

POWER ELECTRONICS AND SIMULATION LABORATORY MANUAL

Subject Code : A60291
Regulations : R15 - JNTUH
Class : III Year II Semester (EEE)



Department of Electrical and Electronics Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)

Dundigal, Hyderabad – 500 043



INSTITUTE OF AERONAUTICAL ENGINEERING **(Autonomous)**

Dundigal, Hyderabad - 500 043

Department of Electrical and Electronics Engineering

VISION AND MISSION OF THE DEPARTMENT:

VISION

The vision of the Electrical and Electronics Engineering department is to build a research identity in all related areas of Electrical Engineering uniquely. Through core research and education, the students will be prepared as the best professional Engineers in the field of Electrical Engineering to face the challenges in such disciplines.

MISSION

The Electrical and Electronics Engineering Department supports the mission of the College through high quality teaching, research and services that provide students a supportive environment. The department will make the best effort to promote intellectual, ethical and technological environment to the students. The department invokes the desire and ability of life - long learning in the students for pursuing successful career in engineering.



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

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Department of Electrical and Electronics Engineering

Program Outcomes	
PO1	General Knowledge: An ability to apply the knowledge of mathematics, science and Engineering for solving multifaceted issues of Electrical Engineering.
PO2	Problem Analysis: An ability to communicate effectively and to prepare formal technical plans leading to solutions and detailed reports for electrical systems.
PO3	Design / Development of Solutions: To develop Broad theoretical knowledge in Electrical Engineering and learn the methods of applying them to identify, formulate and solve practical problems involving electrical power.
PO4	Conduct Investigations of Complex Problems: An ability to apply the techniques of using appropriate technologies to investigate, analyze, design, simulate and / or fabricate / commission complete systems involving generation, transmission and distribution of electrical energy.
PO5	Modern Tool Usage: An ability to model real life problems using different hardware and software platforms, both offline and real - time with the help of various tools along with upgraded versions.
PO6	The Engineer and Society: An Ability to design and fabricate modules, control systems and relevant processes to meet desired performance needs, within realistic constraints for social needs.
PO7	Environment and Sustainability: An ability To estimate the feasibility, applicability, optimality and future scope of power networks and apparatus for design of eco - friendly with sustainability
PO8	Ethics: To Possess an appreciation of professional, societal, environmental and ethical issues and proper use of renewable resources.
PO9	Individual and Team Work: an Ability to design schemes involving signal sensing and processing leading to decision making for real time electrical engineering systems and processes at individual and team levels.
PO10	Communication: an Ability to work in a team and comprehend his / her scope of work, deliverables , issues and be able to communicate both in verbal ,written for effective technical presentation.
PO11	Life - Long Learning: An ability to align with and upgrade to higher learning and research activities along with engaging in life - long learning.
PO12	Project Management and Finance: To be familiar with project management problems and basic financial principles for a multi - disciplinary work.

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	Successful Career and Entrepreneurship: 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.

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ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Exp .No	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Study of characteristics of SCR, MOSFET & IGBT	PO1, PO2, PO3	PSO2
2	Gate firing circuits for SCRs	PO1, PO3	PSO2
3	Single phase A.C. Voltage controller with R and RL loads	PO1, PO2, PO3	PSO2
4	Single phase fully controlled bridge converter with R and RL loads	PO1, PO2, PO3	PSO2
5	Forced commutation circuits	PO1, PO3	PSO2
6	DC Jones Chopper	PO1, PO3	PSO2
7	Single phase parallel inverter with R and RL loads	PO1, PO3	PSO2
8	Single phase Cyclo - converter with R and RL loads	PO1, PO2, PO3	PSO2
9	Single phase half controlled bridge converter with R and RL loads	PO1, PO2, PO3	PSO2
10	Three phase half controlled bridge converter with R load	PO1, PO2, PO3	PSO2
11	Single phase series inverter with R and RL loads	PO1, PO3	PSO2
12	Single phase bridge converter with R and RL loads	PO1, PO2, PO3	PSO2
13	Single phase dual converter with R and RL loads	PO1, PO2, PO3	PSO2
14	Operation of MOSFET based chopper	PO1, PO3	PSO2
15	PSPICE simulation of single phase full converter using RLE loads and single phase AC voltage controller using RLE loads	PO1, PO3, PO12	PSO2, PSO3
16	PSPICE simulation of Resonant pulse commutation circuit and Buak chopper	PO1, PO3, PO12	PSO2, PSO3
17	PSPICE simulation of Single phase inverter with PWM control	PO1, PO3, PO12	PSO2, PSO3

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:

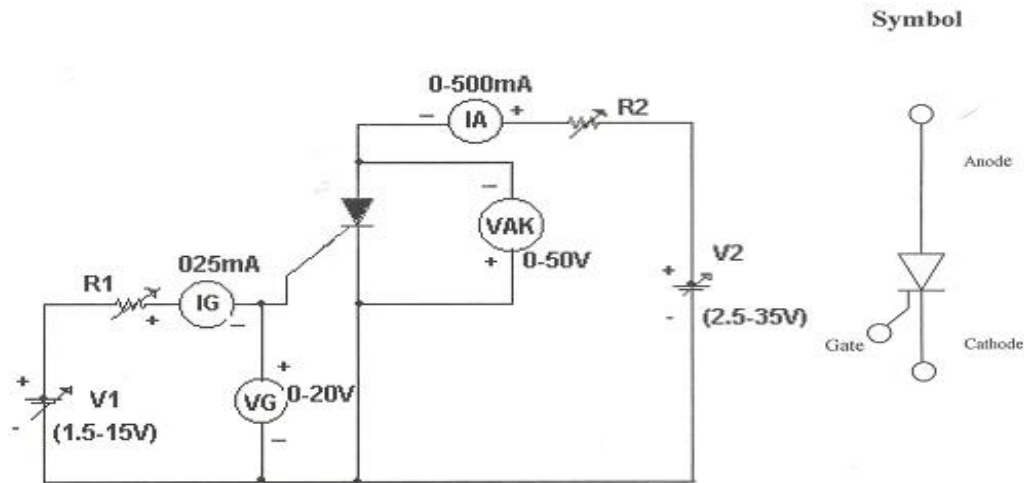


Fig – 1.1 Study of Characteristics of SCR

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 TRIGGERING 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 V_{AK} 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 V_g 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 R_2 at maximum position, then SCR turns OFF, if it is not turned off reduce V_2 up to turn off the device and put the gate voltage.
5. Now decrease the R_2 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 stays 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 R_2 & V_2 .
2. Switch OFF the gate voltage switch S1 permanently (now the device is in ON state).
3. Now increase load resistance (R_2), 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:

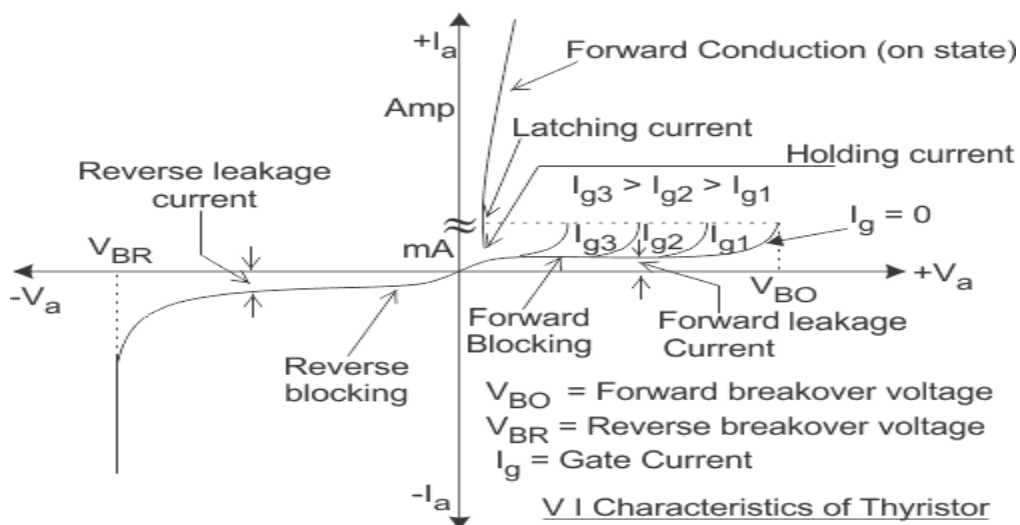


Fig - 1.2 V- I Characteristics of SCR

1.8 RESULT:

1.9 PRE LAB 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 POST LAB 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:

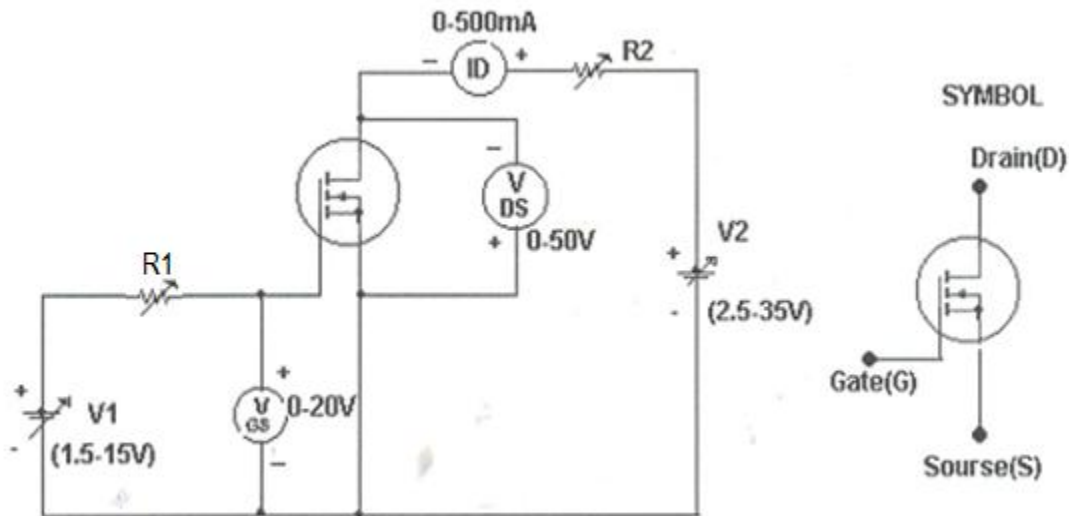


Fig – 1.2.1 Study of Characteristics of MOSFET

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 V_1 .
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_D 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	$V_{DS} = \text{ (Volts)}$	
	V_{GS} (V)	I_D (A)
1		
2		
3		
4		
5		

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

1.2.6 MODEL GRAPH:

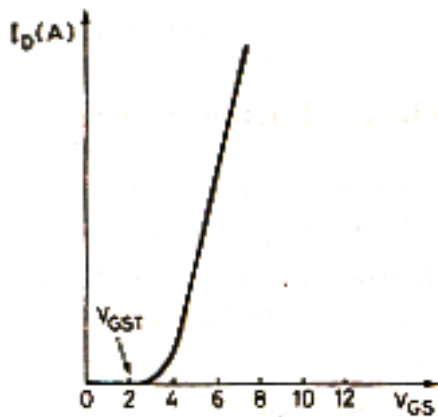


Fig - 1.2.2 Transfer Characteristic of MOSFET

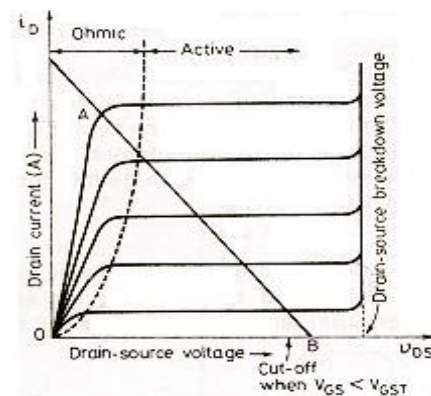


Fig - 1.2.3 Output Characteristics of MOSFET

1.2.7 RESULT:

1.2.8 PRE LAB 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 POST LAB 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:

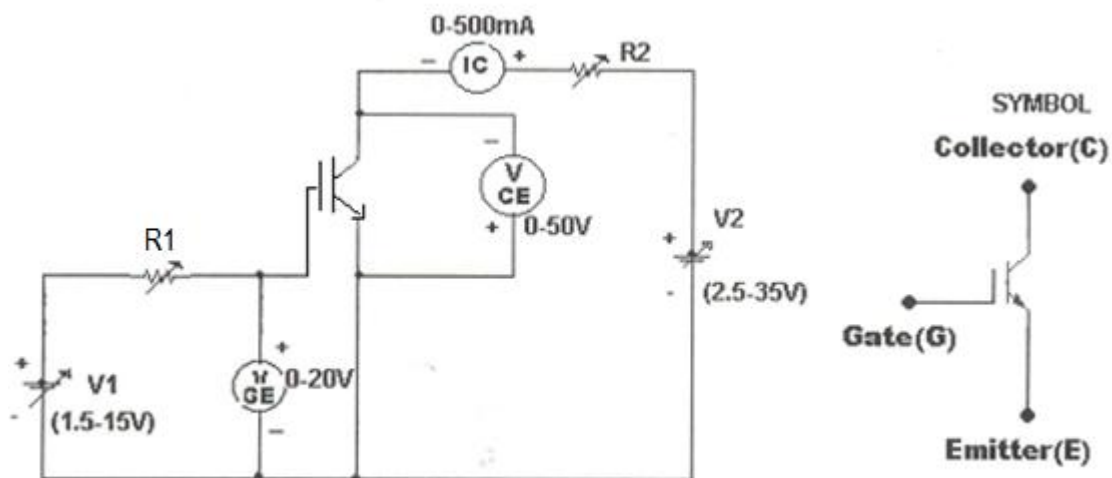


Fig – 1.3.1 Study of Characteristics IGBT

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 V_1 .
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:

- Initially set V_{GE} to some value say 5V by varying V_1 .
- Slowly vary V_2 and note down I_C and V_{CE} readings.
- 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.
- Repeat above procedure for different values of V_{GE} and draw graph between I_C vs 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:

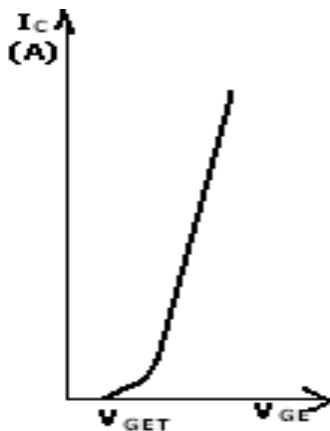


Fig – 1.3.2 Transfer Characteristics of IGBT

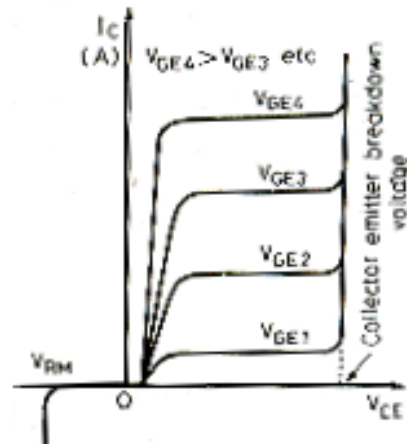


Fig - 1.3.3 Output Characteristics of IGBT

1.3.7 RESULT:

1.3.8 PRE LAB 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 POST LAB 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:

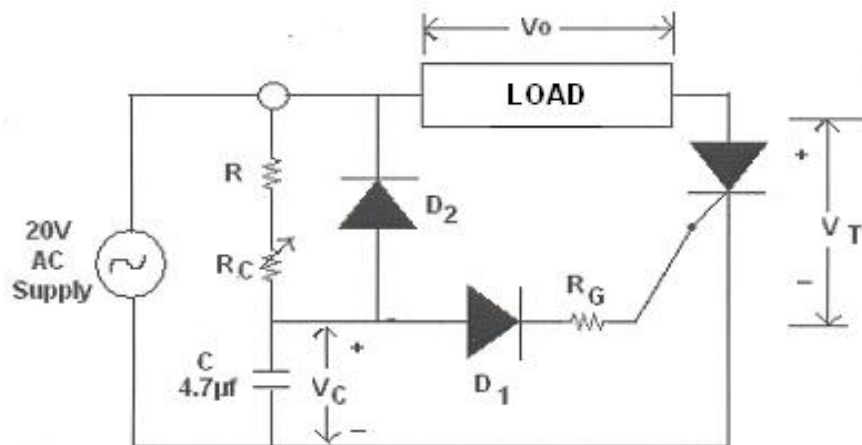


Fig - 2.1.3.1 RC Triggering Circuit

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:

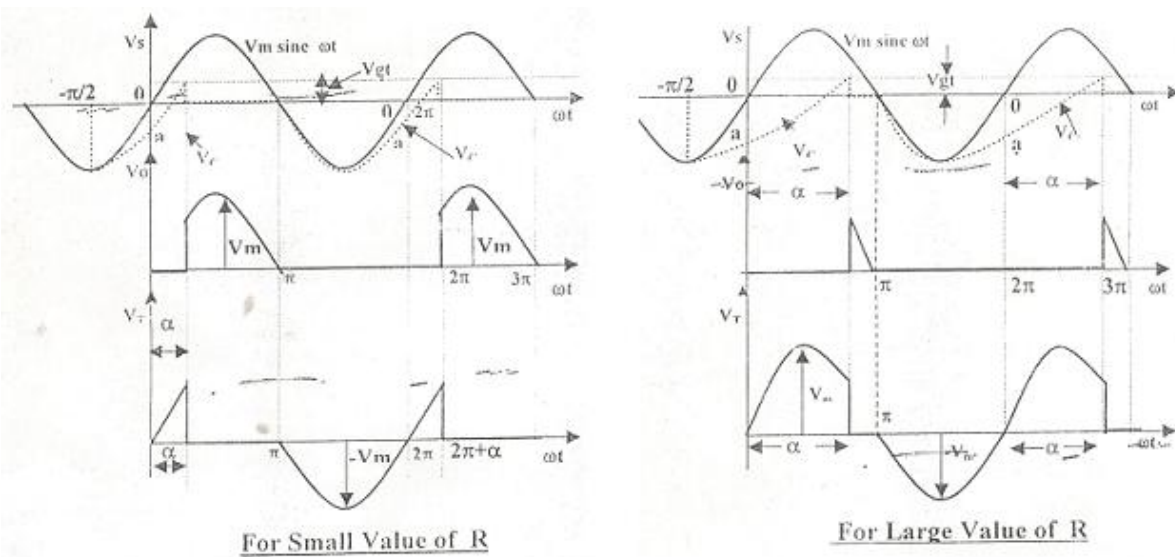


Fig - 2.1.5.2 Output Wave forms of RC Triggerring

2.1.6. RESULT:

2.1.7 PRE LAB 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:

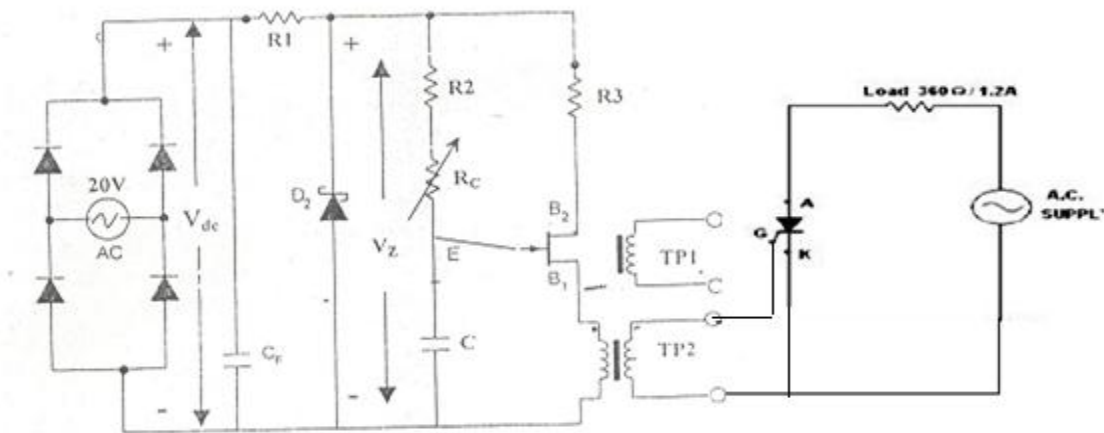


Fig 2.2.3.1 UJT Triggering Circuit

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.

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:

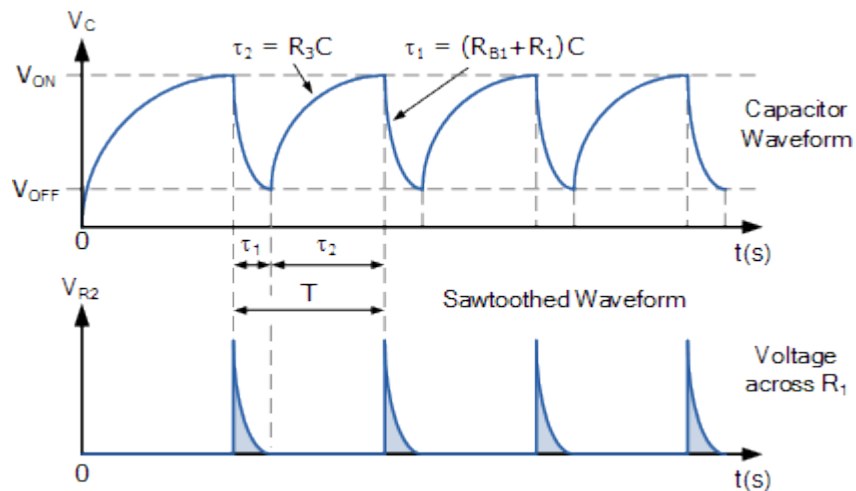


Fig - 2.2.6.2 Output Wave Forms of UJT Triggering

2.2.7 RESULT:

2.2.8 PRE LAB 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 POST LAB 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

3.1 AIM:

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

3.2 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			

3.3 CIRCUIT DIAGRAM:

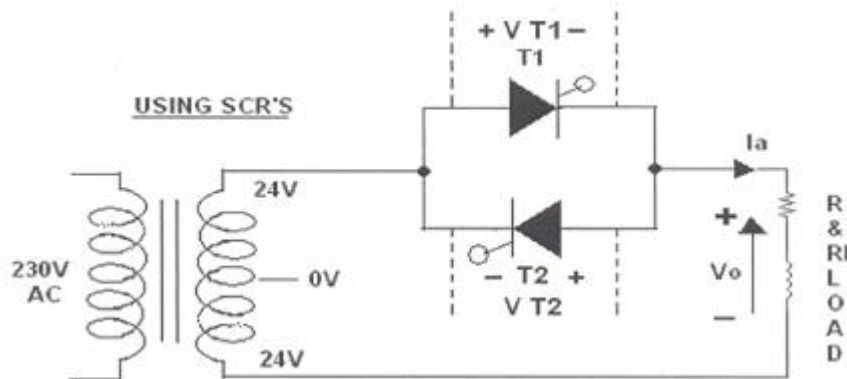


Fig - 3.1 Single Phase AC Voltage Controller with Thyristors

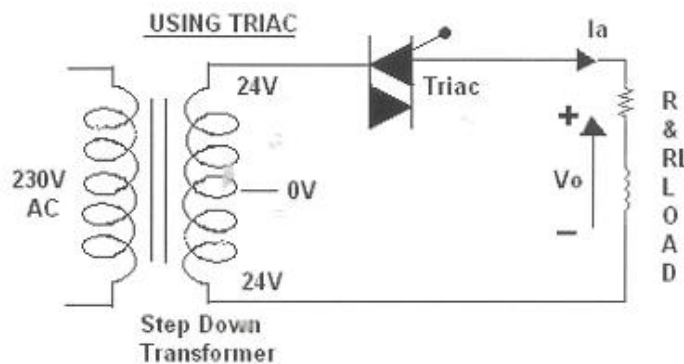


Fig - 3.2 Single Phase AC Voltage Controller with Traic

3.4 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° .
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° .
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.

