POWER ELECTRONICS AND SIMULATION LABORATORY

LAB MANUAL

Course Code	**:**	**AEE108**
Regulations	**:**	**IARE-R16**
Class	**:**	**V Semester (EEE)**

Department of Electrical and Electronics Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad

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(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

Program Outcomes	
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design / Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.
PO4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, APPRATUS, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Life - Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life - long learning in the broadest context of technological change.
PO12	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
Program Specific Outcomes	
PSO1	**Professional Skills:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.
PSO2	**Problem - Solving Skills:** Can explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.
PSO3	**Modern Tools in Electrical Engineering:** The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test, maintain power system and applications.

INDEX

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Exp. No	Name of the Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Study of characteristics of SCR, MOSFET &IGBT	PO1, PO2	-
2	Gate firing circuits for SCRs	PO2, PO3	PSO2
3	Single phase half controlled converter with R and RL loads	PO1, PO4	-
4	Forced commutation circuits (class A, class B, class C, class D)	PO3, PO4	-
5	Single phase fully controlled bridge converter with R and RL loads	PO1, PO4	PSO2
6	Single phase series inverter with R and RL loads	PO1, PO3	-
7	Single phase parallel inverter with R and RL loads	PO1, PO3	PSO2
8	Single phase AC voltage controller with R and RL loads	PO3, PO4	-
9	Single phase Cycloconverter with R and RL loads	PO3, PO4	PSO2
10	Operation of step down chopper using MOSFET	PO2, PO4	PSO2
11	Single phase dual converter with R and RL loads	PO3, PO4	-
12	Three phase half converter with R and RL loads	PO1, PO4	PSO2
13	Simulation of three phase full converter and PWM inverter with R and RL loads by using MATLAB.	PO3, PO5	-
14	Simulation of boost, buck, buck boost converter with R and RL loads by using MATLAB.	PO3, PO4, PO5	PSO2

POWER ELECTRONICS AND SIMULATION LABORATORY

OBJECTIVE:

The objective of Power electronics and simulation laboratory is to expose the students to analyse the characteristics of various power electronic devices such as SCR, MOSFET, and IGBT etc. Power electronics lab gives the students experimental skills about the operation of different types of choppers, rectifiers, inverters, AC voltage controllers and cycloconverters. The lab also gives an emphasis on how to model and simulate the different power electronic circuits and make the students can be capable of designing his/her own power electronic circuit.

COURSE OUTCOMES (COs):

Upon the completion of Power electronics and simulation laboratory course, the student will be able to

1. Describe the operation and characteristics of SCR, MOSFET and IGBT.
2. Explain the operation of Single phase and three phase controlled rectifiers and their commutating circuits.
3. Discuss the operation of different types of Choppers, inverters.
4. Illustrate the functioning of AC voltage controllers and cycloconverters.
5. Design the different power electronic circuits using MATLAB/Simulation.

EXPERIMENT – 1

STUDY OF CHARACTERISTICS OF SCR, MOSFET & IGBT

1.1 SCR CHARACTERISTICS

1.2 AIM:

To plot the V-I Characteristics of SCR, MOSFET & IGBT

1.3 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	SCR characteristics Trainer			
2	Patch chords			
3	DC Voltmeter			
4	DC Ammeter			

1.4 CIRCUIT DIAGRAM:

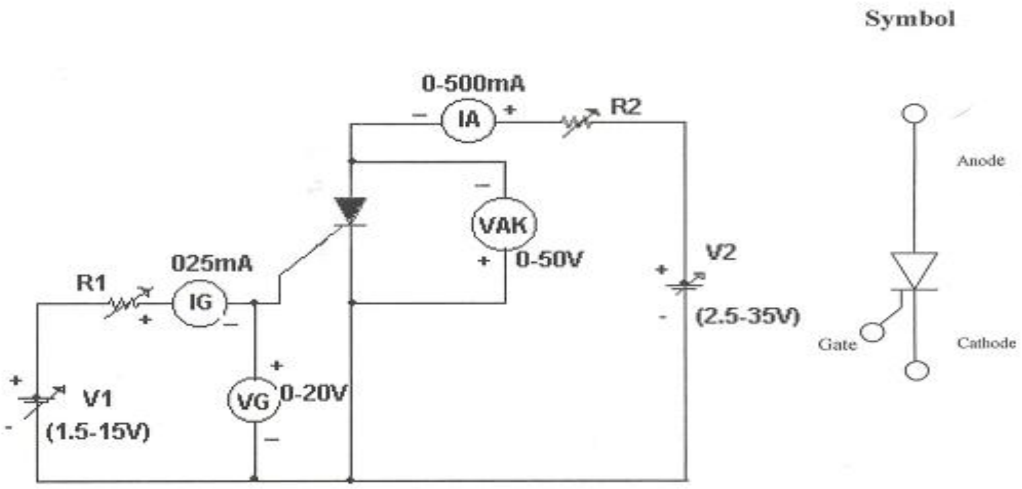

Fig – 1.1 Study of Characteristics of SCR

1.5 PROCEDURE:

V-I CHARACTERISTICS:

1. Make all connections as per the circuit diagram.
2. Initially keep V_1& V_2 at minimum position and R_1& R_2 maximum position.
3. Adjust Gate current I_g to some constant by varying the V_1 or R_1.
4. Now slowly vary V_2 and observe Anode to Cathode voltage V_{AK} and Anode current I_A.
5. Tabulate the readings of Anode to Cathode voltage V_{AK} and Anode current I_A.
6. Repeat the above procedure for different Gate current I_g.

GATE TRIGGRING AND FINDING V_G AND I_G:-

1. Keep all positions at minimum.
2. Set Anode to Cathode voltage V_{AK} to some volts say 15V.
3. Now slowly vary the V1 voltage till the SCR triggers and note down the reading of gate current(I_G) and Gate Cathode voltage(V_{GK}) and rise of anode current I_A.
4. Repeat the same for different Anode to Cathode voltage and find VAK and I_G values.

TO FIND LATCHING CURRENT:

1. Keep R_2 at middle position.
2. Apply 20V to the Anode to cathode by varying V_2.
3. Rise the Vg voltage by varying V1 till the device turns ON indicated by sudden rise in I_A. At what current SCR trigger it is the minimum gate current required to turn ON the SCR.
4. Now set R2 at maximum position, then SCR turns OFF, if it is not turned off reduce V2 up to turn off the device and put the gate voltage.
5. Now decrease the R2 slowly, to increase the Anode current gradually in steps.
6. At each and every step, put OFF and ON the gate voltage switches V1. If the Anode current is greater than the latching current of the device, the device says ON even after switch OFF S1, otherwise device goes to blocking mode as soon as the gate switch is put OFF.
7. If $I_A > I_L$ then, the device remains in ON state and note that anode current as latching current.
8. Take small steps to get accurate latching current value.

TO FIND HOLDING CURRENT:

1. Now increase load current from latching current level by varying R2 & V2.
2. Switch OFF the gate voltage switch S1 permanently (now the device is in ON state).
3. Now increase load resistance (R2), so that anode current reducing, at some anode current the device goes to turn off .Note that anode current as holding current.
4. Take small steps to get accurate holding current value.
5. Observe that $I_H < I_L$.

1.6 TABULAR COLUMN:

S. No	I_G= A	
	V_{AK} (Volts)	I_A (Amps)
1		
2		
3		
4		
5		

S. No	I_G= A	
	V_{AK} (Volts)	I_A (Amps)
1		
2		
3		
4		
5		

S. No	V_{AK} = (Volts)	
	V_{GK} = V	I_G= A
1		
2		
3		
4		
5		

S. No	V_{AK} = (Volts)	
	V_{GK} = V	I_G= A
1		
2		
3		
4		
5		

1.7 MODEL GRAPH:

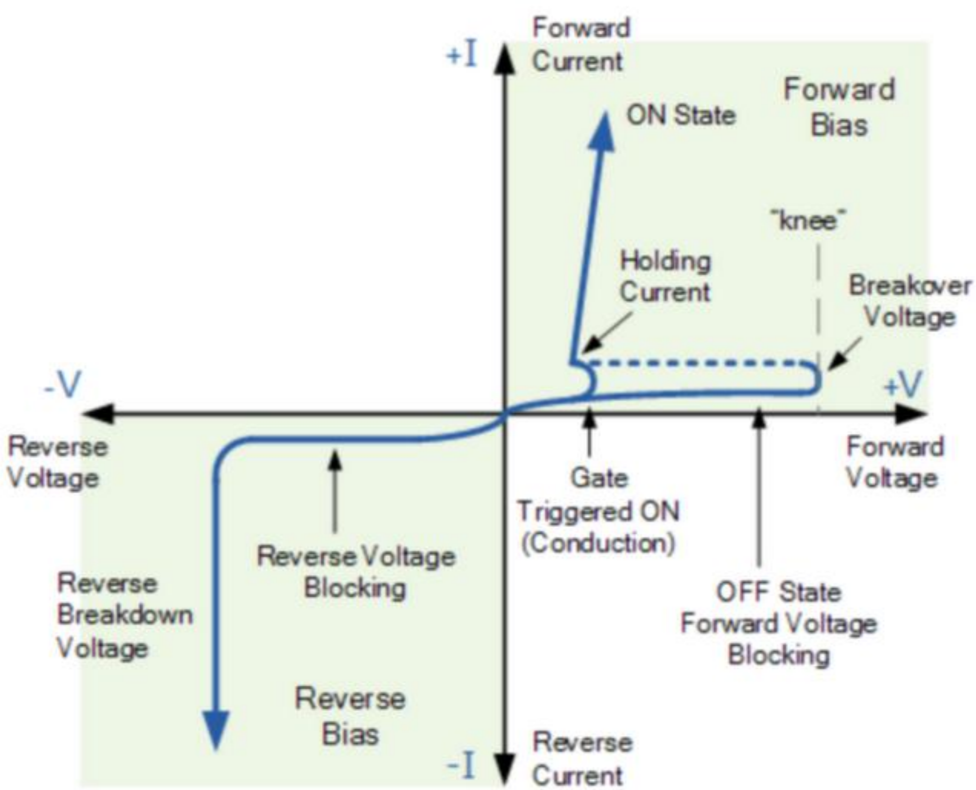

Fig - 1.2 V- I Characteristics of SCR

1.8 RESULT:

1.9 PRELAB VIVA QUESTIONS:

1. What is a Thyristor? Draw the structure of an SCR?
2. What are the different methods of turning on an SCR?
3. What is Forward break over voltage? Reverse break over voltage?
4. What are modes of working of an SCR?
5. Draw the V-I characteristics of SCR.
6. Differentiate between holding and latching currents.
7. Why is dv/dt technique not used for triggering?

1.10 POSTLAB VIVA QUESTIONS:

1. Why is V_{bo} greater than V_{br}?
2. Why does high power dissipation occur in reverse blocking mode?
3. Why shouldn't positive gate signal be applied during reverse blocking Mode?
4. Explain reverse current $I_{rev.}$.
5. What happens when gate drive is applied?
6. Why should the gate signal be removed after turn on?
7. Is a gate signal required when reverse biased?
8. What are applications of SCR?

1.2 MOSFET CHARACTERISTICS

1.2.1 AIM:

To study the output and transfer characteristics of MOSFET

1.2.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	MOSFET characteristics Trainer			
2	Patch chords			
3	DC Voltmeter			
4	DC Ammeter			

1.2.3 CIRCUIT DIAGRAM:

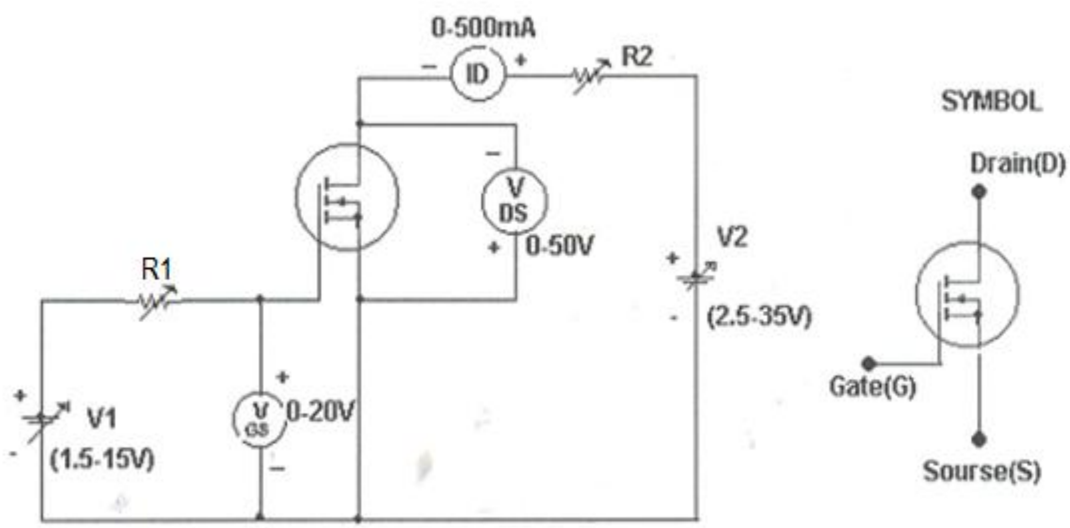

Fig – 1.2.1 Study of Characteristics of MOSFET

1.2.4 PROCEDURE:

TRANSFER CHARACTERISTICS:

1. Make all connections as per the circuit diagram.
2. Initially keep V_1& V_2 at minimum position and R_1& R_2 middle position.
3. Set V_{DS} to some say 10V.
4. Slowly vary Gate source voltage V_{GS} by varying V1.
5. Note down I_D and V_{GS} readings for each step.
6. Repeat above procedure for 20V & 30V of $V_{DS.}$ Draw Graph between I_D& V_{GS}.

OUTPUT CHARACTERISTICS:

1. Initially set V_{GS} to some value say 3V by varying V1.
2. Slowly vary V2 and note down I_D and V_{DS}.
3. At particular value of V_{GS} there a pinch off voltage between drain and source.
   If $V_{DS}< V_P$ device works in the constant resistance region and I_O is directly proportional to V_{DS}. If $V_{DS}>V_P$ device works in the constant current region.
4. Repeat above procedure for different values of V_{GS} and draw graph between I_D VS V_{DS}.

