		0		12		84		**96**
A	20		0		1		0		**1**	
		24.6		0		3		0		**3**
Total	**100**		**9**		**10**		**12**		**31**	
		123		**9**		**30**		**84**		**123**

Question Wise Analysis

Q.No	Module Outcome	Cognitive Level	Marks	Time
I.1	M1.02	R	1	2
I.2	M1.02	R	1	2
I.3	M1.01	R	1	2
I.4	M2.01	R	1	2
I.5	M2.03	R	1	2
I.6	M3.01	R	1	2
I.7	M3.04	R	1	2
I.8	M4.02	R	1	2
I.9	M4.01	R	1	2
II.1	M1.03	R	3	6
II.2	M1.03	U	3	7
II.3	M1.01	R	3	7
II.4	M2.01	U	3	8
II.5	M2.01	R	3	7
II.6	M3.01	A	3	8
II.7	M3.03	R	3	7
II.8	M4.03	U	3	8
II.9	M4.01	R	3	7
II.10	M4.03	U	3	8
III.	M1.03	U	7	17
IV.	M1.01	U	7	17
V	M1.02	U	7	17
VI	M1.01	U	7	17

VII	M2.02	U	7	17
VIII	M2.01	U	7	17
IX	M3.01	U	7	17
X	M3.02	U	7	17
XI	M4.02	U	7	17
XII	M4.03	U	7	17
XIII	M4.01	U	7	17
XIV	M4.02	U	7	17
Total			123	295

Prepared By :	Scrutinised By :
 Chithra S R Lecturer in EEE Govt. Polytechnic College Punalur	 Ajmal M M , Lecturer in EEE Govt polytechnic college Muttom

Sl NO. 1/Sem 4/II

Model Question Paper II

POWER ELECTRONICS DEVICES AND CIRCUITS

Time: 3 Hour *Max.Marks: 75*

PART A

I. Answer **all** questions in one word or one sentence. Each question carries 1 mark. *(9*1=9 marks)*

1.	Define Holding current of SCR	M1.02	R
2.	List different types of MOSFET	M1.01	R
3.	Draw the symbol of TRIAC	M1.01	R
4.	Define phase controlled rectifiers.	M2.01	R
5.	Explain the effect of freewheeling diode on output voltage of phase controlled rectifier with inductive load	M2.01	U
6.	Name the circuit used to step up dc voltage	M 3.03	R
7.	List chopper control strategies	M3.01	R
8.	List the classifications of inverters.	M4.01	R
9.	List different types of SMPS	M4.03	R

PART B

II. Answer ***any eight*** questions from the following, each question carries 3 marks. *(8*3=24 marks)*

1	Label the terminals of GTO, LASCR, and SCS with symbol.	M1.01	R
2	List any six applications of power electronic devices.	M1.01	R
3	Illustrate gate triggering method of SCR.	M1.03	U
4	Draw the circuit diagram of a three phase controlled rectifier.	M2.04	R

5	Draw the circuit diagram and waveforms of single phase fully controlled centre tapped rectifier with R load	M2.02	R
6	A step down chopper has input voltage of 440V and output voltage of 220V. If the total time period of thyristor-chopper is 300μs, then compute its duty cycle (D) and turn ON time (T_{ON})	M3.01	A
7	List the applications of chopper	M3.03	R
8	Compare CSI and VSI	M4.01	U
9	Explain sinusoidal PWM.	M4.02	U
10	List the advantages of electric drives	M4.04	R

PART C

Answer ALL questions. Each question carries 7 marks.

*(6*7=42 marks)*

III	Illustrate the construction and working principle of IGBT	M1.01	U
	OR		
IV	Illustrate the working of UJT with the help of equivalent circuits.	M1.01	U
V	Explain turn off process of SCR and summarize natural commutation and forced commutation	M1.03	U
	OR		
VI	Explain the working of DIAC	M1.01	U
VII	Explain single phase semi controlled rectifier with RL load	M2.03	U
	OR		
VIII	Explain Single phase Fully controlled rectifier with RL load	M2.02	U

IX	Illustrate the four quadrant operation of Class E chopper	M3.02	U
	OR		
X	Illustrate the working of a single phase step up cycloconverter.	M3.04	U
XI	Illustrate the working of a full bridge inverter with RL load and feedback diodes.	M4.02	U
	OR		
XII	Illustrate the working of line interactive UPS with the help of a block diagram	M4.03	U
XIII	Explain the working of Parallel inverter	M4.01	U
	OR		
XIV	Explain the block diagram of electric drive	M4.04	U

BLUE PRINT

Mark Distribution

Module	Hr / Module	(hi / ∑Hi) * 123	TYPE OF QUESTIONS							
			PART A		PART B		PART C		TOTAL	
			No of Questions	Marks	No of Questions	Marks	No of Questions	Marks	No of Questions	Marks
I	16		3		3		4		**10**	
		33.93		3		9		28		**40**
II	14		2		2		2		**6**	
		29.69		2		6		14		**22**
III	12		2		2		2		**6**	
		25.45		2		6		14		**22**
IV	16		2		3		4		**9**	
		33.93		2		9		28		**39**
Total	**58**		**9**		**10**		**12**		**31**	
		123		**9**		**30**		**84**		**123**

Cognitive Level Wise Question Analysis

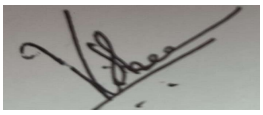
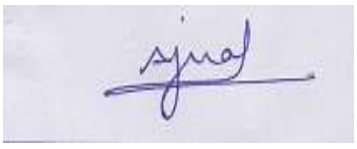
Mark Distribution

Cognitive Level	% Marks	Marks	TYPE OF QUESTIONS							
			PART A		PART B		PART C		TOTAL	
			No of Questions	Marks	No of Questions	Marks	No of Questions	Marks	No of Questions	Marks
R	30		8		6		0		**14**	
		36.9		8		18		0		**26**
U	50		1		3		12		**16**	
		61.5		1		9		84		**94**
A	20		0		1		0		**1**	
		24.6		0		3		0		**3**
Total	**100**		**9**		**10**		**12**		**31**	
		123		**9**		**30**		**84**		**123**

Question Wise Analysis

Q.No	Module Outcome	Cognitive Level	Marks	Time
I.1	M1.02	R	1	2
I.2	M1.01	R	1	2
I.3	M1.01	R	1	2
I.4	M2.01	R	1	2
I.5	M2.01	U	1	2
I.6	M 3.03	R	1	2
I.7	M3.01	R	1	2
I.8	M4.01	R	1	2
I.9	M4.03	R	1	2
II.1	M1.01	R	3	7
II.2	M1.01	R	3	7
II.3	M1.03	U	3	8
II.4	M2.04	R	3	7
II.5	M2.02	R	3	8
II.6	M3.01	A	3	8
II.7	M3.03	R	3	7
II.8	M4.01	U	3	7
II.9	M4.02	U	3	7
II.10	M4.04	R	3	7
III.	M1.01	U	7	17
IV.	M1.01	U	7	17
V	M1.03	U	7	17
VI	M1.01	U	7	17

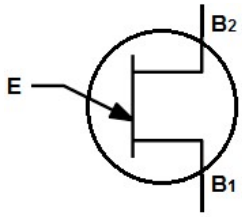
VII	M2.03	U	7	17
VIII	M2.02	U	7	17
IX	M3.02	U	7	17
X	M3.04	U	7	17
XI	M4.02	U	7	17
XII	M4.03	U	7	17
XIII	M4.01	U	7	17
XIV	M4.04	U	7	17
Total			123	295

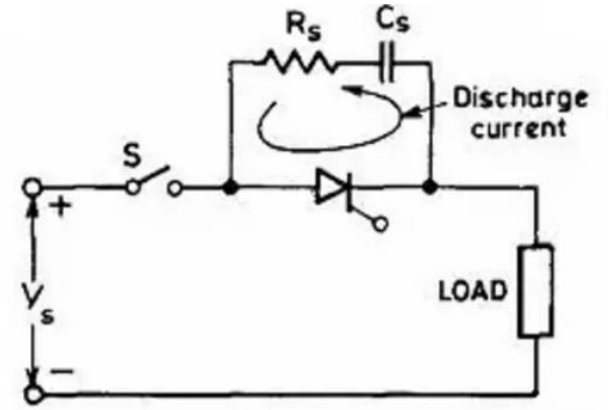
Prepared By : Vineeth V Lecturer Govt polytechnic college Kalamassery 	Scrutinised By : Ajmal M M Lecturer Govt polytechnic college Muttom 