3.5 TABULAR COLUMN:

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

3.6 MODULE CALCULATIONS:

$I_{or} = V_{or}/R$

$\alpha = \text{Firing Angle}$

$V = \text{RMS Value across transformer output}$

3.7 MODEL GRAPH:

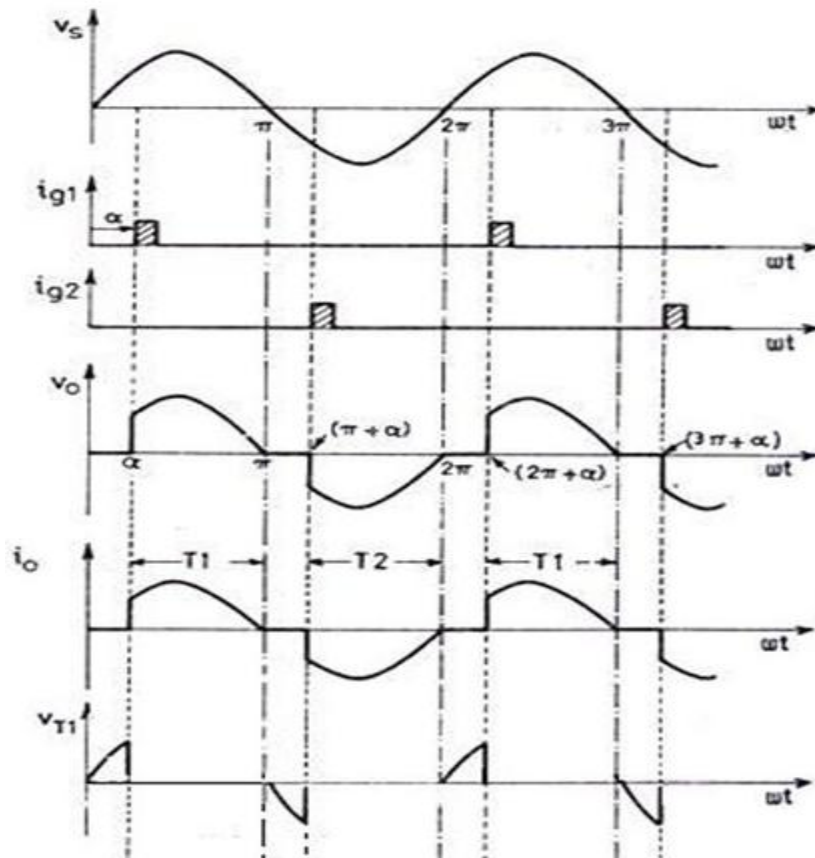


Fig - 3.3 Single Phase AC Voltage controller with R - Load

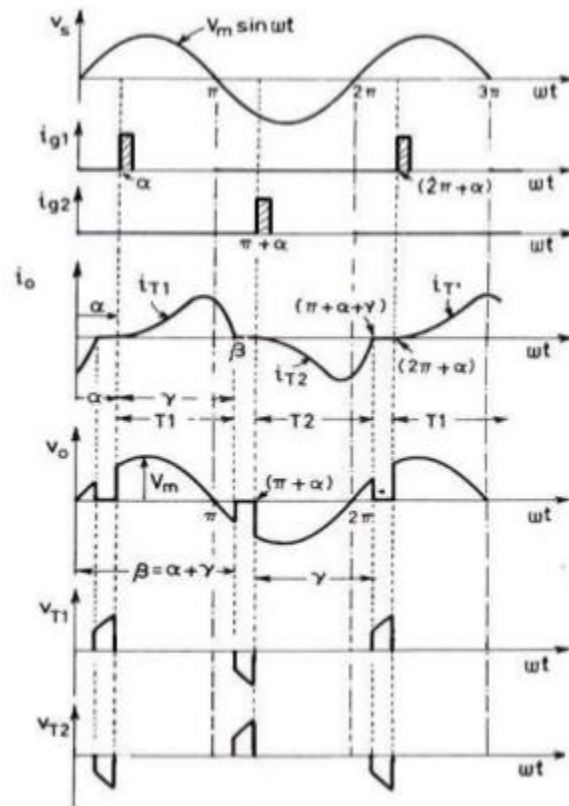


Fig – 3.4 Single Phase AC voltage controller with RL Load

3.8 RESULT:

3.9 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?

3.10 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 – 4

SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R AND RL LOADS

4.1 AIM:

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

4.2 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			

4.3 CIRCUIT DIAGRAM:

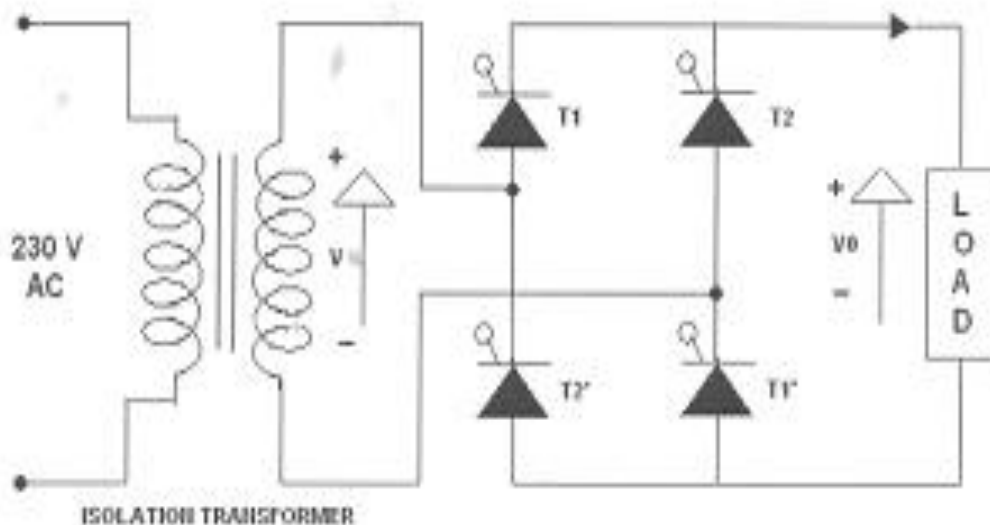


Fig – 4.1 Single Phase Fully Controlled Bridge Converter

4.4 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 $200\Omega / 5A$ 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° 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.

4.5 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						

4.6 MODULE CALCULATIONS:

For R-L Load:

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

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

α = Firing Angle

V = RMS Value across transformer output

For R Load:

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

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

4.7 MODEL GRAPH:

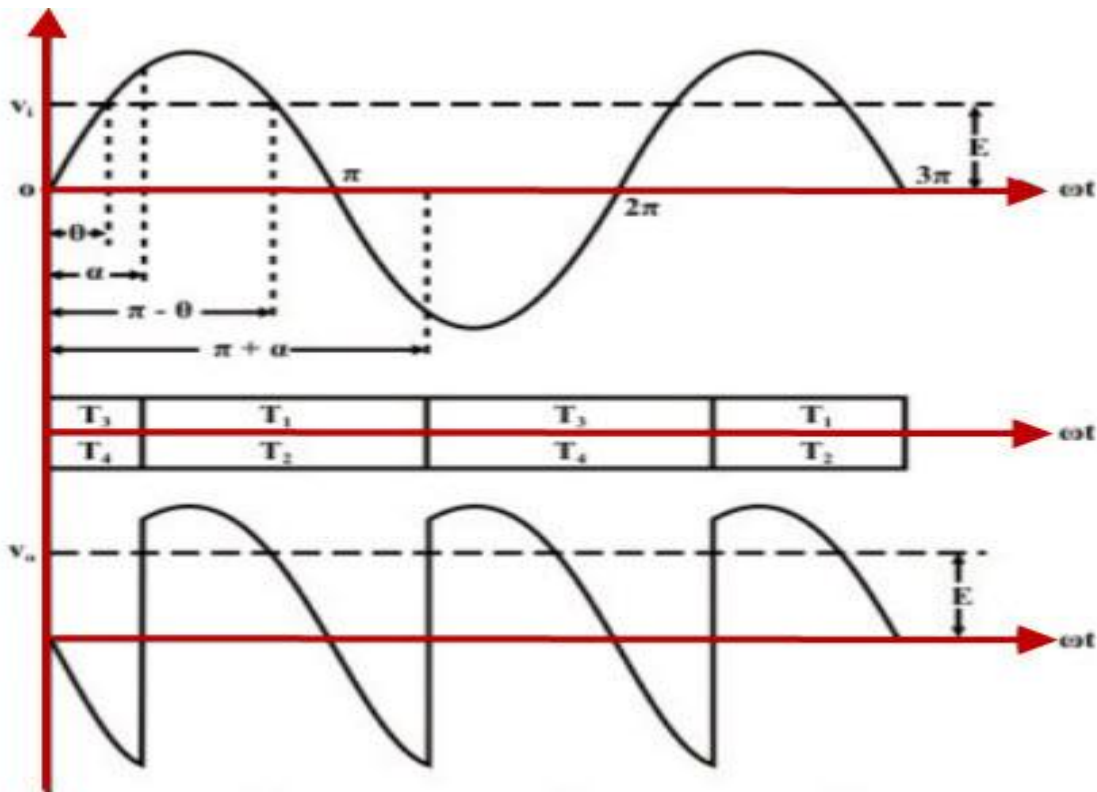


Fig – 4.2 Single Phase Fully Controlled Bridge Converter

4.8 RESULT:

4.9 PRE LAB 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?

4.10 POST LAB 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 – 5

FORCED COMMUTATION CIRCUITS

5.1 AIM:

To Construct and study different commutation circuits.

5.2 APPARATUS:

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

5.3 CIRCUIT DIAGRAM:

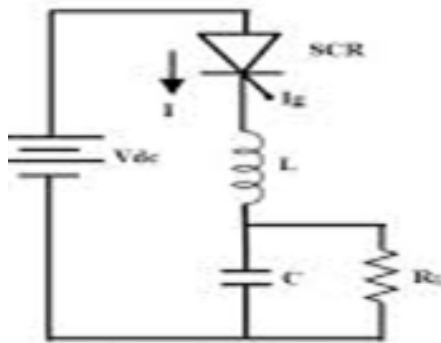


Fig - 5.1 Class - A Commutation

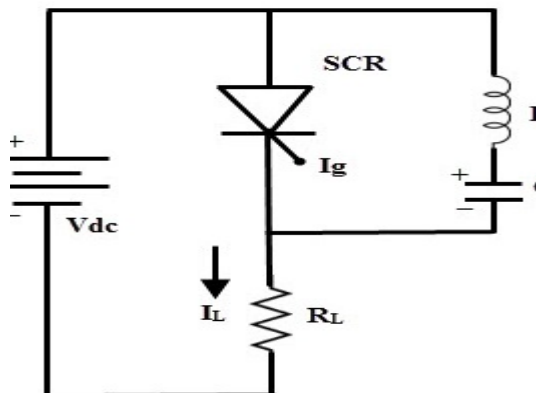
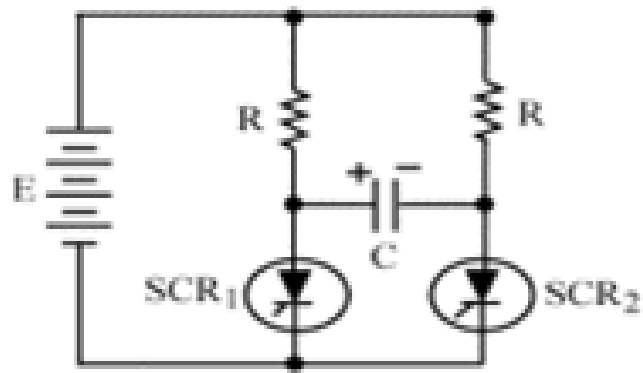


Fig - 5.2 Class - B Commutation



(a)

Fig - 5.3 Class - C commutation

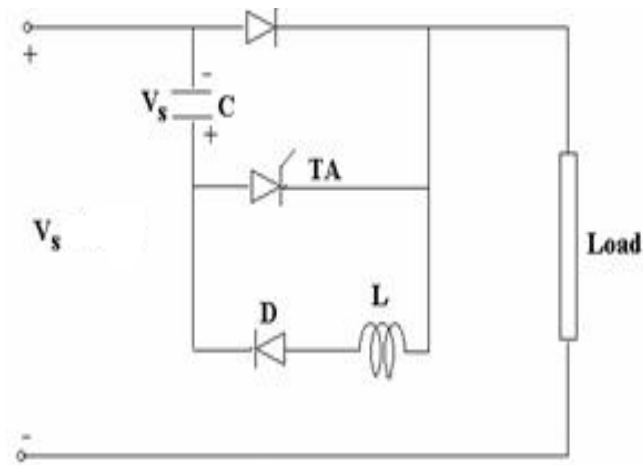


Fig - 5.4 Classes - D Commutation

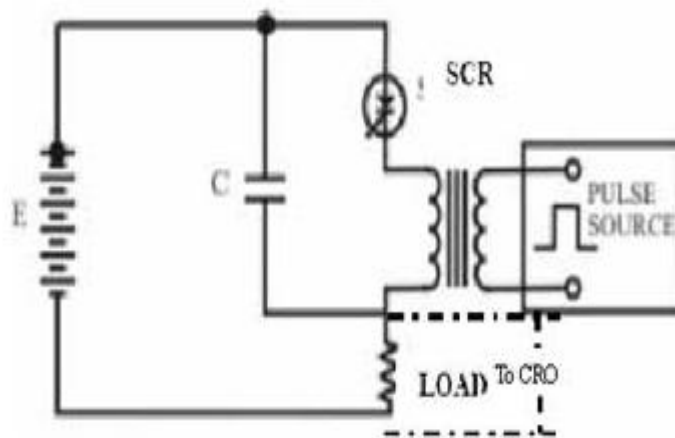


Fig - 5.5 Classes - E Commutation

5.4 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.

