LABORATORY MANUAL

POWER ELECTRONICS LAB
(EE605PC)

III B. Tech II – SEM (EEE)

Department of Electrical & Electronics Engineering
MALLA REDDY ENGINEERING COLLEGE & MANAGEMENT SCIENCES
(Approved by the AICTE, New Delhi and affiliated to JNTU, Hyderabad)
Kistapur Hamlet of Medchal, Hyderabad, R.R. Dist. - 501 505

MALLAREDDY ENGINEERING COLLEGE AND MANAGEMENT SCIENCES
(Approved by AICTE New Delhi & Affiliated to JNTU Hyderabad)
Kistapur Village, Medchal, Medchal District-501401

Department of Electrical and Electronics Engineering

Vision of the Institute:

The aspiration is to emerge as a premier institution in technical education to produce competent engineers and management professionals contributing to Industry and Society.

Mission of the Institute (MI):

The aspirations are fulfilled and continue to be fulfilled:

MI-1: By providing the student supporting systems:
To impart updated pedagogical techniques with supportive learning environment and state-of-the-art facilities.

MI-2: By training the students as per the industry needs:
To cultivate a culture of interdisciplinary approach, problem solving, innovative ecosystem, and entrepreneurship by facilitating critical thinking, teamwork, and research-driven activities with hands-on learning.

MI-3: By educating the students about society's needs:
To instill ethical, social, and environmental values through community engagement resulting in sustainable development of society.

Vision of the EEE-Department:

The aspiration is to produce competent Electrical and Electronics Engineering Graduates capable of making valuable contributions in the field of Electrical and Electronics Engineering.

Mission of the Department:

MD-1: Student Support Systems:
To equip students with advanced learning skills in Electrical and Electronics Engineering, while providing them with the necessary professional competencies to overcome future challenges.

MD-2:Training the students as per the industry needs:
To facilitate the students to acquire interdisciplinary skills in renewable energy, electric vehicles, and power electronics applications through practical knowledge and innovative techniques to meet evolving global challenges.

MD-3:Educating the students, the needs of society:
To develop professional ethics, self-confidence, and leadership qualities among students.

Program Educational Objectives (PEO'S)

PEO 1: MREM B.Tech EEE graduates shall be able to apply technical knowledge in Electrical and Electronics Engineering, empowering them to pursue higher studies or succeed in their professional careers **in the electrical Power Industry**.

PEO 2: MREM B.Tech EEE graduates shall be able to design and implement complex electrical systems, **meeting the electrical and electronics industry** demands.

PEO 3: MREM B.Tech EEE graduates shall be able to handle societal and environmental problems with ethical values **as demanded by society.**

Program Specific Outcomes (PSOs)

PSO1: Provide efficient problem-solving techniques in the areas of Power Electronics, Power Systems, Control systems, and Electrical Machines using MATLAB/MULTISIM.

PSO2: Design and develop a wide range of Electrical and Electronics Systems, specifically emphasizing Electric Drives, Conventional Renewable Energy, and Automation to demonstrate overall knowledge and contribute to the betterment of society.

PROGRAM OUTCOMES (POs)

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, 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, resources, 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, give and receive clear instructions.

PO11 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.

PO12 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.

MALLA REDDY ENGINEERING COLLEGE AND MANAGEMENT SCIENCES

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

GENERAL LABORATORY INSTRUCTIONS

- Before entering the lab the student should carry the following things
  - Identity card issued by the college
  - Class notes
  - Lab Manual
  - Lab Record
  - Calculator, scales, pencils etc
- Student must sign in and sign out in the register provided when attending the lab session without fail
- Come to the laboratory in time. Students, who are late more than 5 min., will not be allowed to attend the lab.
- Students need to maintain 100% attendance in lab if not a strict action will be taken.
- All students must follow a Dress Code while in the laboratory
- Foods, drinks are NOT allowed.
- All bags must be left at the indicated place.
- The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments, conduct the experiments with interest and an attitude of learning
- You need to come well prepared for the experiment.
- Work quietly and carefully
- Be honest in recording and representing your data.
- If a particular reading appears wrong repeat the measurement carefully, to get a better fit for a graph
- All presentations of data, tables and graphs calculations should be neatly and carefully done
- Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs.
- Do not fiddle with apparatus. Handle instruments with care. Report any breakage to the Instructor. Return all the equipment you have signed out for the purpose of your experiment.

MALLA REDDY ENGINEERING COLLEGE AND MANAGEMENT SCIENCES

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SPECIFIC SAFETY RULES FOR LABORATORY

- NO STUDENT is allowed in to the lab without shoe or apron.
- You must not damage or tamper with the equipment or leads.
- You should inspect laboratory equipment for visible damage before using it. If there is a problem with a piece of equipment, report it to the technician or lecturer. DONOT return equipment to a storage area
- You should not work on circuits where the supply voltage exceeds 40 volts without very specific approval from your lab supervisor. If you need to work on such circuits, you should contact your supervisor for approval and instruction on how to do this safely before commencing the work.
- Never strip insulation from a wire with your teeth or a knife, always use an appropriate wire stripping tool.
- Shield wire with your hands when cutting it with a pliers to prevent bits of wire flying about the bench.

DO 'S

1. Without Prior permission do not enter into the Laboratory.
2. While entering into the LAB students should wear their ID cards.
3. The students should come with proper uniform.
4. Students should sign in the LOGIN REGISTER before entering into the laboratory.
5. Students should come with observation and record note book to the laboratory.
6. Students should maintain silence inside the laboratory.
7. Circuit connections must be checked by the lab-in charge before switching the supply

DONT 'S

1. Students bringing the bags inside the laboratory.
2. Students wearing slippers/shoes insides the laboratory.
3. Students scribbling on the desk and mishandling the chairs.
4. Students using mobile phones inside the laboratory.
5. Students making noise inside the laboratory.
6. Students mishandle the devices.
7. Students write anything on the devices

Course Objectives:

- Apply the concepts of power electronic converters for efficient conversion/control of power from source to load.

- Design the power converter with suitable switches meeting a specific load requirement.

After Completion of this course, the student will be able to:

CO. No	Course Outcomes
C301.1	Understand the differences between signal level and power level devices.
C301.2	Illustrate the functioning of firing circuits
C301.3	Analyze controlled rectifier circuits.
C301.4	Analyze the operation of DC-DC choppers.
C301.5	Analyze the operation of voltage source inverters.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C301.1	3	2	1	2	2	-	-	-	-	-	-	2	3	2
C301.2	3	2	3	2	2	-	-	-	-	-	-	2	3	2
C301.3	3	2	3	2	2	-	-	-	-	-	-	2	3	-
C301.4	3	2	3	2	-	-	-	-	-	-	-	2	3	-
C301.5	3	2	3	1	-	-	-	-	-	-	-	2	3	2
Average	**3**	**2**	**2.6**	**1.8**	**2**	-	-	-	-	-	-	**2**	**3**	**2**

1:Slight (low)	2: Moderate (Medium)	3: Substantial (High)	**-** : None

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EXPERIMENT – 1

STUDY OF CHARACTERISTICS OF SCR, MOSFET & IGBT

SCR CHARACTERISTICS

AIM:

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

APPARATUS:

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

CIRCUIT DIAGRAM:

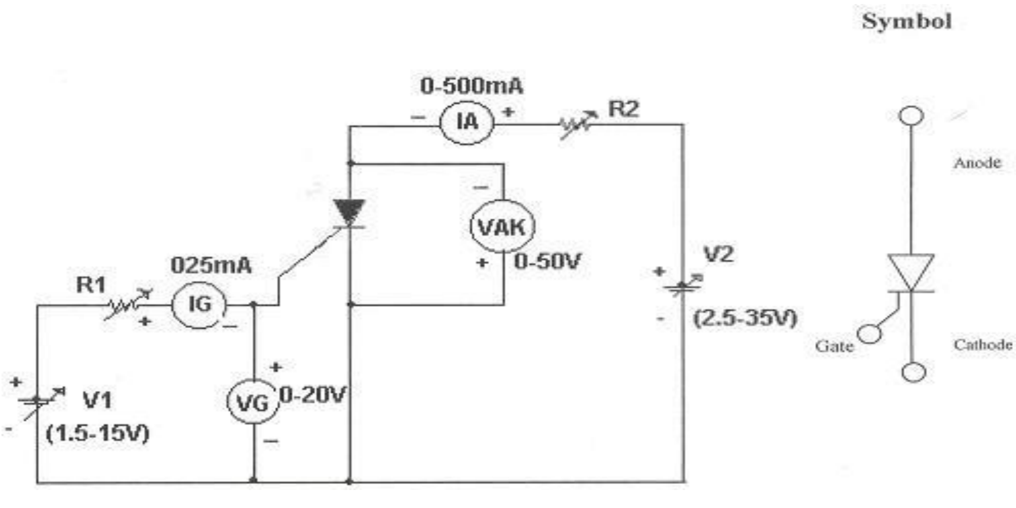


Fig – 1.1Study of Characteristics of SCR

PROCEDURE:

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 constantby varying the V_1 or R_1.
4. Now slowly vary V_2 and observe Anode to Cathode voltage V_{AK} and Anodecurrent 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 $I_H<I_L$.

TABULAR COLUMN:

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

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		

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

MODEL GRAPH:

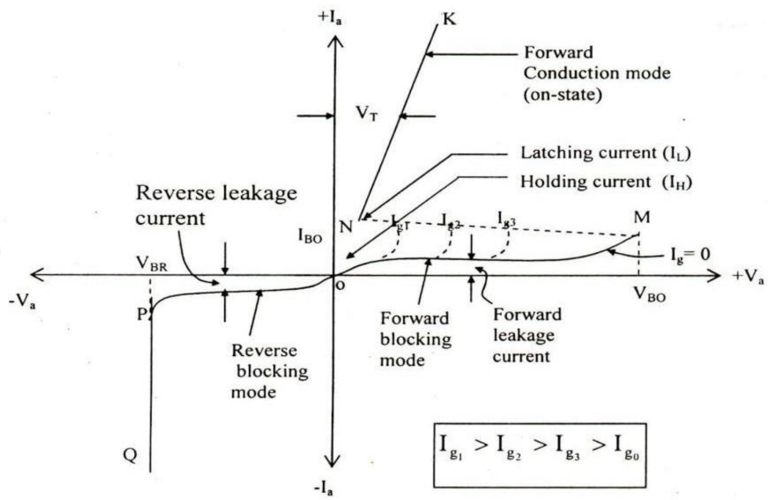


Fig - 1.2 V- I Characteristics of SCR

RESULT:

PRELAB VIVA QUESTIONS:

1. What is a Thyristor? DrawthestructureofanSCR?
2. Whatarethedifferent methods of turningonan 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?

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. List the applications of SCR?