1.2.5 TABULAR COLUMN:

S. No.	V_{GS} = V	
	V_{DS} (Volts)	I_D (Amps)
1		
2		
3		
4		
5		

S. No	V_{GS} = V	
	V_{DS} (Volts)	I_D (Amps)
1		
2		
3		
4		
5		

S. No	V_{DS}= (Volts)	
	V_{GS} (V)	I_D(A)
1		
2		
3		
4		
5		

S. No	V_{DS} = (Volts)	
	V_{GS} (V)	I_D(A)
1		
2		
3		
4		
5		

1.2.6 MODEL GRAPH:

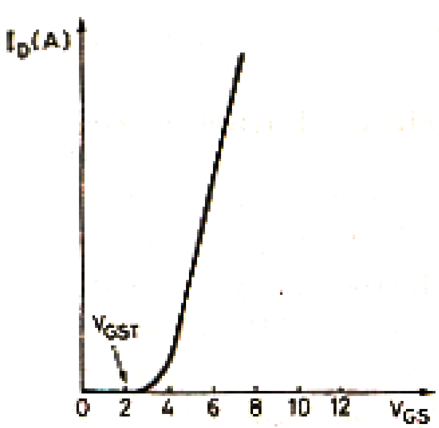

Fig - 1.2.2 Transfer Characteristic of MOSFET

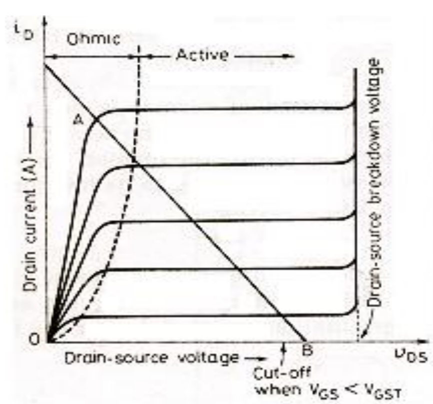

Fig - 1.2.3Output Characteristics of MOSFET

1.2.7 RESULT:

1.2.8 PRELAB VIVA QUESTIONS:

1. What are MOSFET's?
2. Draw the symbol of MOSFET.
3. What is the difference between MOSFET and BJT?
4. What is the difference between JFET and MOSFET?
5. Draw the structure of MOSFET.
6. What are the types of MOSFET?
7. What is the difference between depletion and enhancement MOSFET?

1.2.9 POSTLAB VIVA QUESTIONS:

1. How does n-drift region affect MOSFET?
2. How MOSFET are suitable for low power high frequency applications?
3. What are the requirements of gate drive in MOSFET?
4. Draw the switching model of MOSFET.
5. What is rise time and fall time?
6. In which region does the MOSFET used as a switch?
7. Why are MOSFET's mainly used for low power applications?
8. How is MOSFET turned off?
9. What are the advantages of vertical structure of MOSFET?
10. What are the merits of MOSFET?

1.3 IGBT CHARACTERISTICS

1.3.1 AIM:

To study the output and transfer characteristics of IGBT

1.3.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	IGBT characteristics Trainer			
2	Patch chords			
3	DC Voltmeter			
4	DC Ammeter			

1.3.3 CIRCUIT DIAGRAM:

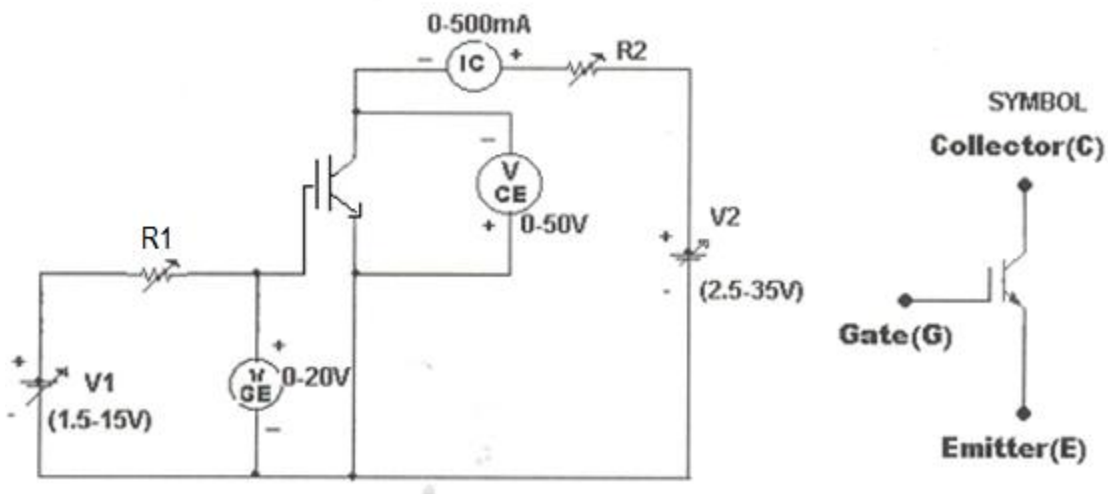

Fig – 1.3.1 Study of Characteristics IGBT

1.3.4 PROCEDURE:

TRANSFER CHARACTERISTICS:

1. Make all connections as per the circuit diagram.
2. Initially keep V_1& V_2 at minimum position and R_1& R_2 middle position.
3. Set V_{CE} to some say 10V.
4. Slowly vary Gate Emitter voltage V_{GE} by varying V1.
5. Note down I_C and V_{GE} readings for each step.
6. Repeat above procedure for 20V & 25V of $V_{DS.}$ Draw Graph between I_D& V_{GS}.

OUTPUT CHARACTERISTICS:

1. Initially set V_{GE} to some value say 5V by varying V1.
2. Slowly vary V2 and note down I_C and V_{CE} readings.
3. At particular value of V_{GS} there a pinch off voltage V_P between Collector and Emitter.

   If $V_{CE} < V_P$ device works in the constant resistance region and I_C is directly proportional to $V_{CE.}$ If $V_{CE} > V_P$ device works in the constant current region.
4. Repeat above procedure for different values of V_{GE} and draw graph between $I_{CVS}V_{GE}$.

1.3.5 TABULAR COLUMN:

S. No	V_{CE} = V	
	V_{GE} (Volts)	I_C (Amps)
1		
2		
3		
4		
5		

S. No	V_{CE} =V	
	V_{GE} (Volts)	I_C (Amps)
1		
2		
3		
4		
5		

S. No	V_{GE}= (Volts)	
	V_{CE} (V)	I_C(A)
1		
2		
3		
4		
5		

S. No	V_{GE} = (Volts)	
	V_{CE} (V)	I_C(A)
1		
2		
3		
4		
5		

1.3.6 MODEL GRAPH:

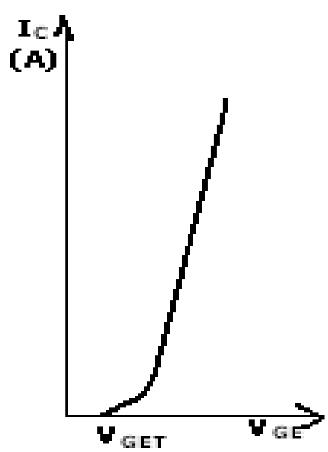

Fig – 1.3.2 Transfer Characteristics of IGBT

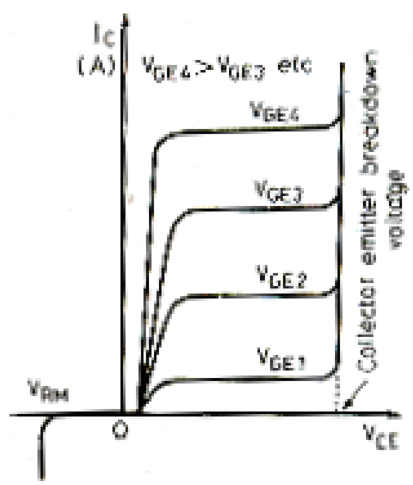

Fig -1.3.3Output Characteristics of IGBT

1.3.7 RESULT:

1.3.8 PRELAB VIVA QUESTIONS:

1. What is IGBT? What is the difference between an IGBT and SCR?
2. In what way IGBT is more advantageous than BJT and MOSFET?
3. Draw the symbol of IGBT.
4. Draw the equivalent circuit of IGBT.
5. What are on state conduction losses? How is it low in IGBT?
6. What is second breakdown phenomenon?
7. What is switching speed of IGBT?
8. Can we observe the transfer and collector characteristics of IGBT on CRO?

1.3.9 POSTLAB VIVA QUESTIONS:

1. What are merits of IGBT?
2. What are demerits of IGBT?
3. What are the applications of IGBT's?
4. Why silicon used in all power semiconductor devices and why not? Germanium?
5. What is pinch off voltage?
6. What is threshold voltage?

EXPERIMENT – 2

GATE FIRING CIRCUITS FOR SCRS

2.1 R-C TRIGGERING

2.1.1 AIM:

To study the Resistance-capacitance (RC) Triggering circuit of SCR.

2.1.2 APPARATUS:

S. No	Name of the Equipment	Range	Qty
1	Resistance-Capacitance Firing Circuit		
2	Patch chords		
3	CRO with differential module		
4	R-Load		

2.1.3 CIRCUIT DIAGRAM:

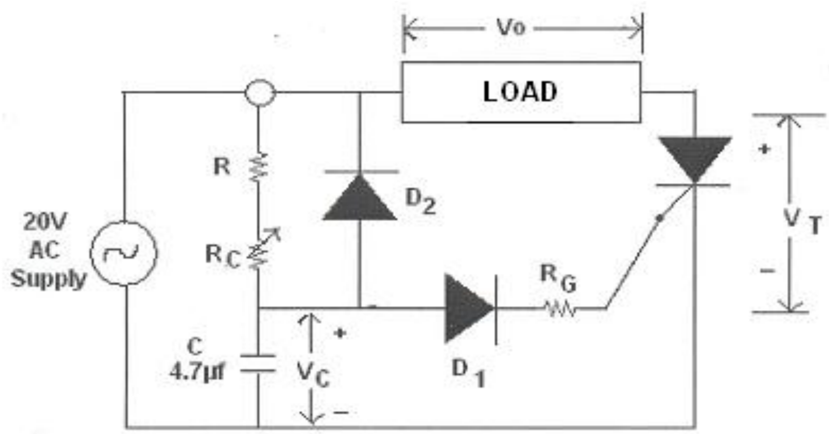

Fig - 2.1.3.1 RC Triggering Circuit

2.1.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Give the AC Power supply 20V/1A from the source indicated in the front panel.
3. Connect Load i.e., Rheostat of 200Ω between two points.
4. Switch ON Power supply and observe the wave forms of input &output at a time in the CRO. [CH-1 or CH-2]
5. Slowly vary the control Resistor R_C, that firing angle can vary from 0-180°.
6. Observe various voltage waveforms across load, SCR and other points, by varying the Load Resistance and Firing R_C part
7. Compare practical obtained voltage waveform with theoretical waveform and observe the Firing angle in R-C Triggering

2.1.5 MODEL GRAPH:

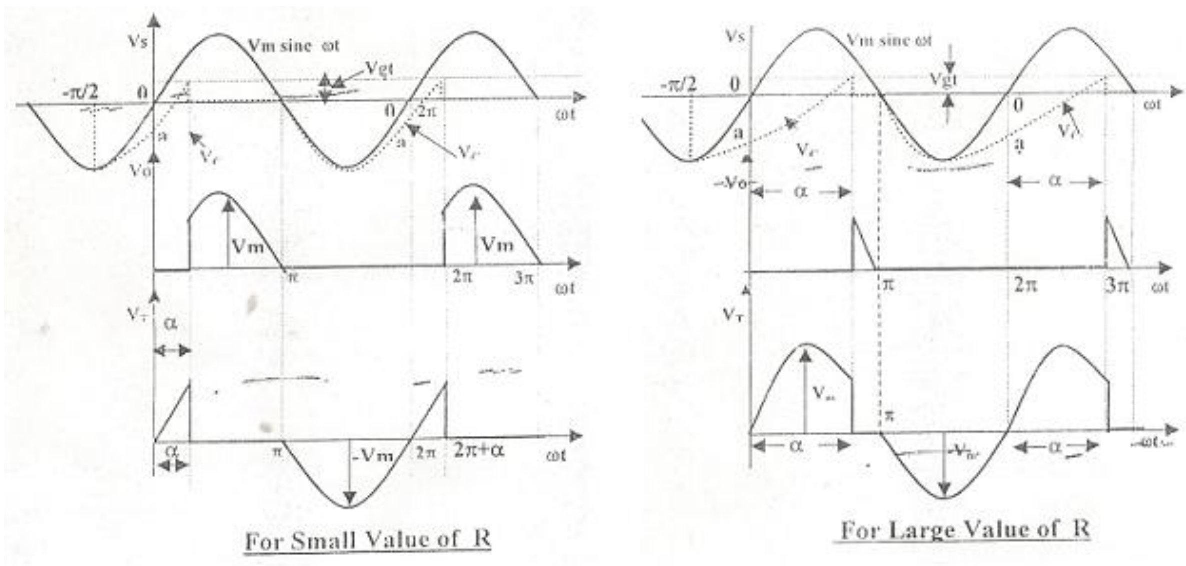

Fig - 2.1.5.2 Output Wave forms of RC Triggering

2.1.6. RESULT:

2.1.7 PRELAB VIVA QUESTIONS:

1. Draw the characteristics of SCR.
2. Define firing angle.
3. Define extinction angle.

2.1.8 POST LAB VIVA QUESTIONS:

1. What are the advantages of R triggering?
2. What are the advantages of RC triggering?
3. What are the limitations of RC triggering?
4. What are the limitations of R triggering?