5.5 MODEL GRAPHS:

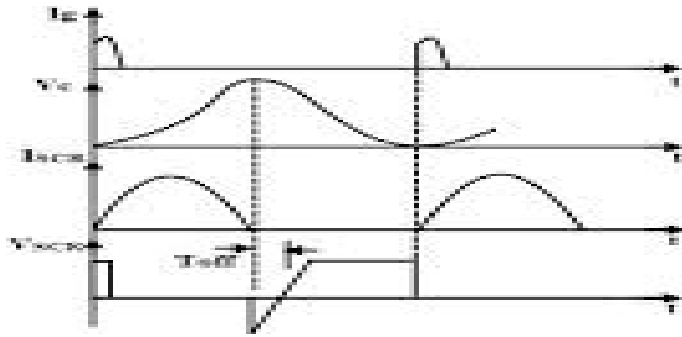


Fig - 5.6 Output Wave Forms of Class - A Commutation

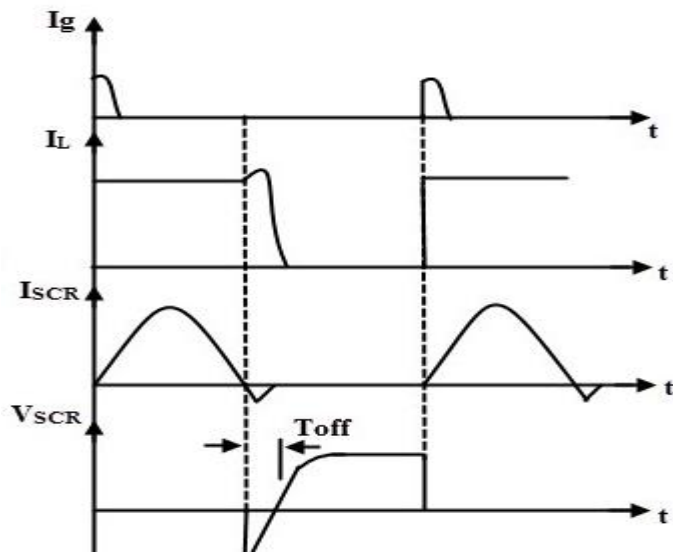


Fig - 5.7 Output Wave Forms of Class - B Commutation

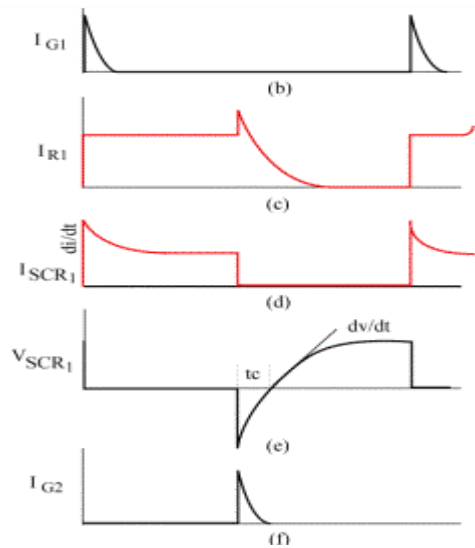


Fig - 5.8 Output Wave Forms of Class - C Commutation

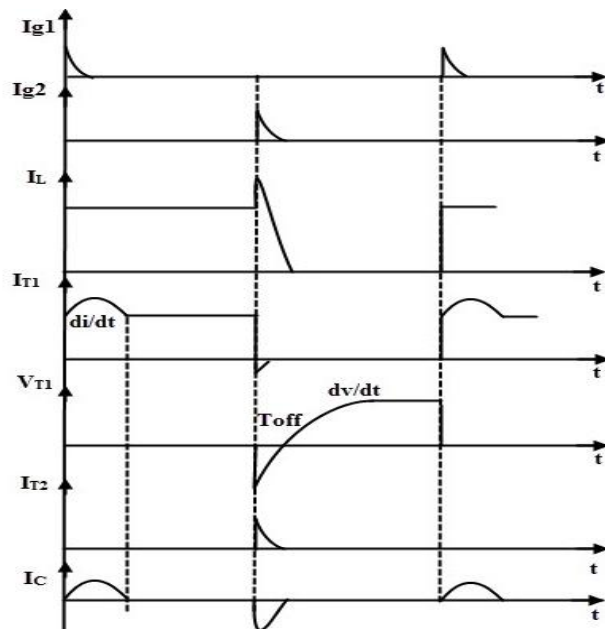


Fig - 5.9 Output Wave Forms of Class - D Commutation

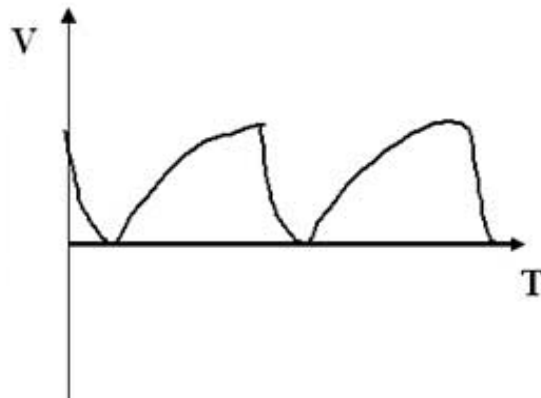


Fig - 5.10 Output Wave Forms of Class - E Commutation

5.6 RESULT:

5.7 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?

5.8 POST LAB 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

DC JONE’S CHOPPER

6.1 AIM:

To study the characteristics of DC Jone’s Chopper.

6.2 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			

6.3 CIRCUIT DIAGRAM:

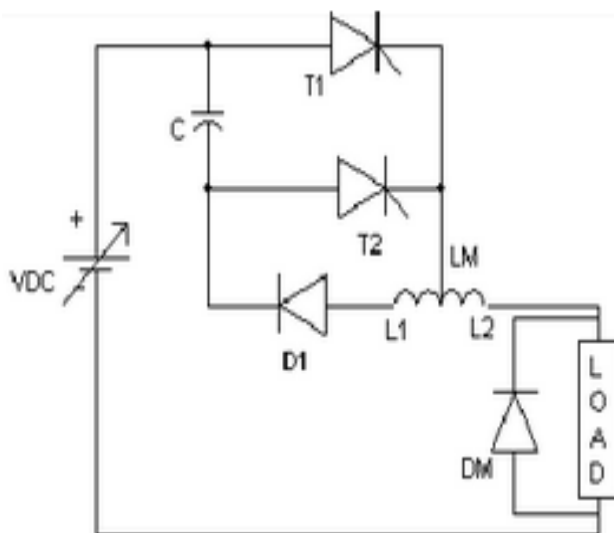


Fig - 6.1 Circuit Diagram of Jones Chopper

T1, T2 – TYN 616

D1 – BYQ 28200

C – Commutation Capacitor 10 μ F / 100V

L1- 0 –L2 - Commutation Inductor 500-0-500 μ H / 2A

6.4 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 $L = 25\text{mH}$ 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].

6.5 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				

6.6 MODEL GRAPH:

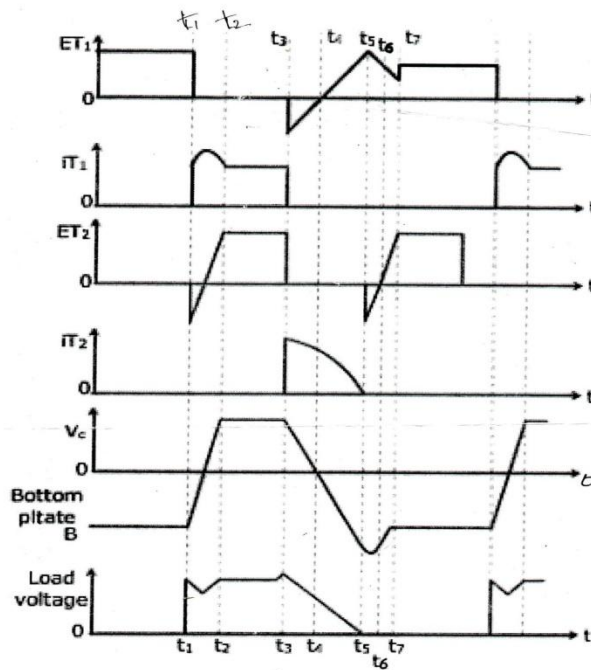


Fig – 6.2 Output Characteristics of DC Jones Chopper

6.7 RESULT:

6.8 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?

6.9 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 - 7

SINGLE PHASE PARALLEL INVERTER WITH R AND RL LOADS

7.1 AIM:

To study the parallel inverter

7.2 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:

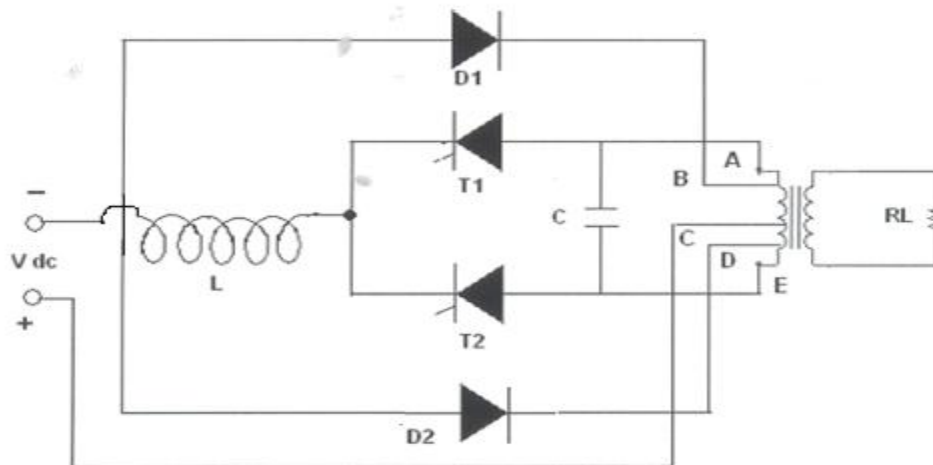


Fig - 7.1 Circuit Diagram of Single Phase Parallel Inverter

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:

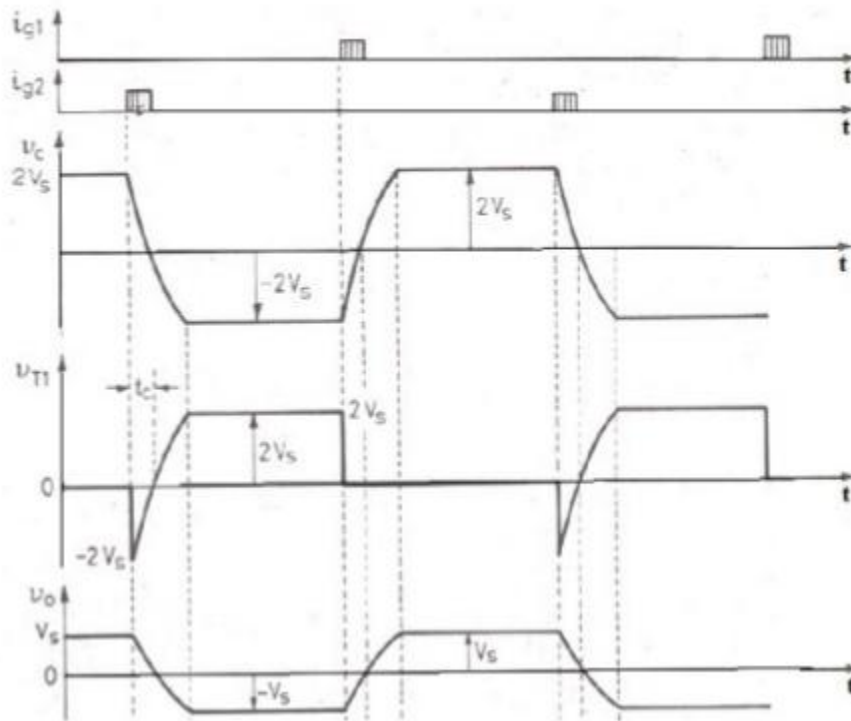


Fig - 7.2 Output Wave Forms of Single Phase Parallel Inverter

7.6 RESULT:

7.7 PRE LAB 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 CYCLO - CONVERTER WITH R AND RL LOADS

8.1 AIM:

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

8.2 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			

8.3 CIRCUIT DIAGRAM :

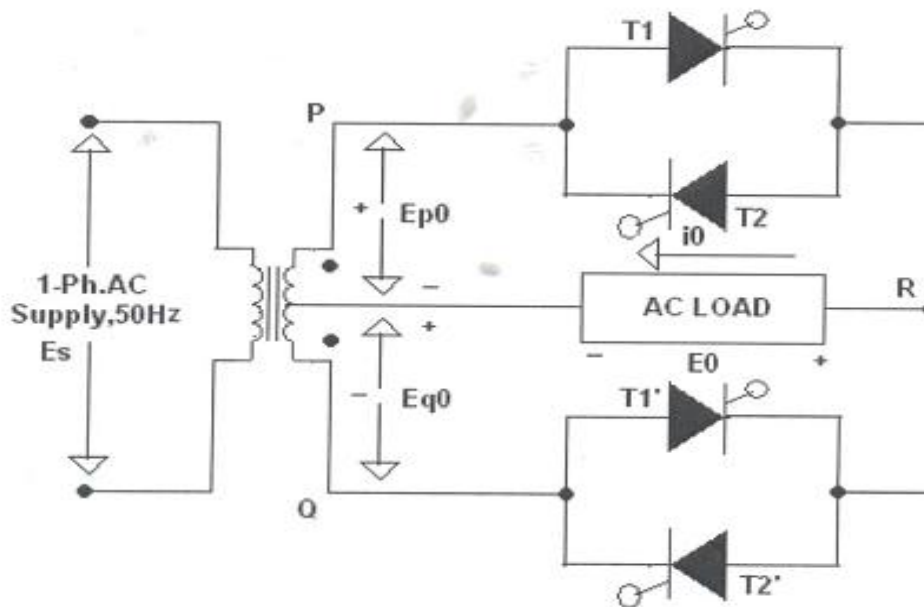


Fig – 8.1 Circuit Diagram of Single Phase Cyclo - Converter

8.4 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.

8.5 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

8.6 MODEL CALCULATIONS:

$$\begin{aligned}V_{0r} &= \\I_{0r} &= V_{0r}/R \\ \theta &= \text{Firing Angle} \\ V &= \text{RMS Value across transformer output}\end{aligned}$$

8.7 MODEL GRAPH:

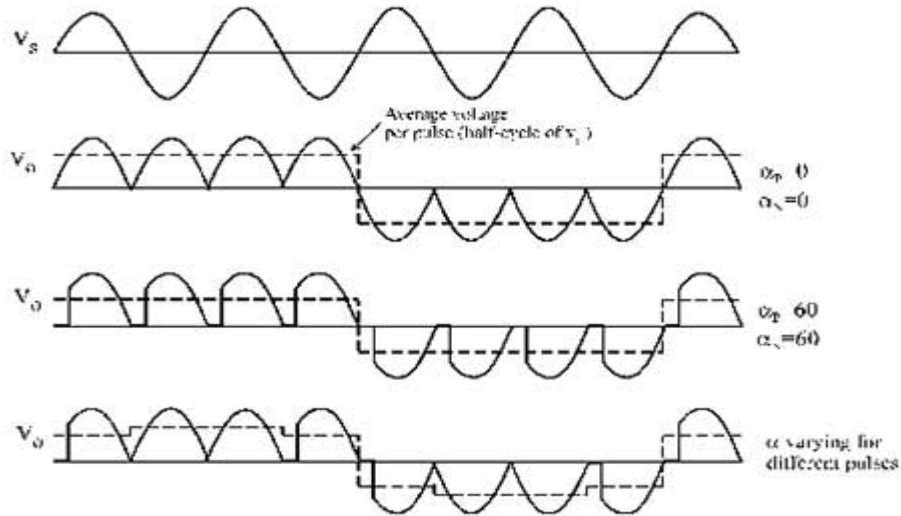


Fig – 8.2 Output Wave Forms of Single Phase Cyclo - Converter

8.8 RESULT:

8.9 PRE LAB VIVA QUESTIONS:

1. What is meant by Cyclo-converter? What are the types of Cyclo-converters?
2. Classify Cyclo converters.
3. What is step up Cyclo-converter & 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 cyclo converter.
7. Draw the circuit diagram of three phase to single phase bridge configuration of cyclo converter.

8.10 POST LAB 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 – 9

SINGLE PHASE HALF CONTROLLED BRIDGE CONVERTER

9.1 AIM:

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

9.2 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			

9.3 CIRCUIT DIAGRAM:

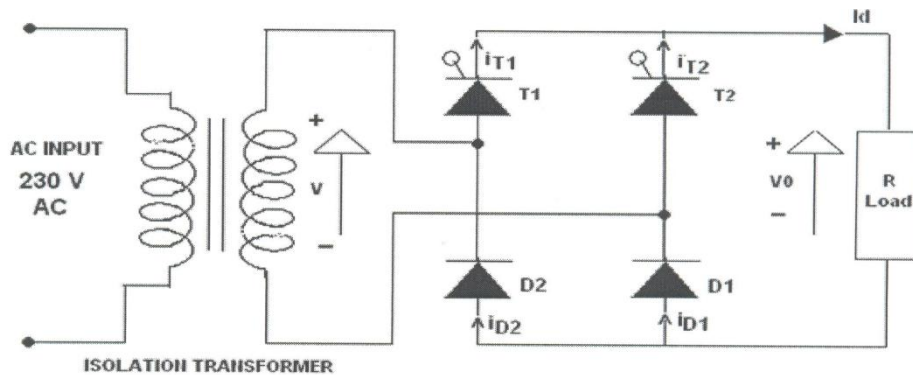


Fig – 9.1 Circuit Diagram of Single Phase Half Controlled Bridge Converter

9.4 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 $200\Omega / 5A$ 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° 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.

9.5 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						

9.6 MODULE CALCULATIONS:

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

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

α = Firing Angle
 V = RMS Value across transformer output

9.7 MODEL GRAPH:

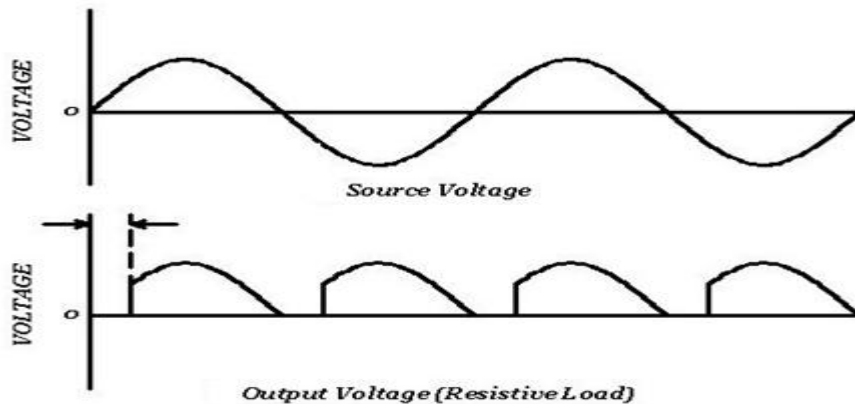


Fig - 9.2 Output Wave Forms of Single Phase Half Controlled Bridge Converter

9.8 RESULT:

9.9 PRE LAB 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?

9.10 POST LAB 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 – 10

THREE PHASE HALF CONTROLLED BRIDGE CONVERTER WITH R LOAD

10.1 AIM:

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

10.2 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			

10.3 CIRCUIT DIAGRAM:

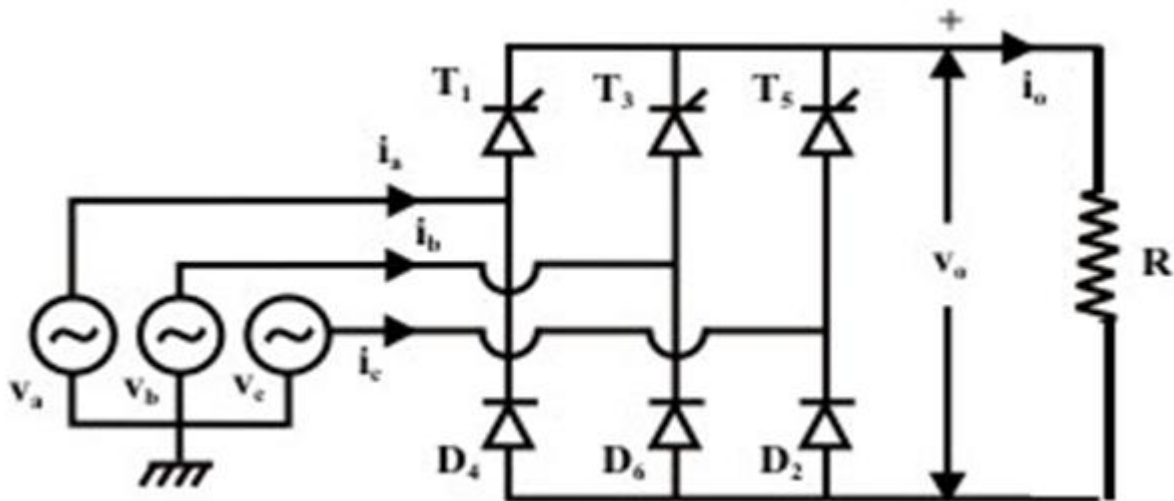


Fig – 10.1 Half Controlled bridge converter with R load

10.4 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 $200\Omega / 5A$ 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° 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.

10.5 TABULAR COLUMN:

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

10.6 MODEL CALCULATIONS:

$$V_o = 3 V_{ml} * (1 + \cos\alpha) / 2\pi$$

$$I_o = 3 V_{ml} * (1 + \cos\alpha) / 2\pi R$$

α = firing angle

V_{ml} = line to line voltage

10.7 MODEL GRAPHS:

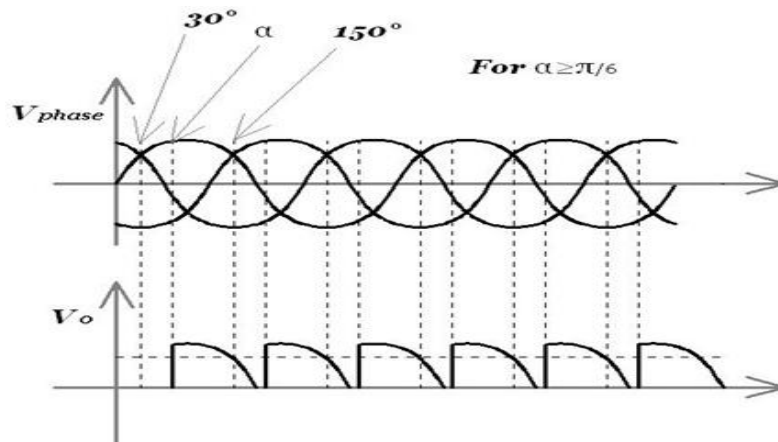


Fig – 10.2 Input and output wave forms of a three phase half controlled bridge converter

10.8 RESULT:

10.9 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?