MOSFET CHARACTERISTICS

AIM: To study the output and transfer characteristics of MOSFET

APPARATUS:

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

CIRCUIT DIAGRAM:

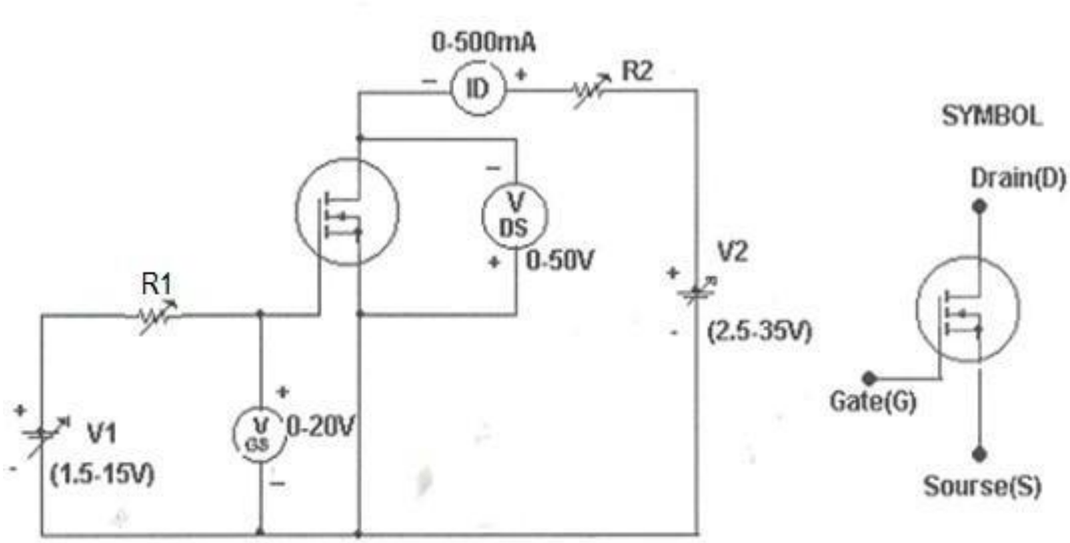


Fig – 1.2.1 Studyof Characteristics of MOSFET

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}.

TABULAR COLUMN:

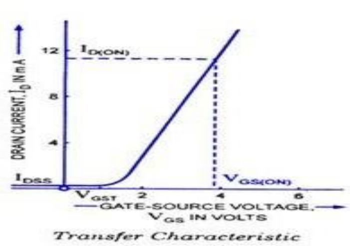
S. No.	V_{GS} = V	
	V_{DS} (Volts)	I_D (Amps)
1		
2		
3		
4		
5		

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		

MODEL GRAPH:



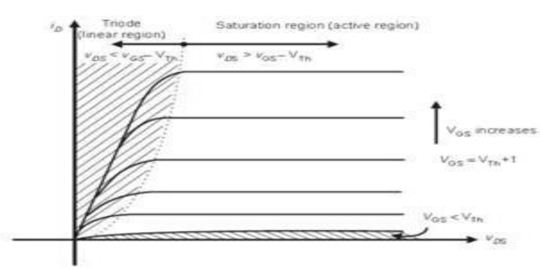


Fig - 1.2.2 Transfer Characteristic of MOSFET

Fig - 1.2.3Output Characteristics of MOSFET

RESULT:

PRELAB VIVA QUESTIONS:

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

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. Define rise time and fall time?
6. In which region does the MOSFET used as a switch?
7. List the advantages of vertical structure of MOSFET
8. List the merits of MOSFET

IGBT CHARACTERISTICS

AIM: To study the output and transfer characteristics of IGBT

APPARATUS:

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

CIRCUIT DIAGRAM:

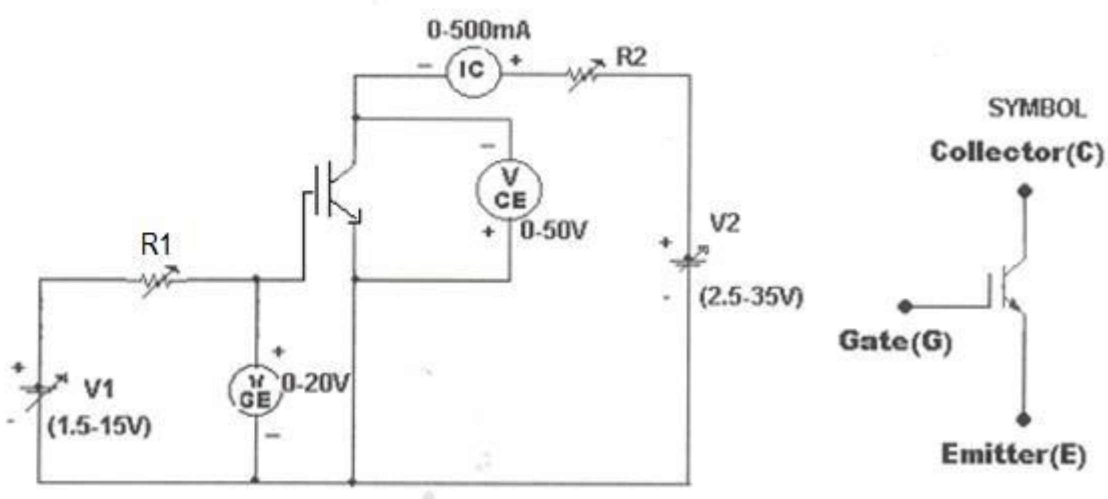


Fig – 1.3.1 Study of Characteristics IGBT

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_C VS V_{GE}.

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		

MODEL GRAPH:

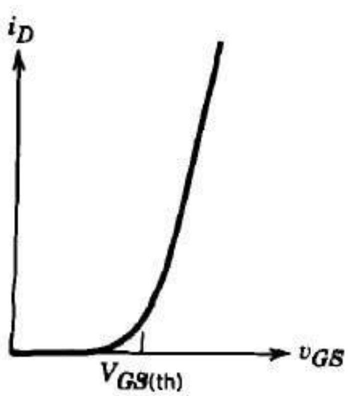


Fig – 1.3.2 Transfer Characteristics of IGBT

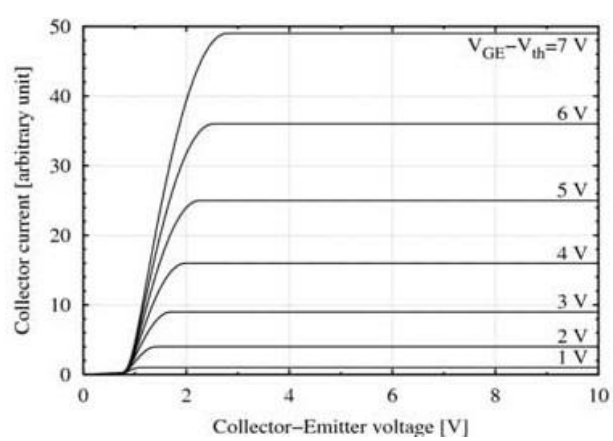


Fig -1.3.3Output Characteristics of IGBT

RESULT:

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 it is low in IGBT?
6. What is second breakdown phenomenon?

POSTLAB VIVA QUESTIONS:

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

EXPERIMENT – 2

GATE FIRING CIRCUITS FOR SCRS

2.1.R-C TRIGGERING

AIM:

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

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		

CIRCUIT DIAGRAM:

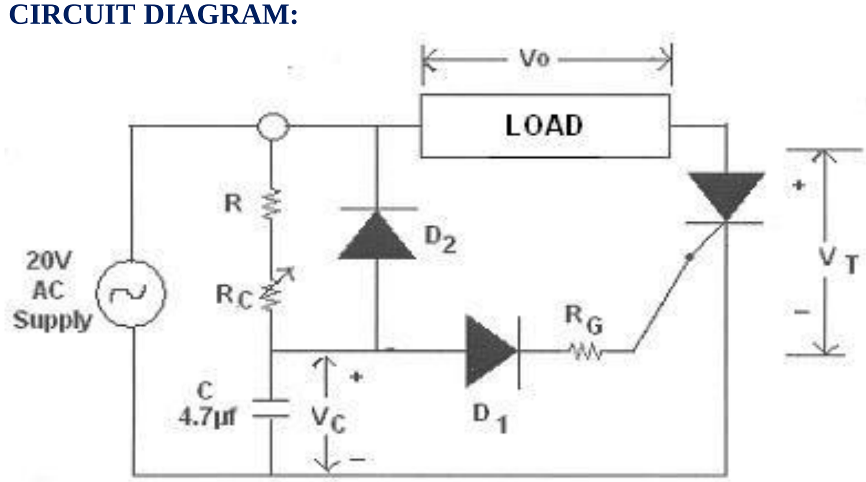


Fig - 2.1.3.1 RC Triggering Circuit

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.

MODEL GRAPH:

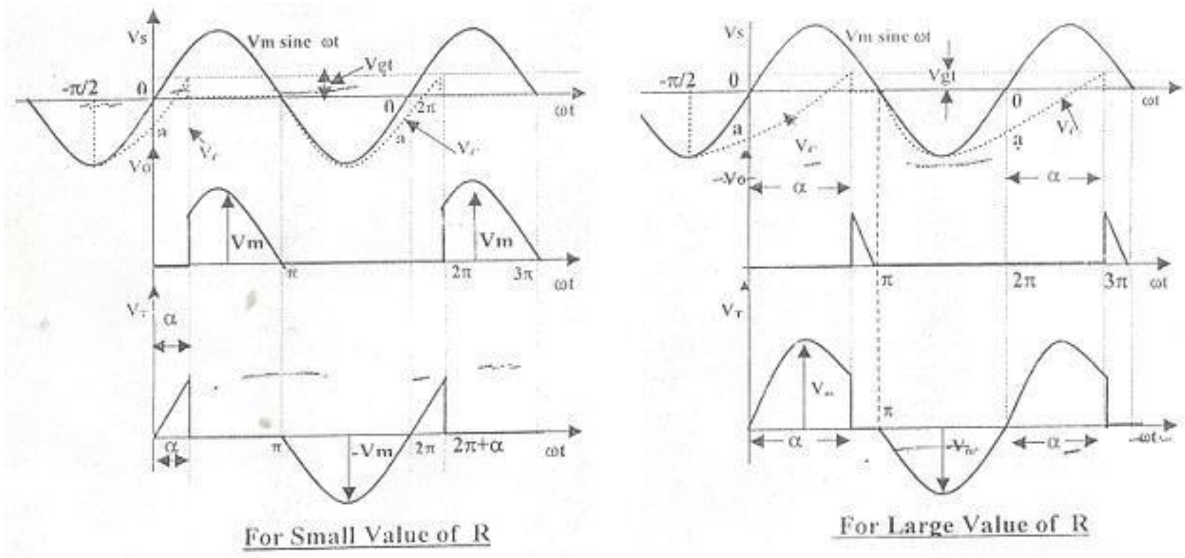


Fig - 2.1.5.2Output Wave forms of RC Traggering

2.1.6.RESULT:

PRELAB VIVA QUESTIONS:

1. List the turn on methods of SCR.
2. Define firing angle.
3. Define extinction angle.

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?

UJT TRIGGERING

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

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		

CIRCUIT DIAGRAM:

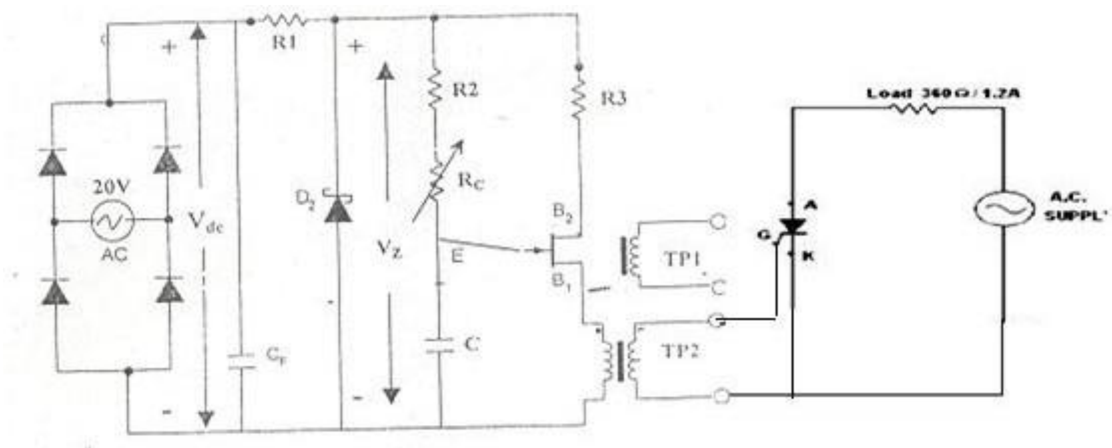


Fig 2.2.3.1 UJT Triggering Circuit

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.