2. 2 UJT TRIGGERING

2.2.1 AIM:

To study Firing of SCR using UJT Relaxation Oscillator and also to study UJT Relaxation

2.2.2 APPARATUS:

S. No.	Name of the equipment	Range	Qty
1	UJT Firing Circuit		
2	Patch chords & Probes		
3	CRO with differential module		
4	R-Load		

2.2.3 CIRCUIT DIAGRAM:

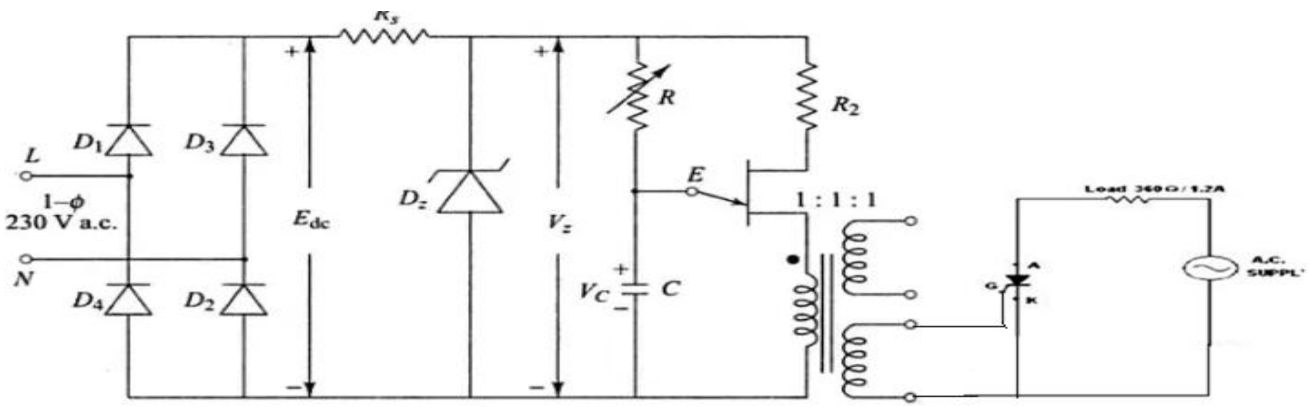

Fig 2.2.3.1 UJT Triggering Circuit

2.2.4 PROCEDURE:

1. First observe the waveforms at different points in circuit and also trigger output T1 and T1` observe the pulses are synchronized.
2. Now make the connections as per circuit using AC source, UJT Relaxation Oscillator, SCR's and Loads.
3. Observe the waveforms across the load and SCR and other points, by varying the variable resistor RC and resistance load, observe firing angle of SCR.
4. Use differential module for observing two waveforms (input and output) simultaneously in channel 1 and channel 2.
5. Check the waveforms for large value of RC and small value of RC and also triggering points of SCR.
6.

2.2.5 FOR RELAXATION OSCILLATOR:

1. Short the CF capacitor to the diode bridge rectifier to get filtered AC Output.
2. We get equidistance pulses at the output of pulse transformer.
3. The frequency of pulse can be varied by varying the potentiometer.
4. Observe that capacitor charging and discharging time periods and calculate frequency and RC time constant of UJT Relaxation Oscillator by using given formulas.

2.2.6 MODEL GRAPH:

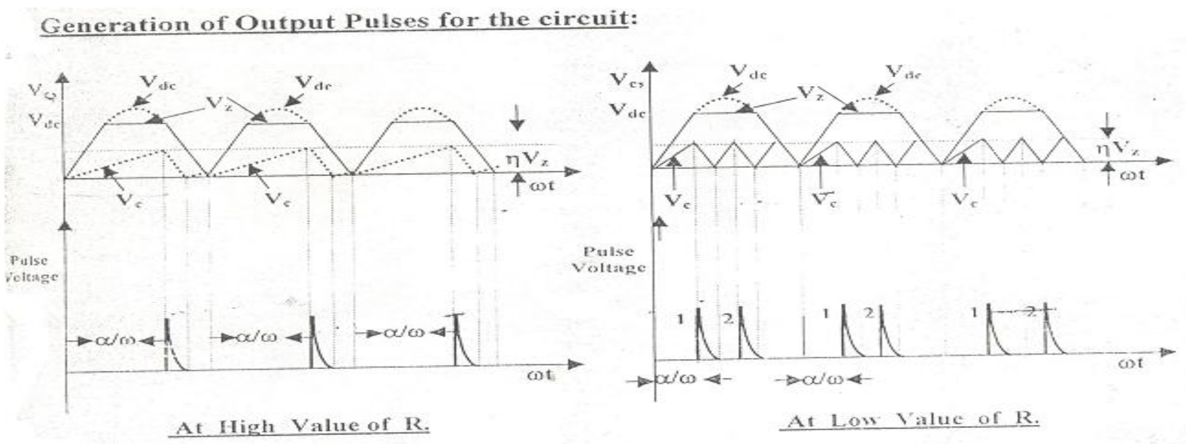

Fig - 2.2.6.2 Output Wave Forms of UJT Triggering

2.2.7 RESULT:

2.2.8 PRELAB VIVA QUESTIONS:

1. What is the ratio of latching current to holding current?
2. What is the difference between UJT triggering and temperature triggering?
3. What are the limitations of light triggering?
4. What are the advantages and disadvantages of temperature triggering?

2.2.9 POSTLAB VIVA QUESTIONS:

1. What are the merits of UJT triggering?
2. What are the demerits of UJT triggering?
3. What are the limitations of UJT triggering?

EXPERIMENT – 3

SINGLE PHASE HALF CONTROLLED BRIDGE CONVERTER

3.1 AIM:

To study the single-phase half controlled bridge converter with R & RL Load.

3.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Single phase half controlled bridge converter power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Isolation Transformer			
5	Variable Rheostat			
6	Inductor			
7	DC Voltmeter			
8	DC Ammeter			

3.3 CIRCUIT DIAGRAM:

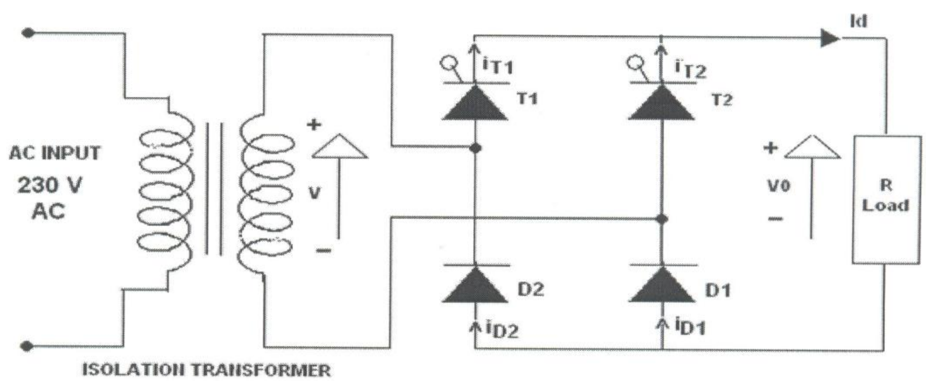

Fig – 3.1 Circuit Diagram of Single Phase Half Controlled Bridge Converter

3.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Connect first 30V AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.

5. Connect CRO probes and observe waveforms in CRO, Ch-1 or Ch-2, across load and device in single phase half controlled bridge converter.
6. By varying firing angle gradually up to 180^0 and observe related waveforms.
7. Measure output voltage and current by connecting AC voltmeter & Ammeter.
8. Tabulate all readings for various firing angles.
9. For RL Load connect a large inductance load in series with Resistance and observe all waveforms and readings as same as above.
10. Observe the various waveforms at different points in circuit by varying the Resistive Load and Inductive Load.
11. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

3.5 TABULAR COLUMN:

S. No	Input Voltage (V_{in})	Firing angle in Degrees	Output voltage (V_0)		Output Current (I_0)	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						
6						

3.6 MODULE CALCULATIONS:

V_0 = $(\sqrt{2}V / \prod) * (1+\cos\alpha)$

I_0 = $(\sqrt{2}V / \prod R) * (1+\cos\alpha)$

α = Firing Angle

V = RMS Value across transformer output

3.7 MODEL GRAPH:

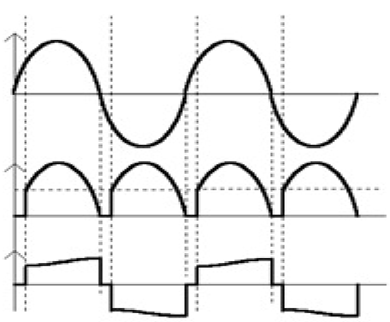

Fig - 3.2 Output Wave Forms of Single Phase Half Controlled Bridge Converter

3.8 RESULT:

3.9 PRELAB VIVA QUESTIONS:

1. What is the delay angle control of converters?
2. What is natural or line commutation?
3. What is the principle of phase control?
4. What is extinction angle?
5. Can a freewheeling diode be used in this circuit and justify the reason?

3.10 POSTLAB VIVA QUESTIONS:

1. What is conduction angle?
2. What are the effects of adding freewheeling diode in this circuit?
3. What are the effects of removing the freewheeling diode in single phase semi converter?
4. Why is the power factor of semi converters better than that of full converters?
5. What is the inversion mode of converters?

EXPERIMENT – 4

FORCED COMMUTATION CIRCUITS

4.1 AIM:

To Construct and study different commutation circuits.

4.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Commutation Study Unit			
2	Dc power supply			
3	Rheostat			
4	Digital multimeter			
5	CRO			
6	Patch Cards			

4.3 CIRCUIT DIAGRAM:

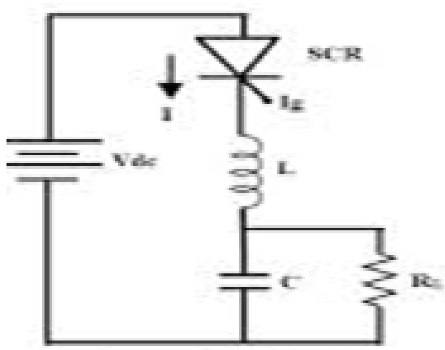

Fig -4.1 Class - A Commutation

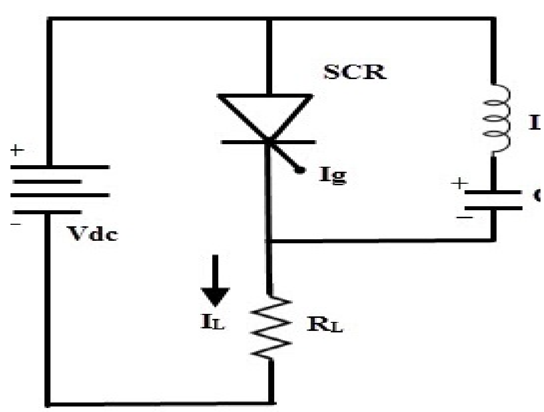

Fig - 4.2 Class - B Commutation

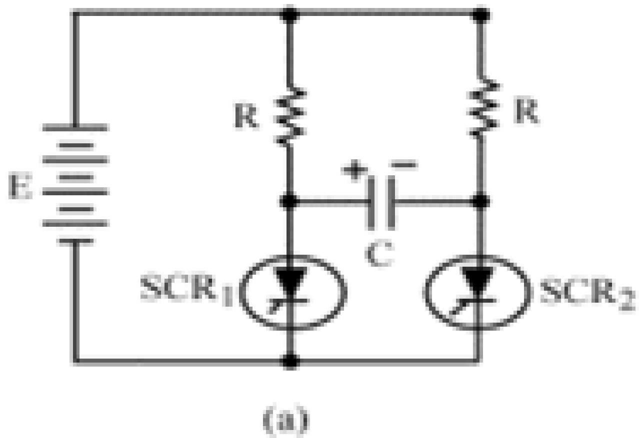

Fig - 4.3 Class - C Commutation

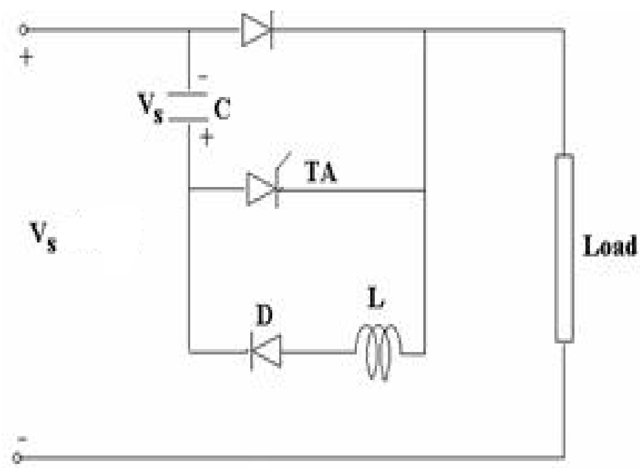

Fig - 4.4 Class - D Commutation

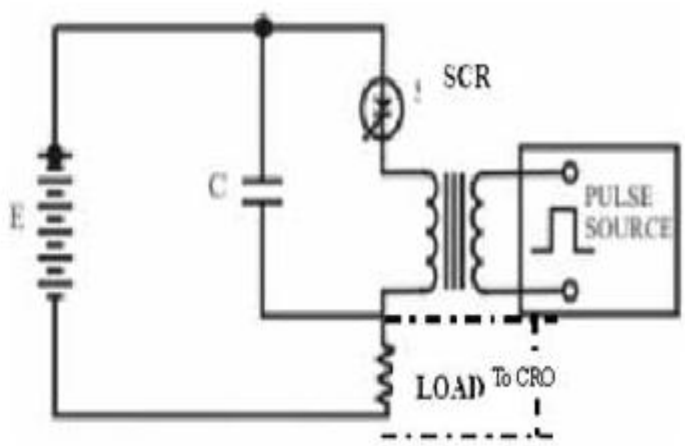

Fig - 4.5 Classes - E Commutation

4.4 PROCEDURE:

Class – A Commutation:

1. Connect the circuit as shown in the circuit.
2. Connect trigger output T1 to gate and cathode of SCR T1.
3. Switch on the DC supply to the power circuit and observe the voltage waveform across load by varying frequency potentiometer.
4. Repeat the same for different values of L, c and R.

Class –B Commutation:

1. Connect the circuit as shown in the circuit.
2. Connect trigger output T1 to gate and cathode of SCR T1.
3. Switch on the DC supply to the power circuit and observe the voltage waveform across load by varying frequency potentiometer.
4. Repeat the same for different values of L, c and R.

Class –C Commutation:

1. Connect the circuit as shown in the circuit.
2. Connect T1 and T2 from firing circuit to gate and cathode of SCR T1 and T2.
3. Observe the waveforms across R1, R2 and C by varying frequency and also duty cycle potentiometer.
4. Repeat the same for different values of L, c and R.

Class –D Commutation:

1. Connect the circuit as shown in the circuit.
2. Connect T1 and T2 from firing circuit to gate and cathode of SCR T1 and T2.
3. Initially keep the trigger at OFF position to initially charge the capacitor, this can be observed by connecting CRO across the capacitor.
4. Now switch ON the trigger output switch and observe the voltage waveform across the load T1, T2 and Capacitor. Note down the voltage waveforms at different frequency of chopping and also at different duty cycles.
5. Repeat the experiment for different values of L, C and R.

Class –E Commutation:

1. Connect the circuit as shown in the circuit.
2. Connect trigger output T1 to gate and cathode of SCR T1.
3. Connect T2 to the transistor base and emitter points.
4. Switch on the power supply and External Dc Supply.
5. Switch on the trigger output and observe and note down waveforms. Repeat the same by varying frequency and duty cycle.