10.10 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 – 11

SINGLE PHASE SERIES INVERTER WITH R AND RL LOADS

11.1 AIM:

To obtain the performance characteristics of a single phase series inverter

11.2 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			

11.3 CIRCUIT DIAGRAM:

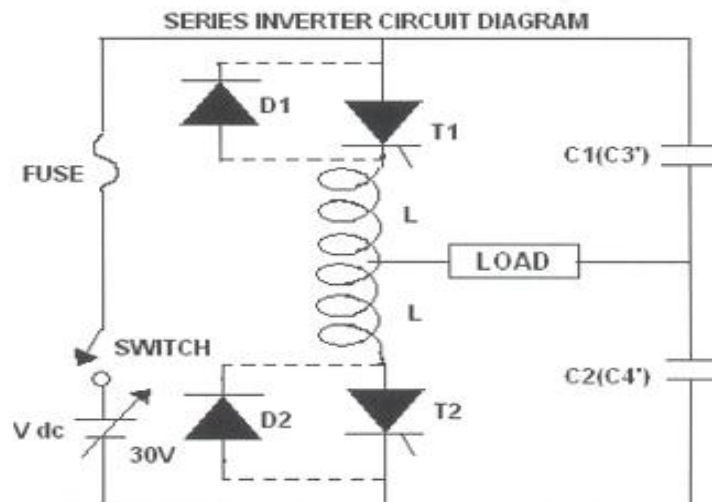


Fig 11.1 Circuit Diagram Single Phase Series Inverter

14.4 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 $200\Omega / 5A$ 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)

11.5 MODEL WAVEFORMS:

FULL WAVE CONVERTER

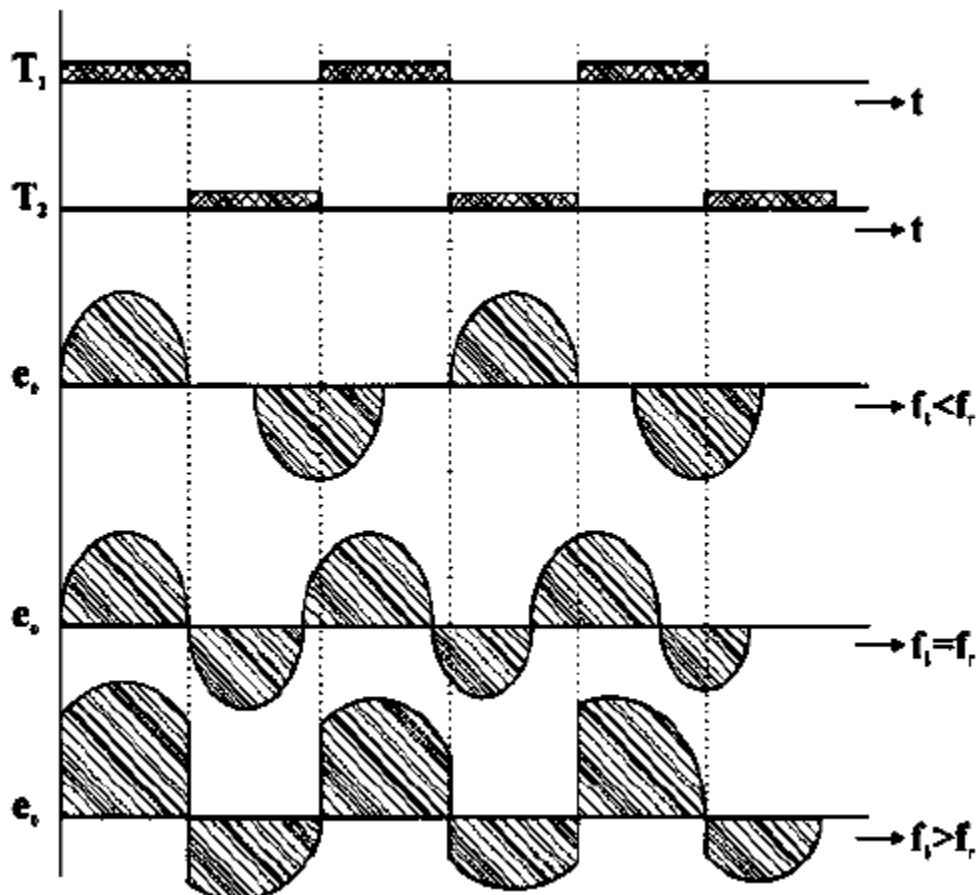


Fig 11.2 Output Wave Forms of Single Phase Series Inverter

11.6 RESULT:

11.7 PRE LAB 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?

11.8 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 - 12

SINGLE PHASE BRIDGE CONVERTER WITH R AND RL LOADS

12.1 AIM:

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

12.2 APPARATUS:

S. No	Equipment	Range	Type	Quantity
1	Single phase 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			

12.3 CIRCUIT DIAGRAM:

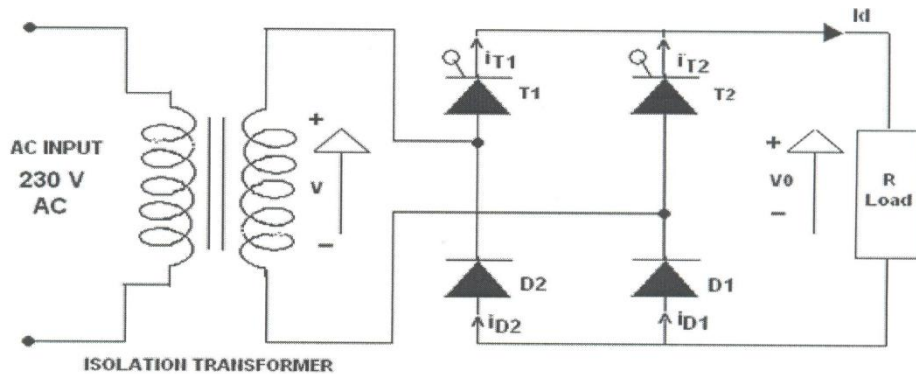


Fig - 12.1 Single Phase Bridge Converter

12.4 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 $200\Omega / 5A$ 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 bridge converter.
6. By varying firing angle gradually up to 180° 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.

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 MODULE CALCULATIONS:

For R-L Load:

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

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

$$\alpha = \text{Firing Angle}$$

$$V = \text{RMS Value across transformer output}$$

For R Load:

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

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

12.7 MODEL GRAPH:

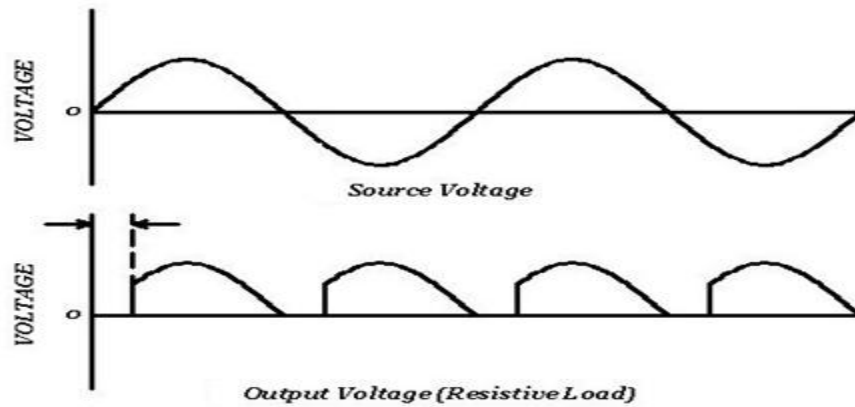


Fig – 12.2 Output waveforms of Single Phase Bridge Converter

12.8 RESULT:

12.9 PRE LAB 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?

12.10 POST LAB 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 - 13

SINGLE PHASE DUAL CONVERTER WITH RL LOADS

13.1 AIM:

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

13.2 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			

13.3 CIRCUIT DIAGRAM:

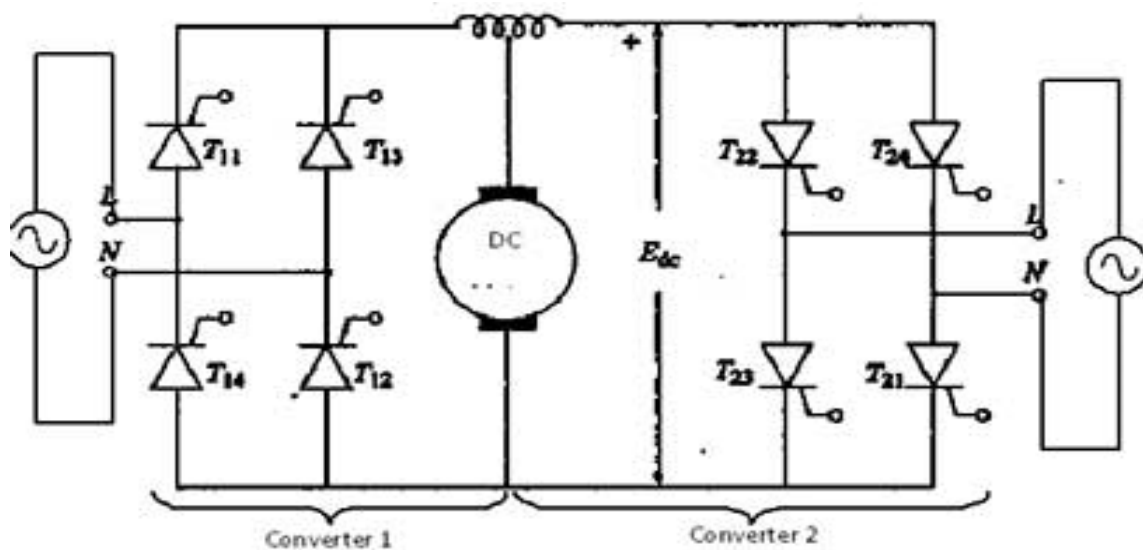


Fig – 13.1 Single Phase Dual Converter

13.4 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 $200\Omega / 5A$ 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.

13.5 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						

13.6 MODEL CALCULATIONS:

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

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

$$\alpha = \text{Firing Angle}$$

$$V = \text{RMS Value across transformer output}$$

13.7 MODEL GRAPH:

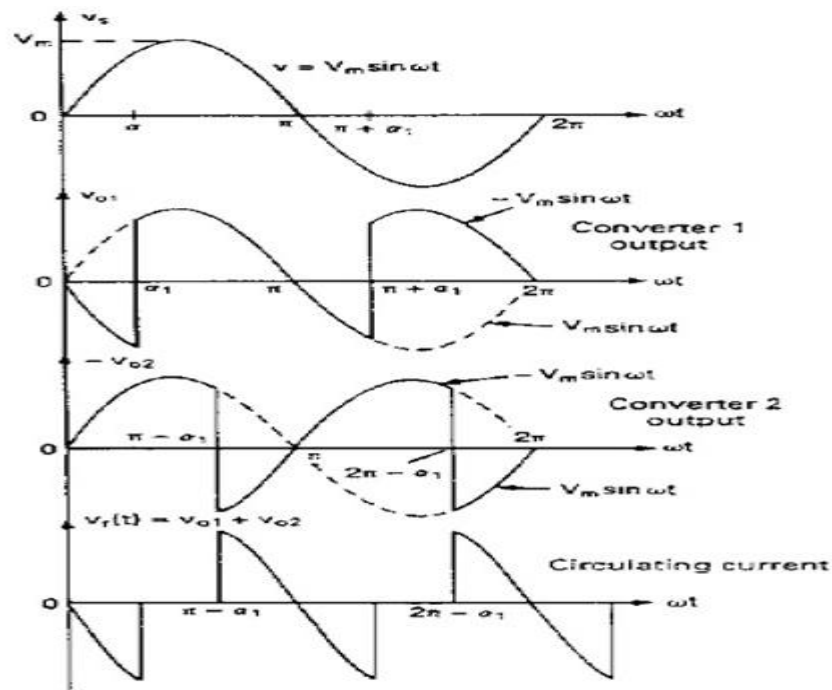


Fig – 13.2 Single Phase Dual Converter output waveforms

13.8 RESULT:

13.9 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?

13.10 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 - 14

OPERATION OF MOSFET BASED CHOPPER

14.1 AIM:

To study the operation of chopper with MOSFET

14.2 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			

14.3 CIRCUIT DIAGRAM:

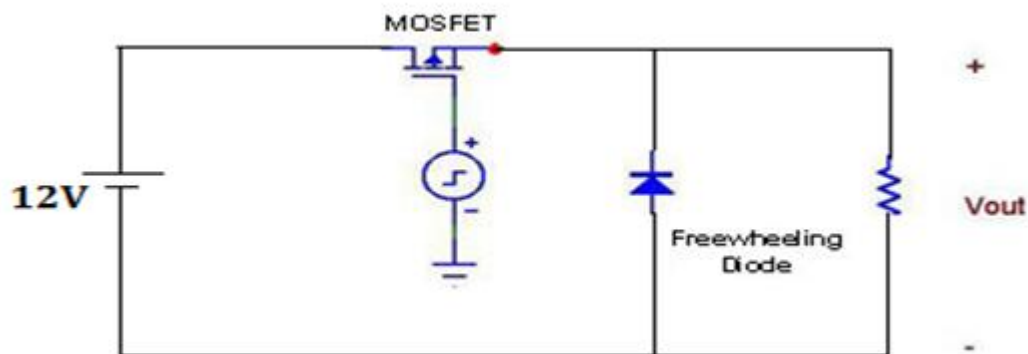


Fig – 14.1 MOSFET based chopper

14.4 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 waveform for mid value of frequency and duty cycle.