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.

MODEL GRAPH:

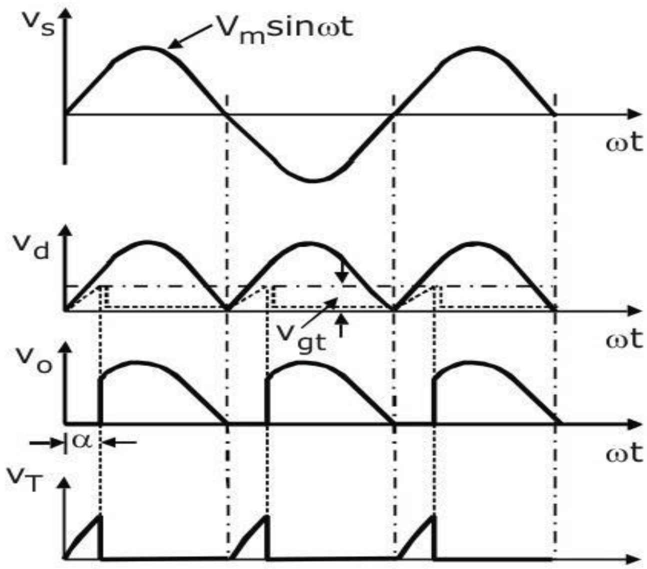


Fig - 2.2.6.2 Output Wave Forms of UJT Triggering

RESULT:

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?

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 A.C. VOLTAGE CONTROLLER

AIM:

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

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			

CIRCUIT DIAGRAM:

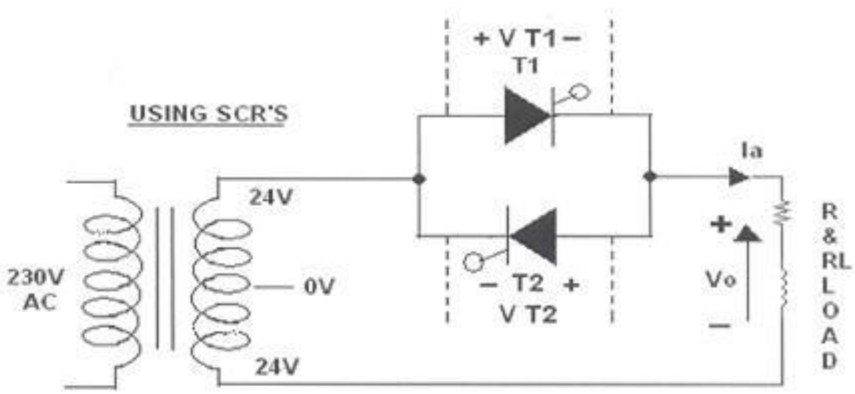


Fig - 8.1 Single Phase AC Voltage Controller with Thyristors

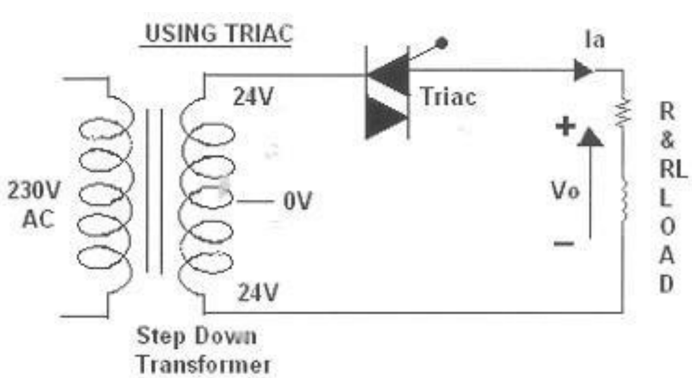


Fig - 8.2 Single Phase AC Voltage Controller with Traic

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.

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						

MODULE CALCULATIONS:

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

α = Firing Angle

V = RMS Value across transformer output

MODEL GRAPH:

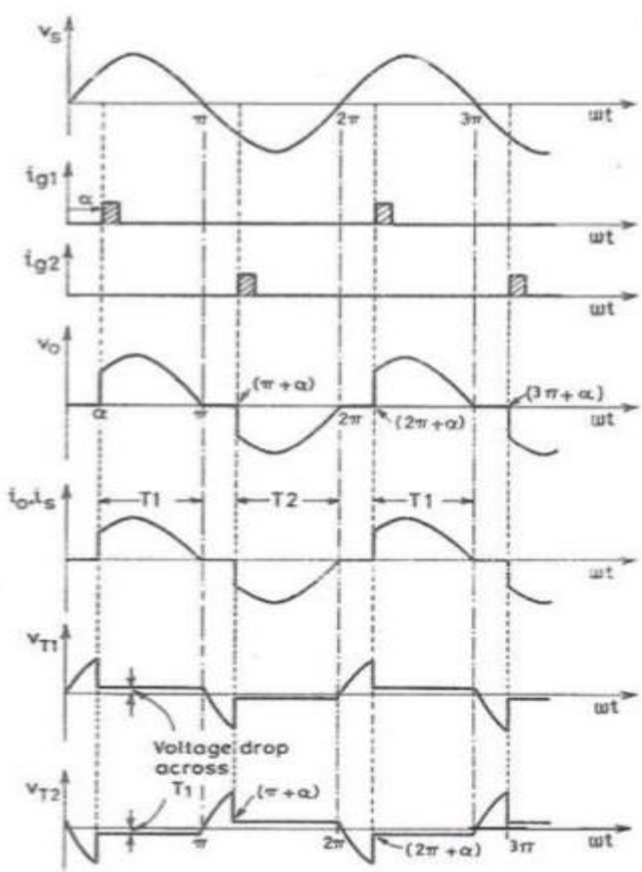


Fig - 8.3Single Phase AC Voltage controller with R-Load

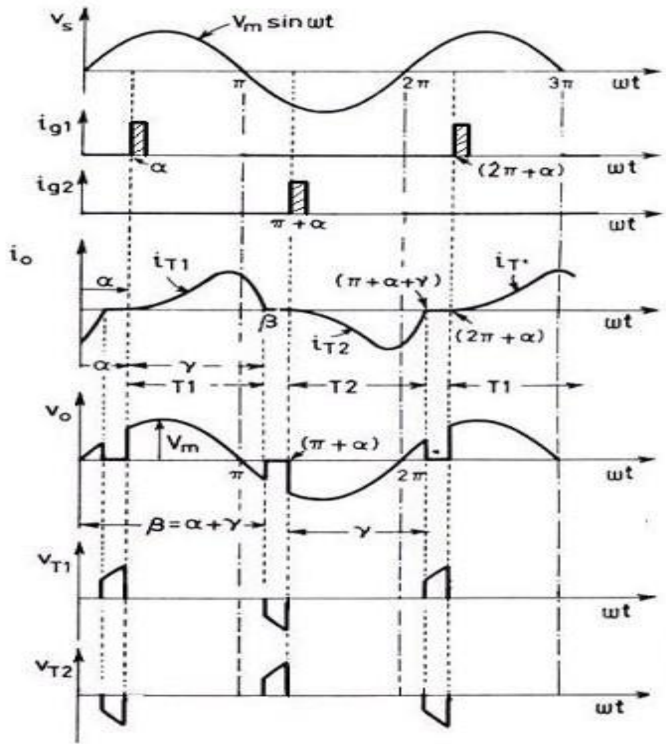


Fig – 8.4 Single Phase AC voltage controller with RL Load

RESULT:

PRE LAB VIVA QUESTIONS:

1. What is the importance of two trigger sources in AC voltage controller?
2. What are the advantages and disadvantages of phase control?
3. What is phase angle control?
4. What are the advantages of bidirectional controllers?
5. What is meant by duty cycle in ON-OFF control method?

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 are the disadvantages of unidirectional controllers?
4. What are the advantages of ON-OFF control?

EXPERIMENT – 3

SINGLE PHASE HALF CONTROLLED& FULLY CONTROLLED BRIDGE CONVERTER

AIM:

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

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			

CIRCUIT DIAGRAM:

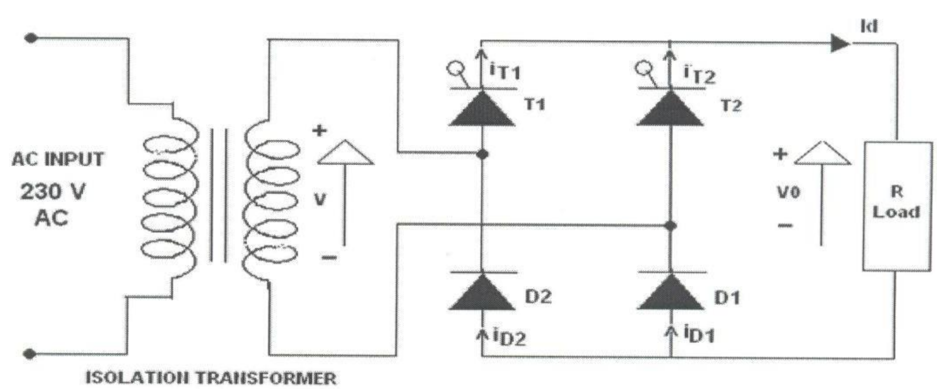


Fig – 3.1 Circuit Diagram of Single Phase Half Controlled Bridge Converter

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.

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						

MODULE CALCULATIONS:

V_0 = (√2V / ∏) * (1+Cos
α) I_0 = (√2V / ∏R) *
(1+Cos α) α = Firing
Angle
V = RMS Value across transformer output

MODEL GRAPH:

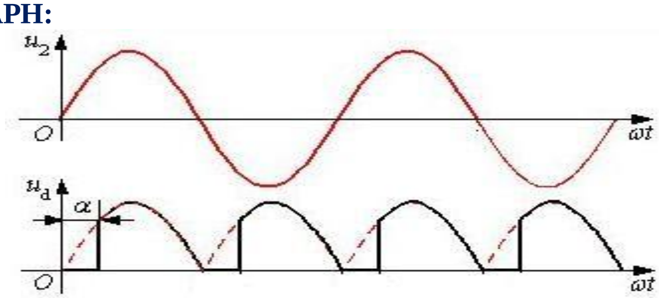


Fig - 3.2 Output Wave Forms of Single Phase Half Controlled Bridge Converter

RESULT:

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?

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?

SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R AND RL LOADS

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

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			

CIRCUIT DIAGRAM:

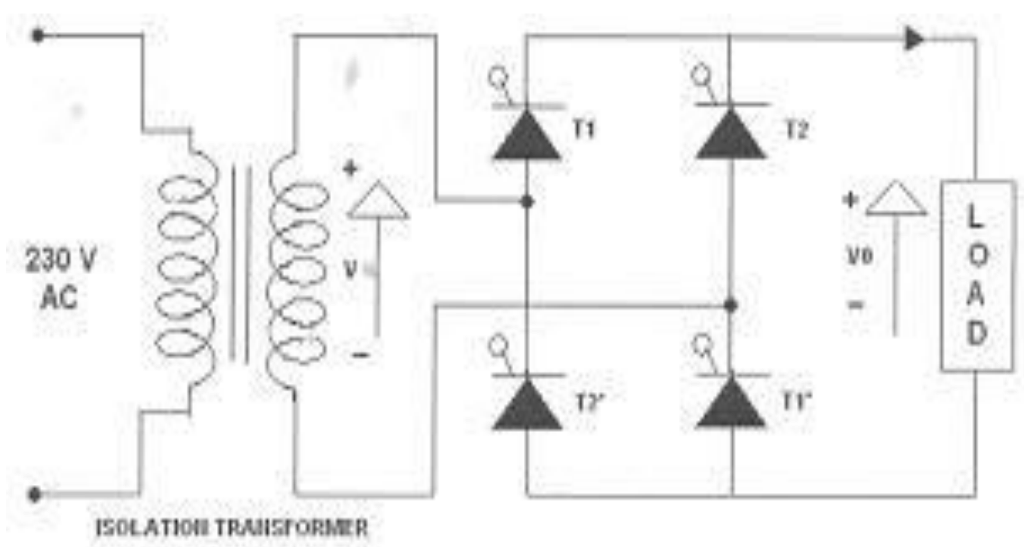


Fig – 5.1Single Phase Fully Controlled Bridge Converter

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.

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						

MODEL CALCULATIONS:

For R-L Load:

V_0 = (2√2V/∏) * Cos α

I_0 = (2√2V/∏R) * Cos α

(1+Cosα) α

V = RMS Value across transformer output

For R Load:

V_0 = (√2V/∏) * (1+Cos α)

I_0 = (√2V /∏R) *

=Firing Angle

MODEL GRAPH:

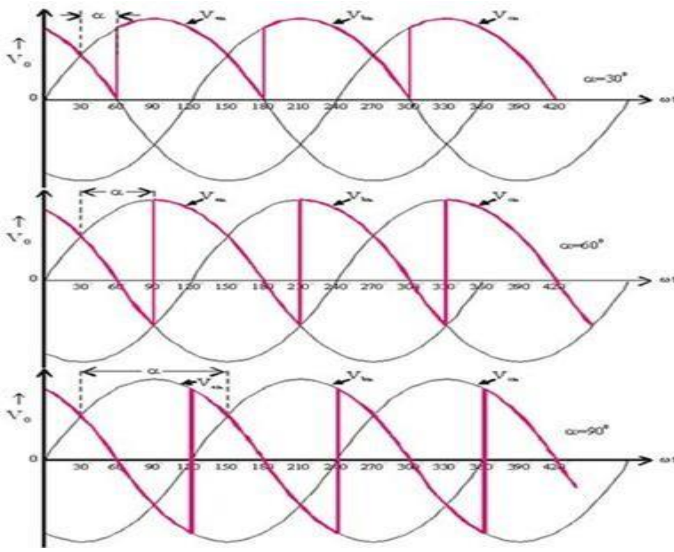


Fig – 5.2 Single Phase Fully Controlled Bridge Converter

RESULT:

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?

POSTLAB VIVA QUESTIONS:

1. What is displacement factor?
2. What is DC output voltage of single phase full wave controller?
3. What are the effects of source inductance on the output voltage of a rectifier?
4. What is commutation angle of a rectifier?
5. What are the advantages of three phase rectifier over a single phase rectifier?

EXPERIMENT – 5

FORCED COMMUTATION CIRCUITS

AIM: **To Construct and study different commutation circuits.**

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			

CIRCUIT DIAGRAM:

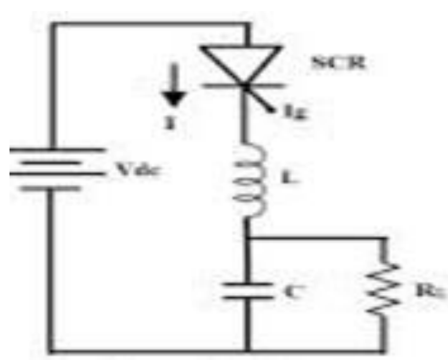


Fig -4.1 Class-A Commutation

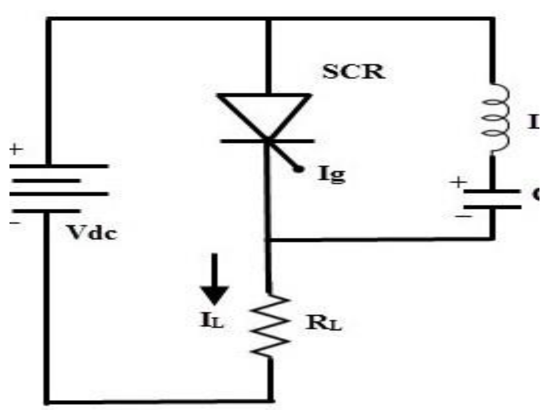


Fig - 4.2 Class - B Commutation

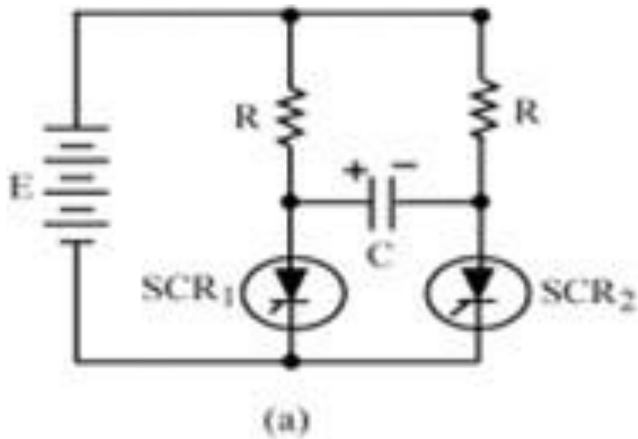


Fig - 4.3 Class- Ccommutation

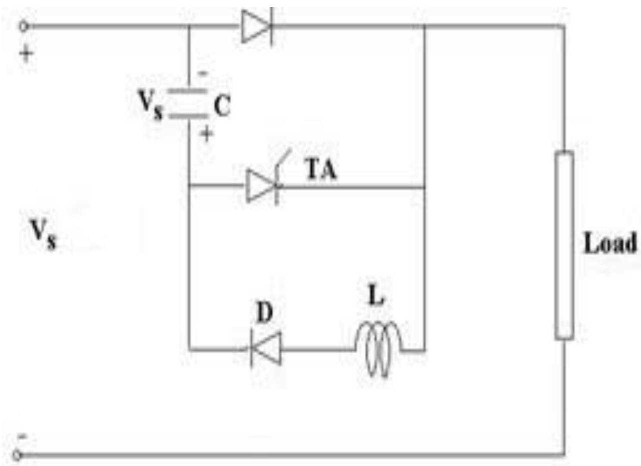


Fig - 4.4 Classes- D Commutation

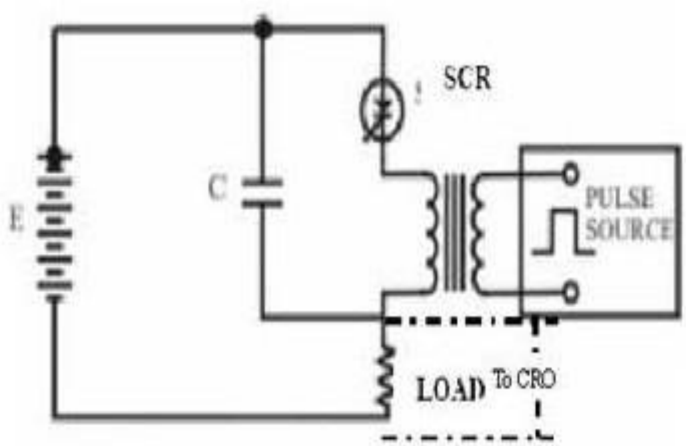


Fig - 4.5 Classes- E Commutation

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.

MODEL GRAPHS:

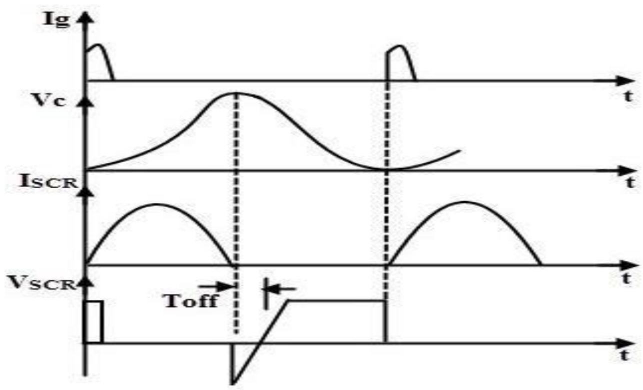


Fig - 4.6 Output Wave Forms of Class - A Commutation

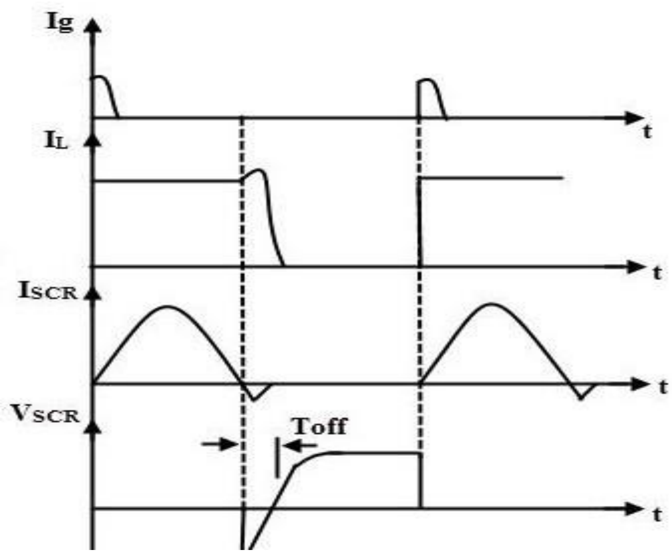


Fig - 4.7 Output Wave Forms of Class - B Commutation

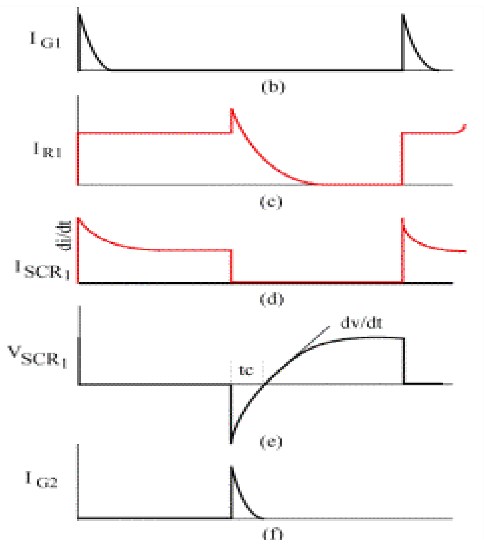


Fig - 4.8 Output Wave Forms of Class - C Commutation

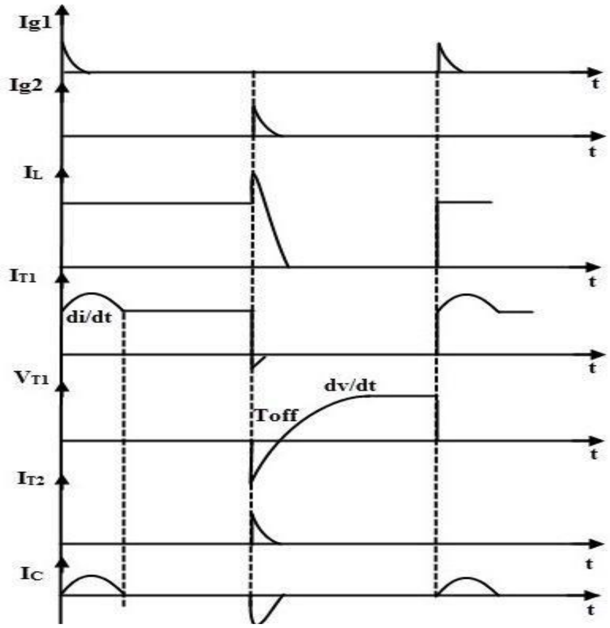


Fig - 4.9 Output Wave Forms of Class - D Commutation

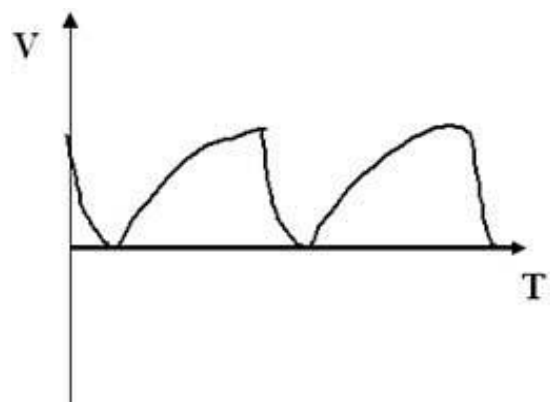


Fig - 4.10 Output Wave Forms of Class - E Commutation

RESULT:

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?