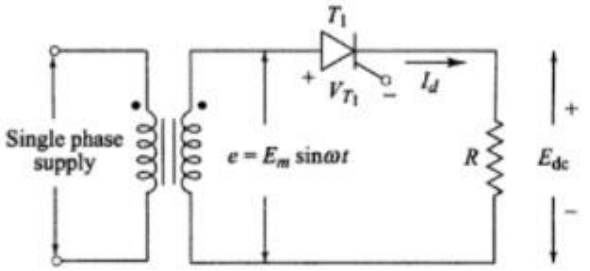
Scoring Indicators

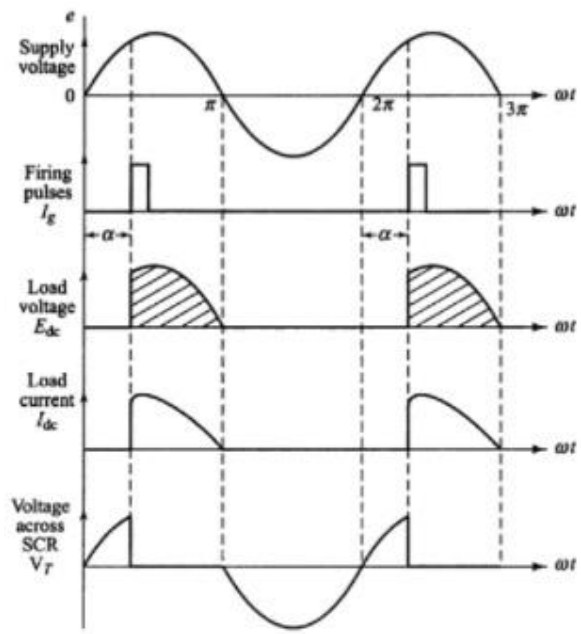
Model Question Paper I

POWER ELECTRONICS DEVICES AND CIRCUITS

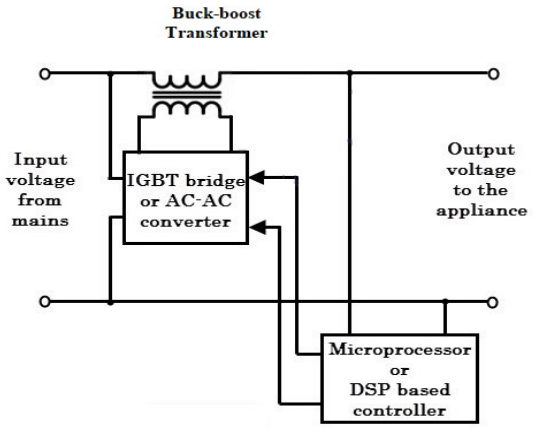
Q No	Scoring Indicators	Split score	Sub Total	Total Score
	PART A			
I. 1	Latching current can be defined as it is the least amount of anode current which is necessary to supply from the anode terminal to the cathode terminal to activate the SCR after detaching the gate terminal	1	1	1
I. 2	4 layer,3 junction, 3 terminal	1	1	1
I. 3		1	1	1
I. 4	The angle at which thyristor gate gets fired is called firing angle	1	1	1
I. 5	Two	1	1	1
I. 6	Chopper is a converter to convert fixed DC to Variable DC converter (simply DC to DC converter)	1	1	1
I. 7	Cycloconverts converts constant voltage, constant frequency AC waveform to another AC waveform at different frequencies.	1	1	1
I. 8	The output voltage of an inverter is controlled by varying the width of the gate pulses having constant amplitude, is called a pulse-width modulated inverter.	1	1	1
I. 9	An inverter which converts a voltage from a stiff DC voltage source is called Voltage source Inverter.	1	1	1
	PART B II. Answer any **eight** questions from the following, each question carries 3 marks.			
	<u>Commutation of SCR</u>	2+1	3	

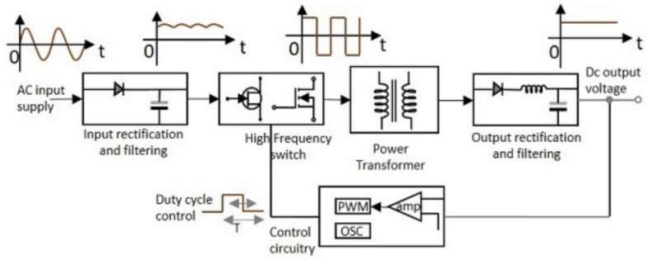
II. 1	*Definition-2Marks* *List types-1 Mark*			
	❖ Turn OFF process of a Conducting SCR is called Commutation of SCR. ❖ To turn OFF a conducting SCR, the following conditions must be satisfied. ➢ The anode or forward current of SCR must be reduced to zero or below the level of holding current and then, ➢ A sufficient reverse voltage must be applied across the SCR to regain its forward blocking state. <u>Types</u> 1. Natural Commutation: - used To Turn OFF SCRs in AC circuits. Eg:- Rectifier 2. Forced Commutation: - Used to Turn OFF SCRs in DC circuits eg. Inverter, Chopper etc.			
II. 2	**<u>Snubber Circuits</u>** *figure-2 mark* *need (any one)- 1 mark*	2 + 1	3	
	 ❖ dv/dt protection of a thyristor is achieved by a Snubber Circuit ❖ Snubber circuit consists of a series combination of resistance Rs and capacitance Cs in parallel with the thyristor			
II. 3	<u>Applications of UJT</u>	0.5*6	3	3

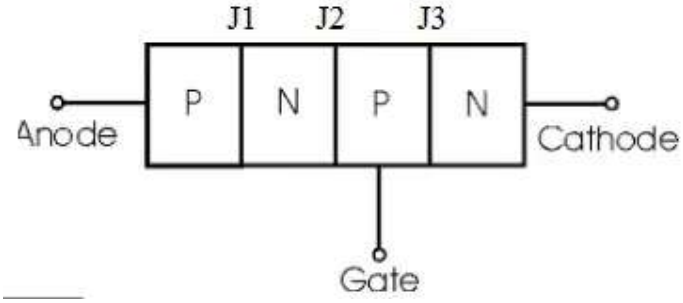
	Any six application *0.5 marks each*			
	1. Relaxation Oscillator 2. Timing Circuits 3. Gate pulse generation circuit 4. Saw tooth Generator 5. Used as Voltage detector 6. Used in phase control Circuit 7. used to measure magnetic flux			
II. 4	Half wave controlled rectifier with R load *Circuit diagram-1mark* *Waveform-1 Mark* *brief explanation-1 marks*	1+1+1	3	3
	Circuit diagram  Brief Explanation ● During the positive half cycle, thyristor T is forward biased and is triggered at a firing angle α. ● During the negative half cycle, T is in reverse biased and no current flows through the circuit. ● Since the load is Resistive, the output current has no phase lag with the output voltage. Waveform			

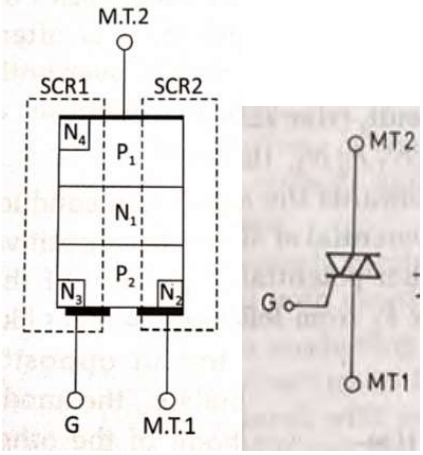
				
II. 5	Roles of Freewheeling diode *list any three roles* *1 Marks each*	1+1+1	3	
	1.Load current become continuous and gets improved 2. Input Power factor is improved. 3. Load Performance is increased.			
II. 6	duty cycle,α=⅔, *Duty cycle-1.5 marks* ON time, T_{ON}=200μs *On time-1.5 marks*	1.5+1.5	3	3
	V_{in}=220V, V_o=660V, T=300μs $V_O=V_{in}/(1-\alpha)$ Solving α=⅔ $T_{ON}=\alpha T$ Solving T_{ON}= 200μs			
II. 7	Buck and Boost converter *Any three comparisons* *1 marks each*	1+1+1	3	3

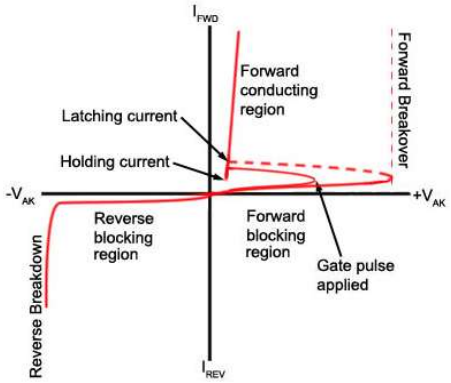
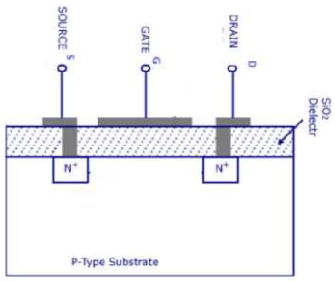
SI No.	Buck converter	Boost Converter
1	It step down the input voltage level	It step up the input voltage level
2	The magnitude of output voltage is less than the magnitude of input voltage	The magnitude of output voltage is higher than the magnitude of input voltage
3	The input current is discontinuous in nature	the input current is continuous in nature
4	It provide low voltage and high current	It provide high voltage and low current
5	Not suited for PV cells	Suited for PV cells
6	they are used in self-regulating power supplies, advanced telecommunication and data communication systems	They are used in regulated power supplies, regenerative braking of DC motor and portable device applications

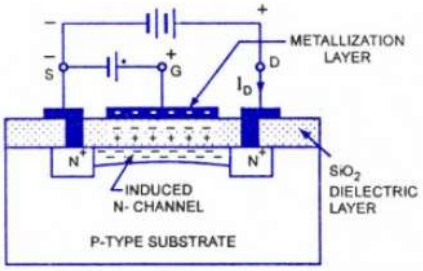
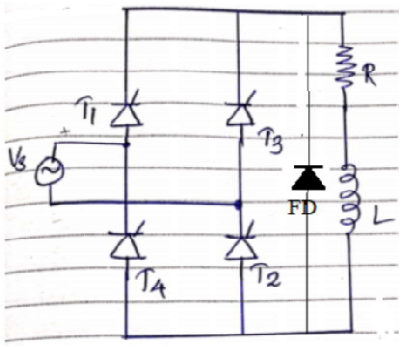
II.8	<u>Static Servo Voltage Stabilizer</u> *Figure- 2 Marks* *Explanation-1 marks*	2+1	3	3
	<u>Block diagram</u>  			

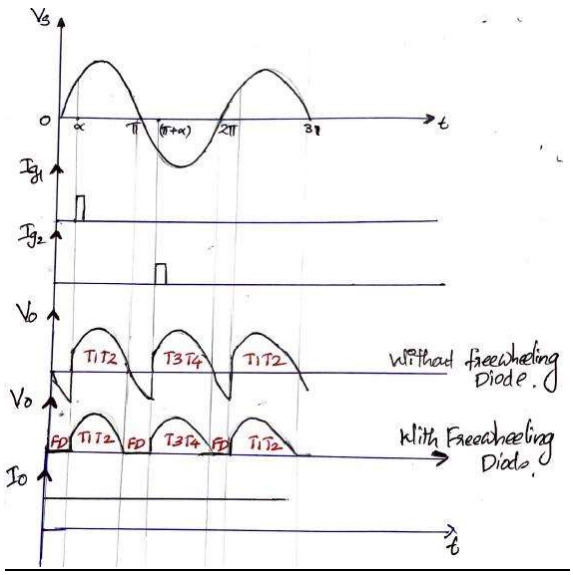
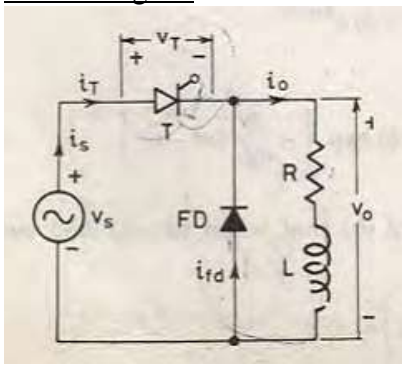
	Explanation • In static stabilizer, no moving parts as in servo stabilizer. It consists of buck boost transformer, IGBT power converter, and microcontroller or DSP based Controller. • Whenever the microprocessor detects the voltage dip, it sends the PWM pulses to the IGBT converter such that it generates the voltage which is equal to that of the deviated amount from nominal value.			
II. 9	Requirements of practical inverter *Any six requirements* *0.5 marks each*	0.5*6	3	3
	1. The voltage source inverter will produce an output voltage or current to required ranges and frequencies. 2. Power factor of an inverter ranges from 0.6 to 0.8 3. VA rating of inverter= Power Required/Power Factor 4. The inverter must have limited starting current. 5. It must possess efficient energy saving property. 6. An inverter with less noise is preferred. 7. The output voltage of an inverter must be pure sine wave, sometimes it may be square wave. 8. Pure sine wave inverters will have great accuracy and less power loss. But the cost is high.			
II.10	SMPS *Figure-2 marks* *Explanation -1 Marks*	2+1	3	3
	Block diagram of SMPS  • an electrical power supply which incorporate a switching regulator to convert an electrical power efficiently, termed			

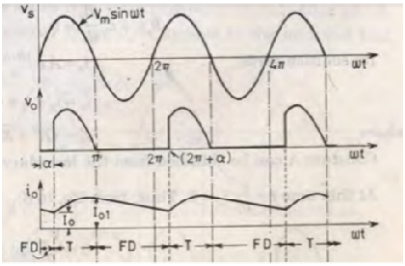
	as SMPS ● It consists of an input rectifier, high frequency converter, output rectifier and a feedback control circuitry.			
	PART C			
III	Turn ON methods of SCR *State turn ON Process of SCR-1 mark* *Structure of SCR-1 mark* *any two methods (2.5 marks each)*	1+1+5	7	7
	Turn ON Process of a SCR means to bring the SCR from forward blocking mode to Forward Conduction Mode.  Explain any two methods With Anode is positive with respect to cathode, a thyristor can be turned ON by the following methods. 1Forward voltage triggering Increase forward voltage so that reverse biased junction J2 breaks down and SCR conducts 2.Thermal/or temperature triggering The increase in temperature causes increase in leakage current and junction J2 breaks down and SCR conducts 3. dv/dt triggering, Reverse biased junction J2 behaves like a capacitance. If dc/dt is increased, $i_c$increases and SCR conducts			

	4. Gate triggering. When a positive voltage is applied at the gate terminal of a forward biased SCR, charge carriers are injected in the inner P-layer, thereby reducing the depletion layer thickness. As the applied voltage increases, the carrier injection increases, therefore the voltage at which forward break-over occurs decreases.			
IV	TRIAC *Figure -3 Marks* *Working -4Marks*	3+4	7	7
	Circuit diagram of TRIAC  Working ❖ Bidirectional switch ❖ Five layer structure ❖ Mode 1: MT2 positive and G positive. ➢ current flows through P1 N1 P2 N2 from MT2 to MT1 ❖ Mode 2: MT2 negative and G positive. ➢ Leakage current flows through P2 N1 P1 N4 from MT1 to MT2. ❖ Mode 3: MT2 positive and G negative. ➢ leakage current flows through P1 N1 P2 N2			

	from MT2 to MT1 ❖ Mode 4: MT2 negative and G negative ➢ current flows through P1 N1 P2 N2 from MT1 to MT2 ❖			
V	V-I characteristics of SCR *Figure- 3 Marks* *Explain four modes-1 mark each*	3+1+1+1+1	7	
	 Explain Four Modes of Operation:- 1. Forward Blocking Mode 2. Forward Conduction Mode 3. Reverse Blocking Mode 4. Reverse conduction mode			
VI	N channel MOSFET *Figure-3 marks* *Explanation-4 marks*	3+4	7	
	● Lightly doped or undoped N channel. ● The device is normally 'OFF'. ● When VGS=0 and VDS=+Ve, then no current is flowing through the MOSFET due to the absence of N channel. 			

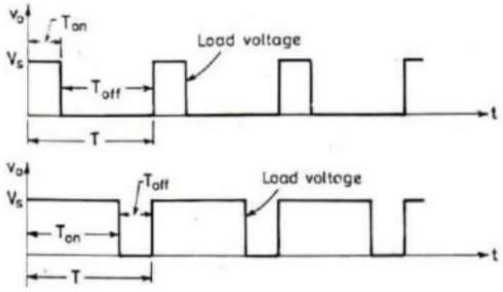
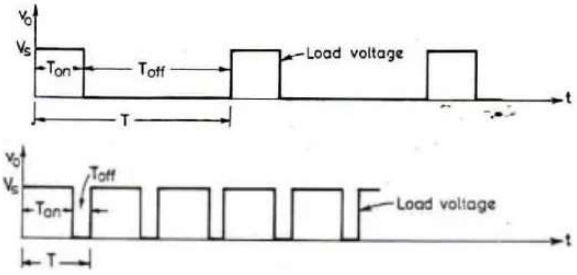
	● When VGS=+ve, negative charge electrons are induced in the substrate near to the oxide layer. ● This enhance the N channel formation and the current is flowing through the MOSFET from Drain to source  			
VII	Single phase full wave controlled Rectifier with R L load *Figure-3marks* *Waveform-2Marks* *Working-2 Marks*	3+2+2	7	7
	Circuit diagram  waveform			

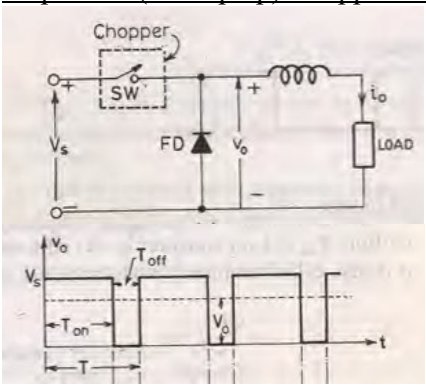
	 Explanation ❖ During positive half cycle (ωt= 0 to π) T1 ,T2 ON ❖ During negative half cycle(ωt= π+α to 2π) T3, T4 ON ❖ At ωt=π, V_0 becomes zero but I_0 does not become zero. With the reverse voltage after ωt=π, the Freewheeling diode is Forward biased and the load current circulates through the FD.			
VIII	Single phase half wave controlled Rectifier with RL load and FD *figure-3Marks* *Waveform-2 Marks* *Working-2 Marks*	3+2+2	7	7
	Circuit diagram  Waveform			

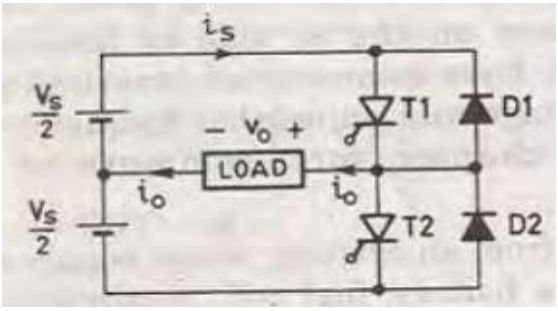
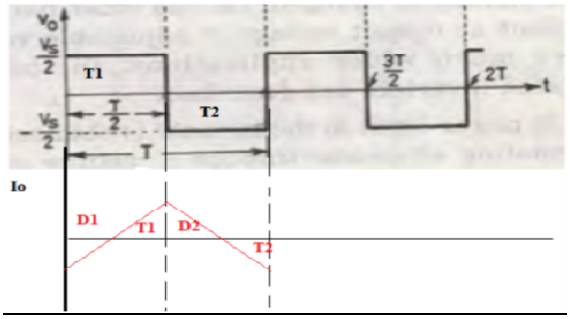


Explanation

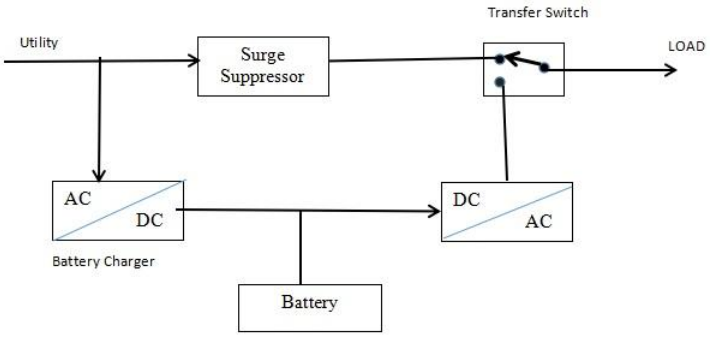
- At ωt=α, Thyristor is triggered by giving Gate pulse.
- The load voltage V_0 becomes equal to source voltage Vs after ωt=α.
- The load Inductor, L gradually increases I_0 as shown in the fig.
- After sometime I_0 reaches maximum and reduces.
- At ωt=π, V_0 becomes zero but I_0 does not become zero.
- With the reverse voltage after ωt=π, the Freewheeling diode is Forward biased and the load current circulates through the FD.
- Thus the SCR Turn OFF at ωt=π.

IX	Control methods of DC Chopper *List two control methods-1 mark* *explanation of two methods with diagram-3 marks each*	1+3+3	7	7
	List two control methods 1. Constant Frequency control 2. Variable frequency Control Constant Frequency control:- ❖ ON time (T_{on}) of the chopper is varied but the chopping period T is kept constant. ❖ Variation of T_{on} means adjust the pulse width.  Variable Frequency method This method is controlling the duty cycle of the switch.  			

X	DC Chopper *Definition-1 Mark* *Figure-2 Marks* *Working-2 Marks* *list types of Chopper-2 marks*	1+2+2+2	7	
	Definition:- DC chopper converts Fixed DC to variable DC. Step down (or Step up) Chopper Diagram.  working:- Sw is ON, current flows through the inductor and load. Sw is OFF, the stored energy in the inductor discharged through the load and the freewheeling diode. Hence output voltage is less than the input voltage and it is called a step down Chopper. ❖ Duty cycle, $\alpha=T_{on}/T$ Different types of Chopper 1. Type A (first Quadrant Chopper) 2. Type B (second Quadrant Chopper) 3. Type C (Two Quadrant type A Chopper) 4. Type D (Two Quadrant Type B chopper) 5. Type E(four quadrant Chopper)			7
XI	Half Bridge Inverter with RL load and Feedback diode *Figure-3 marks* *Waveform-2 marks* *Working-2Marks*	3+2+2	7	7
	Circuit diagram			

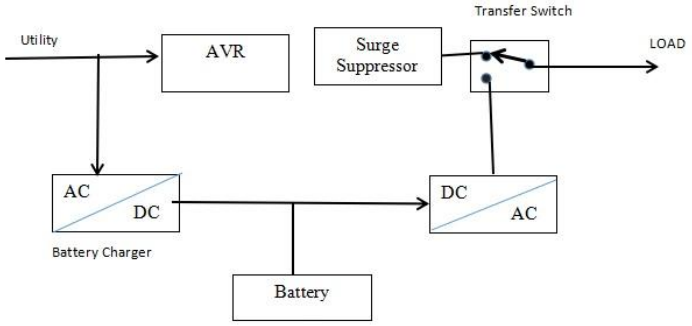
	 Waveform  Explanation ● Consist of two SCR T1 T2 and Two feedback diodes D1 D2. ● When T1 is triggered ON, the circuit is completed through Vs/2, T1,load. (0<t<T/2) ● After T1 turned OFF , due to RL load the load current could not be zero and the charged inductor take a path through D2 to discharge. ● At t=T/2, T1 is turned off by forced commutation and turned On the thyristor T2. ● After T2 is turned OFF, the negative load current flows through the diode D1.			
XII	Types Of UPS *list types of UPS-1 Mark* *explain each type with Block Diagram-2 Marks each*	1+2+2+2	7	7
	List three types of UPS 1. Online UPS 2. Offline UPS 3. Line interactive UPS OFFLINE UPS ● also called STAND BY UPS ● This UPS includes a battery, an inverter, a static switch and a LPF which is used to decrease the switching frequency from the o/p voltage & a surge suppressor.			

- The standby UPS system works with the switch arrangement to select the AC i/p as a primary power source, and interchanging to the battery & inverter as backup sources in case primary power gets disrupted.



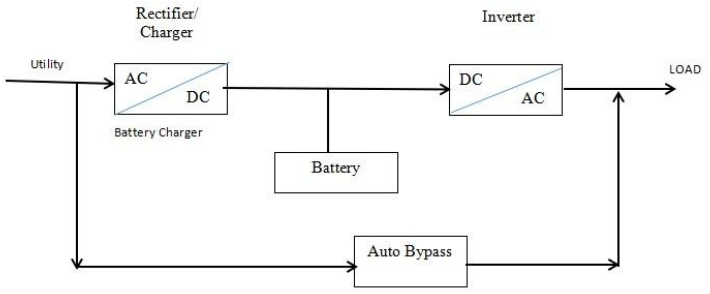
LINE INTERACTIVE UPS

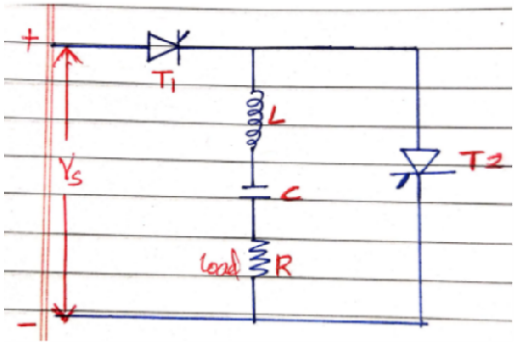
- It has an Automatic Voltage Regulator (AVR) to enhance the voltage regulation while some voltage dip is introduced. Otherwise the UPS changed the switch to battery and inverter system.

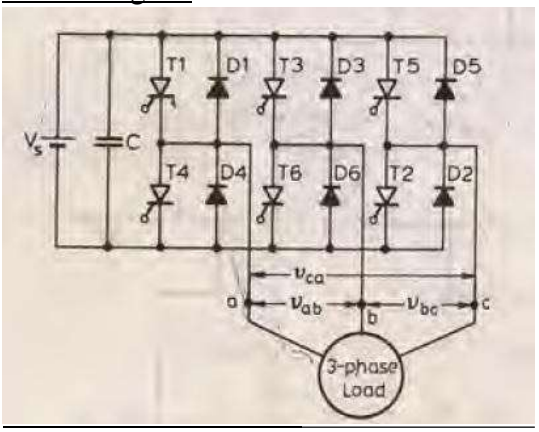
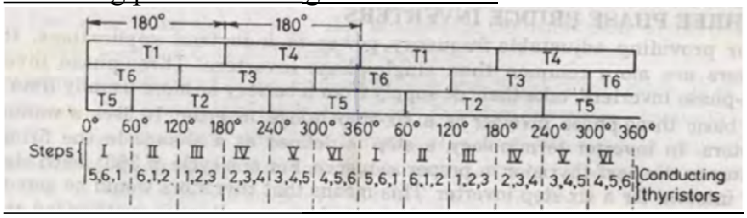


ONLINE UPS

- It is also called double conversion online UPS.
- The design of this UPS is similar to the Standby UPS, excluding that the primary power source is the inverter instead of the AC main.
- If the main Ac source gets failed then the battery give supply without any time lag.



XIII	Series inverter *Series Inverter (definition)-1 Mark* *Figure-3 marks* *Working-3 Marks*	1+3+3	7	7
	❖ Inverters in which commutating elements such as L and C are connected in series with the load is called a series inverter. ❖ Self-commutated inverter or load commutated inverter ❖ These inverters are operated at high frequencies and hence small commutating elements. ❖ Used in induction heating, fluorescent lighting etc. ❖ Circuit consists of Thyristor T1, T2 and a load R which is connected in series with the commutating elements L and C ❖ Mode 1: T1 is ON, T2 is OFF. The circuit current is flowing through T1, L ,C, R.the capacitor and inductor charges with this polarity. ❖ Mode 2: Both T1 and T2 are OFF. The charge in the capacitor commutated the thyristor T1. No output current is flowing in this Mode ❖ Mode 3: T1 OFF, T2 ON. The capacitor and inductor discharged through T2 and the load current is reversed. 			

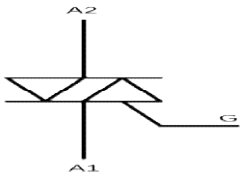
XIV	Three phase Bridge Inverter (180 degree) *Figure- 3 marks* *Switching Sequence-2 marks* *Explanation-2 Marks*	3+2+2	7	7
	Circuit diagram  Switching pattern 180 degree conduction  Explanation ● Three phase inverters have a minimum 6 thyristors. ● It consists of three half- bridge inverters arranged side by side. ● The three phase load is connected to the star. ● Each thyristors conducts for 180^0 of a cycle ● Thyristor pair on each arm T1 T4, T3 T6, T5 T2 are turned ON with 180degree intervals. ● Thyristors in the upper group (T1, T3, T5) conducts at an interval 120 degree ● T1 gets ON at ωt=00, then T3 ON at 120^0 and T5 ON at 240^0 (Upper part) ● T4 gets ON at 180^0(same leg of T1)			

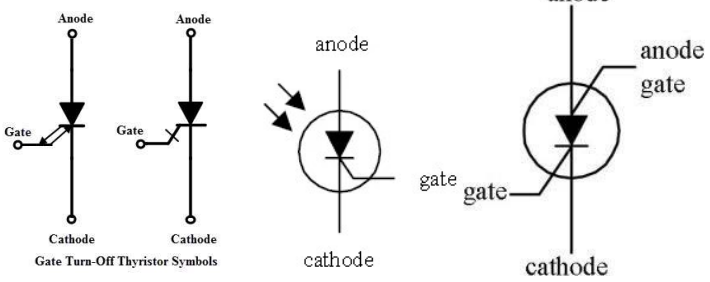
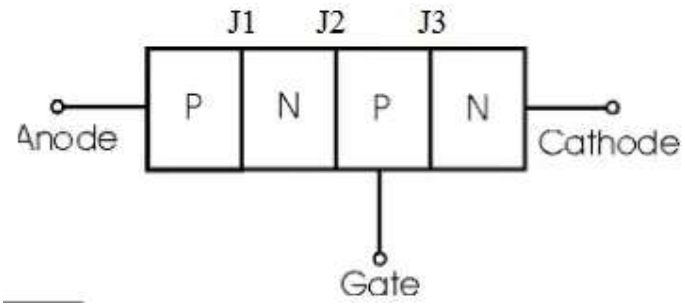
Sl NO. 1/Sem 4/II

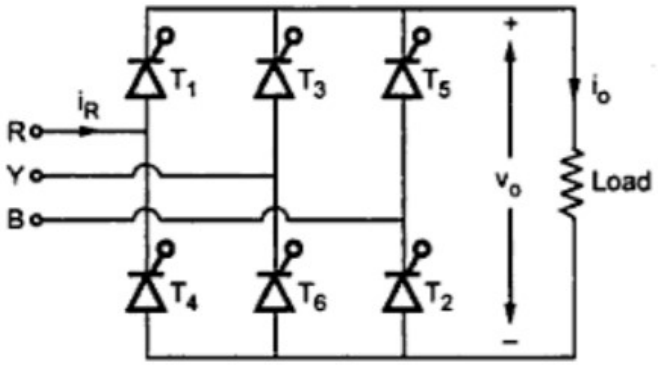
Scoring Indicators

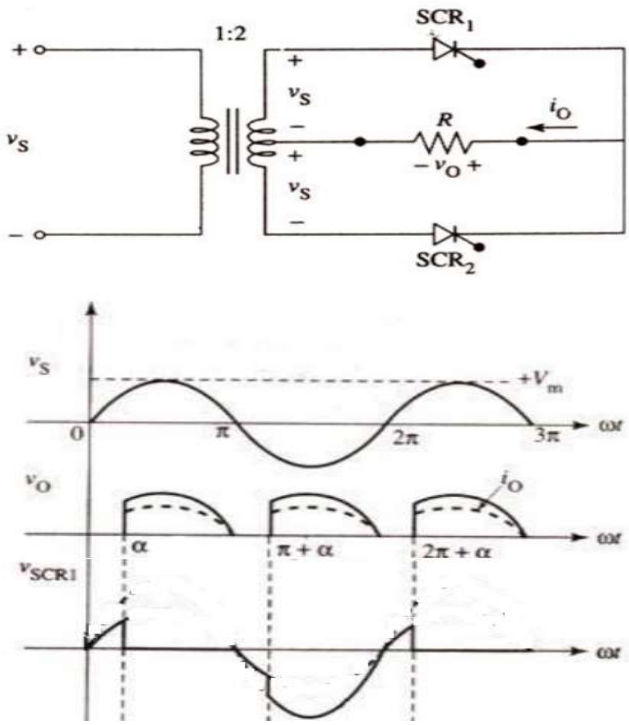
Model Question Paper II

POWER ELECTRONICS AND CIRCUITS

Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			
I. 1	It is the value of anode current below which SCR cannot maintain current through it and turns Off.	1	1	
I. 2	Depletion mode, Enhancement mode	0.5x2	1	
I. 3		1	1	
I. 4	Phase controlled rectifiers are a class of rectifier in which diodes are replaced by thyristors and this thyristors can be used to control the output voltage by varying the firing angle of SCR.	1	1	
I. 5	Increases average output voltage by preventing it from going into negative	1	1	
I. 6	Boost converter/Step up chopper	0.5x2	1	
I. 7	Constant frequency and Variable frequency control	0.5x2	1	
I. 8	(Any two) Series, Parallel, CSI, VSI, Half bridge, Full bridge, Three phase	0.5x2	1	
I. 9	(Any two) Buck, Boost, Buck boost ...	1	1	

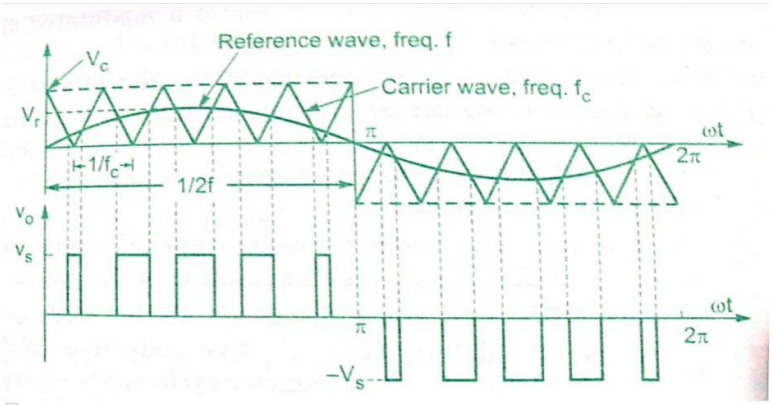
	PART B			
II. 1	**GTO, LASCR, SCS** *symbolic representation-1 mark each* *3* 1 mark = 3 marks*	3 * 1	3	
	 1)GTO 2)LASCR 3)SCS			
II. 2	**Applications of power electronic devices** *Any six application -0.5 mark each*	0.5x6	3	
	SMPS, Battery chargers, Variable frequency drives, HVDC transmission, UPS, Renewable energy systems, UPS ...			
II. 3	**Gate triggering of SCR**. *Structure of scr - 1mark* *Explanation- 2marks*	1+2	3	
	 Gate triggering: When SCR is forward biased, junction J1 and J3 are forward biased and J2 is reverse bias. To turn-on an SCR, a positive gate voltage between gate and cathode of a forward biased SCR.			

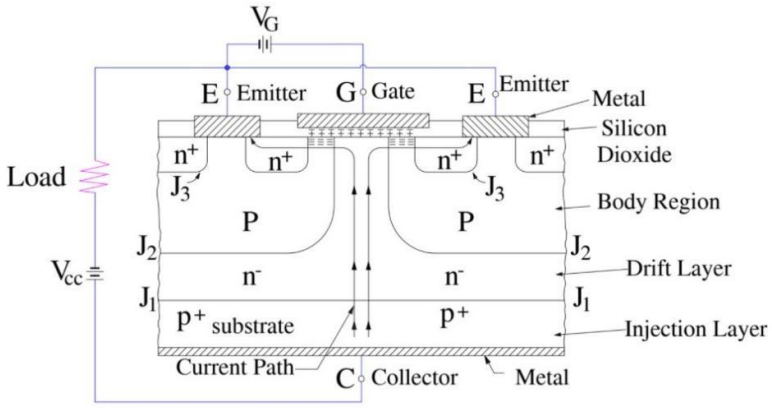
	This gives rise to a gate current where charges are injected into the inner p layer of the device. This effectively reduces the voltage at which forward break-over occurs. ie; the voltage at which junction J2 goes into avalanche break down and SCR moves into conduction state. Higher the gate current, the lower the forward break-over voltage.			
II. 4	**<u>Three phase controlled bridge rectifier</u>***figure -3 marks*	3	3	
				
II. 5	**<u>Single phase fully controlled centre tapped rectifier</u>** *Circuit diagram -1.5 marks* *Waveforms- 1.5 marks*	1.5+1.5	3	

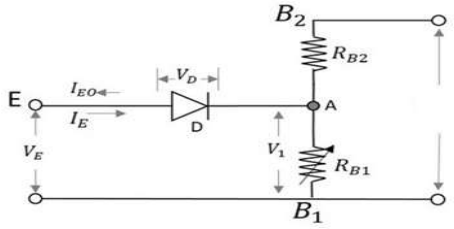
				
II. 6	**Duty ratio (D)= 0.5** *Duty ratio-1.5marks* **On time (T_{ON})=150 µs** *On time-1.5 marks*	1.5+1.5	3	
	V_{in} =440V, V_o=220V, T=300 µs $V_o=DV_{in}$ Duty ratio, D= V_o/V_{in}=220/440=0.5 On time T_{ON}=DT=0.5x300 µs= 150 µs			
II. 7	**<u>Applications of chopper</u>***Any six applications0.5 marks each*	6x0.5	3	
	SMPS, Speed control of DC motors, DC voltage boosters. Batterychargers. Railway traction, Battery powered eclectic cars, Variable frequency drives. BLDC motor drives ...			

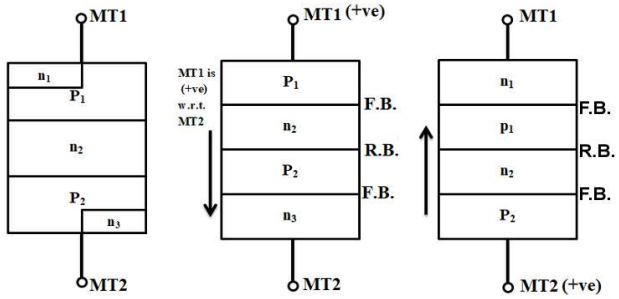
II. 8	**<u>Comparison between CSI and VSI</u>**, *Any three 1 marks each*	1x3	3	

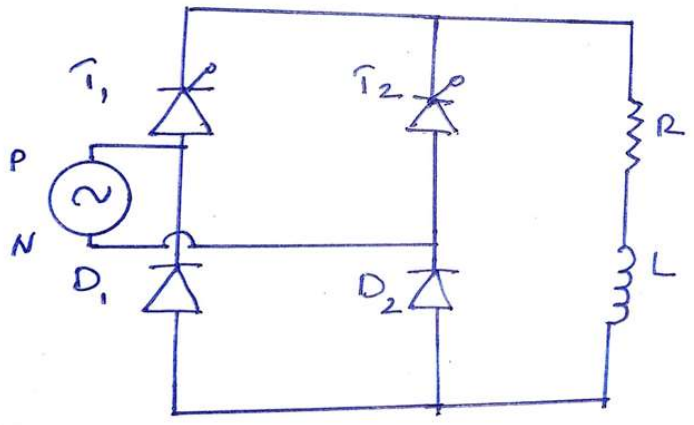
CSI	VSI
VSI is fed from a DC voltage source having small or negligible impedance	CSI is fed from a DC source having high impedance
Input voltage is maintained constant	Input current is made constant
The output voltage does not depend on load	The output current does not depend on load
The load current waveform and magnitude depends upon load impedance	The load voltage waveform and magnitude depends upon load impedance
Commutation circuit is complicated	Commutation circuit is simple

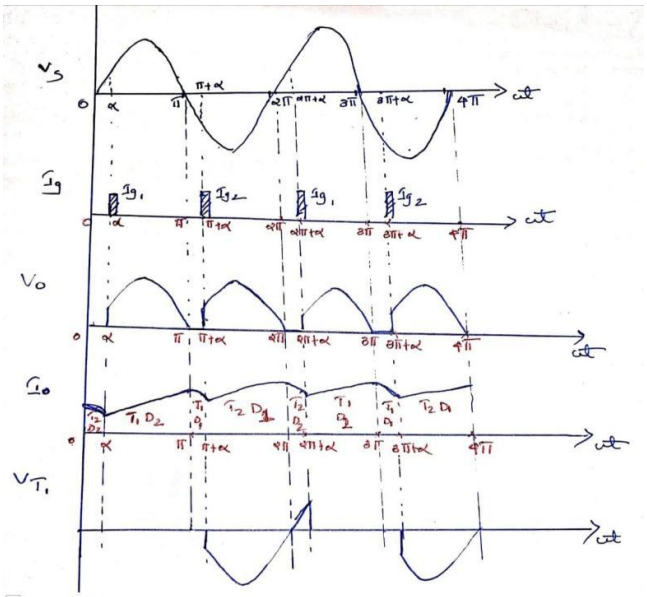
II. 9	**Sine PWM** *Figure-1.5 marks* *Explanation-1.5 mark*	1.5+1.5	3	
	 A high frequency triangular carrier wave is compared with a sinusoidal reference signal When a sinusoidal wave has magnitude higher than the triangular wave, the comparator output is high, otherwise it is low. The comparator output is processed in trigger pulse generator so that the output voltage wave of inverter has a pulse width in agreement with comparator output pulse width			
II.10	**Advantages of electric drive** *Any 6 advantages- 0.5 marks each*	6x0.5	3	
	1. It is quite clean due to the absence of fuel, fumes etc. 2.Electric motors are available over a wide range of power few watt(5W) to mega watt 3.Electrical energy can be transmitted easily 4.No need of fuel storage and fuel consumption 5.No hazardous fuel is required 6. Less pollution			

	PART C			
III	**IGBT** *Structure-3marks* *Explanation-4marks*	3+4	7	
	 Fig-1 ● IGBT (Insulated Gate Bipolar Transistor) has three terminals attached to three different metal layers, the metal layer of the gate terminal is insulated from the semiconductors by a layer of silicon dioxide (SIO2). ● Consider the voltage source VCC connected across the Emitter and the Collector and When gate voltage V_{GS}=0. Due to the voltage source VCC the junction J1 will be forward-biased whereas the junction J2 will be reverse biased. Since J2 is in reverse bias there will not be any current flow inside the IGBT (from collector to emitter). ● When gate voltage is applied, a region of negatively charged carriers is induced in the upper part P region, ● Now electrons from n+ region move to n- drift region through the n channel. ● Holes are injected from P+ region to n- region due to the positive voltage connected to the collector. ● n- region is flooded with charge carriers , conductivity increases and IGBT gets turned on			

IV	**Working of UJT***Equivalent circuit-3 marks* *Explanation-4 mark*s	3+4	7	
	• The equivalent circuit of UJT is shown with voltage biasing. • $R_{BB} = R_{B1}+R_{B2}$ • Voltage across R_{B1},$V_1= V_{BB}R_{B1}/(R_{B1+}R_{B2})=V_{BB}xR_{B1}/R_{BB}$ • $V_{B1}= \eta V_{BB}$ • $\eta=R_{B1}/R_{BB}$ is called the intrinsic stand off ratio • As P region is closer to B , $R_{B1}>R_{B2}$  • If $V_E< V_D+ \eta V_{BB,}$ then PN junction become reverse biased and UJT is in off state (V_D-cut in voltage of diode) • If $V_E>V_D+ \eta V_{BB,\ then}$ PN junction become forward biased. • This emitter voltage value V_E is called the peak-point voltage and is denoted by V_P. When $V_E = V_P$, emitter current I_E flows through the R_{B1} to the ground, that is, B_1. • Under these conditions, holes are injected from P type material to N type bar • In N type bar, these holes are repelled by positive B_2 terminal and are attracted by B_1 terminal • This accumulation of holes decreases the resistance R_{B1} in the B_1region. Hence the emitter current $I_E$increases. Now UJT is in on state.			
V	**Turn off process of SCR** *Commutation explanation- 2 marks* *Natural commutation-2.5 marks* *Forced commutation-2.5 marks*	2+2.5+2 .5	7	
	To turn off a conducting SCR, • The anode or forward current of SCR must be reduced to zero or below the level of **holding current** and then, • A sufficient reverse voltage must be applied across the SCR to regain its forward blocking state. The reverse voltage which causes to commutate the SCR is called commutation voltage. Depending on the commutation voltage located, the commutation methods are classified into two major types. • Those are 1) Natural commutation			

	If the SCR is connected to an AC supply, at every end of the positive half cycle the anode current goes through the natural current zero and also immediately a reverse voltage is applied across the SCR. These are the conditions to turn OFF the SCR.This method of commutation is also called as source commutation, or line commutation 2) Forced commutation In case of DC circuits, there is no natural current zero to turn OFF the SCR. In such circuits, forward current must be forced to zero with an external circuit to commutate the SCR hence named as forced commutation. Here the commutating circuit consists of components like inductors and capacitors called as commutating components. These commutating components cause a reverse voltage across the SCR that immediately bring the current in the SCR to zero.			
VI	**DIAC** *Construction figure-3 marks* *Explanation- 4 marks*	3+4	7	
	 ● The above image shows the clear operation of the DIAC with respective to the polarities. ● Consider the MT1 terminal to be positive, then the P1 layer near MT1 will be activated, ● Junction between P1-N2 and P2-N3 are Forward Biased and the junction between N2-P2 is reverse biased. ● When applied voltage is greater than break over voltage N2-P2 junction breaks down and DIAC moves into conduction ● The conduction will be taking place in the order of P1-			

	N2-P2-N3. When the current is flowing from MT1 to MT2 ● If we consider MT2 terminal to be positive, then the P2 layer near MT2 will be activated and ● The junctions between P2-N2 and P1-N1 are forward biased and the junction Between N2- P1 is reverse biased ● When applied voltage is greater than break over voltage N2-P1 junction breaks down and DIAC moves into conduction ● The conduction will be taking place in the order of P2-N2-P1-N1. The current will be flowing from MT2 to MT1 ● Hence the conduction will be possible in both the directions.			
VII	**Full wave semi controlled rectifier** *Circuit -2 marks* *Wave forms- 3marks* *Explanation-2 marks*	2+3+2	7	
				



Mode 1

T1 is triggered at ωt= α T1 and D2 conducts

Mode 2

At □t= □

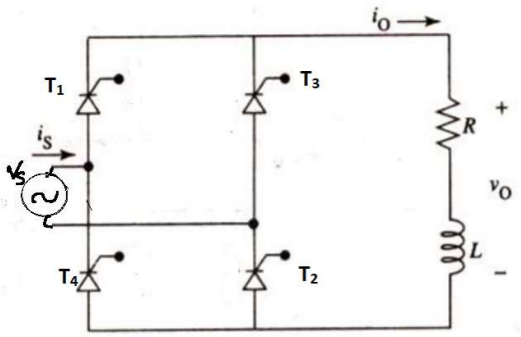
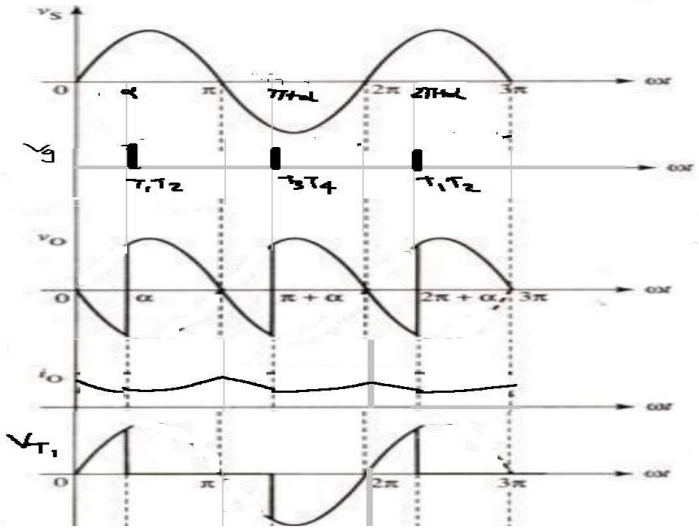
Supply voltage reverses polarity. D2 gets turned off. Due to inductive load, D1 gets forward biased, current free wheels through T1 and D1

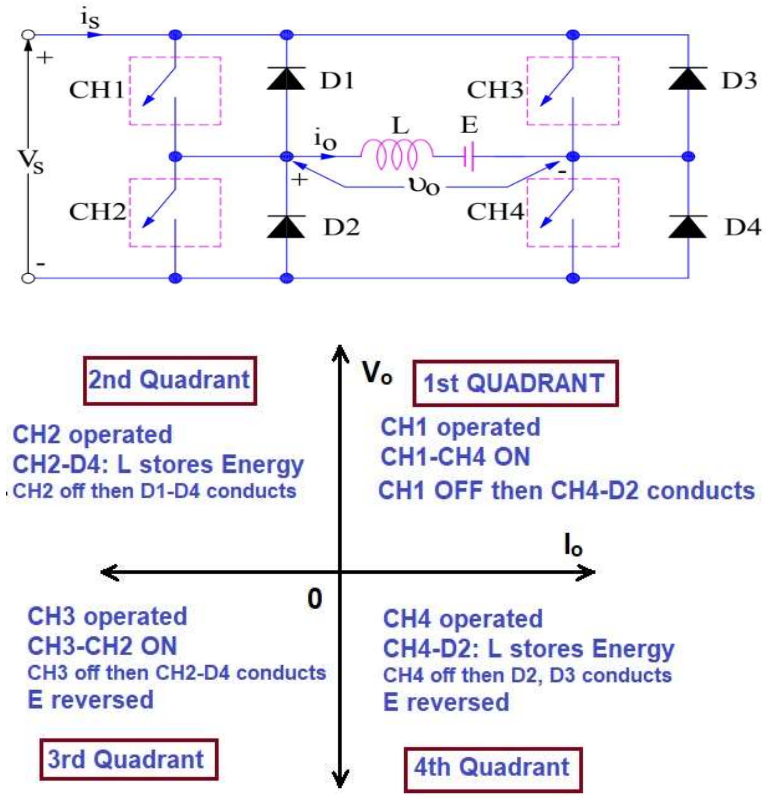
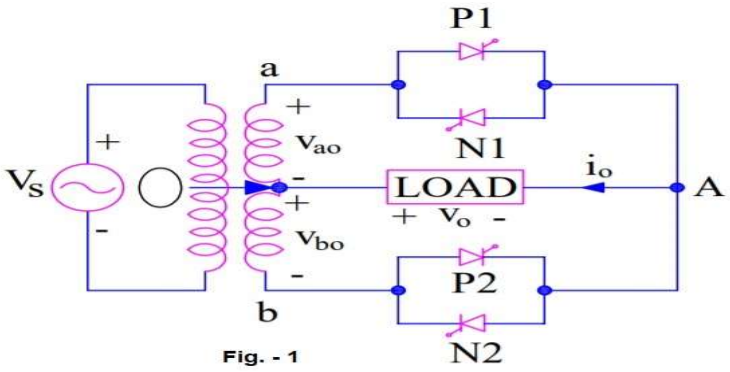
Mode-3

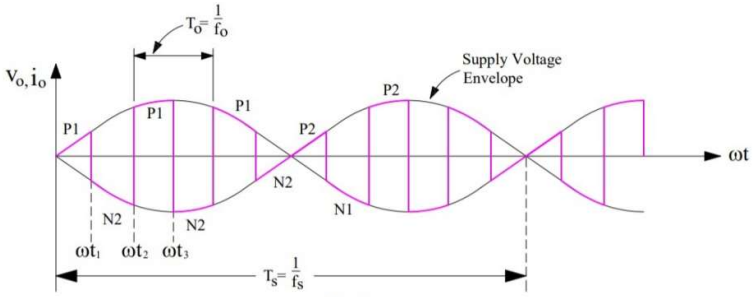
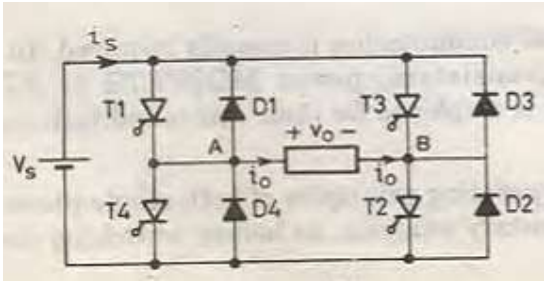
At □t=□+ α, T2 is triggered, current flows through T2, D1

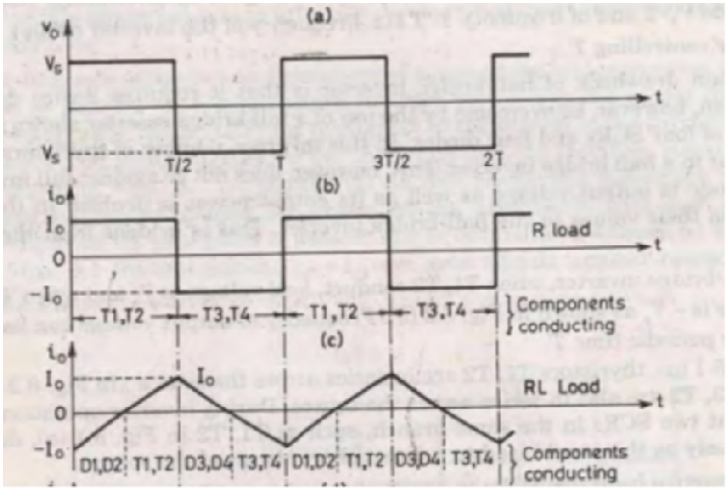
Mode-4

At □t=2□, supply voltage changes its polarity. D1 gets turned off. Due to inductive load, D1 gets turned on and current free-wheels through T2 and D2

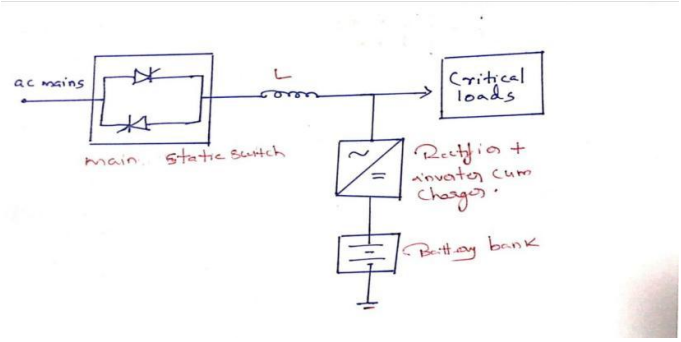
VIII	**Single phase full converter with RL load** *Circuit -2 marks* *Waveforms- 3 marks* *Explanation -2 marks*	2+3+2	7	
	  Positive half cycle T1and T2 are Forward biased □ to □ : T1 and T2 are triggered at □t=□, supply voltage appears across load, current flows through inductive load □ to □ +□ : At □t= □, supply voltage reverses, current do not goes to zero due to inductive load, T1 and T2 will remain in conduction □ +□ to 2□ : T3 and T4 are triggered at □t=□+□, rectified supply voltage appears across load, current flows through inductive load 2□ to 2□ +□ : At □t= 2□, supply voltage reverses, current do not goes to zero due to inductive load. T3 and T4 will remain in conduction			

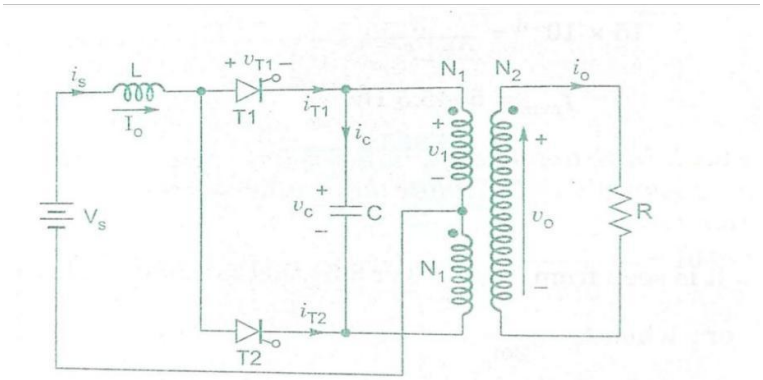
IX	**Four quadrant operation of class E chopper** *Circuit-3 marks* *Explanation-4 marks*	3+4	7	
				
X	**Single phase step up cyclo converter** *Circuit -3 marks* *Waveform-2 marks* *Explanation-2 marks*	3+2+2	7	
	 Fig. - 1 • During the positive half cycle of input supply voltage, positive group thyristors P1 & N2 are forward biased for ωt = 0 to ωt = π.			

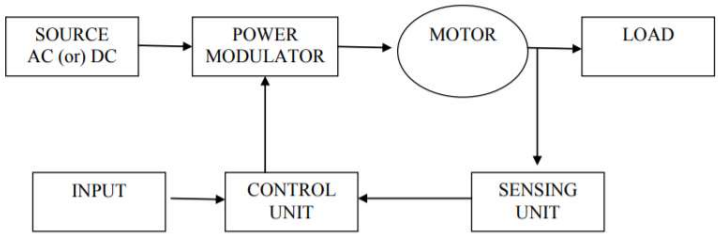
	• SCR P1 is fired to turn it ON at ωt = 0 such that load voltage is positive with terminal A positive and O negative. The load voltage, thus, follows the positive envelope of the input supply voltage. • At ωt = ωt1, the conducting thyristor P1 is force commutated and the forward biased thyristor N2 is fired to turn it ON. During the period N2 conducts, the load voltage is negative because O is positive & A is negative this time. The load or output voltage traces the negative envelop of the supply voltage • At ωt = ωt2, N2 is force commutated and P1 is turned ON. The load voltage is now positive and follows the positive envelope of the supply voltage. This process is repeated in the positive half cycle. • At ωt = π, terminal "b" is positive with respect to terminal "a"; both SCRs P2 & N1 are therefore forward biased from ωt = π to ωt = 2π. • When P2 is turned on, the load voltage is positive • To make the load voltage negative P2 is force commutated and N1 is triggered • This process is repeated in the negative half cycle • The frequency of output wave form is greater than input voltage and it is determined by proper switching of SCRs  Fig. - 2			
XI	**Full bridge inverter with RL load** *Circuit-3 marks* *Wave form-2 marks* *Explanation-2 marks*	3+2+2	7	
	 			

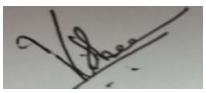


- Before t=0, Thyristor T3 and T4 were conducting, load current from B to A
- At t=0, T3 and T4 are turned off by forced commutation
- Due to inductive load, current cannot change direction immediately, D1 and D2 gets turned on and load current flows against supply voltage
- T1 and T2 are gated at t=0 , but they wont turn on because they are reverse biased by voltage across D1 and D2
- When current through D1 and D2 falls to zero, T1 and T2 gets forward biased by source voltage and gets turned on as they are given gate pulse for T/2 load current flows from A to B
- T1 and T2 is turned off by forced commutation at T/2..
- D3 and D4 gets turned on to allow current flow in same direction due to inductive load.
- Even though T3 and T4 are given gate pulses at T/2, they won't turn on because they are reverse biased by voltage across D3 and D4
- When current through D3 and D4 falls to zero, T3 and T4 gets turned on and conduct current from B to A

XII	**<u>Line interactive UPS</u>** *Block diagram-4 marks* *Explanation-3 marks*			
	 Mode 1 When main is ON: - static switch is closed. Load gets connected directly to ac mains through inductance Inverter cum charger block operates as charger to battery bank. Mode 2 When mains is off (fails) - static switch is open. Inverter cum charger block operates as an inverter and battery supplies power to load through inverter. Total time taken for sensing and changeover of switch after failure of mains is less than 5 ms			

XIII	**<u>Parallel inverter</u>***Circuit diagram-3 marks* *Explanation-4 marks*	3+4	7	
	 Explain the 3 modes of operation in one or two sentences. It consists of Two Thyristors T1, T2, Inductor, Capacitor C and a Transformer. ❖ Inductor connected in series with the source to improve the load current as constant. ❖ Capacitor is the commutating element connected in parallel with the load. ❖ Transformer having turns ratio from each primary half to secondary is one ❖ Mode 1: T1 is ON, T2 is OFF. The current is flowing through the upper half of the transformer. This current produces the same flux in the lower half and hence the voltage across the primary winding is 2Vs. This voltage charges the capacitor to 2 Vs and this voltage commutated T1. ❖ Mode 2: T2 is ON, T1 is OFF. Current flows through the lower part of primary and the total voltage across primary winding charges capacitor in the opposite polarity. It will turn off T2. ❖ Mode 3: time between T1 is turned OFF and T2 is ON. Time b/w T2 is OFF and T1 is ON. In both cases the charged capacitor gets discharged in the same direction as it flows.			

XIV	**Electric drive** *Block diagram- 3 marks* *Explanation- 4 marks*	3+4	7	
	 Block diagram of electric drive: 1. Load: usually a machinery to accomplish a given task. Eg- fans, pumps, washing machine etc. 2. Power modulator: modulators (adjust or converter) power flow from the source to the motion 3. Motor: actual energy converting machine (electrical to mechanical) 4. Source: The electrical power supply to the electric drive is either dc or ac supply 5. Control: adjust motor and load characteristics for the optimal mode. 6. Sensing unit: It is employed for sensing the drive parameters, such as speed motor current etc. These signals provide the feedback to the control unit			

Prepared By :  Chithra S R Lecturer in EEE Govt. Polytechnic College Punalur  Vineeth V Lecturer Govt polytechnic college Kalamassery	Scrutinized By : Ajmal M M Lecturer Govt polytechnic college Muttom