14.5 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				

14.6 MODEL GRAPH:

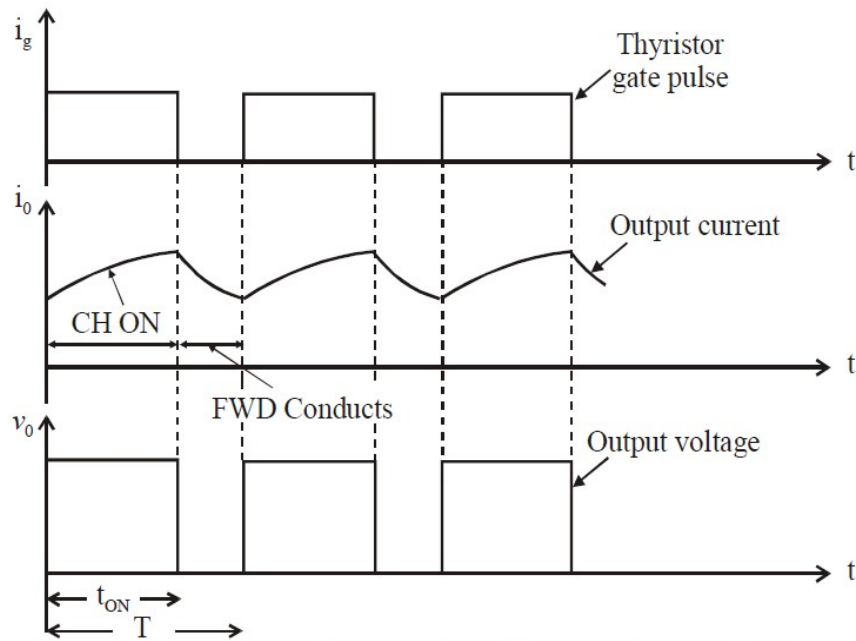


Fig – 14.2 Chopper output waveforms

14.7 RESULT:

14.8 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?

14.9 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 – 15 (A)

PSPICE SIMULATION OF SINGLE PHASE FULL WAVE RECTIFIER USING RLE LOADS

15.A.1 AIM:

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

15.A.2 APPARATUS:

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

15.A.3 CIRCUIT DIAGRAM:

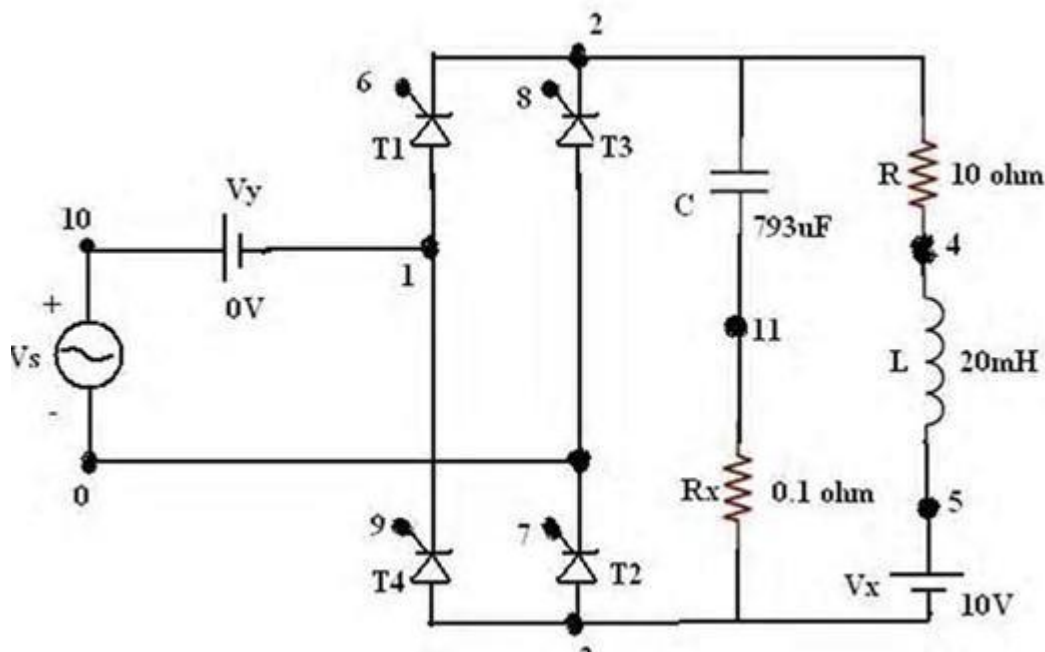


Fig - 15.1 Circuit Diagram of PSPICE Simulation of Single Phase Full Wave Rectifier

15.A.4 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.

15.A.5 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)

```

15.A.6 MODEL WAVEFORMS:

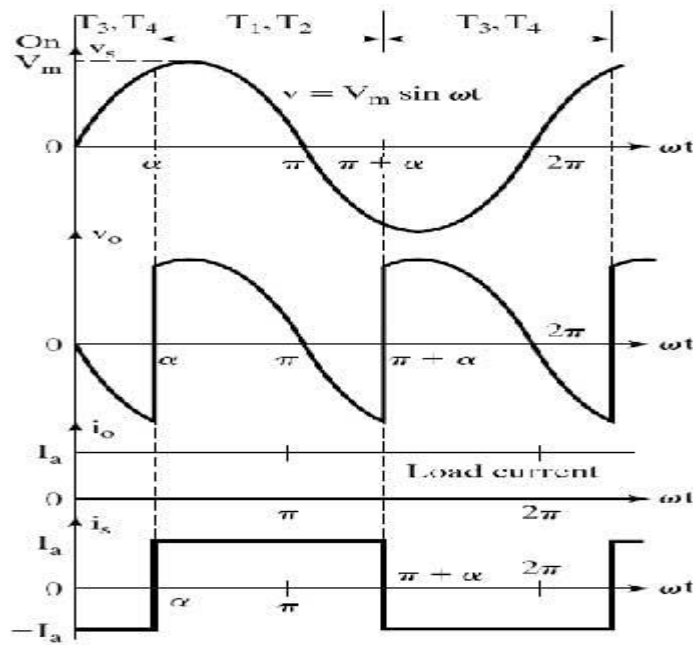


Fig - 15.2 Output Wave Forms of PSPICE Simulation of Single Phase Full Wave Rectifier

15.A.7 RESULT:

15.A.8. 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?

15.A.9 POST LAB VIVA QUESTIONS:

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

EXPERIMENT – 15 (B)

PSPICE SIMULATION OF SINGLE PHASE AC VOLTAGE CONTROLLER USING RLE LOADS

15.B.1 AIM:

To obtain the performance characteristics of Single Phase for R, RL, RLE Loads Using MATLAB / Simulink

15.B.2 APPARATUS:

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

15.B.3 CIRCUIT DIAGRAM:

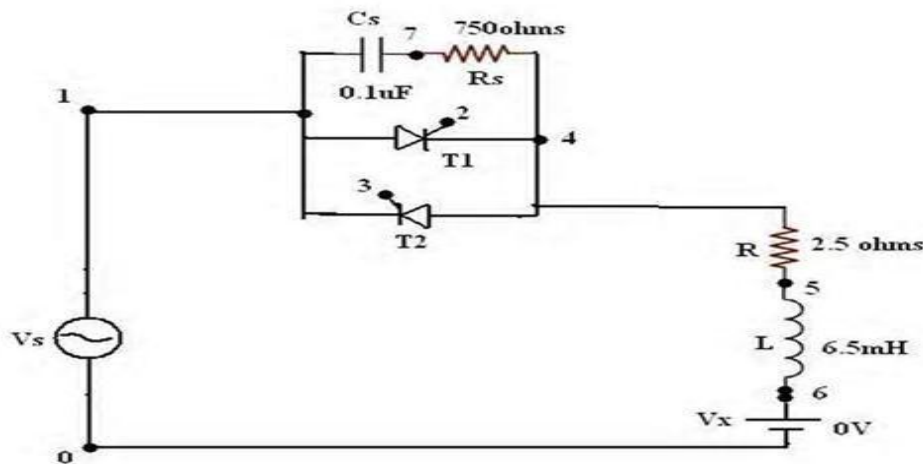


Fig - 15.3 Circuit Diagram of PSPICE Simulation of Single Phase Ac Voltage Controller

15.B.4 PROCEDURE:

1. Represent the nodes for again circuit.
2. Write PSPICE program by initializing all the circuit parameters as per given flow chart
3. From desktop of your computer click “start” menu followed “PROGRAMS” & then clicking appropriate program group as “DESIGN LAB tv 218” followed by design manager.
3. Open the Run text editor from microsim window & start writing PSPICE program.
4. Save the program with .cir extension. (Ex: DA.cir).
5. Open the RUN SPICE A / D window from microsim window.
6. Open file menu from RUN SPICE A / D window then open saved circuit file.
7. If there are any errors, simulation will be displayed with statement as “simulation error occurred.”

8. To see the errors click on output file icon & open examine output.
9. To make changes in the program open the circuit file modifies & run the program.
10. If there are no errors simulation modifies be displayed with a statement as “simulation completed”.
11. To see the output click on the output file icon & open examine output then note down the values.
12. If probe command is used in the program click on output file icon & open Run probe select variable to plot on graphical window & observe the plots then the printouts of that.

15.B.5 PROGRAM CODE:

```

CLC
VS 1 0 SIN (0 325V 50HZ)
VG1 2 4 PULSE (0V 10V 2500US 1NS 1NS 100US 20000US)
VG2 3 1 PULSE (0V 10V 2500US 1NS 1NS 100US 20000US)
R 4 5 2.5
L 5 6 6.5MH
VX 6 0 DC 10V
XT1 1 4 2 4 SCR
XT2 4 1 3 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 100F
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
.FOUR 50HZ I(VX)
.END
PLOT V (2)

```

15.B.6 MODEL WAVEFORMS:

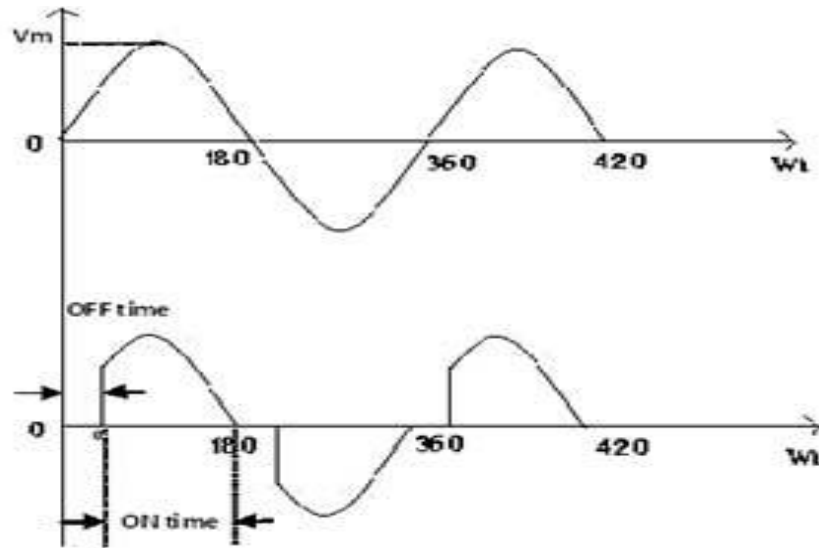


Fig – 15.4 Output Wave Forms of PSPICE Simulation of Single Phase Ac Voltage Controller

15.B.7 RESULT:

15.B.8 PRE LAB VIVA QUESTIONS:

1. What is the output voltage equation of AC Voltage controller?
2. Draw the output waveform of AC voltage controllers with a firing angle of 90 degrees.

15.B.9 POST LAB VIVA QUESTIONS:

1. What are the applications of fully controlled rectifiers?
2. What are the advantages of fully controlled over half controlled rectifiers?

EXPERIMENT – 16 (A)

PSPICE SIMULATION OF RESONANT PULSE COMMUTATION CIRCUIT

16. A.1 AIM:

To obtain the performance characteristics of a Resonant Pulse Commutation Circuit

16. A.2 APPARATUS:

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

16. A.3 CIRCUIT DIAGRAM:

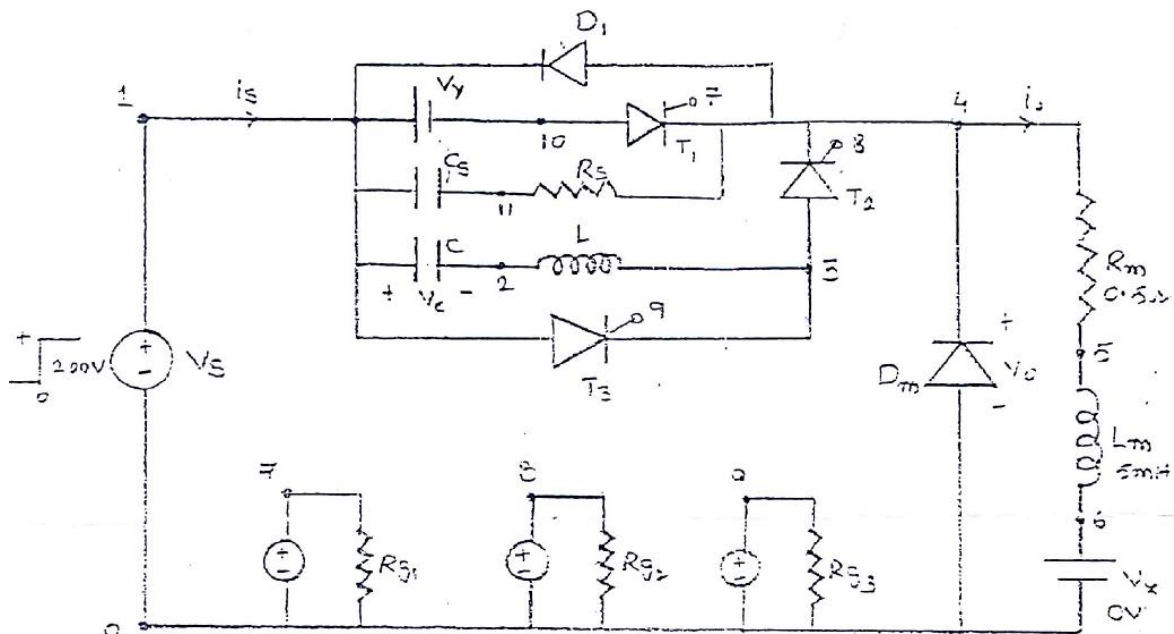


Fig - 16.1 Circuit Diagram of PSPICE Simulation of Resonant Pulse Commutation Circuit

16. A.4 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 spice 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.

16. A.5 PROGRAM CODE:

```

CLC
VS 1 0 DC 200V
VG1 7 0 PULSE (0V 100V 0 1US 1US 0.4MS 1MS)
VG2 8 0 PULSE (0V 100V 0.4MS 1US 1US 0.6MS 1MS)
VG3 9 0 PULSE (0V 100V 0.1US 1US 1US 0.2MS 1MS)
RG1 7 0 10MEG
RG2 8 0 10MEG
RG3 9 0 10MEG
CS 10 11 0.1UF
RS 11 4 750
C 1 2 31.2UF IC=200V
L 2 3 6.4UH
D1 4 1 DMOD
DM 0 4 DMOD
.MODEL DMOD D(IS=1E-25 BV=1000V)
RM 4 5 0.5
LM 5 6 5MH
VX 6 0 DC 0V
VY 1 10 DC 0V
XT1 10 4 7 0 DCSCR
XT2 3 4 8 0 DCSCR
XT3 1 3 9 0 DCSCR

```

```
.SUBCKT DCSCR 1 2 3 4
DT 5 2 DMOD
ST 1 5 3 4 SMOD
.MODEL DMOD D (IS=1E-25 BV=1000V)
.MODEL SMOD VSWITCH (RON=0.1 ROFF=10E+6 VON=10 VOFF=5V)
.ENDS DCSCR
.TRAN 0.5US 3MS 1.5MS 0.5US
.PROBE
.END

PLOT I (C ) AND V(2)
```

16. A.6 RESULT:

16. A.7 PRE LAB VIVA QUESTIONS:

1. What is mean by Commutation?
2. What is mean by Resonant Commutation?
3. Explain Resonant Pulse Commutation.

16. A.8 POST LAB VIVA QUESTIONS:

1. What are the applications of Resonant pulse Commutation?

EXPERIMENT – 16 (B)

PSPICE SIMULATION OF BUCK CHOPPER

16. B.1 AIM:

To obtain the performance characteristics of BUCK CHOPPER

16. B.2 APPARTUS:

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

16. B.3 CIRCUIT DIAGRAM:

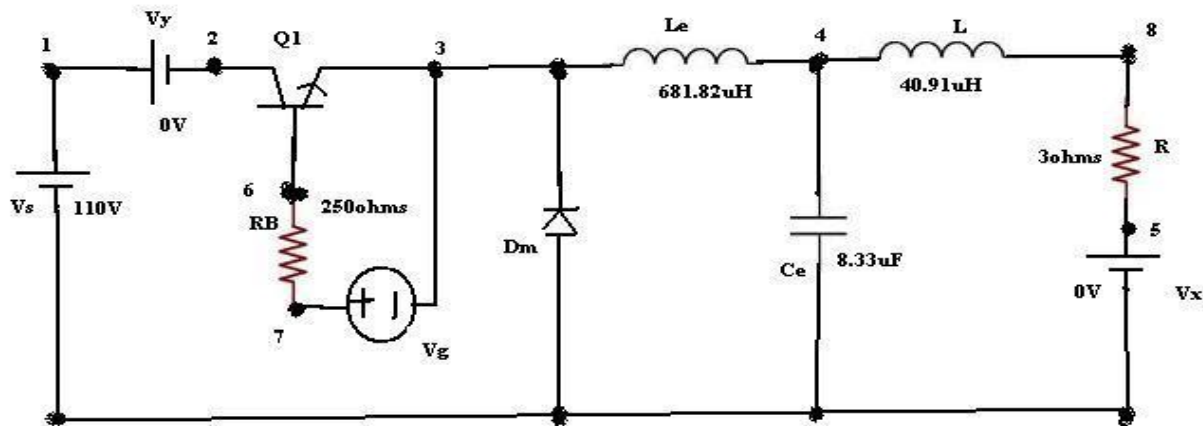


Fig – 16.2 Circuit Diagram of PSPICE Simulation of Buck Chopper

16. B.4 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 spice 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.

16. B.5 PROGRAM CODE:

```

CLC
VS 1 0 DC 110V
VY 1 2 DC 0V
VG 7 3 PULSE (0V 20V 0 0.1NS 0.1NS 27.28US 50US)
RB 7 6 250
LE 3 4 681.82UH
CE 4 0 8.33UF IC=60V
L 4 8 40.91UH
R 8 5 3
VX 5 0 DC 0V
DM 0 3 DMOD
.MODEL DMOD D (IS=2.2E-15 BV=1800V TT=0)
Q1 2 6 3 QMOD
.MODEL QMOD NPN (IS=6.734F BF=416.4 BR=0.7371 CJC=3.638P CJE=4.493P
TR=239.5N TF=301.2P)
.TRAN 1US 1.6MS 1.5MS 1US UIC
.PROBE
.FOUR 20KHZ I (VY)
.END
PLOT I (LE) I(VX) V4

```

16. B.6 RESULT:

16. B.7 PRE LAB VIVA QUESTIONS:

1. What is mean by Buck Chopper?
2. What is the difference between the Buck and Boost Chopper?
3. What are the applications of Buck Chopper?
4. What are the applications of Boost Chopper?

16. B.8 POST LAB VIVA QUESTIONS:

1. What is the output voltage equation for step up chopper?
2. Define duty cycle.
3. What is the output voltage equation for step down chopper?
4. What is the output voltage equation for step up / down chopper?

EXPERIMENT – 17

PSPICE SIMULATION OF SINGLE PHASE INVERTER WITH PWM CONTROL

17.1 AIM:

To obtain the performance characteristics of single phase inverter with PWM control.

17.2 APPARATUS:

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

17.3 CIRCUIT DIAGRAM:

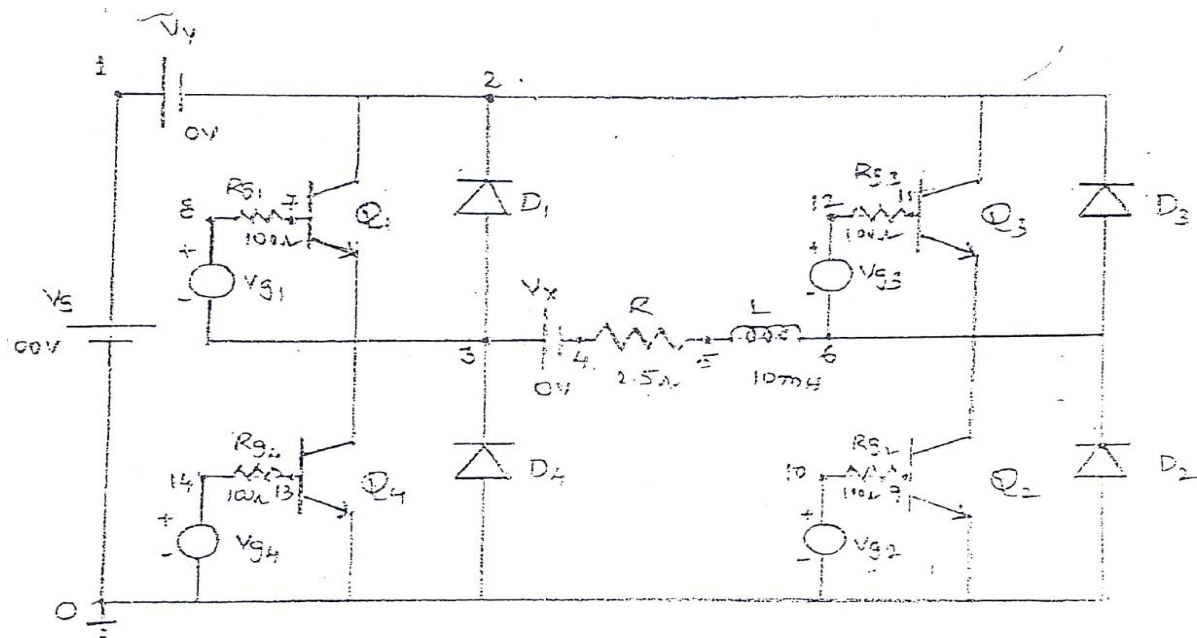


Fig - 17.1 Circuit Diagram of PSPICE Simulation of Single Phase Inverter

17.4 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.

17.5 PROGRAM CODE:

```

VS 1 0 DC 100V
VT 17 0 PULSE (50V 0V 0 833.33US 833.33US 1NS 1666.67US)
RT 17 0 2MEG
VC1 15 0 PULSE (0 -30V 1NS 1NS 8333.33US 1666.67US)
RC1 15 0 2MEG
VC3 16 0 PULSE (0 -30V 8333.33US 1NS 1NS 8333.33US 16666.67US)
RC3 16 0 2MEG
R 4 5 2.5
L 5 6 10MH
VX 3 4 DC 0V
VY 1 2 DC 0V
D1 3 2 DMOD
D2 0 6 DMOD
D3 6 2 DMOD
D4 0 3 DMOD
.MODEL DMOD D(IS=2.2E-15 BV=1800V TT=0)
Q1 2 7 3 QMOD
Q2 6 9 0 QMOD
Q3 2 11 6 QMOD
Q4 3 13 0 QMOD
.MODEL QMOD NPN(IS=6.74F BF=416.5 CJC=3.638P CJE=4.451P)
RG1 8 7 100

```

```
RG2 10 9 100
RG3 12 11 100
RG4 14 13 100
*SUBCKT CALL FOR PWM CONTROL
XPW1 17 15 8 3 PWM
XPW2 17 15 10 0 PWM
XPW3 17 16 12 6 PWM
XPW4 17 16 14 0 PWM
.SUBCKT PWM 1 2 3 4
*model ref carrier +control -control
R1 1 5 1K
R2 2 5 1K
RIN 5 0 2MEG
RF 5 3 100K
R0 6 3 75
C0 3 4 10PF
E1 6 4 0 5 2E+5
.ENDS PWM
.TRAN 10US 16.67MS 0 10US
.PROBE
.options abstol=1.00n reltol=0.01 vntol=0.1 itl5=20000
.FOUR 60HZ V(3,6)
.END
PLOT V (14) I(VX) I(vy)V(10)
```

17.6 RESULT:

17.7 PRE LAB VIVA QUESTIONS:

1. What is the function of inverter?
2. What is meant by carrier wave form in PWM control?
3. What are the control strategies for inverter?

17.8 POST LAB VIVA QUESTIONS:

1. What are the advantages of PWM inverter?
2. What are the applications of PWM inverter?
3. What are the advantages of simulation using PSPICE?