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 – 6

SINGLE PHASE CYCLO-CONVERTER WITH R AND RL LOADS

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

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			

CIRCUIT DIAGRAM :

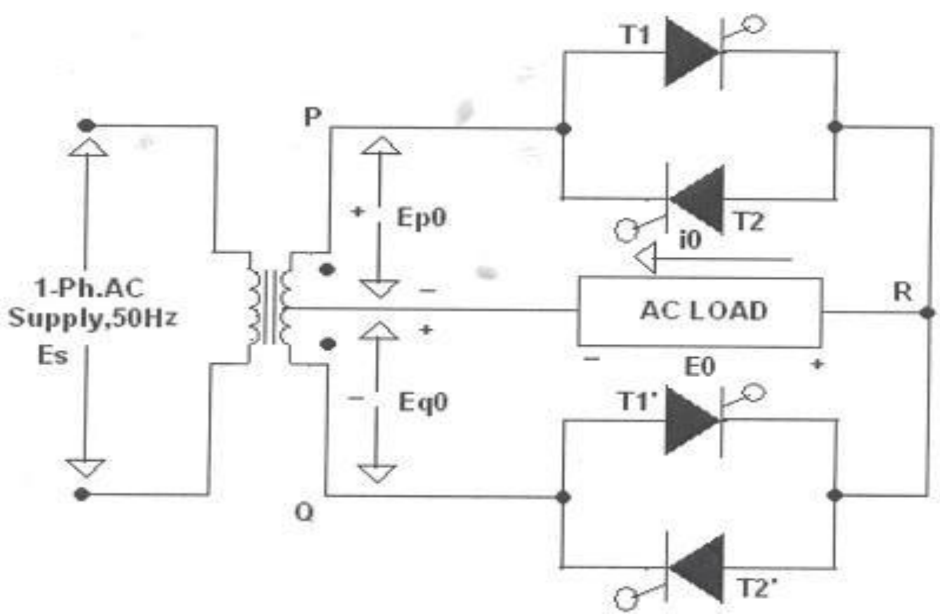


Fig – 10.1 Circuit Diagram of Single Phase Cyclo - Converter

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.

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

MODEL CALCULATIONS:

V_{0r} =

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

θ = Firing Angle

V = RMS Value across transformer output

MODEL GRAPH:

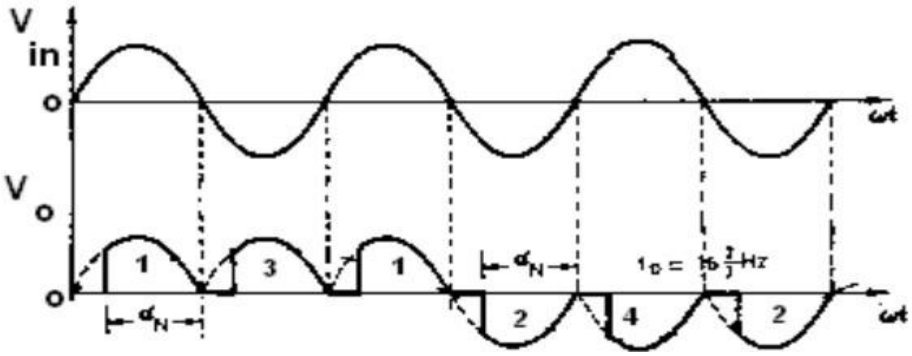


Fig – 10.2 Output Wave Forms of Single Phase Cyclo - Converter

RESULT:

PRELAB VIVA QUESTIONS:

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

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 – 7

SINGLE PHASE SERIES & PARALLEL INVERTER WITH R AND RL LOADS

AIM:To obtain the performance characteristics of a single phase series inverter

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			

CIRCUIT DIAGRAM:

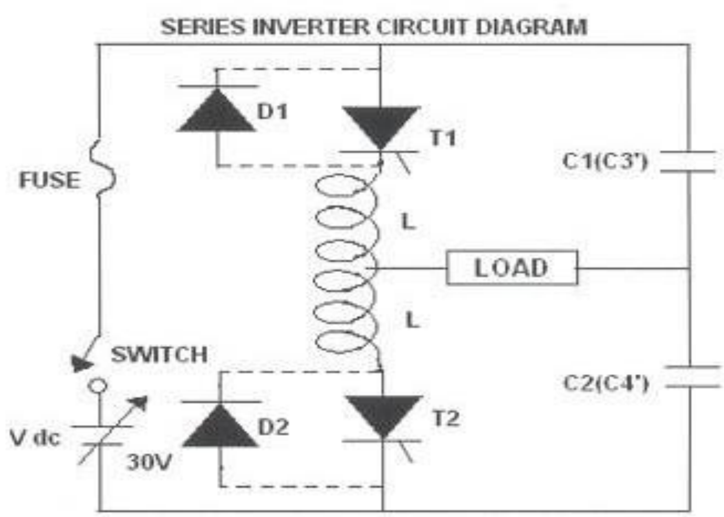


Fig 6. 1Circuit Diagram Single Phase Series Inverter

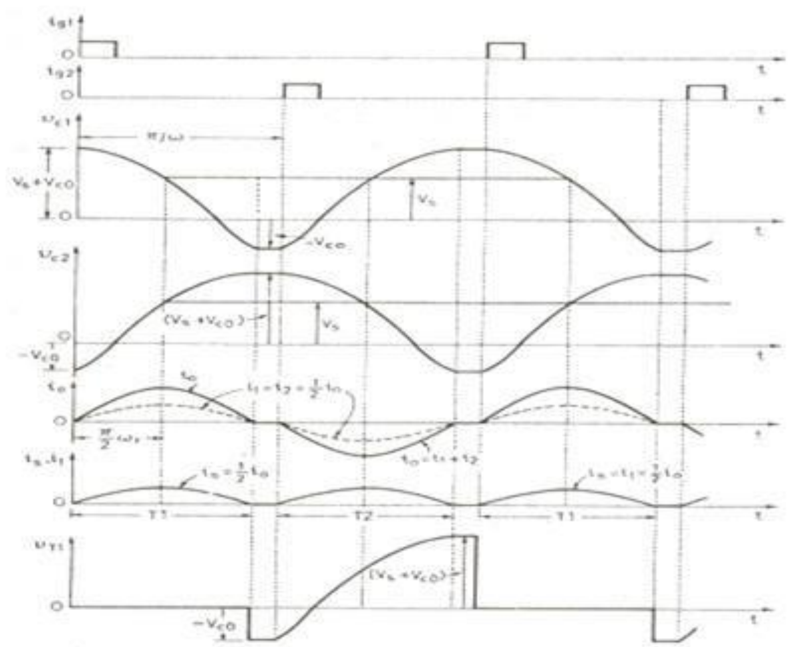
PROCEDURE:

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)

MODEL WAVEFORMS:

FULL WAVE



CONVERTER

Fig 6. 2Output Wave Forms of Single Phase Series Inverter

RESULT:

PRELAB VIVA QUESTIONS:

1. What is the type of commutation for series inverter?
2. What is the configuration of inductor?
3. What is the principle of series inverter?
4. Disadvantages of series inverter.

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?

SINGLE PHASE PARALLEL INVERTER WITH R AND RL LOADS

AIM:To study the parallel inverter.

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		

CIRCUIT DIAGRAM:

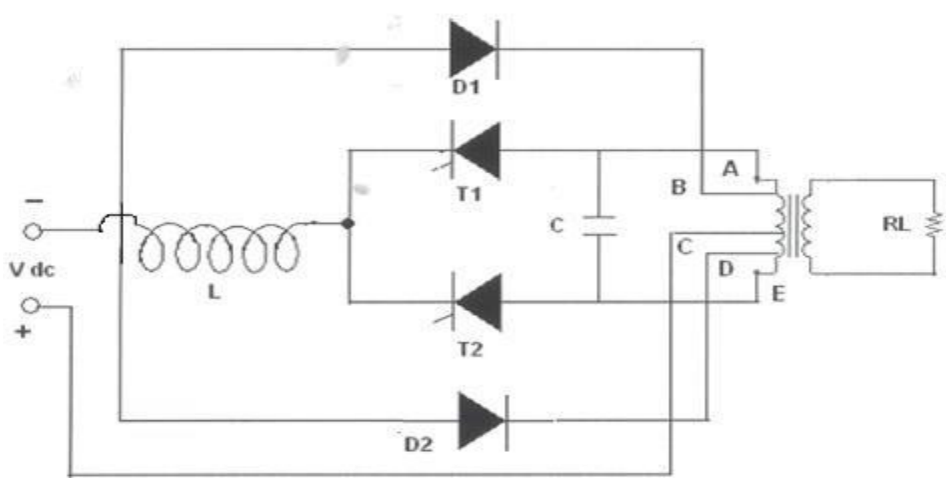


Fig - 7.1Circuit Diagram of Single Phase Parallel Inverter

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)

MODEL GRAPH:

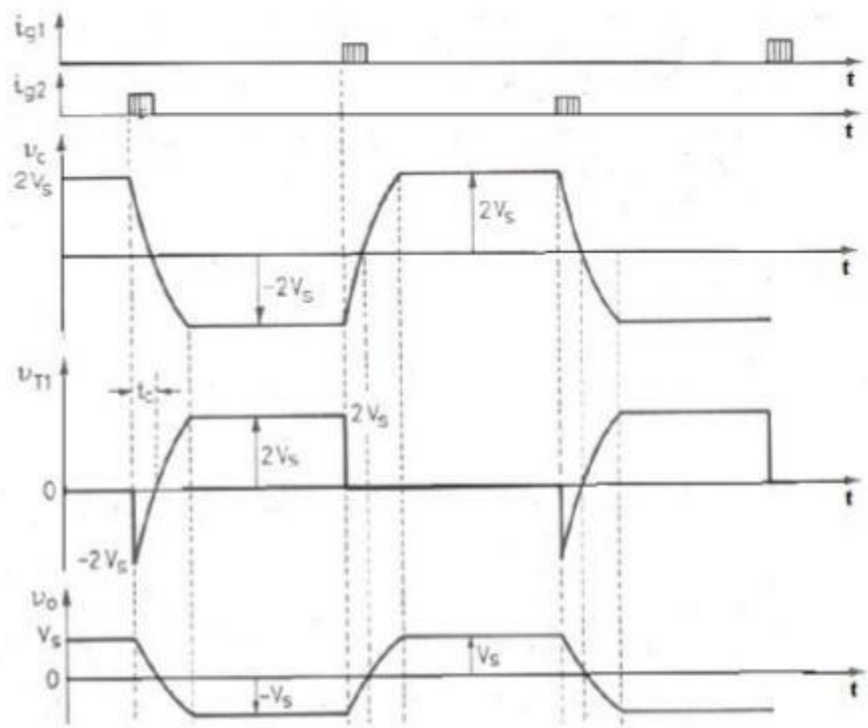


Fig - 7.2Output Wave Forms of Single Phase Parallel Inverter

RESULT:

PRELAB VIVA QUESTIONS:

1. What is the type of commutation for parallel inverter?
2. What is the configuration of capacitor?
3. What is the principle of parallel inverter?
4. Disadvantages of parallel inverter.
5. On what principle parallel inverter works?