4.5 MODEL GRAPHS:

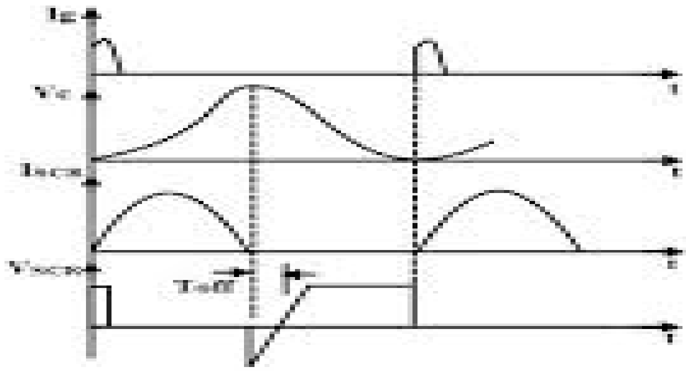

Fig - 4.6 Output Wave Forms of Class - A Commutation

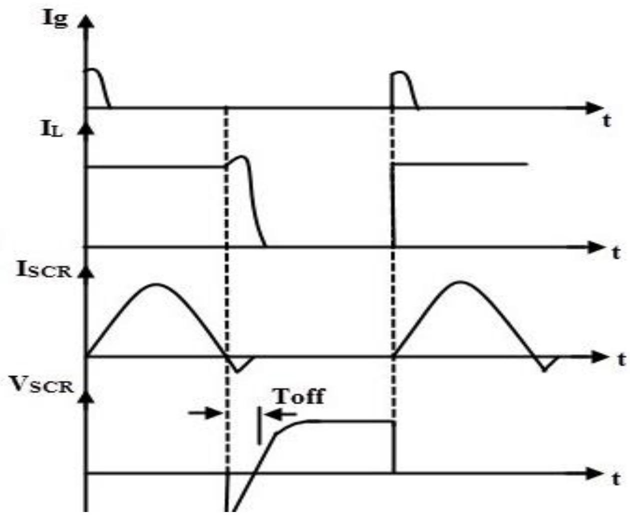

Fig - 4.7 Output Wave Forms of Class - B Commutation

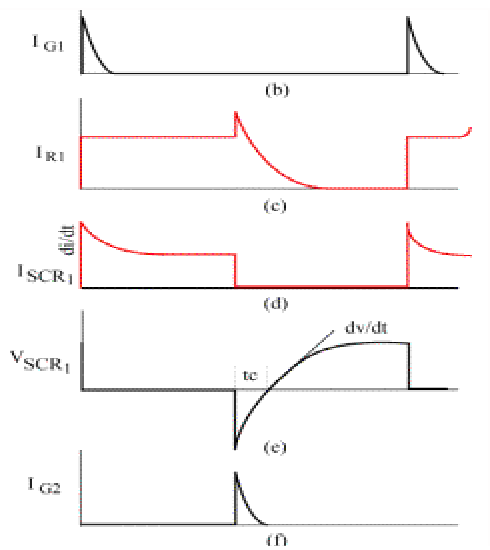

Fig - 4.8 Output Wave Forms of Class - C Commutation

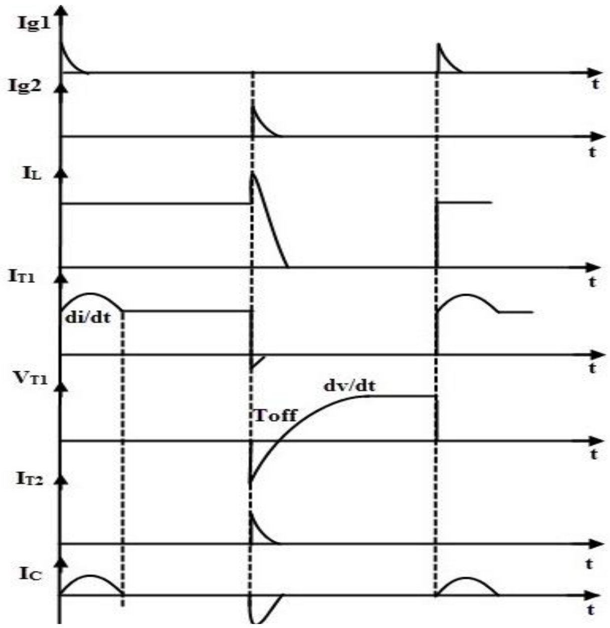

Fig - 4.9 Output Wave Forms of Class - D Commutation

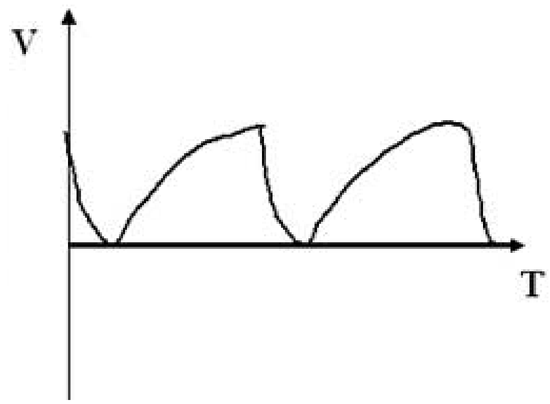

Fig - 4.10 Output Wave Forms of Class - E Commutation

4.6 RESULT:

4.7 PRE-LAB VIVA QUESTIONS:

1. What is the need of commutation circuits?
2. What is the difference between forced commutation and natural commutation?
3. What is the difference between Class A and class B commutations?
4. Which type of commutation circuit is easy to construct?

4.8 POSTLAB VIVA QUESTIONS:

1. What are the components required for class A commutation?
2. Why external pulse is required for class E commutation?
3. Which commutation circuit gives fast response?
4. Which commutation circuit gives slow response?

EXPERIMENT – 5

SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R AND RL LOADS

5.1 AIM:

To study the single phase fully controlled bridge converter with R & RL Load.

5.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Single phase full controlled bridge converter power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Isolation Transformer			
5	Variable Rheostat			
6	Inductor			
7	DC Voltmeter			
8	DC Ammeter			

5.3 CIRCUIT DIAGRAM:

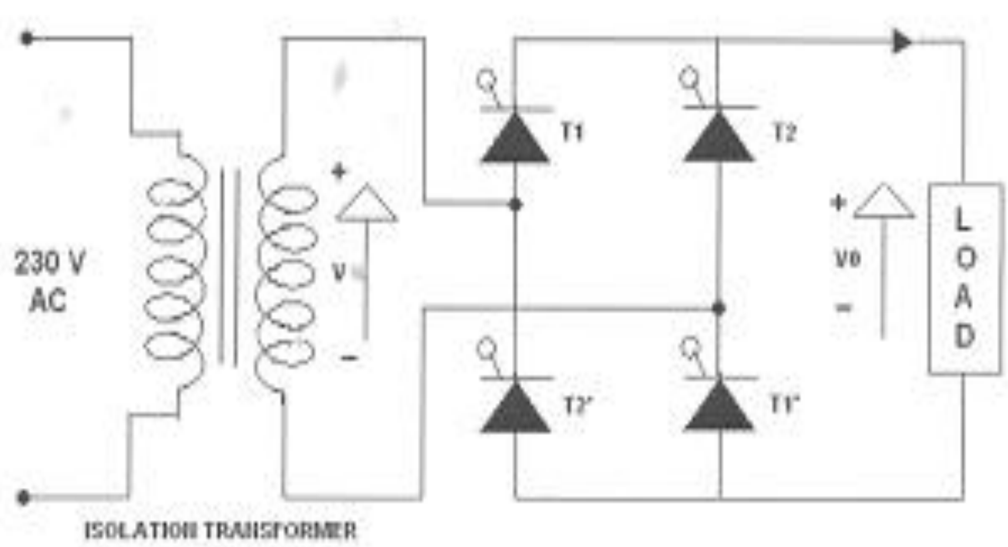

Fig – 5.1Single Phase Fully Controlled Bridge Converter

5.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Connect firstly 30V AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Connect CRO probes and observe waveforms in CRO across load and device in single phase fully controlled bridge converter.
6. By varying firing angle gradually up to 180^0 and observe related waveforms.
7. Measure output voltage and current by connecting AC voltmeter & Ammeter.
8. Tabulate all readings for various firing angles.
9. For RL Load connect a large inductance load in series with Resistance and observe all waveforms and readings as same as above.
10. Observe the various waveforms at different points in circuit by varying the Resistive Load and Inductive Load.
11. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

5.5 TABULAR COLUMN:

S. No	Input Voltage (V_{in})	Firing angle in Degrees	Output voltage (V_0)		Output Current (I_0)	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						
6						

5.6 MODEL CALCULATIONS:

For R-L Load:

$V_0 = (2\sqrt{2}V/\prod) * \cos\alpha$

$I_0 = (2\sqrt{2}V/\prod R) * \cos\alpha$

α =Firing Angle

V = RMS Value across transformer output

For R Load:

$V_0 = (\sqrt{2}V/\prod) * (1+\cos\alpha)$

$I_0 = (\sqrt{2}V/\prod R) * (1+\cos\alpha)$

5.7 MODEL GRAPH:

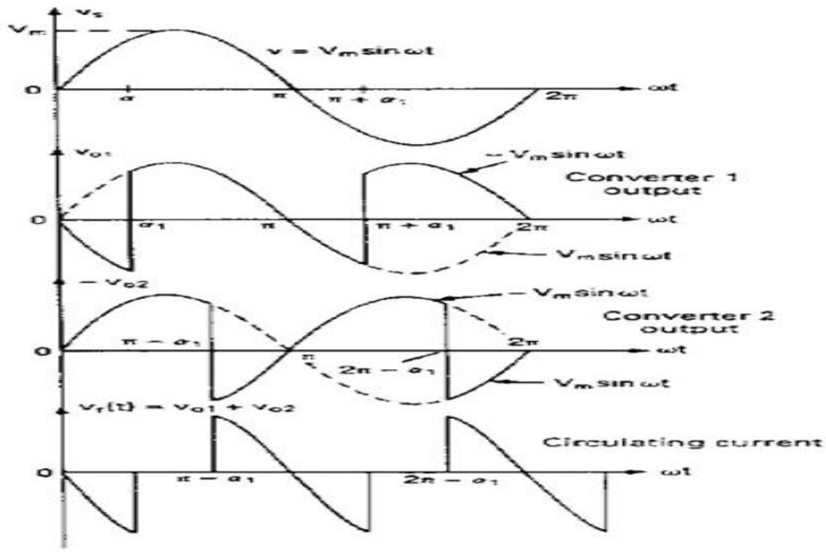

Fig – 5.2 Single Phase Fully Controlled Bridge Converter

5.8 RESULT:

5.9 PRELAB VIVA QUESTIONS:

1. State the type of commutation used in this circuit.
2. What will happen if the firing angle is greater than 90 degrees?
3. What are the performance parameters of rectifier?
4. What is the difference between half wave and full wave rectifier?

5.10 POSTLAB VIVA QUESTIONS:

1. If firing angle is greater than 90 degrees, the inverter circuit formed is called as?
2. What is displacement factor?
3. What is DC output voltage of single phase full wave controller?
4. What are the effects of source inductance on the output voltage of a rectifier?
5. What is commutation angle of a rectifier?
6. What are the advantages of three phase rectifier over a single phase rectifier?

EXPERIMENT – 6

SINGLE PHASE SERIES INVERTER WITH R AND RL LOADS

6.1 AIM:

To obtain the performance characteristics of a single phase series inverter

6.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Series inverter power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Regulated dc power supply			
5	Variable Rheostat			
6	Inductor			

6.3 CIRCUIT DIAGRAM:

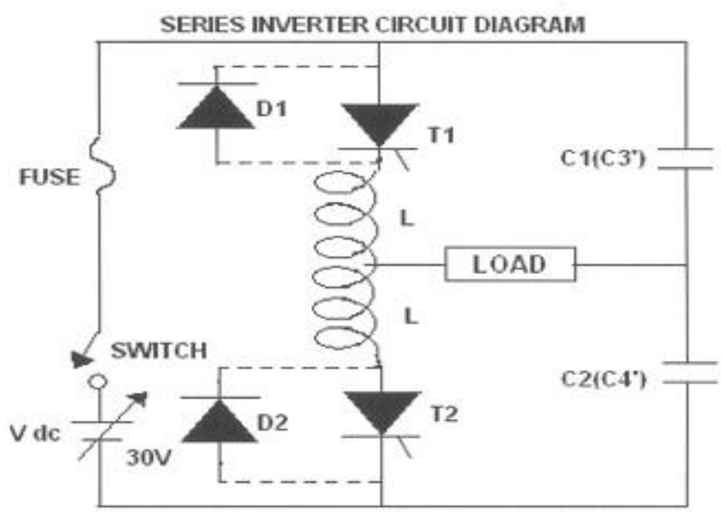

Fig 6.1Circuit Diagram Single Phase Series Inverter

6.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Give the DC power supply 30V to the terminal pins located in the power circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. By varying the frequency pot, observe related waveforms.

6. If the inverter frequency is increases above the resonant frequency of the power circuit commutation fails. Then switch OFF the DC supply, reduce the inverter frequency and try again.
7. Repeat the above same procedure for different value of L,C load and also above the wave forms with and without fly wheel diodes.
8. Total output wave forms entirely depends on the load, and after getting the perfect wave forms increase the input supply voltage up to 30V and follow the above procedure.
9. Switch OFF the DC supply first and then Switch OFF the inverter.(Switch OFF the trigger pulses will lead to short circuit)

6.5 MODEL WAVEFORMS:

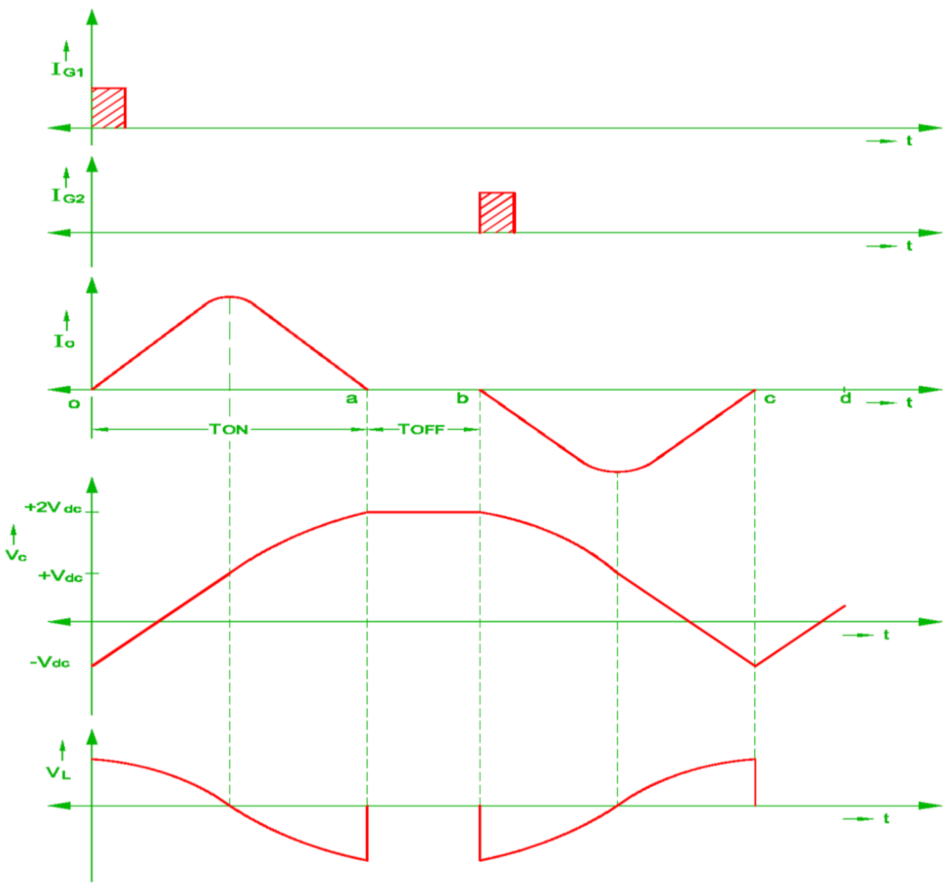

Fig 6.2Output Wave Forms of Single Phase Series Inverter

6.6 RESULT:

6.7 PRELAB VIVA QUESTIONS:

1. Why is this circuit called as series inverter?
2. What is the type of commutation for series inverter?
3. What is the configuration of inductor?
4. What is the principle of series inverter?
5. Disadvantages of series inverter.
6. On what principle series inverter works?

6.8 POST LAB VIVA QUESTIONS:

1. What is the dead zone of an inverter?
2. Up to what maximum voltage will the capacitor charge during circuit operation?
3. What is the amount of power delivered by capacitor?
4. What is the purpose of coupled inductors in half bridge resonant inverters?

EXPERIMENT – 7

SINGLE PHASE PARALLEL INVERTER WITH R AND RL LOADS

1.1 AIM:

To study the parallel inverter

1.2 APPARATUS:

S. No	Name of the Equipment	Range	Qty
1	Parallel inverter circuit.		
2	Patch chords & Probes		
3	CRO		
4	Regulated power supply		
5	R load		

7.3 CIRCUIT DIAGRAM:

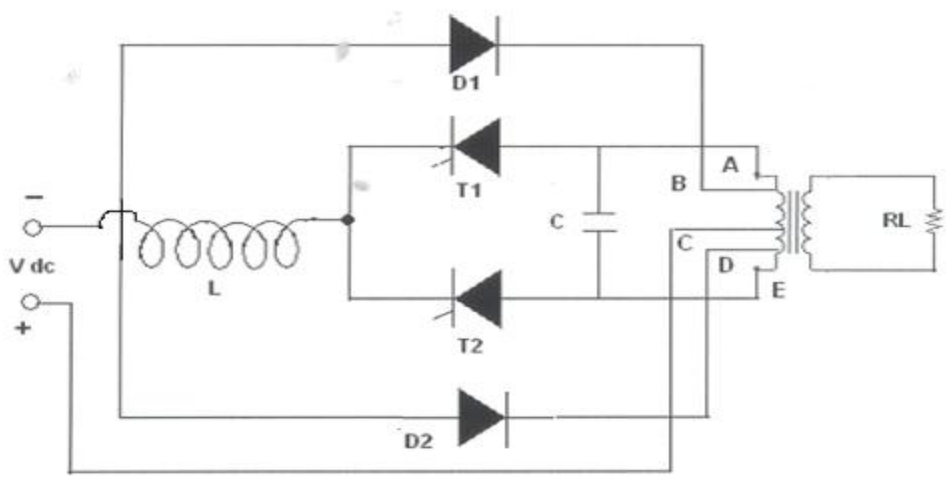

Fig - 7.1Circuit Diagram of Single Phase Parallel Inverter

7.4 PROCEDURE:

1. Make all connections as per the circuit, and give regulated power supply 30V/5A.
2. Give trigger pulses from firing circuit to gate and cathode of SCR's T1 & T2.
3. Set input voltage 15V, connect load across load terminals.
4. Now switch ON the DC supply, switch ON the trigger output pulses.
5. Observe the output voltage waveforms across load by varying the frequency pot.
6. Repeat the above same procedure for different value of L, C load values.
7. Switch off the DC supply first and then switch off the inverter.

   (switch off the trigger pulses will lead to short circuit)

7.5 MODEL GRAPH:

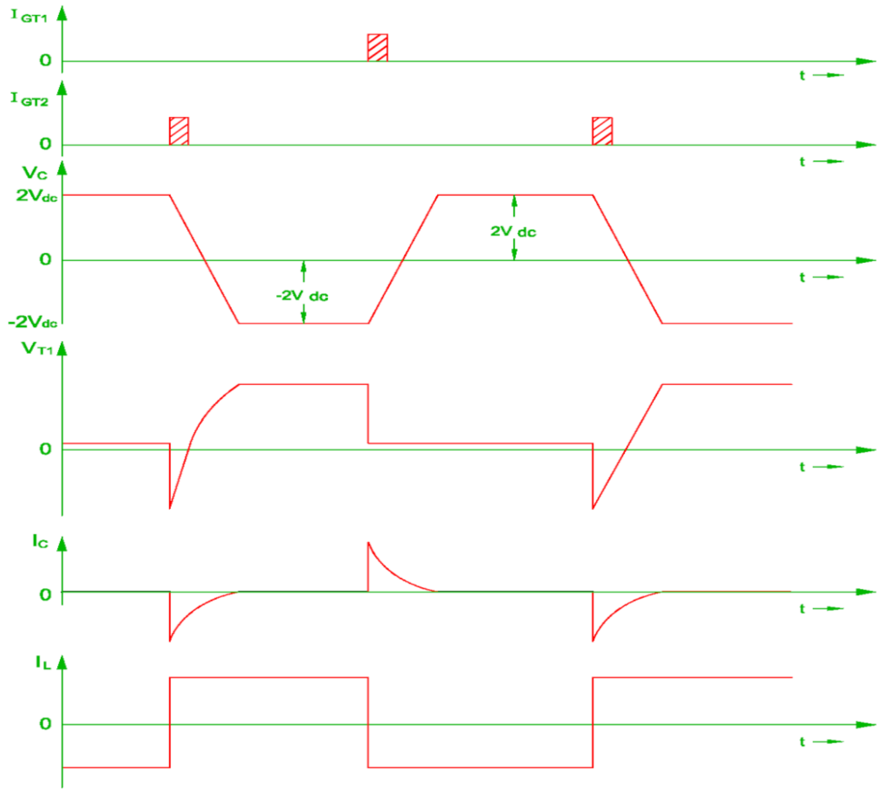

Fig - 7.2 Output Wave Forms of Single Phase Parallel Inverter

7.6 RESULT:

7.7 PRELAB VIVA QUESTIONS:

1. Why is this circuit called as parallel inverter?
2. What is the type of commutation for parallel inverter?
3. What is the configuration of capacitor?
4. What is the principle of parallel inverter?
5. Disadvantages of parallel inverter.
6. On what principle parallel inverter works?

7.8 POST LAB VIVA QUESTIONS:

1. What is the dead zone of an inverter?
2. Up to what maximum voltage will the capacitor charge during circuit operation?
3. What is the amount of power delivered by capacitor?
4. What is the purpose of inductors in parallel inverters?

EXPERIMENT – 8

SINGLE PHASE A.C. VOLTAGE CONTROLLER

8.1 AIM:

To study the single phase AC voltage controller with R and RL Load

8.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Single phase AC voltage controller power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Isolation Transformer			
5	Variable Rheostat			
6	Inductor			
7	AC Voltmeter			
8	AC Ammeter			

8.3 CIRCUIT DIAGRAM:

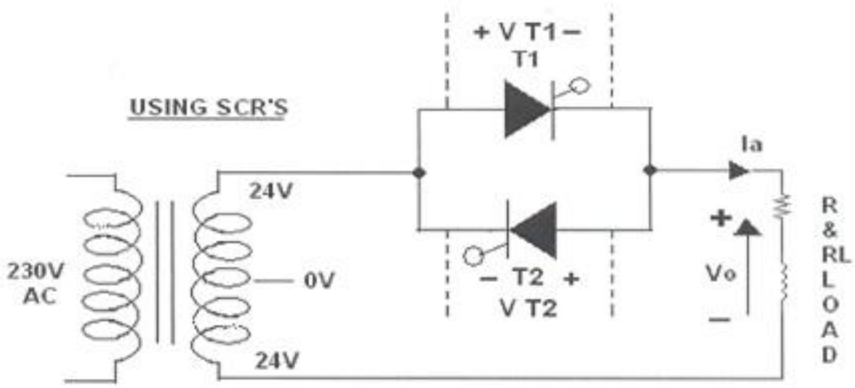

Fig - 8.1 Single Phase AC Voltage Controller with Thyristors

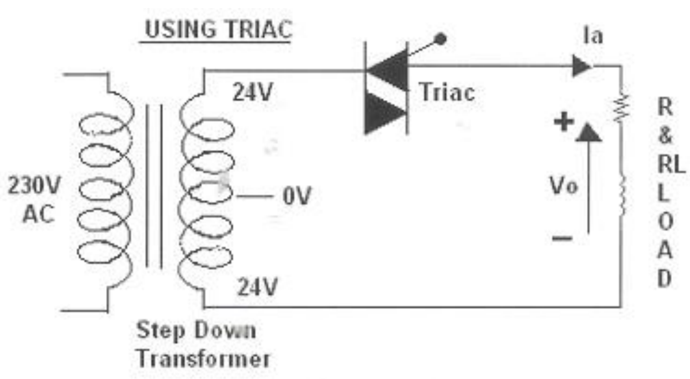

Fig - 8.2 Single Phase AC Voltage Controller with Traic

8.4 PROCEDURE:

AC VOLTAGE CONTROLLER WITH TWO THYRISTORS:

1. Make all connections as per the circuit diagram.
2. Connect firstly 30V AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Observe waveforms in CRO, across load by varying firing angle gradually up to 180^0.
6. Measure output voltage and current by connecting AC voltmeter & Ammeter.
7. Tabulate all readings for various firing angles.
8. For RL Load connect a large inductance load in series with Resistance and observe all waveforms and readings as same as above.
9. Observe the various waveforms at different points in circuit by varying the Resistive Load and Inductive Load.
10. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

A.C. VOLTAGE CONTROLLER WITH TRIAC:

1. Make all connections as per the circuit diagram.
2. Connect firstly 30V AC supply from Isolation Transformer to circuit.
3. Connect firing pulse from firing circuit to TRIAC as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Observe waveforms in CRO, across load by varying firing angle gradually up to 180^0.
6. Measure output voltage and current by connecting AC voltmeter & Ammeter.
7. Tabulate all readings for various firing angles.
8. For RL Load connect a large inductance load in series with Resistance and observe all waveforms and readings as same as above.
9. Observe the various waveforms at different points in circuit by varying the Resistive Load and Inductive Load.
10. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

8.5 TABULAR COLUMN:

S. No.	Input Voltage (V_{in})	Firing angle in Degrees	Output voltage (V_{0r})		Output Current (I_{0r})	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						
6						

8.6 MODULE CALCULATIONS:

I_{0r} = V_{0r}/R

α = Firing Angle

V = RMS Value across transformer output

8.7 MODEL GRAPH:

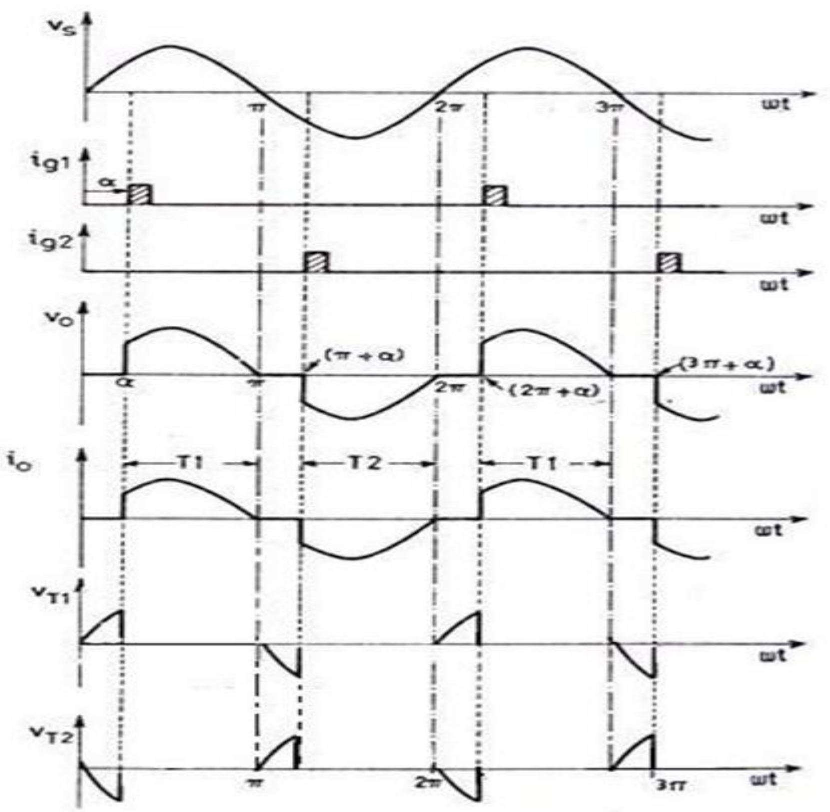

Fig - 8.3 Single Phase AC Voltage controller with R-Load

8.8 RESULT:

8.9 PRE LAB VIVA QUESTIONS:

1. Why should the two trigger sources be isolated?
2. What are the advantages and the disadvantages of phase control?
3. What is phase control?
4. What are the advantages of bidirectional controllers?
5. What is meant by duty cycle in ON-OFF control method?

8.10 POST LAB VIVA QUESTIONS:

1. What type of commutation is used in this circuit?
2. What are the effects of load inductance on the performance of AC voltage controllers?
3. What is extinction angle?
4. What are the disadvantages of unidirectional controllers?
5. What are the advantages of ON-OFF control?

EXPERIMENT – 9

SINGLE PHASE CYCLO-CONVERTER WITH R AND RL LOADS

9.1 AIM:

To study the single - phase Cyclo Converter with R & RL Load.

9.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Single phase Cycloconverter power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Isolation Transformer(Centre-Tapped)			
5	Variable Rheostat			
6	Inductor			
7	AC Voltmeter			
8	AC Ammeter			

9.3 CIRCUIT DIAGRAM :

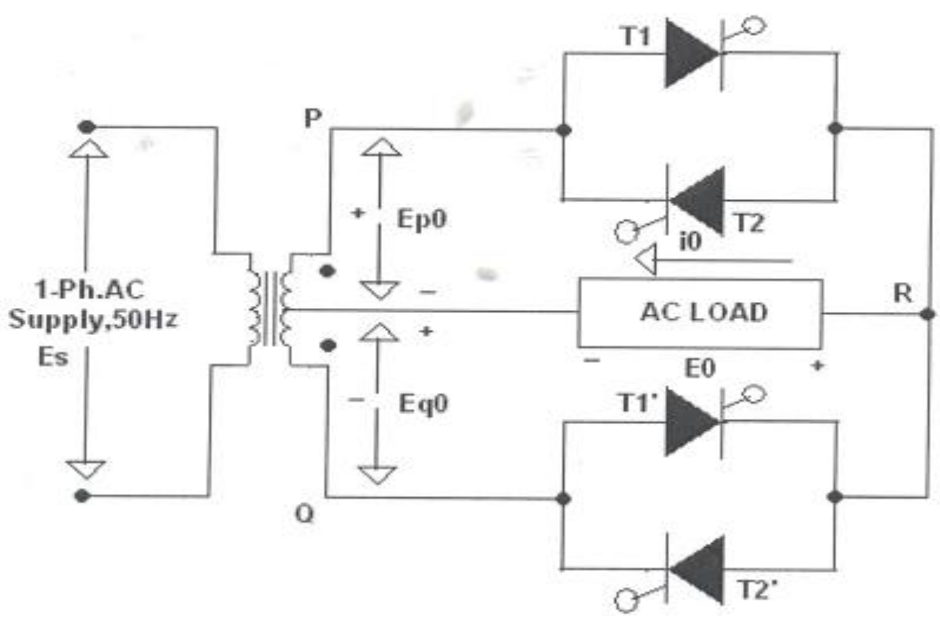

Fig – 9.1 Circuit Diagram of Single Phase Cyclo - Converter

9.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Connect firstly (30V-0-30V) AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals.
5. Set the frequency division switch to (2, 3, 4…9) your required output frequency.
6. Switch ON the MCB and IRS switch and trigger output ON switch.
7. Observe waveforms in CRO, across load by varying firing angle gradually up to 180^0 and also for various frequency divisions (2, 3, 4…9).
8. Measure output voltage and current by connecting AC voltmeter & Ammeter.
9. Tabulate all readings for various firing angles.
10. For RL Load connect a large inductance load in series with Resistance and observe all waveforms and readings as same as above.
11. Observe the various waveforms at different points in circuit by varying the Resistive Load and Inductive Load.
12. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

9.5 TABULAR COLUMN:

S. No	Input Voltage (V_{in})	Firing angle in Degrees	Frequency Division	V_o (V)	I_o (A)	Input frequency f_s	Output frequency f_o	f_o/f_s

9.6 MODEL CALCULATIONS:

V_{0r} =

I_{0r} = V_{0r}/R

θ = Firing Angle

V = RMS Value across transformer output

9.7 MODEL GRAPH:

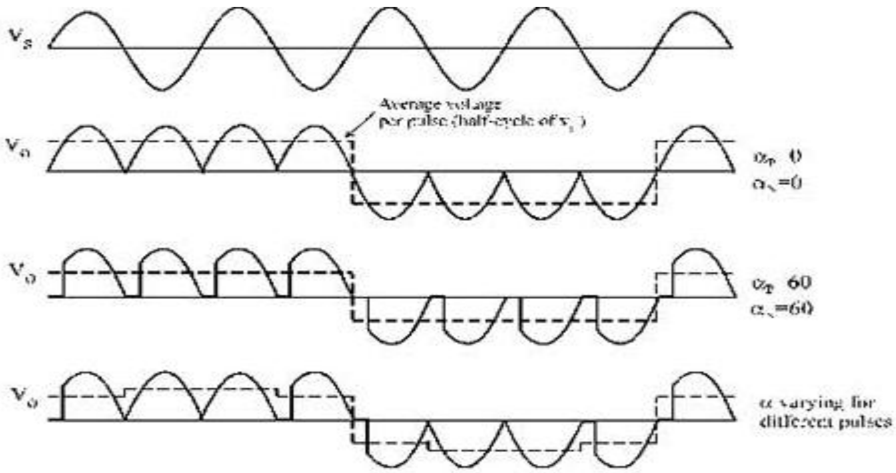

Fig – 9.2Output Wave Forms of Single Phase Cyclo - Converter

9.8 RESULT:

9.9 PRELAB VIVA QUESTIONS:

1. What is meant by Cycloconverter? What are the types of Cycloconverters?
2. Classify Cycloconverters.
3. What is step up Cycloconverter & step down cyclo-converter?
4. Differentiate step-down cycloconverter and step-up cycloconverter.
5. Why forced commutation circuit is employed in case of cyclo inverter?
6. Draw the circuit diagram of three phase to single phase bridge configuration of cycloconverter.
7. Draw the circuit diagram of three phase to single phase bridge configuration of cycloconverter.

9.10 POSTLAB VIVA QUESTIONS:

1. What are the Applications of Cycloconverter?
2. What is meant by Positive & negative converter groups in cycloconverter?
3. List the applications of cycloconverter.
4. List the advantages & disadvantages of cycloconverters.
5. What are the factors affecting the harmonics in cycloconverters?
6. Why the output frequency of a cycloconverter is significantly lower than the input frequency?

EXPERIMENT – 10

OPERATION OF MOSFET BASED CHOPPER

10.1 AIM:

To study the operation of chopper with MOSFET

10.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	MOSFET based chopper power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Regulated Power Supply			
5	Variable Rheostat			
7	DC Voltmeter			
8	DC Ammeter			

10.3 CIRCUIT DIAGRAM:

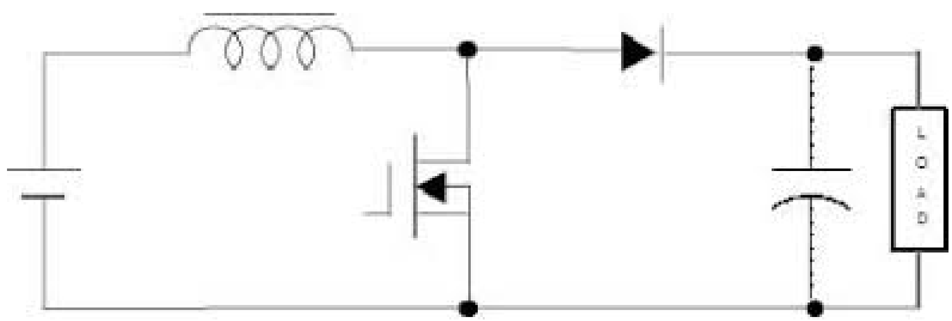

Fig – 10.1 MOSFET Based Chopper

10.4 PROCEDURE:

1. Connections are made as shown in the figure. Use 50Ω Rheostat for R - Load (Freewheeling diode (DM) is to be connected only for RL load).
2. Adjust VRPS output to 10v and connect to DC chopper module.
3. Switch on DC toggle switch of chopper module.
4. Switch on the trigger input by pushing- in pulse switch.
5. Observe the output waveform across load on CRO.
6. Keep the duty cycle at mid position and vary the frequency from minimum to maximum and record the output voltage readings.

7. Keep the frequency at mid position, vary duty cycle from minimum to maximum and output voltage readings.
8. Note down the output wave form for mid value of frequency and duty cycle.

10.5 TABULAR COLUMN:

Constant pulse width and variable frequency:

S. No	Frequency(Hz)	V0(Volts)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Constant Frequency and Variable Pulse width:

S. No	T_{ON}(sec)	T_{OFF}(sec)	Duty Cycle (%)	V_O(Volts)
1				
2				
3				
4				
5				
6				
7				
8				
9				

10.6 MODEL GRAPH:

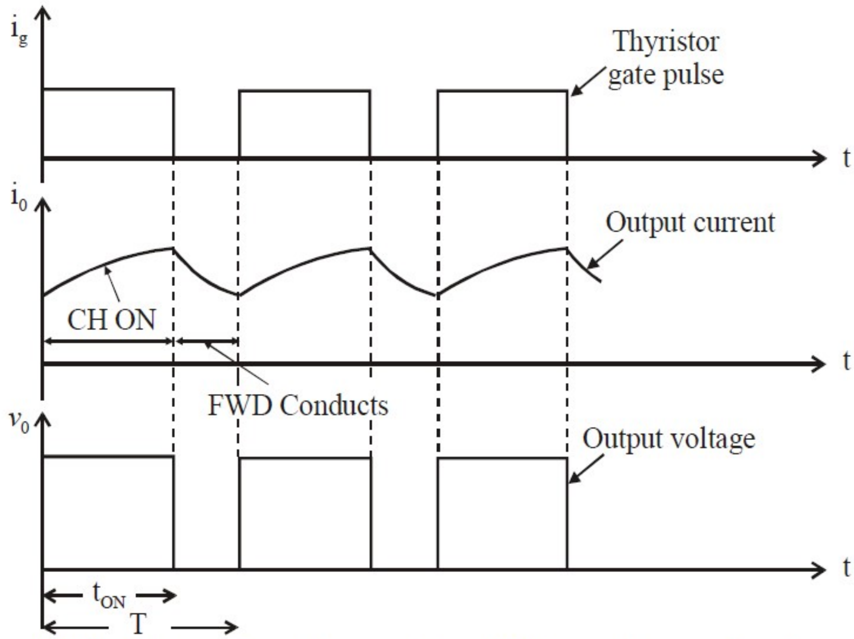

Fig – 10.2 Chopper output waveforms

10.7 RESULT:

10.8 PRE-LAB VIVA QUESTIONS:

1. What are the different control strategies found in choppers?
2. Explain the principle of operation of a chopper?
3. What is the function of chopper?
4. What are the advantages of DC choppers?

10.9 POST LAB VIVA QUESTIONS:

1. How can ripple current be controlled?
2. What is step up chopper?
3. On what does the commutating capacitor value depend on?
4. What are the disadvantages of choppers?

EXPERIMENT – 11

SINGLE PHASE DUAL CONVERTER WITH R AND RL LOADS

11.1 AIM:

To study the operation of single phase dual converter with RL loads.

11.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Single phase dual converter power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Isolation Transformer			
5	Variable Rheostat			
6	Inductor			
7	DC Voltmeter			
8	DC Ammeter			

11.3 CIRCUIT DIAGRAM:

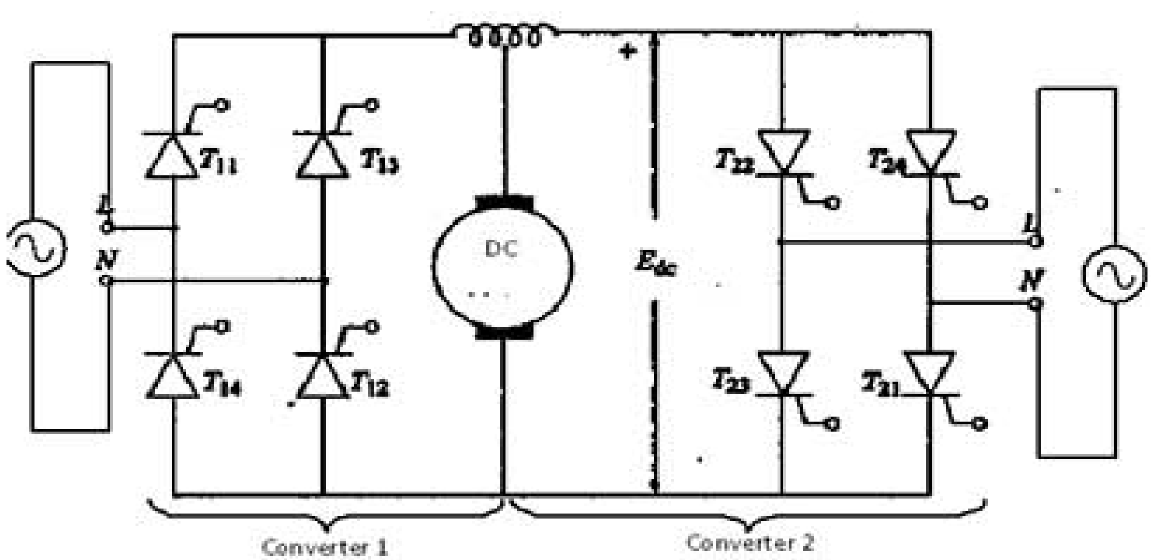

Fig – 11.1 Single Phase Dual Converter

11.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Connect firstly AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Connect CRO probes and observe waveforms in CRO across load and device in single phase dual converter.
6. By varying firing angle gradually up to 180^0 and observe related waveforms.
7. Measure output voltage and current by connecting AC voltmeter & Ammeter.
8. Tabulate all readings for various firing angles.
9. For RL Load connect a large inductance load in series with Resistance and observe all waveforms and readings as same as above.
10. Observe the various waveforms at different points in circuit by varying the Resistive Load and Inductive Load.
11. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

11.5 TABULAR COLUMN:

S. No	Input Voltage (V_{in})	Firing angle in Degrees	Output voltage (V_0)		Output Current (I_0)	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						
6						

11.6 MODEL CALCULATIONS:

$V_0 = (2\sqrt{2}V/\prod) * \text{Cos}\ \alpha$

$I_0 = (2\sqrt{2}V/\prod R) * \text{Cos}\ \alpha$

α = Firing Angle

V = RMS Value across transformer output

11.7 MODEL GRAPH:

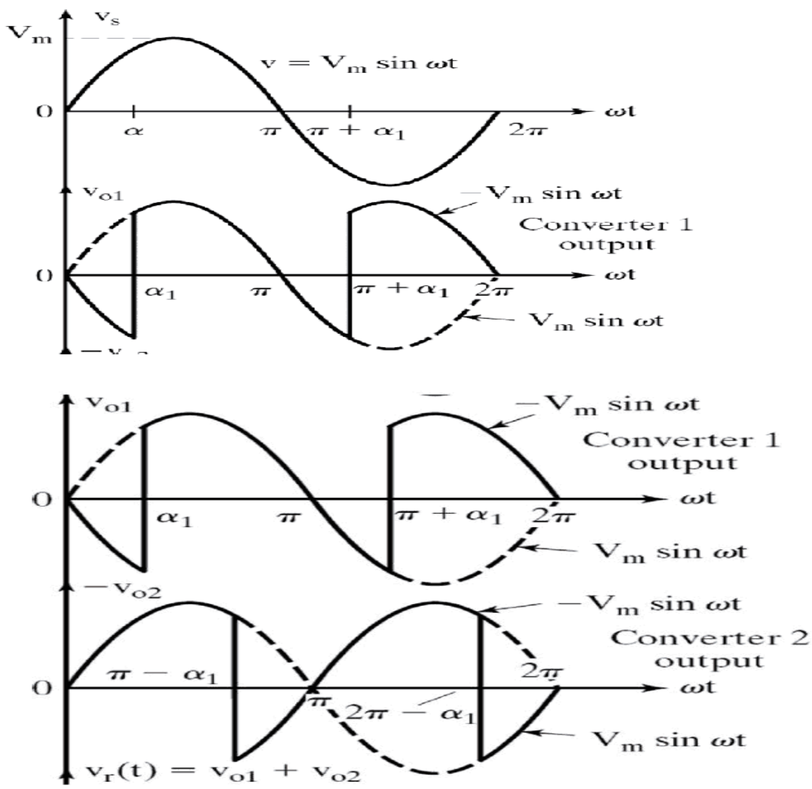

Fig – 11.2 Single Phase Dual Converter output waveforms

11.8 RESULT:

11.9 PRE LAB VIVA QUESTIONS:

1. What is the condition for ideal dual converter operation?
2. What are the four quadrant operations are possible with dual converter drives?
3. What is the purpose of inductor in dual converters?
4. What are the modes of operations for a dual converter?

11.10 POST LAB VIVA QUESTIONS:

1. What are the applications of dual converters?
2. Which mode of operation is suitable for four quadrant operation of dual converter?

EXPERIMENT – 12

THREE PHASE HALF CONTROLLED BRIDGE CONVERTER WITH R LOAD

12.1 AIM:

To study the three phase half controlled bridge converter with R load.

12.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Three phase half controlled bridge converter power circuit and firing circuit			
2	CRO with deferential module			
3	Patch chords and probes			
4	Three phase transformer			
5	Rheostat			
6	DC Voltmeter			
7	DC Ammeter			

12.3 CIRCUIT DIAGRAM:

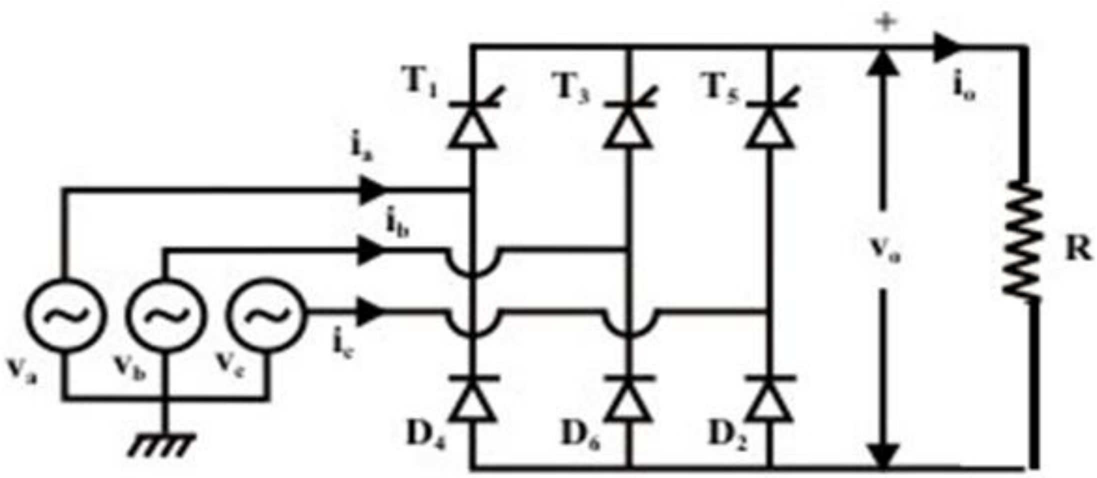

Fig – 12.1Half Controlled bridge converter with R load

12.4 PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Connect firstly 3 phase AC supply from three phase transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.

5. Connect CRO probes and observe waveforms in CRO across load and device in three phase half controlled bridge converter.
6. By varying firing angle gradually up to 180^0 and observe related waveforms.
7. Measure output voltage and current by connecting DC voltmeter & Ammeter.
8. Tabulate all readings for various firing angles.
9. Calculate the output voltage and current by theoretically and compare with it practically obtained values.

12.5 TABULAR COLUMN:

S. No	Input Voltage (V_{in})	Firing Angle in Degrees	Output voltage (V_0)		Output Current (I_0)	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						
6						

12.6 MODEL CALCULATIONS:

$Vo = 3\ Vml*(1+\cos\alpha)/2\pi$
$Io = 3\ Vml*(1+\cos\alpha)/2\pi R$
α= firing angle
Vml = line to line voltage

12.7 MODEL GRAPHS:

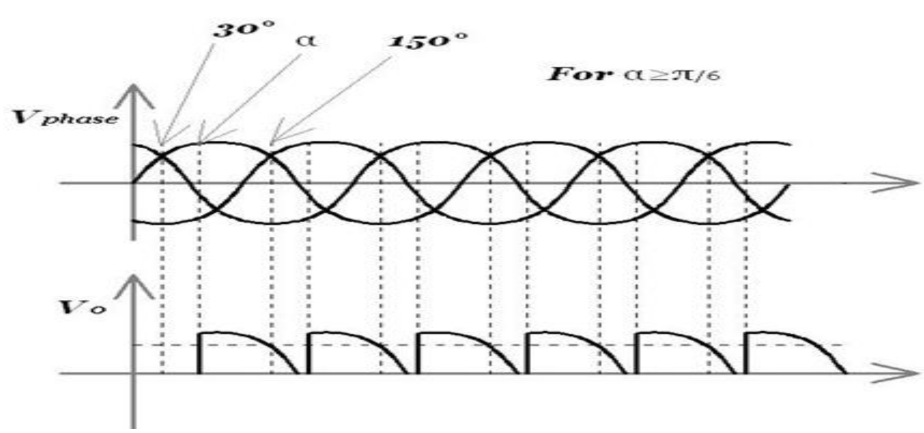

Fig – 12.2 Input and output wave forms of a three phase half controlled bridge converter

12.8 RESULT:

12.9 PRE LAB VIVA QUESTIONS

1. A converter which can operate in both 3 pulse and six pulse modes is?
2. What is the interval for SCRs triggering in three phase semi converter?
3. What is the interval for SCRs triggering in three phase full converter?
4. What is the function of freewheeling diode in three phase converters?

12.10 POST LAB VIVA QUESTIONS

1. What are the advantages of three phase half controlled converters?
2. Which quadrant operation is possible with three phase half controlled converter?

EXPERIMENT - 13

SIMULATION OF THREE PHASE FULL CONVERTER AND PWM INVERTER

13.1 AIM:

Simulation of three phase full converter and PWM inverter with R and RL loads by using MATLAB.

13.2 APPARATUS:

S. No	Equipment	Quantity
1	Desktop With MATLAB	1

13.3 THEORY:

Three phase full converter:

Three phase bridge controlled rectifier consist of upper group (T_1, T_3, T_5) and lower group (T_2,T_4,T_5) of thyristors. Thyristor T1 is forward biased ad can be triggered for conduction only when V_A is greater than both V_B and V_C. From figure this condition occurs at w_t=30^0 . Hence T_1 can be triggered only at w_t=30^0.If firing angle is α, then T_1 starts conduction at w_t=30^0 + α and conducts for 120^0 where it get commutated by turning on of next thyristor ie,T_3.Similarly triggering instant for T_3 and T_5 are determined when considering V_B and V_C respectively. For lower group T_4,T_6 and T_2, negative voltages,-V_A,-V_B and -V_C respectively are considered.

Average Value of output voltage is given by

$$V_{avg} = \frac{3\sqrt{3}}{\pi} V_m \cos\alpha$$ where Vm is the maximum value of phase to neutral voltage

Average Value of output current is given by

$$I_{avg} = \frac{3\sqrt{3}}{\pi R} V_m \cos\alpha$$ where R is the load resistance

Three Phase PWM Inverter:

Three phase inverter consists of on and off controlled switches such as MOSFET or IGBT. Sine PWM pulses are used to gate the switches. Upper switches are gated with signals obtained by comparing three reference sine waves each are phase shifted with 1200 with a high frequency triangular carrier wave. Thus, switches are ON when amplitude of corresponding reference sine wave is greater than amplitude of triangular carrier wave. Lower switches are gated with a gate signal which is complement of upper switches of same leg.

Rms Value of phase to neutral output voltage is given by

$$V_{ph.rms} = \frac{mV_{dc}}{2\sqrt{2}}$$

Rms Value of line to line output voltage is given by

$$V_{line.rms} = \frac{\sqrt{3}mV_{dc}}{2\sqrt{2}}$$

13.4 CIRCUIT DIAGRAM:

Three phase full converter:

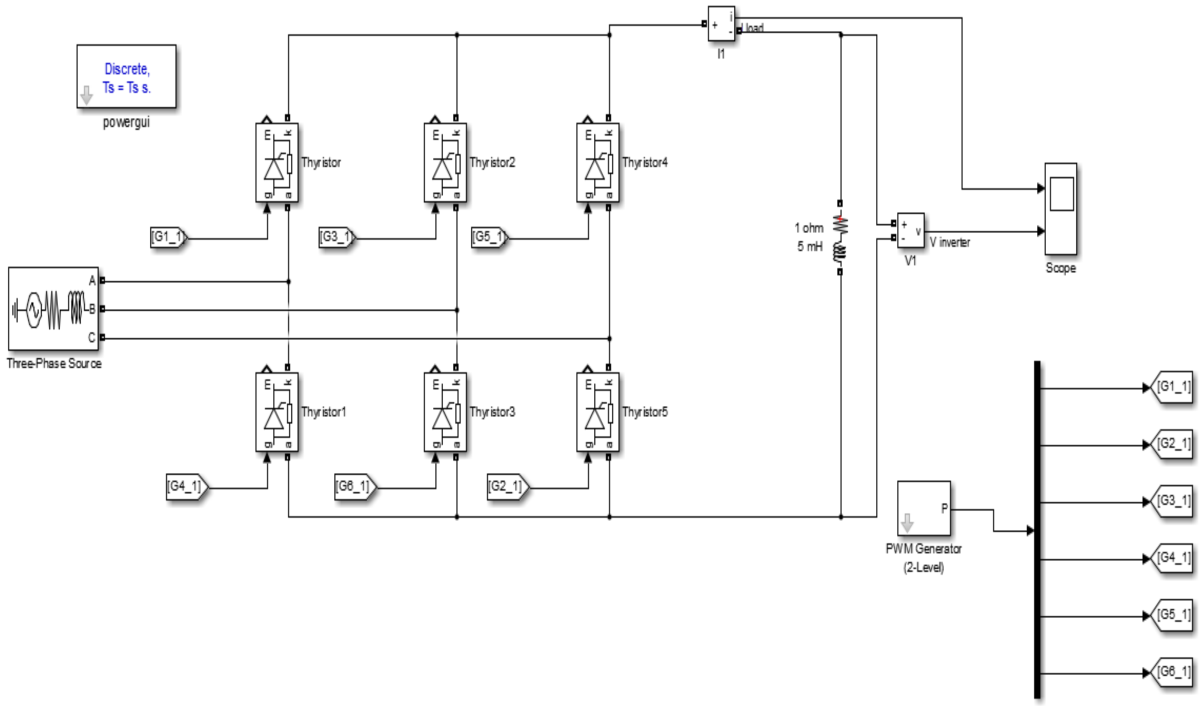

Fig: 13.1 Circuit diagram for three phase full converter

Three Phase PWM Inverter:

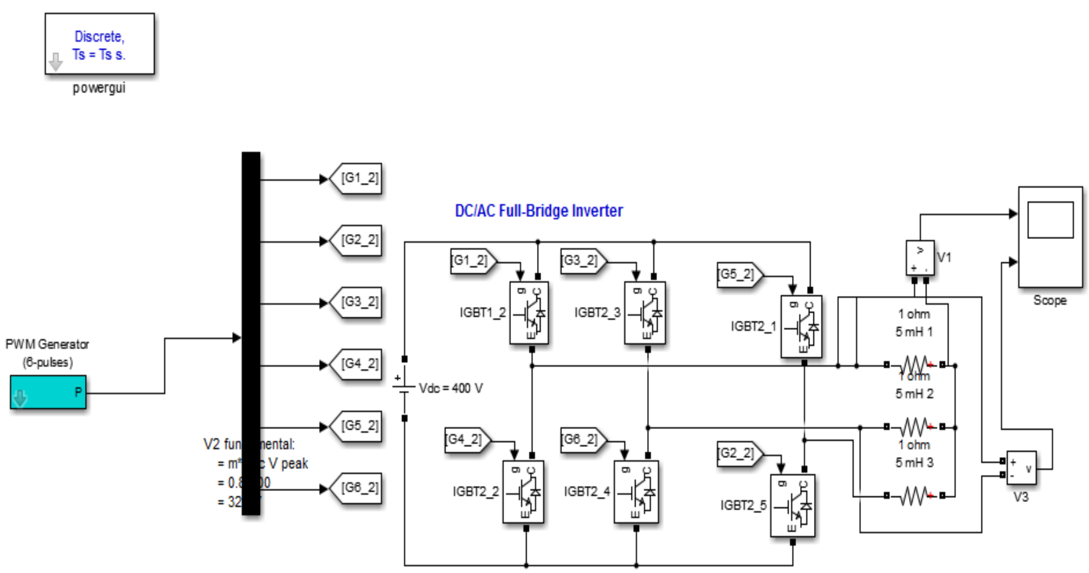

Fig: 13.2 circuit diagram for Three phase PWM Inverter

13.5 PROCEDURE:

1. Make the connections as shown in the figures 13.1 and 13.2 by using MATLAB Simulink.
2. Set the parameters in PWM generator for firing the switches, set the values for load and input voltage.
3. Check the scope wave forms in each circuit.

13.6 EXPECTED GRAPH

Three phase full converter:

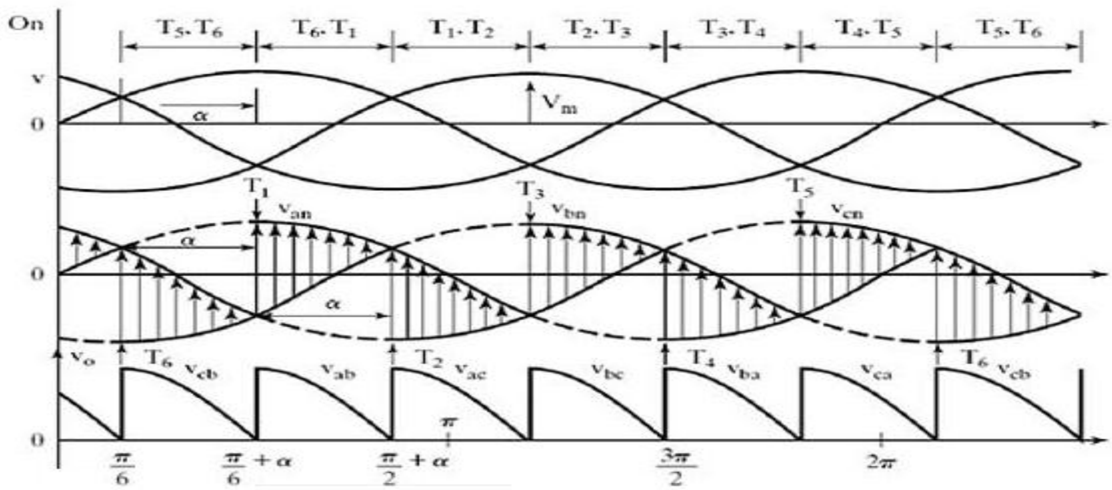

Fig: 13.3 output voltage and current waveforms of Three Phase Full Converter

Three Phase PWM Inverter:

Fig: 13.4 output voltage and current waveforms of Three Phase PWM Inverter

13.7 RESULT:

13.8 PRE-LAB VIVA QUESTIONS:

1. What is PWM?
2. What is Duty cycle?
3. What is three phase converter?
4. What is an inverter?

13.9 POST LAB VIVA QUESTIONS:

1. What are the advantages of PWM inverters?
2. What is the difference between three phase and single phase inverters?
3. What is the time delay for each thyristor conduction in three phase full converter?

EXPERIMENT – 14

SIMULATION OF BUCK – BOOST CHOPPER

14.1 AIM:

Simulation of boost, buck, buck boost converter with R and RL loads by using MATLAB.

14.2 APPARATUS:

S. No	Equipment	Quantity
1	Desktop with MATLAB	1

14.3 THEORY:

Boost Converter:

Figure below shows the circuit diagram of step-up DC-DC converter, commonly known as boost converter. When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. Polarity of the left side of the inductor is positive. When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current towards the load. Thus the polarity will be reversed (means left side of inductor will be negative now). As a result, two sources will be in series causing a higher voltage to charge the capacitor through the diode D.

$$V_o = \frac{1}{(1-D)} V_s$$ Where D is duty cycle and V_S is input voltage

Buck converter:

Figure below shows the circuit diagram of step down DC-DC converter, commonly known as buck converter. When switch S is ON, diode D is reverse biased and voltage across inductor will be Vs-Vo. So inductor current increases and attains peak. When switch S is OFF, diode D is forward biased and voltage across inductor will be -Vo. So, inductor current decreases. Hence inductor with diode ensures an uninterrupted current flow and hence a constant output voltage with capacitor for removing voltage ripples.

Output voltage is given by

$$V_o = DV_s$$ Where D is duty cycle and V_S is input voltage

Buck Boost converter:

Figure below shows the circuit diagram of Buck Boost Converter. When Switch is ON, inductor stored energy. Diode isolates input from the output. Capacitor supplies the load. When the switch is OFF, the inductor stored energy charges the capacitor and supplies the load through the diode. As the inductance polarity is reversed when it transfers power, the output has a reverse polarity compared to the input.

Output voltage is given by

$$V_o = \frac{D}{(1-D)} V_s$$ Where D is duty cycle and V_S is input voltage

14.4 CIRCUIT DIAGRAM:

Buck converter:

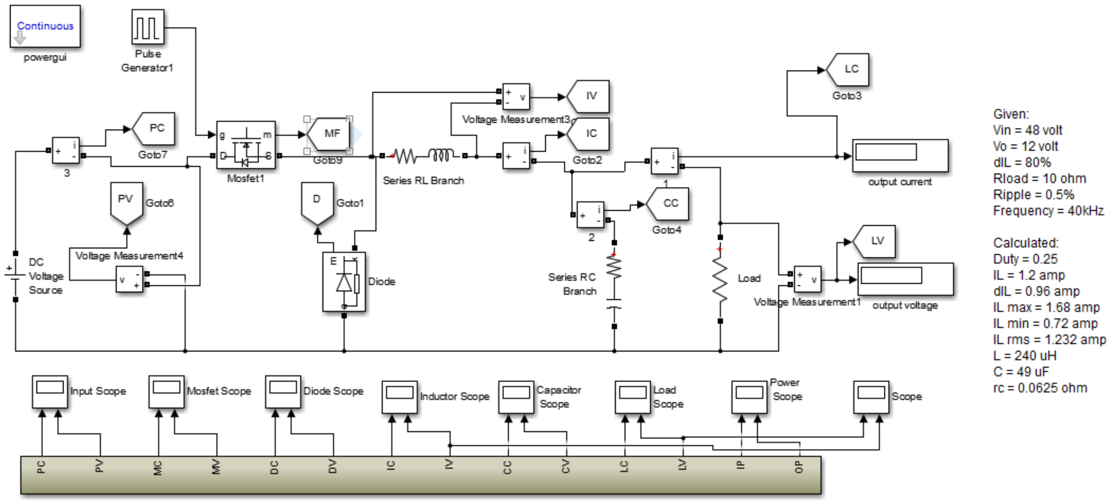

Fig: 14.1 circuit diagram for Buck converter

Boost Converter:

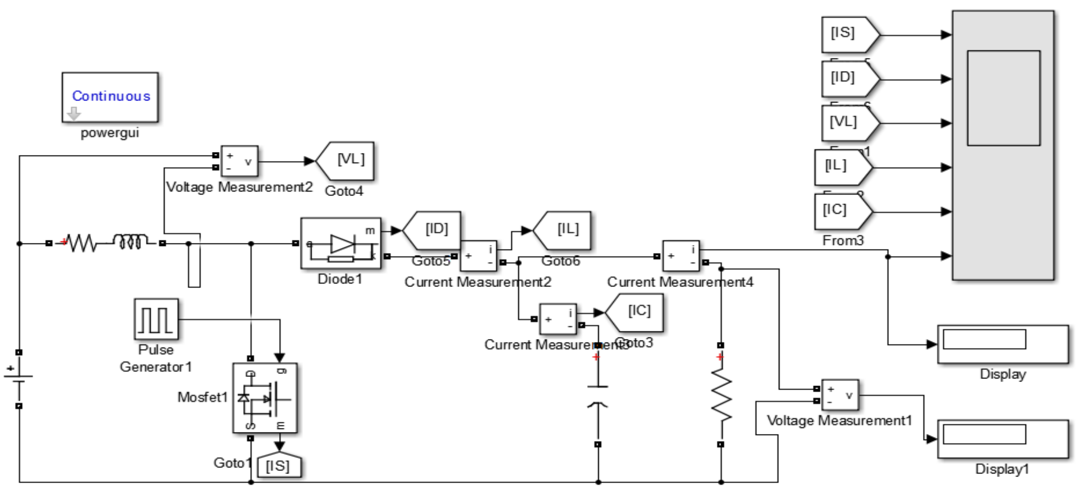

Fig: 14.2 circuit diagram for Boost converter

Buck Boost Converter:

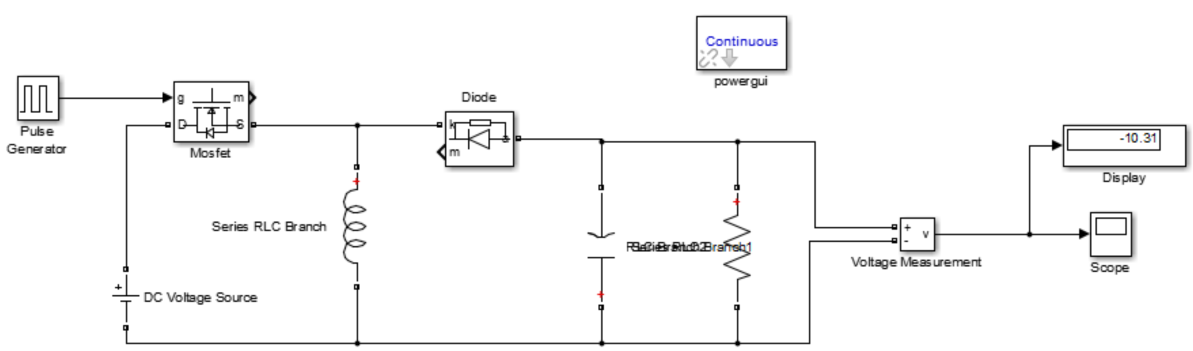

Fig: 14.3 circuit diagram for Buck Boost converter

14.5 PROCEDURE:

1. Make the connections as shown in the figures 13.1 and 13.2 by using MATLAB Simulink.
2. Set the parameters in PWM generator for firing the switches, set the values for load and input voltage.
3. Check the scope wave forms in each circuit.

14.6 EXPECTED GRAPH

Buck converter:

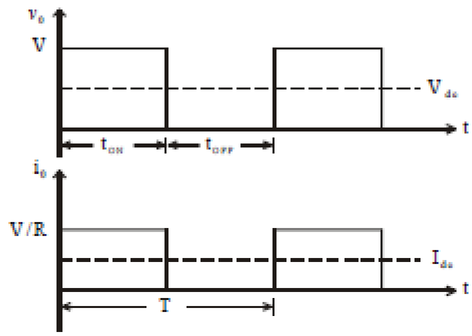

Fig: 14.4 output and input voltage for buck converter

Boost converter:

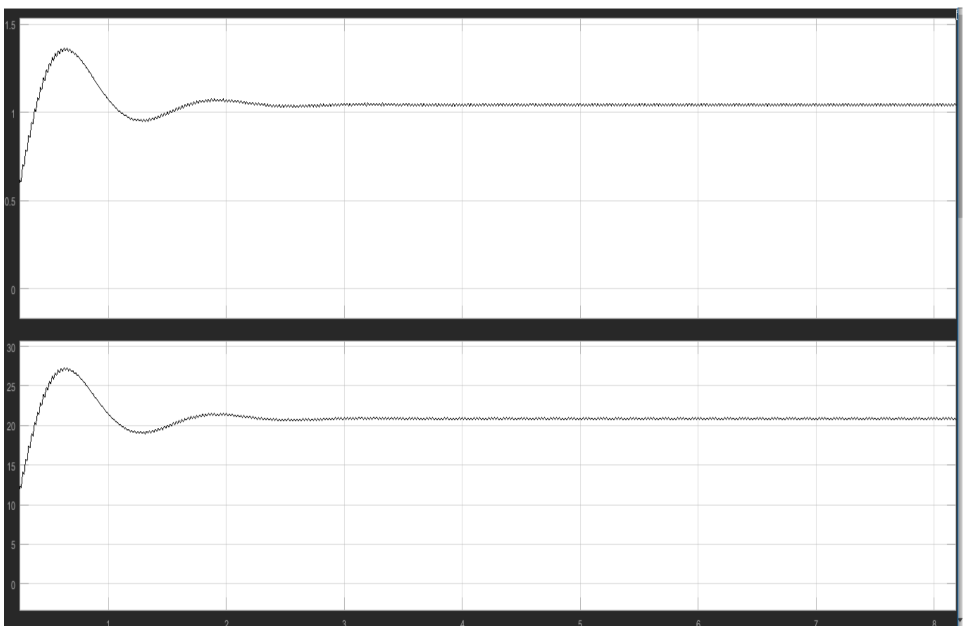

Fig: 14.5 Output voltage and current waveforms for boost converter

Buck boost converter:

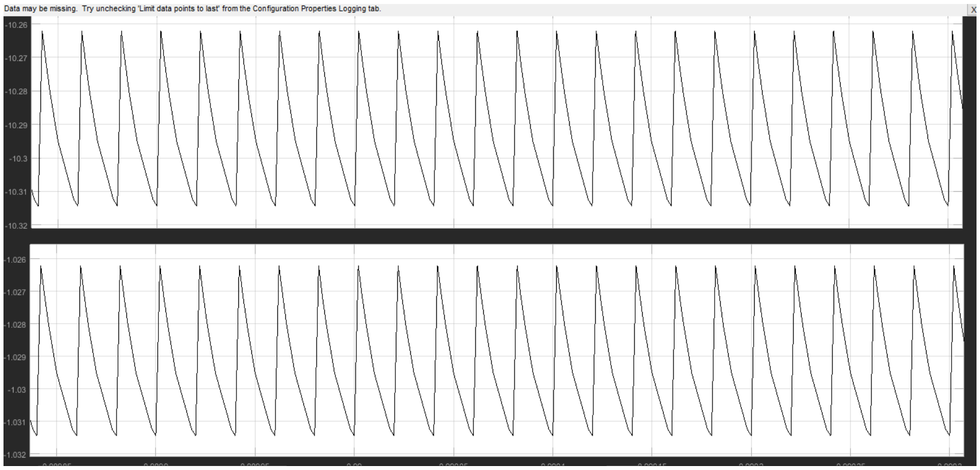

Fig: 14.6 Output voltage and current waveforms for Buck Boost Converter

14.7 RESULT:

14.8 PRE-LAB VIVA QUESTIONS:

1 What is DC-DC step up converter?

2 What is buck converter?

3 What is principle of operation of buck boost converter?

4 What is the function of MOSFET?

14.9 POST LAB VIVA QUESTIONS:

1. Which type of control strategy is best suited for buck and boost converters?
2. What are the disadvantages of choppers?