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 BRIDGE INVERTER WITH R AND RL LOADS

AIM:To obtain the performance characteristics of a single phase Bridge inverter

APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Bridge 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			

CIRCUIT DIAGRAM:

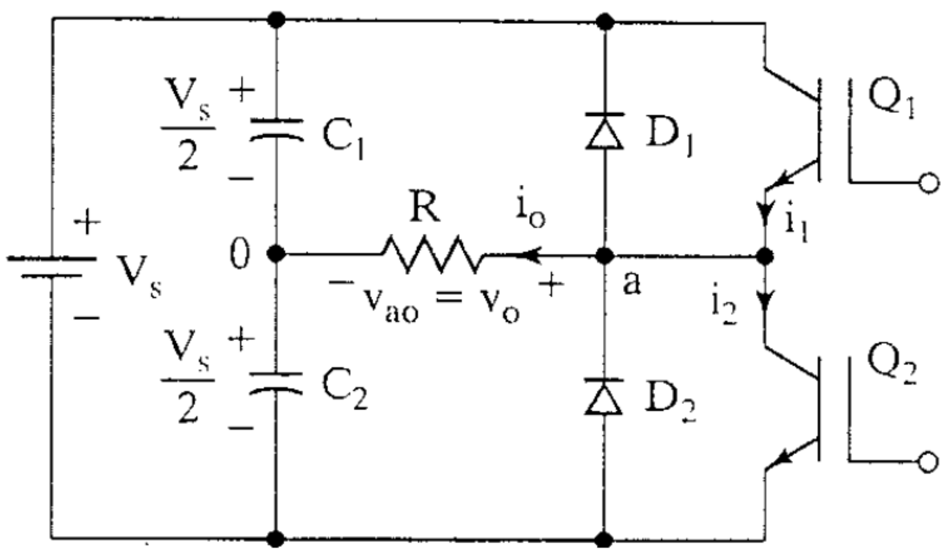


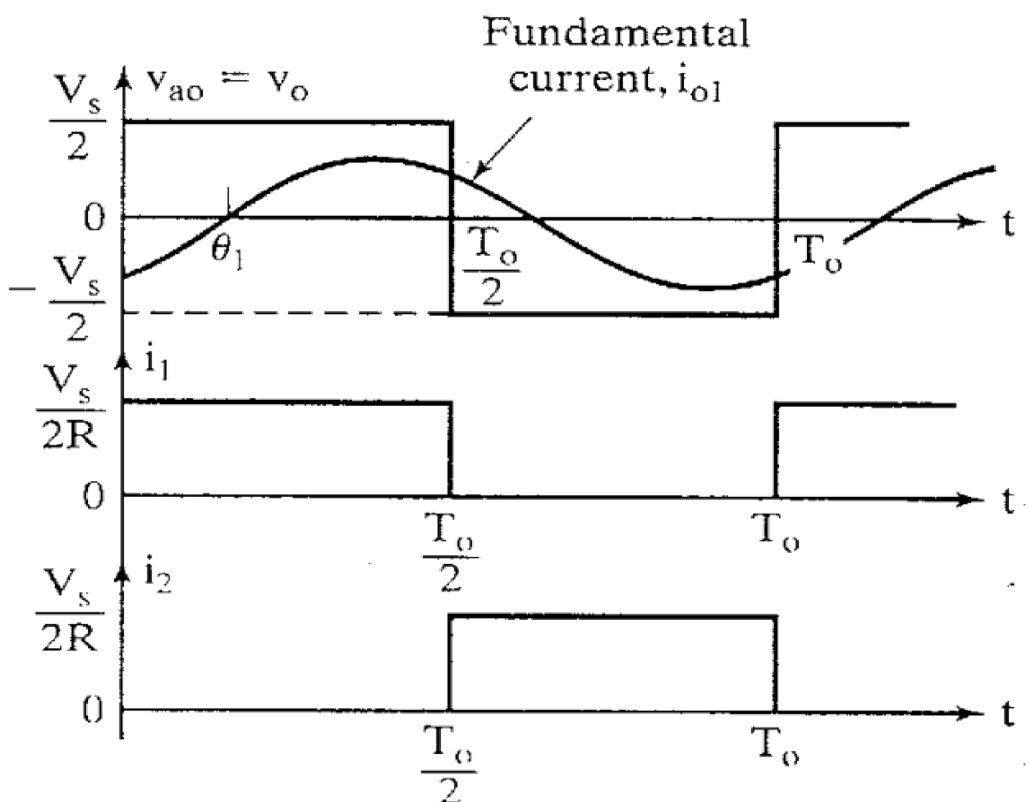
Fig 6. 1Circuit Diagram Single Phase Bridge Inverter

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 resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.

4. By varying the frequency pot, observe related waveforms.
5. 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.
6. Repeat the above same procedure for different value of L,C load and also above the wave forms with and without fly wheel diodes.
7. 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.
8. Switch OFF the DC supply first and then Switch OFF the inverter.(Switch OFF the trigger pulses will lead to short circuit)

MODEL WAVEFORMS:



FULL WAVE CONVERTER

Fig 6. 2Output Wave Forms of Single Phase Bridge Inverter

RESULT:

EXPERIMENT – 9

DC JONE'S CHOPPER

AIM: **To study the characteristics of DC Jone's Chopper.**

APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	DC chopper power module			
2	Triggering circuit (DC chopper)			
3	Rheostat			
4	Digital multimeter			
5	CRO			
6	Patch Cards			

CIRCUIT DIAGRAM:

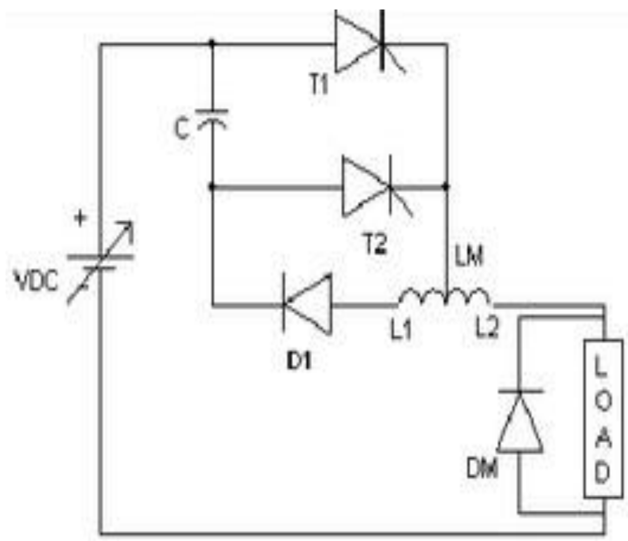


Fig - 6.1 Circuit Diagram of Jones Chopper

T1, T2 – TYN

616 D1 – BYQ

28200

C – Commutation Capacitor 10µF / 100V

L1- 0 –L2 - Commutation Inductor 500-0-500µH / 2A

PROCEDURE:

a) For R – Load:

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 V_{RPS} 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. Note down the output waveform for mid value of frequency and duty cycle.

b) R - L Load:

1. Connections are made as shown in fig. Load is 50Ω Rheostat in series with inductor L =25mH or 50mH.
2. Follow the same procedure as listed in steps 2 to 8 above.3. Readings and output waveform is to be recorded with and without freewheeling diode. [NOTE: In both switching on / switching off of the equipment. First use DC toggle switch and then the pulsar].

TABULAR COLUMN:

Constant Duty Cycle

Duty Cycle: 50%, V_{IN}=10 to 15 V

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

Constant Frequency, Frequency Control

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

MODEL GRAPH:

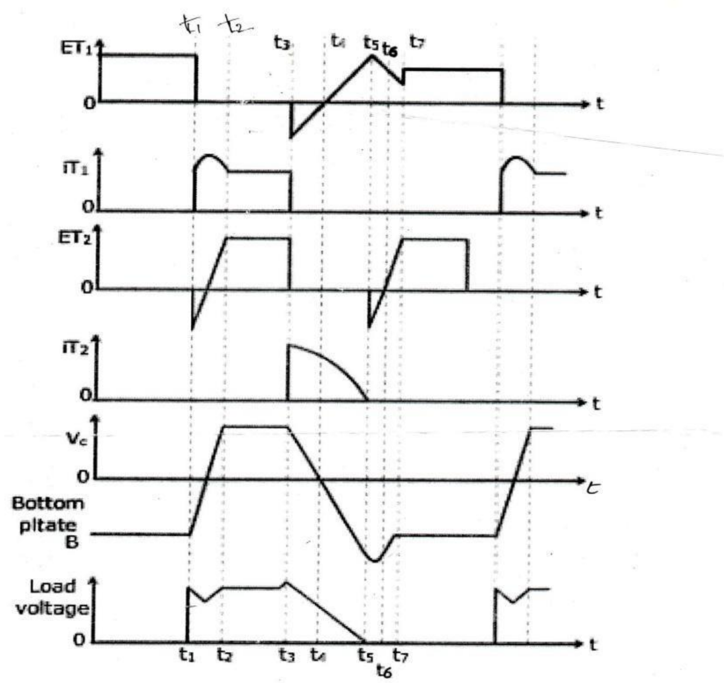


Fig – 6.2 Output Characteristics of DC Jones Chopper

RESULT:

PRE LAB VIVA QUESTIONS:

1. What are choppers?
2. What does a chopper consist of?
3. On what basis choppers are classified in quadrant configurations?

POST LAB VIVA QUESTIONS:

1. Define duty cycle.
2. How can ripple current be controlled?
3. What is step up chopper?
4. On what does the commutating capacitor value depend on?
5. What are the disadvantages of choppers?
6. How do they have high efficiency?
7. What are the applications of dc choppers?

EXPERIMENT – 10

THREE PHASE HALF CONTROLLED BRIDGE CONVERTER WITH R LOAD

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

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			

10.3 CIRCUIT DIAGRAM:

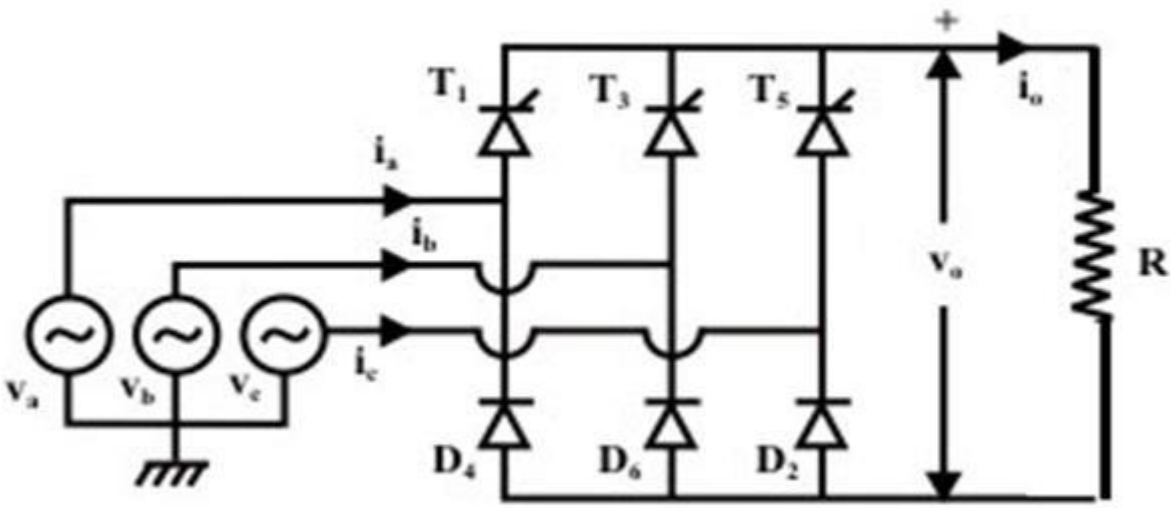


Fig – 11.1Half Controlled bridge converter with R load

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.

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						

MODEL CALCULATIONS:

Vo = 3
Vml*(1+cosα)/2π Io =
3 Vml*(1+cosα)/2πR
α= firing angle
Vml = line to line voltage

MODEL GRAPHS:

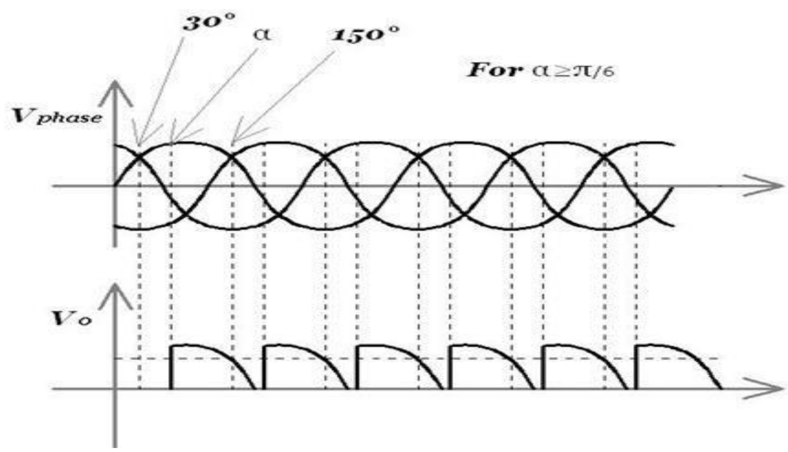


Fig – 11.2 Input and output wave forms of a three phase half controlled bridge converter

RESULT:

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?

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 - 11

SINGLE PHASE DUAL CONVERTER WITH RL LOADS

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

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			

CIRCUIT DIAGRAM:

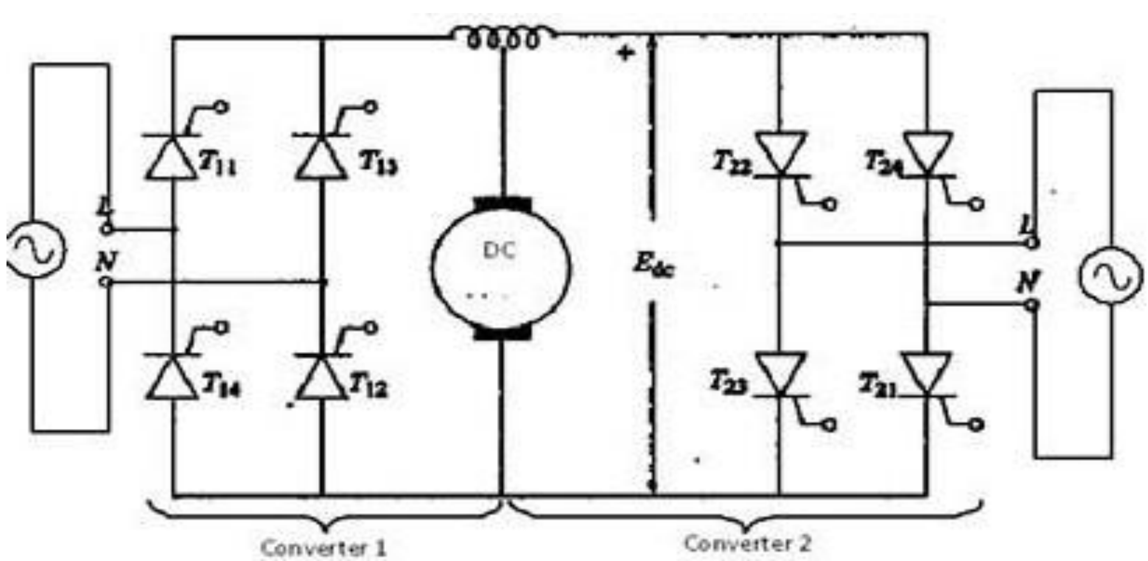


Fig – 9.1 Single Phase Dual Converter

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.

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						

MODEL CALCULATIONS:

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

α I_0 = $(2\sqrt{2}V/\prod R)$ *

Cos α α = Firing Angle

V = RMS Value across transformer output

9.7 MODEL GRAPH:

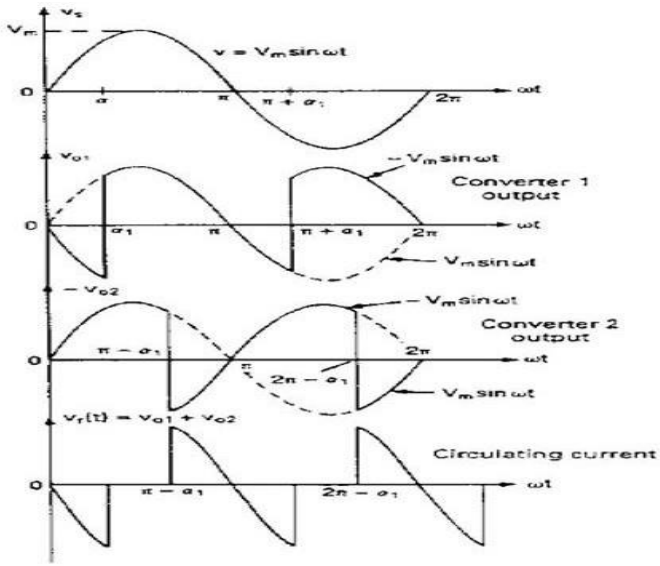


Fig – 9.2 Single Phase Dual Converter output waveforms

RESULT:

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?

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

PSPICE SIMULATION OF SINGLE PHASE FULL WAVE RECTIFIER USING RLE LOADS

AIM: **To obtain the performance characteristics of Single Phase Semi converter for R, RL, RLE Loads Using MATLAB / Simulink**

APPARATUS:

S. No.	Name of the Equipment
1.	PC With Desktop
2.	Matlab / Simulink

CIRCUIT DIAGRAM:

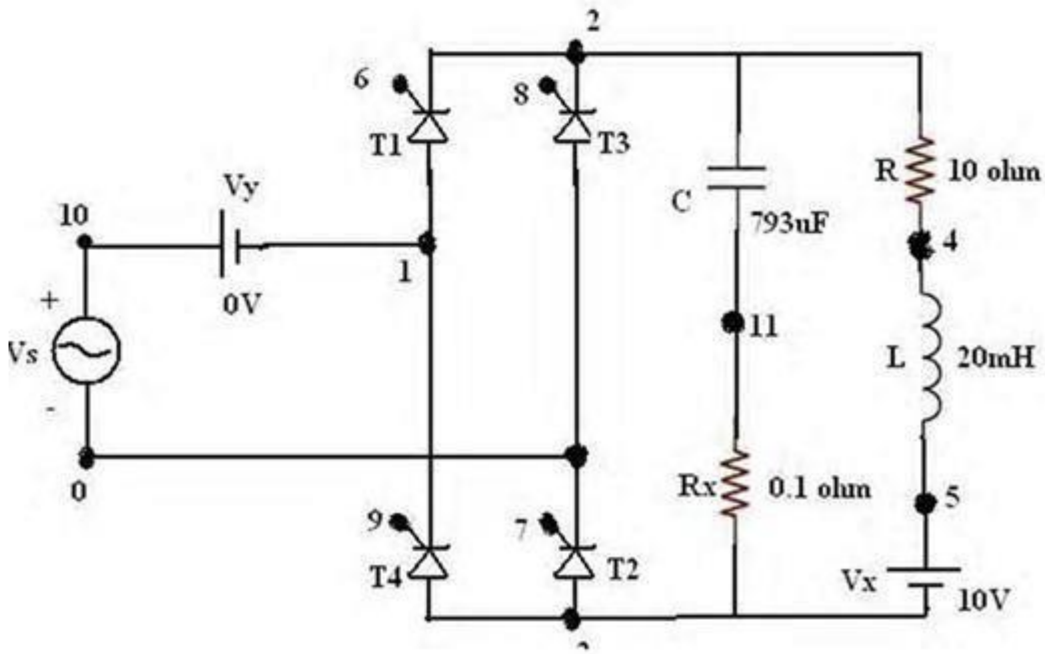


Fig - 15.1 Circuit Diagram of PSPICE Simulation of Single Phase Full Wave Rectifier

PROCEDURE:

1. Represent the nodes for a given circuit.
2. Write spice program by initializing all the circuit parameter as per given flow chart.
3. From desktop of your computer click on "START" menu followed by "programs" and then clicking appropriate program group as "DESIGN LAB EVAL8 followed by "DESIGN MANAGER".
4. Open the run text editor from microsim window & start writing pspice program.

5. Save the program with .cir extension.
6. Open the run spice A / D window from microsim window.
7. Open file menu from run spice A / D window then open saved circuit file.
8. If there are any errors, simulates will be displayed with statement as “simulation error occurred”.
9. To see the errors click on o/p file icon and open examine o / p.
10. To make changes in the program open the circuit file, modify, save & Run the program.
11. If there are no errors, simulation will be completed & it will be displayed with a statement as “simulation completed”.
12. To see the o / p click on o / p file icon & open examine o / p then note down the values.
13. If probe command is used in the program, click on o / p file icon &open run probe. Select variables to plot on graphical window and observe the o / p plots then take print outs of that.

PROGRAM CODE:

```
CLC
VS 10 0 SIN(0 325V 50HZ)
VG1 6 2 PULSE (0V 10V 2500US 1NS 1NS 100US
20000US) VG2 7 0 PULSE (0V 10V 2500US 1NS 1NS
100US 20000US) VG3 8 2 PULSE (0V 10V 12500US 1NS
1NS 100US 20000US) VG4 9 1 PULSE (0V 10V 12500US
1NS 1NS 100US 20000US) R 2 4 10
L 4 5 20MH
VX 5 3 DC 10V
VY 10 1 DC 10V
C 2 11 793UF
RX 11 3 0.1
XT1 1 2 6 2 SCR
XT2 3 0 7 0 SCR
XT3 0 2 8 2 SCR
XT4 3 1 9 1 SCR
.SUBCKT SCR 1 2 3 2
S1 1 5 6 2 SMOD
RG 3 4 50
VX 4 2 DC 0V
VY 5 7 DC 0V
DT 7 2 DMOD
```

```
RT 6 2 1
CT 6 2 10UF
F1 2 6 POLY (2) VX VY 0 50 11
.MODEL SMOD VSWITCH (RON=0.0105 ROFF=10E+5 VON=0.5V VOFF=0V)
.MODEL DMOD D (IS=2.2E-15 BV=1200V TT=0 CJO=0)
.ENDS SCR
.TRAN 50US 100MS 50MS 50US
.PROBE
.OPTIONS ABSTOL=1.00N RELTOL=1.0M VNTOL=0.1 ITL5=20000
.FOUR 50HZ I(VY)
.END
```

Plot v (2)

MODEL WAVEFORMS:

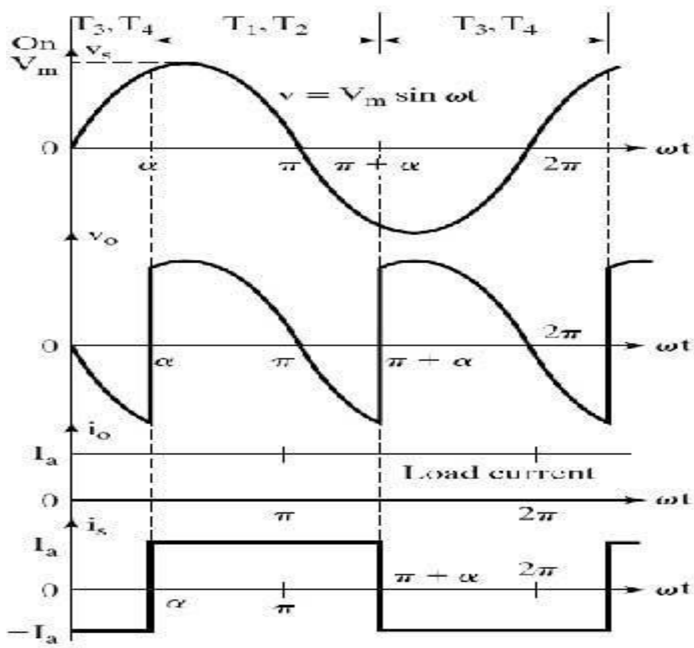


Fig - 15.2 Output Wave Forms of PSPICE Simulation of Single Phase Full Wave Rectifier

RESULT:

PRE LAB VIVA QUESTIONS:

1. If we place freewheeling diode what happens in full controlled converters?
2. What is the output voltage equation of a 3-phase fully controlled bridge converter?
3. What are the parameters effects the frequency of the ripple in the output voltage of 3-phase semi converter?

POST LAB VIVA QUESTIONS:

1. Explain operation of rectifier with RL Load.
2. How to plot rectifier output waveforms?

EXPERIMENT- 13

Single Phase Mc-Murray converter with R and RL loads

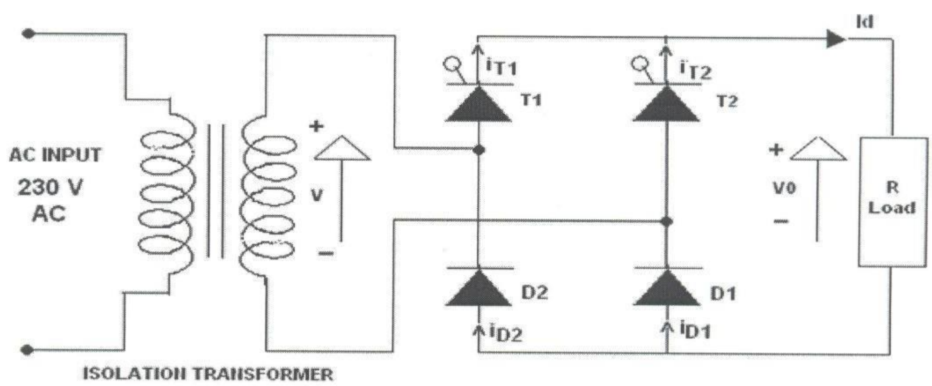
AIM:

To study the Single Phase Mc-Murray converter with R& RL Load.

APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Singlephasebridgeconverterpower circuitand firing circuit			
2	CROwithdeferentialMODEL			
3	Patchchordsandprobes			
4	IsolationTransformer			
5	VariableRheostat			
6	Inductor			
7	DCVoltmeter			
8	DCAmmeter			

CIRCUITDIAGRAM:



SinglePhaseBridgeConverter

PROCEDURE:

1. Makeallconnectionsasperthecircuitdiagram.
2. Connectfirstly30VACsupplyfromIsolationTransformer tocircuit.
3. ConnectfiringpulsesfromfiringcircuittoThyristorsasindicationincircuit.
4. Connect resistiveload200Ω/ 5Atoload terminals and switchONtheMCBandIRS switch and trigger output ON switch.

5. Connect CROprobesandobservewaveformsinCROacross loadanddeviceinsingle phase bridge converter.
6. Byvaryingfiringanglegraduallyup to180^{0}and observerelatedwaveforms.
7. MeasureoutputvoltageandcurrentbyconnectingACvoltmeter&Ammeter.
8. Tabulateallreadingsfor variousfiringangles.
9. For RLLoadconnect alargeinductanceload inseries withResistanceandobserveall waveforms and readings as same as above.
10. ObservethevariouswaveformsatdifferentpointsincircuitbyvaryingtheResistiveLoad and Inductive Load.
11. Calculatetheoutput voltageandcurrent bytheoreticallyandcomparewithit practically obtained values.

TABULARCOLUMN:

S. No	InputVoltage (V_{in})	Firingangle in Degrees	Outputvoltage(V_0)		OutputCurrent(I_0)	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						

MODELCALCULATIONS:

ForR-LLoad:

ForRLoad:

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

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

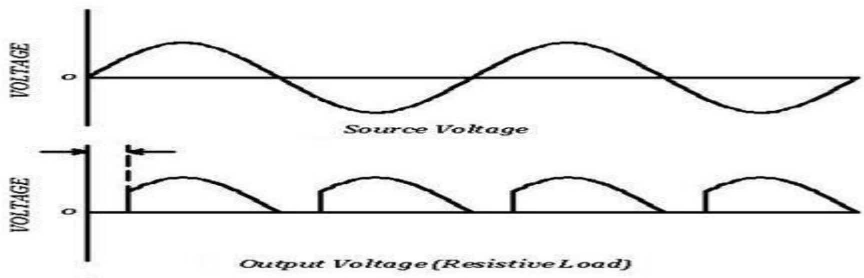
α = FiringAngle

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

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

V =RMS Value across transformer output

MODEL GRAPH:



EXPERIMENT- 14

PSPICE SIMULATION OF SINGLE PHASE INVERTER WITH PWM CONTROL

AIM:

Toobtaintheperformancecharacteristicsofsinglephaseinverterwith PWMcontrol.

APPARATUS:

S. No	Name of the Equipment
1.	PC With Desktop
2.	PSPICE

CIRCUITDIAGRAM:

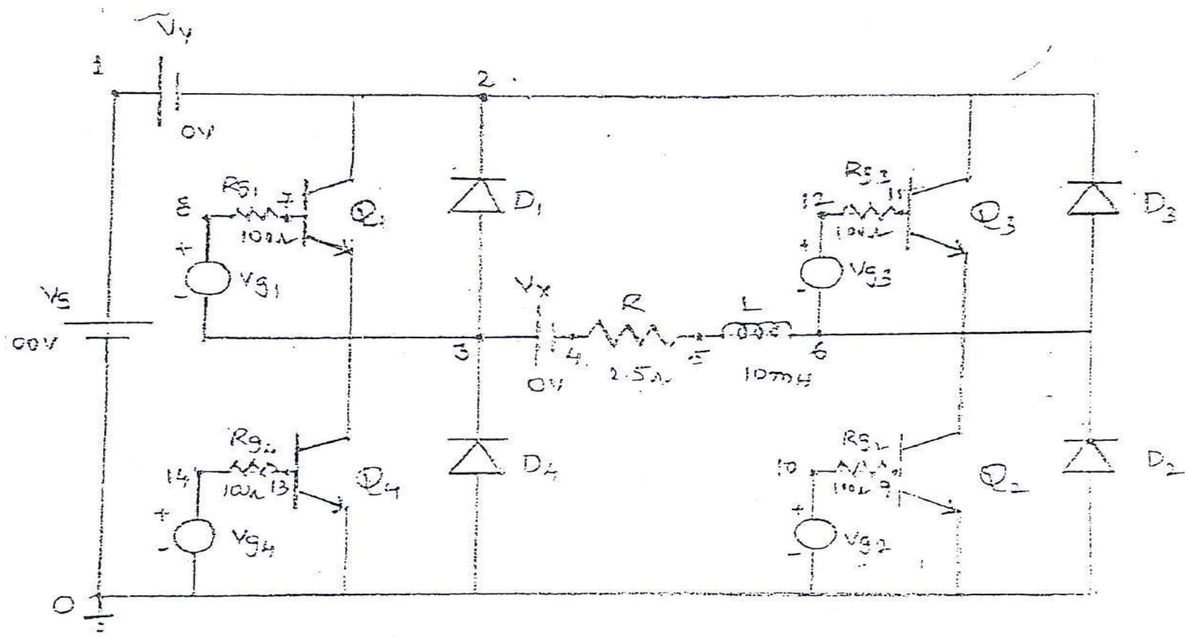


Fig-17.1Circuit Diagram of PSPICE Simulation ofSingle Phase Inverter

PROCEDURE:

1. Represent the nodes for a given circuit.
2. Write spice program by initializing all the circuit parameter as per given flowchart.
3. From desktop of your computer click on" START " menu followedby" programs " and then clicking appropriate program group as " DESIGN LAB EVAL8 followed by " DESIGN MANAGER."
4. Open the run text editor from micro sim window & start writing PSPICE program.
5. Savetheprogramwith.cir extension.
6. Open the run spice A/D window from micro sim window.

7. Open file menu from run spice A/D window then open saved circuit file.
8. If there are any errors, simulates will be displayed with statement as“simulation error occurred”.
9. To see the errors click on o/p file icon and open examine o/p.
10. To make changes in the program open the circuit file,modify,save&Runtheprogram.
11. If there are no errors,simulation will be completed& it will be displayed with a statement as“simulation completed”.
12. To see the o/p click on o/p file icon&open examine o/p then note down the values.
13. If.probe comman disused in the program, click on o/ p file icon &open run probe. Select variables to plot on graphical window and observe the o / p plots then take print outs of that.

PROGRAM CODE:

```
VS 10 DC 100V
VT 170PULSE(50V0V0833.33US833.33US1NS
1666.67US) RT 17 0 2MEG
VC115 0PULSE(0-30V1NS1NS8333.33US
1666.67US)RC1 150 2MEG
VC3160PULSE(0-30V8333.33US1NS1NS8333.33US
16666.67US) RC3 16 0 2MEG
R452.5
L5610MH
VX34 DC0V
VY12DC0V
D132DMOD
D206DMOD
D362DMOD
D403DMOD
.MODELDMODD(IS=2.2E-15BV=1800V
TT=0) Q1 2 7 3 QMOD
Q2690QMOD
Q32116QMOD
Q43130QMOD
.MODELQMODNPN(IS=6.74FBF=416.5CJC=3.638P
CJE=4.451P) RG1 8 7 100
```

RG2109100
RG31211100
RG41413100
*SUBCKT
CALL FOR
PWM
CONTROLXP
W1171583PW
M
XPW21715100
PWM
XPW31716126
PWM
XPW41716140
PWM
.SUBCKTPWM
1234
*modelrefcarrie
r+control-
control R1 1 5
1K
R2 251K
RIN 502MEG
RF53100K
R06375
C0 3410PF
E164052E+5
.ENDSPWM
.TRAN10US
16.67MS010US
.PROBE
.optionsabstol=1
.00nreltol=0.01
vntol=0.1itl5=2
0000
.FOUR60HZV(
3,6)
.END
PLOTV(14)I(V
X)I (vy)V(10)

Results: