DRONACHARYA
Group of Institutions

POWER ELECTRONICS

LABORATORY MANUAL

B.Tech. Semester

Subject Code: BEE-653

Session: 2024-25, Even Semester

Name:	
Roll. No.:	
Group/Branch:	

DRONACHARYA GROUP OF INSTITUTIONS
DEPARTMENT OF EEE

#27 KNOWLEDGE PARK 3

GREATER NOIDA

AFFILATED TO Dr. ABDUL KALAM TECHNICAL UNIVERSITY,LUCKNOW

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Vision and Mission of the Institute

Vision:

"Instilling core human values and facilitating competence to address global challenges by providing Quality Technical Education."

Mission:

M1 - Enhancing technical expertise through innovative research and education, fostering creativity and excellence in problem-solving.

M2 - Cultivating a culture of ethical innovation and user-focused design, ensuring technological progress enhances the well-being of society.

M3 - Equipping individuals with the technical skills and ethical values to lead and innovate responsibly in an ever-evolving digital landscape

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Vision and Mission of the Department

Vision:

"To be a Centre of Excellence in Globalizing Education and Research in the field of Electrical and Electronics Engineering."

Mission:

M1: To empower technocrats with state-of-art knowledge to excel as eminent electrical engineers with multi-disciplinary skills.

M2: To emphasize social values and leadership qualities to meet the industrial needs, societal problems and global challenges**.**

M3: To enable the technocrats to accomplish impactful research and innovations.

Programme Educational Objectives (PEOs)

PEO1: To foster strong knowledge in basic sciences and electrical engineering that enable technocrats to have successful careers**.**

PEO2: Imbibed with the state of art knowledge to adapt ever transforming technical scenario.

PEO3: Inspire engineers to provide innovative solutions to real-world challenging problems by applying electrical and electronics engineering principles.

Programme 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, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, 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, and 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.

Program Specific Outcomes (PSOs)

PSO1: Graduates will be capable to gain knowledge in diverse areas of electrical and electronics engineering and apply that to a successful career, entrepreneurship and higher education.

PSO2: Enhance the competence of graduates to design and analyze systems used in advanced power applications, renewable energy, electrical drives in allied technical fields.

PSO3. Graduate will use advance tools to analyze, design and develop electrical and electronic systems for feasible operation and meet the industry requirements.

University Syllabus

1. To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor
2. To study V-I characteristics of SCR and measure latching and holding currents.
3. To compare the R, RC & UJT trigger circuit for SCR.
4. To study the commutation circuit for SCR.
5. To study single phase fully controlled bridge rectifiers with resistiveand inductive loads.
6. To study single phase fully controlled bridge rectifiers with DC motor load.
7. To study three-phase fully controlled bridge rectifier with resistive and inductive loads.
8. To study single-phase ac voltage regulator with resistive and inductive loads.
9. To study single phase cyclo-converter
10. To study the four quadrant operation of chopper circuit
11. To study MOSFET/IGBT based single-phase bridge inverter.

Software based experiments (Scilab/MATLAB or any equivalent open source software)

12. To obtain the simulation of single phase half wave controlled rectifier with R and RL load and plot load voltage and load current waveforms.
13. To obtain simulation of single phase fully controlled bridge rectifier and plot load voltage and load current waveform for inductive load
14. To obtain simulation of single phase full wave ac voltage controller and draw load voltage And load current waveforms for inductive load.
15. To obtain simulation of step down dc chopper with L-C output filter for inductive load and determine steady-state values of output voltage ripples in output voltage and load current.

Course Outcomes (COs)

Upon successful completion of the course, the students will be able to:

CO1	Demonstrate the characteristics and triggering of IGBT, MOSFET, Power transistor and SCR.
CO2	Analyze the performance of single phase fully controlled bridge rectifiers under different loading conditions
CO3	Develop simulation models of power electronic circuits.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
	3	-	-	3	2	-	-	-	1	1	-	2
	3	2	1	-	-	-	-	-	2	2	-	2
	2	2	2	-	2	-	-	-	1	1	-	1
Course Correlation mapping	**2.2**	**1.4**	**1.6**	**1.6**	**1.2**	**-**	**-**	**-**	**1.2**	**1.2**	**-**	**1.8**

CO-PSO Mapping

	PSO1	**PSO2**	**PSO3**
CO 1	2	3	2
CO 2	2	3	2
CO 3	2	3	2

Course Overview

1. To know the behavior of Power semiconductor devices and compare their performances.
2. To know how to synthesize a power converter using power electronics equipment.

List of Experiments mapped with COs

Si No.	Name of the Experiment	Course Outcome
1	To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor	CO 1
2	To study V-I characteristics of SCR and measure latching and holding currents.	CO 1
3	To study the output and transfer characteristics of MOSFET	CO 2
4	To Study Single Phase Half Controlled Bridge Converter	CO 2
5	To study three-phase fully controlled bridge rectifier with resistive and inductive loads.	CO 3
6	To study single-phase ac voltage regulator with resistive and inductive loads.	CO 2
7	To study single phase cyclo-converter	CO 4
8	To study MOSFET/IGBT based single-phase bridge inverter	CO 2
9	To obtain the simulation of single-phase half wave-controlled rectifier with R and RL load and plot load voltage and load current waveforms.	CO 3
10	To obtain simulation of single phase fully controlled bridge rectifier and plot load voltage and load current waveform for inductive load.	CO 2

DOs and DON'Ts

DOs

1. Login-on with your username and password.
2. Log off the computer every time when you leave the Lab.
3. Arrange your chair properly when you are leaving the lab.
4. Put your bags in the designated area.
5. Ask permission to print.

DON'Ts

1. Do not share your username and password.
2. Do not remove or disconnect cables or hardware parts.
3. Do not personalize the computer setting.
4. Do not run programs that continue to execute after you log off.
5. Do not download or install any programs, games or music on computer in Lab.
6. Personal Internet use chat room for Instant Messaging (IM) and Sites is strictly prohibited.
7. No Internet gaming activities allowed.
8. Tea, Coffee, Water & Eatables are not allowed in the Computer Lab.

General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as fire wood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.
4. Immediately call medical emergency and security. Remember! Time is critical; be best.

Precautions (In case of Fire)

1. Turn the equipment off. If power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire, if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.
4. Call security and emergency department immediately:

Emergency : 201 (Reception)

Security : 231 (Gate No.1)

Guidelines to students for report preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows: -

1) All files must contain a title page followed by an index page. ***The files will not be signed by the faculty without an entry in the index page.***

2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.

3) For each experiment, the record must contain the following

(i) Aim/Objective of the experiment

(ii) Pre-experiment work (as given by the faculty)

(iii) Lab assignment questions and their solutions

(iv) Test Cases (if applicable to the course)

(v) Results/ output

Note:

1. Students must bring their lab record along with them whenever they come for the lab.

2. Students must ensure that their lab record is regularly evaluated.

Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute CO attainment as well as internal marks in the lab course.

Grading Criteria	**Exemplary (4)**	**Competent (3)**	**Needs Improvement (2)**	**Poor (1)**
AC1: Designing experiments	The student chooses the problems to explore.	The student chooses the problems but does not set an appropriate goal for how to explore them.	The student fails to define the problem adequately.	The student does not identify the problem.
AC2: Collecting data through observation and/or experimentation	Develops a clear procedure for investigating the problem	Observations are completed with necessary theoretical calculations and proper identification of required components.	Observations are completed with necessary theoretical calculations but without proper understanding. Obtain the correct values for only a few components after calculations. Followed the given experimental procedures but obtained results with some errors.	Observations are incomplete. Lacks the appropriate knowledge of the lab procedures.
AC3: Interpreting data	Decides what data and observations are to be collected and verified	Can decide what data and observations are to be collected but lacks the knowledge to verify	Student decides what data to gather but not sufficient	Student has no knowledge of what data and observations are to be collected
AC4: Drawing conclusions	Interprets and analyses the data in order to propose viable conclusions and solutions	Incomplete analysis of data hence the quality of conclusions drawn is not up to the mark	Cannot analyse the data or observations for any kind of conclusions.	Lacks the required knowledge to propose viable conclusions and solutions
AC5: Lab record assessment	Well-organized and confident presentation of record & ability to correlate the theoretical concepts with the concerned lab results with appropriate reasons.	Presentation of record is acceptable	Presentation of record lacks clarity and organization	No efforts were exhibited

LAB EXPERIMENT

EXPERIMENT 1

OBJECTIVE: To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor

APPARATUS REQUIRED:

S. no.	Name of equipments/components	Specification	Range/Rating	Qty.
1	IGBT, MOSFET & Power Transistor Trainer Kit	-	-	1
2	Patch chords	-	-	
3	DC Voltmeter	-	Digital	1
4	DC Ammeter	-	Digital	1

BRIEF THEORY:

The meaning of IGBT, MOSFET & Power Transistoris to switch on the concerning components. Switch on means in the case of IGBT collector to emitter should fully internally shorted i.e., voltage between emitter and collector should be almost zero or few milli volts and in the case of non-triggering conditions emitter to collector internally totally open circuit. In the field the requirement is to operate many or at least two IGBTs at a time. To make proper electrically isolation in between triggering pulses is required here we will be discussed the same. Such type of triggering circuit is use for MOSFET and for power transistor more current is required so driver amplifier is used to drive the power transistor.

Gate Frequency Generation: The Gate frequency generation circuit is given in Fig-'1'. To operate Gate wave circuit +5 V DC is developed through diode D1, D2, D3, D4, C3,C4 and IC 5. IC_1 is a stable multi vibrator VR1 to control its frequency. It will give the output from pin no. 3 and fed to IC2 that is JK flip-flop and its output will come through pin no. 14 & pin no. 15. The frequency at 14 and 15 will half a stable multivibrator frequency. The output from pin no. 15 will feed to opto coupler IC3 and output of opto coupler is fed to driver transistor T1. The output of T1 will be fed to the base of power transistor T2, the process will same as IC3 and T1. The difference between them pins no 15 of IC2 will at 0^o and pin no 14 of IC 2 will at 180^o.

For electric isolation every opto coupler is required separate isolated 12 V supply, so it also given in diagram.

Triggering of IGBT:

To triggering of IGBT, its required emitter to gate voltage approximates 10 V DC. To operate at a time many IGBTs, electrically isolation is required. So, it's necessary to use opto coupler for triggering of IGBTs at a time with perfect electrically isolation. IGBT is volt- age operated device so voltage with current is not required the gate current almost negligible. The output voltage from opto coupler is sufficient to trigger IGBT.

The gate of IGBT should never hang in air. Because due to available voltage in air the IGBT may partially ON and may heat & damage so its Gate to emitter a high ohmic resistance approximate 10K is hard coupled. The IGBTs is the combination of MOSFET &power transistor to use at high voltage switching.

Triggering of MOSFET:

All features to trigger the MOSFET is same as IGBT, only difference is MOSFET is used for low voltage switching. Safety measures 10 K resistance is also required. Source to gate voltage approximate 10 V DC is required. Same electrically isolation is required which is operate by opto coupler.

Triggering of Power Transistor:

Transistor is current operated device to switching it the requirement is low voltage but few milli amps current also. The output of opto coupler is fed to a driver transistor and transistor will provide sufficient power to a drive a power transistor. Power transistor mostly used for high voltage and high frequency switching.

Circuit diagram

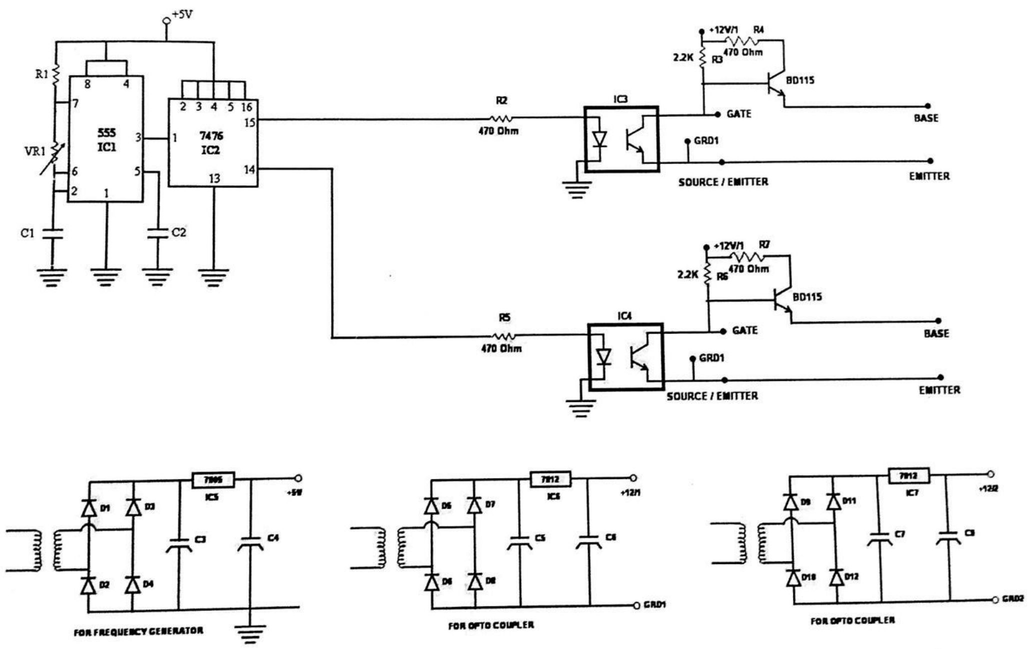


FIG-'1' : TRIGGERING CIRCUIT DIAGRAM FOR IGBT, MOSFET & POWER TRANSISTOR

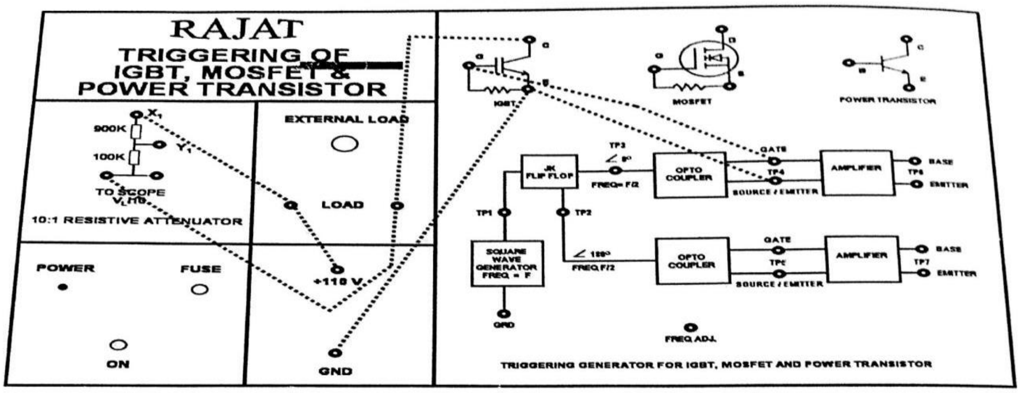


FIG – '3'

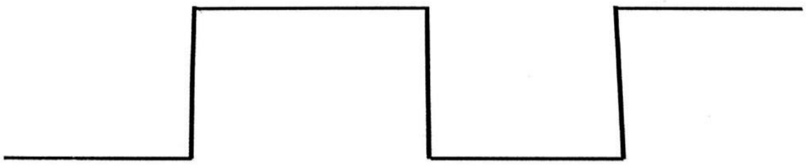


FIG – '4'

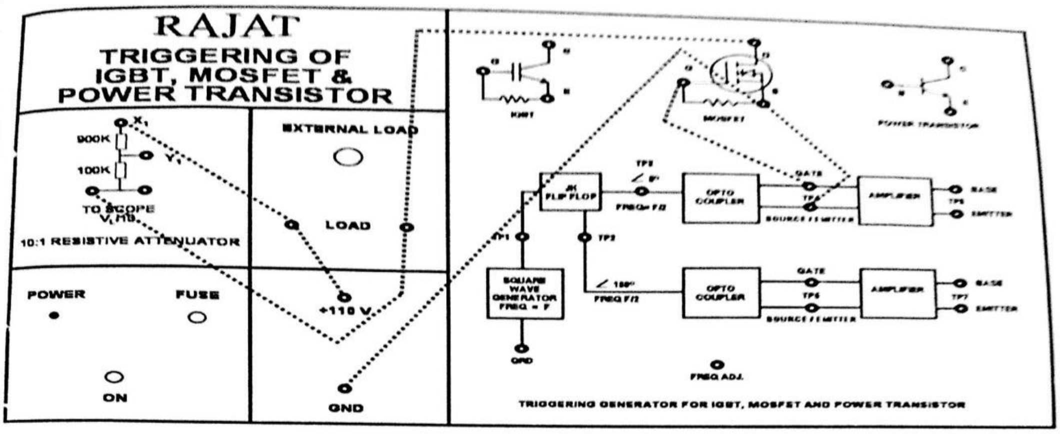


FIG – '5'

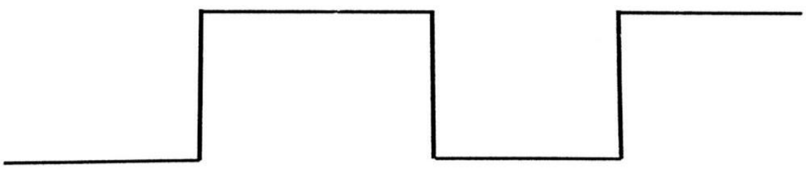


FIG – '6'

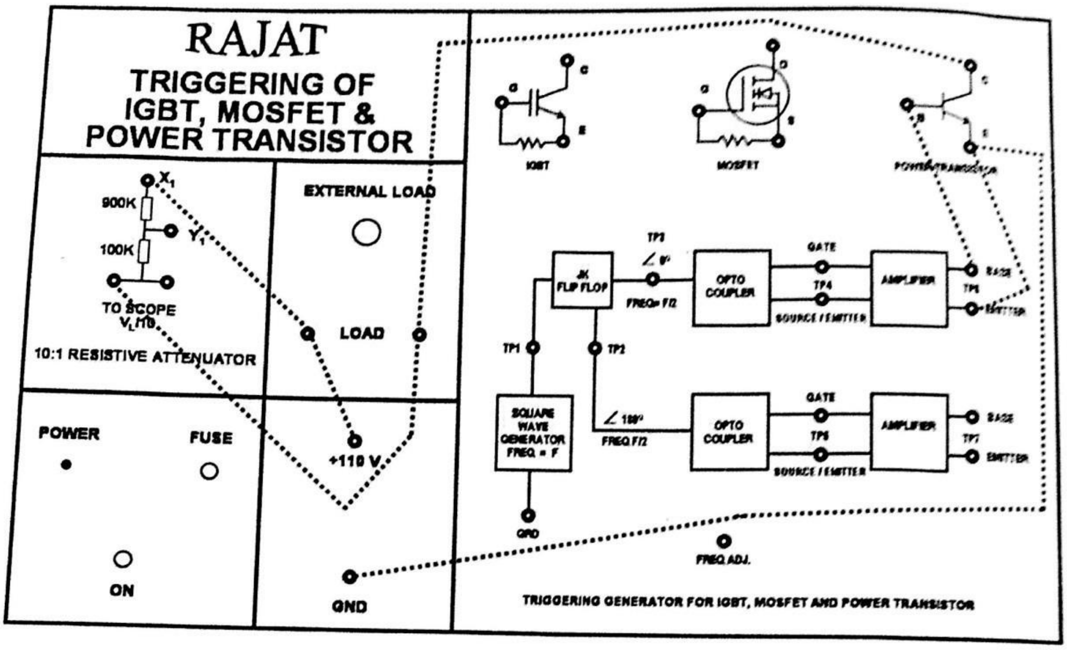


FIG – '7'

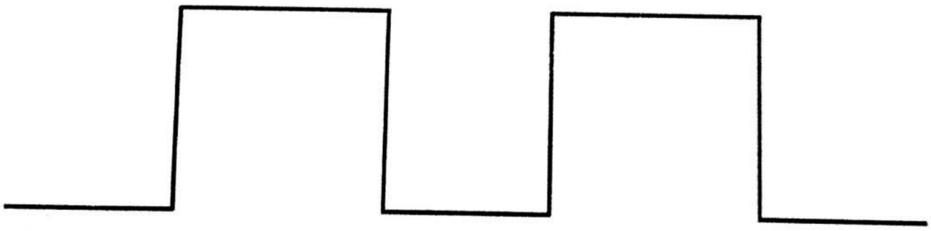


FIG – '8'

RESULT:

PROCEDURE:

1. Keep all positions at minimum.
2. Set Anode to Cathode voltage V_{AK} to some volts say 15V.
3. Now slowly vary the V_G 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.

Viva Questions:

1. What is a Thyristor? Draw the structure of an SCR?
2. What are the different methods of turning on 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?
8. Why is V_{bo} greater than V_{br}?
9. Why does high power dissipation occur in reverse blocking mode?
10. Why shouldn't positive gate signal be applied during reverse blocking Mode?
11. Explain reverse current Irev..
12. What happens when gate drive is applied?
13. Why should the gate signal be removed after turn on?
14. Is a gate signal required when reverse biased?
15. What are applications of SCR?

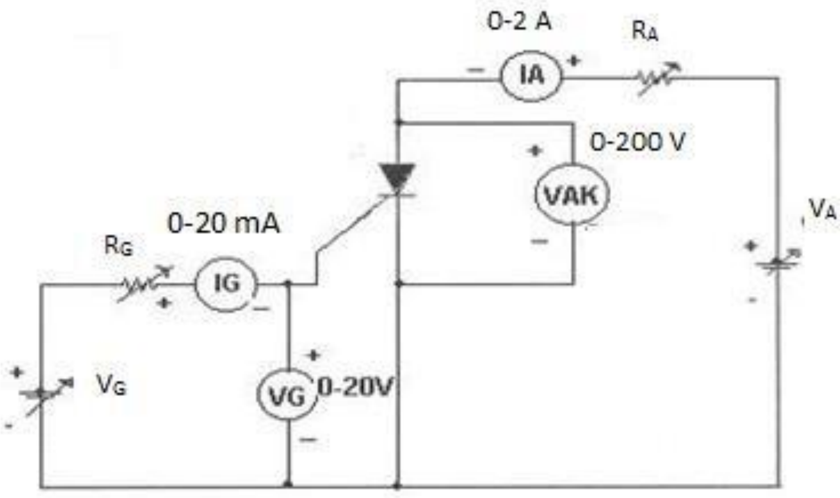
EXPERIMENT 2

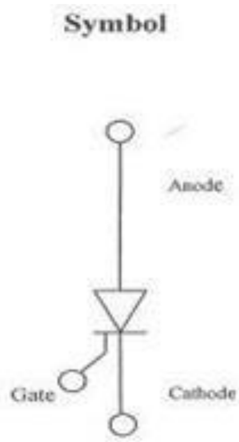
OBJECTIVE: To plot the V - I Characteristics of SCR.

APPARATUS REQUIRED:

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

CIRCUIT DIAGRAM:





Study of Characteristics of SCR

PROCEDURE:

V - I CHARACTERISTICS:

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

GATE TRIGGRING AND FINDING V_G AND I_G:-

1. Keep all positions at minimum.

2. Set Anode to Cathode voltage V_{AK} to some volts say 15V.
3. Now slowly vary the V_G 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:

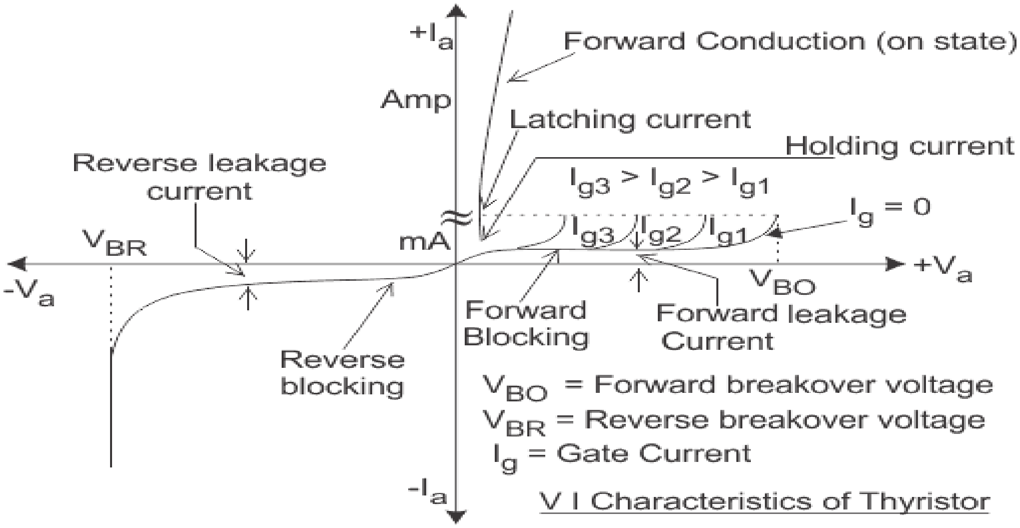
1. Keep R_2 at middle position.
2. Apply 20V to the Anode to cathode by varying V_2.
3. Rise the Vg voltage by varying V_G till the device turns ON indicated by sudden rise in I_A. At what current SCR trigger it is the minimum gate current required to turn ON the SCR.
4. Now set R_A at maximum position, then SCR turns OFF, if it is not turned off reduce V_A

   up to turn off the device and put the gate voltage.
5. Now decrease the R_A slowly, to increase the Anode current gradually in steps.
6. At each and every step, put OFF and ON the gate voltage switches V_G. 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 R_A & V_A.
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 $I_H < I_L$.

MODEL GRAPH:



V- I Characteristics of SCR

RESULT:

VIVA QUESTIONS:

1. What are modes of working of an SCR?
2. Draw the V-I characteristics of SCR.
3. Differentiate between holding and latching currents.
4. Why is dv /dt technique not used for triggering?
5. Why is V_{bo} greater than V_{br}?
6. Why does high power dissipation occur in reverse blocking mode?
7. Why shouldn't positive gate signal be applied during reverse blocking Mode?
8. Explain reverse current I_{rev}..
9. What happens when gate drive is applied?
10. Why should the gate signal be removed after turn on?
11. Is a gate signal required when reverse biased?
12. What are applications of SCR?

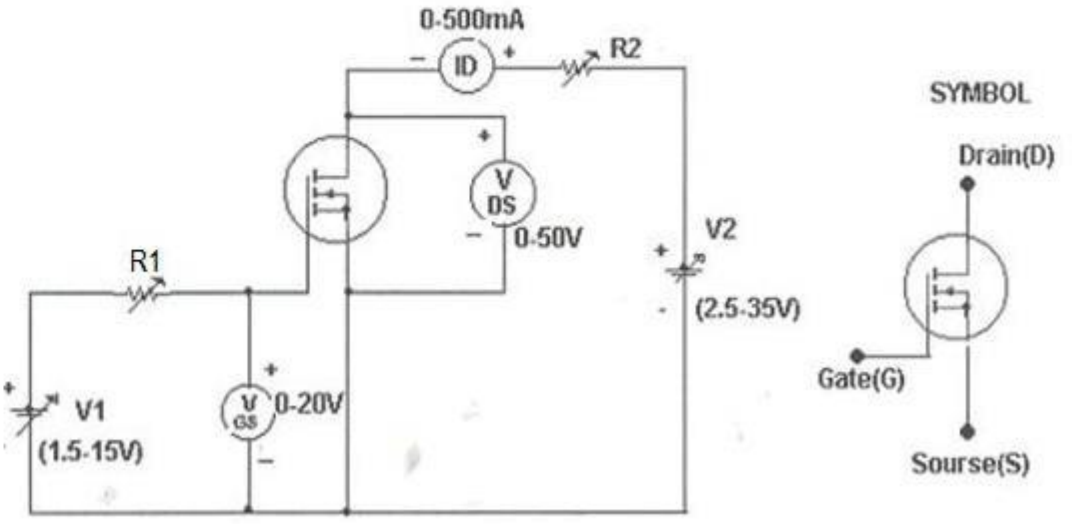
EXPERIMENT 3

OBJECTIVE: To study the output and transfer characteristics of MOSFET

APPARATUS REQUIRED:

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

CIRCUIT DIAGRAM:



Study of Characteristics of MOSFET

PROCEDURE:

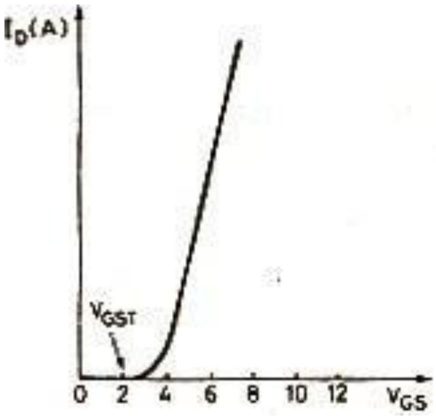
TRANSFER CHARACTERISTICS:

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}.

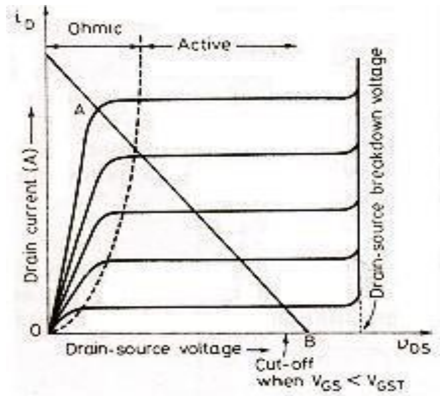
OUTPUT CHARACTERISTICS:

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}

MODEL GRAPH:



Transfer Characteristic of MOSFET



Output Characteristics of MOSFET

V- I Characteristics of SCR

TABULAR COLUMN:

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

S. No	V_{GS} = VOLTS	
	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		

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

RESULT:

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?

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?

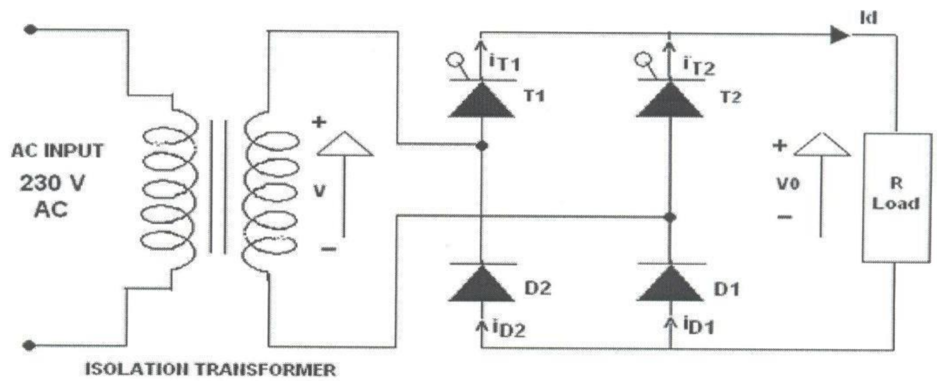
EXPERIMENT – 4

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

APPARATUS:

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

CIRCUIT DIAGRAM:



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 IRSswitch and trigger output ON switch.

5. Connect CRO probes and observe waveforms in CRO, Ch-1 or Ch-2, across load anddevice 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 allwaveforms and readings as same as above.
10. Observe the various waveforms at different points in circuit by varying the Resistive Loadand Inductive Load.
11. Calculate the output voltage and current by theoretically and compare with it practicallyobtained values.

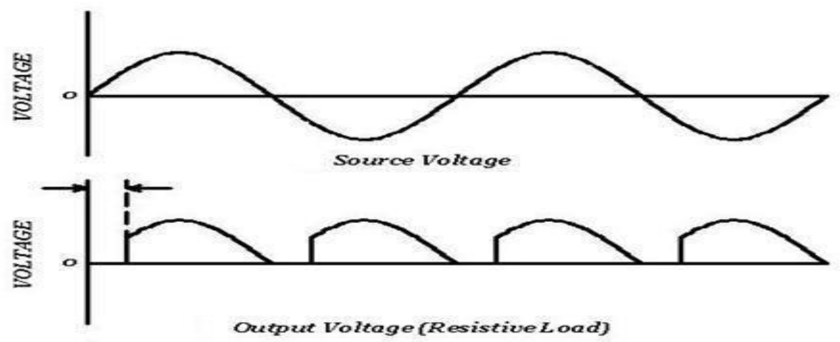
TABULAR COLUMN:

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

MODEL GRAPH:



Output Wave Forms of Single Phase Half Controlled Bridge Converter

RESULT:

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?

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?

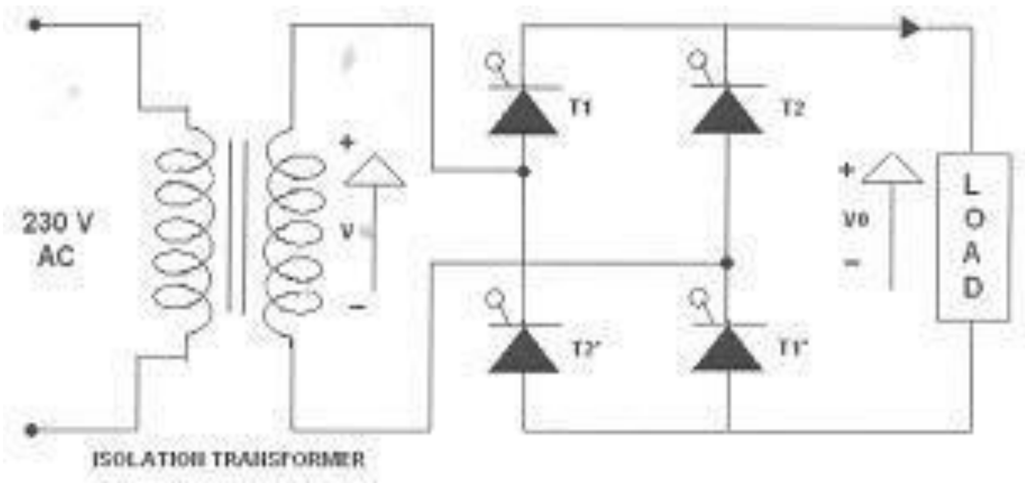
EXPERIMENT – 5

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

APPARATUS:

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

CIRCUIT DIAGRAM:



Single 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 IRSswitch and trigger output ON switch.

5. Connect CRO probes and observe waveforms in CRO across load and device in singlephase 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 allwaveforms and readings as same as above.
10. Observe the various waveforms at different points in circuit by varying the Resistive Loadand Inductive Load.
11. Calculate the output voltage and current by theoretically and compare with it practicallyobtained values.

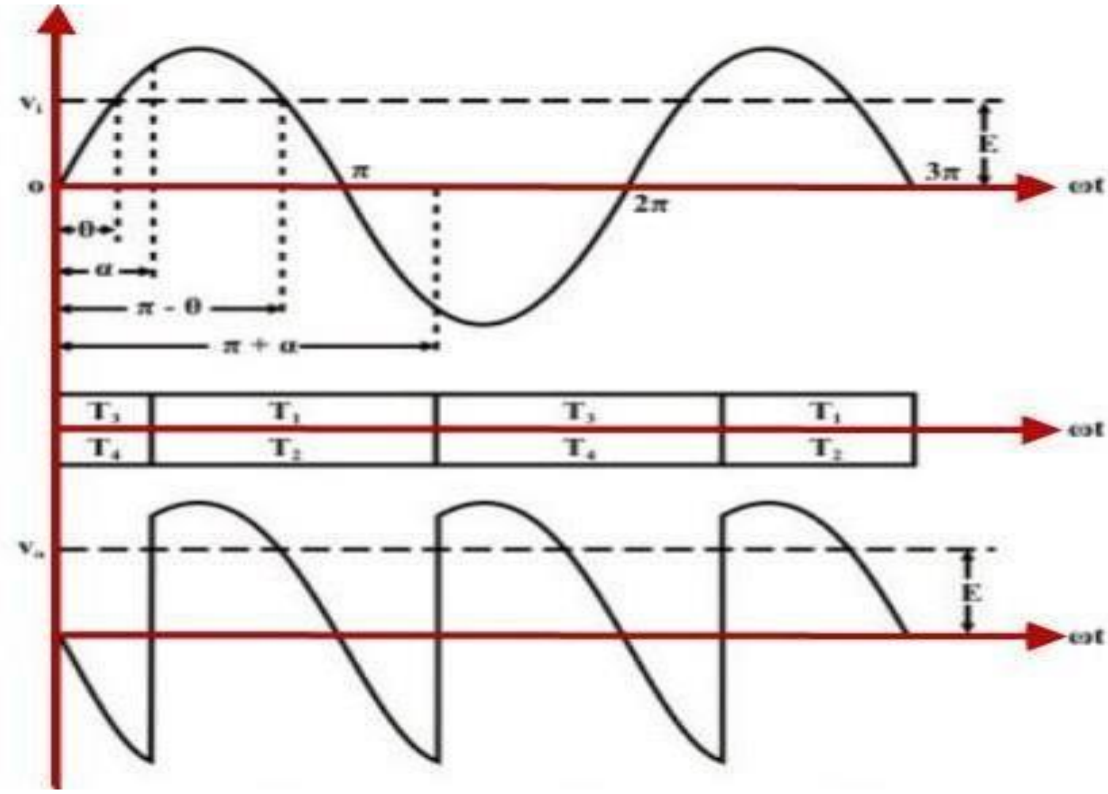
TABULAR COLUMN:

S. No	Input Voltage (Vin)	Firing anglein Degrees	Output voltage (V0)		Output Current (I0)	
			Theoretical	Practical	Theoretical	Practical
1						
2						
3						
4						
5						
6						

MODEL CALCULATIONS:

	For R-L Load:	For R Load:
V0	= (2√2V/∏) * Cos α	V0 = (√2V/∏) * (1+Cos α)
I0 α	= (2√2V/∏R) * Cos α = Firing Angle	I0 = (√2V /∏R) * (1+Cosα)
V	= RMS Value across transformer output	

MODEL GRAPH:



Single Phase Fully Controlled Bridge Converter

RESULT:

PRE LAB VIVA QUESTIONS:

1. What will happen if the firing angle is greater than 90 degrees?
2. What are the performance parameters of rectifier?
3. What is the difference between half wave and full wave rectifier?

POST LAB VIVA QUESTIONS:

1. If firing angle is greater than 90 degrees, the inverter circuit formed is called as?
2. What is DC output voltage of single phase full wave controller?

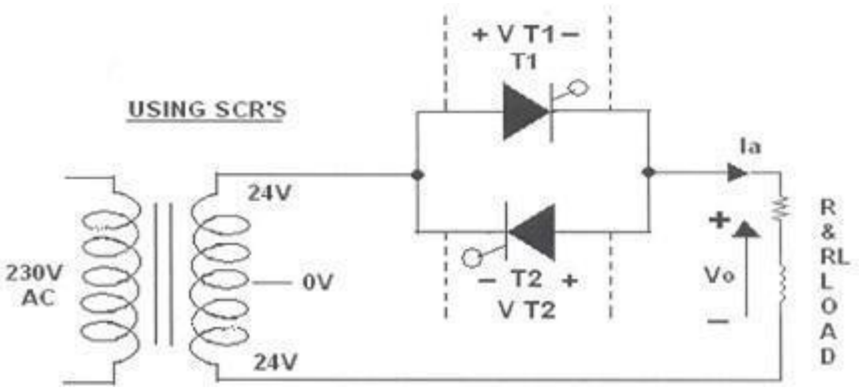
EXPERIMENT – 6

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

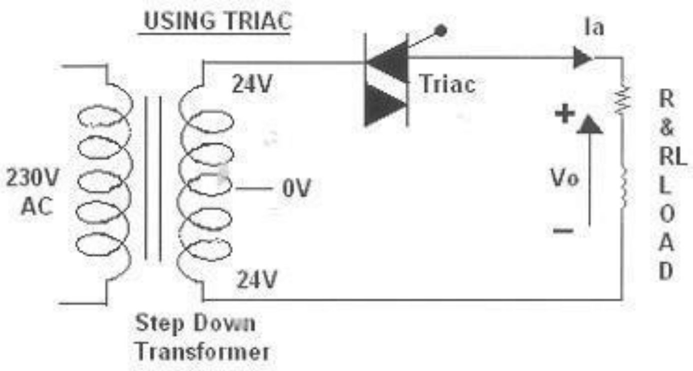
APPARATUS:

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

CIRCUIT DIAGRAM:



Single Phase AC Voltage Controller with Thyristors



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 IRSswitch 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 allwaveforms and readings as same as above.
9. Observe the various waveforms at different points in circuit by varying the Resistive Loadand Inductive Load.
10. Calculate the output voltage and current by theoretically and compare with it practicallyobtained 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 IRSswitch 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 allwaveforms and readings as same as above.
9. Observe the various waveforms at different points in circuit by varying the Resistive Loadand Inductive Load.
10. Calculate the output voltage and current by theoretically and compare with it practicallyobtained 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						

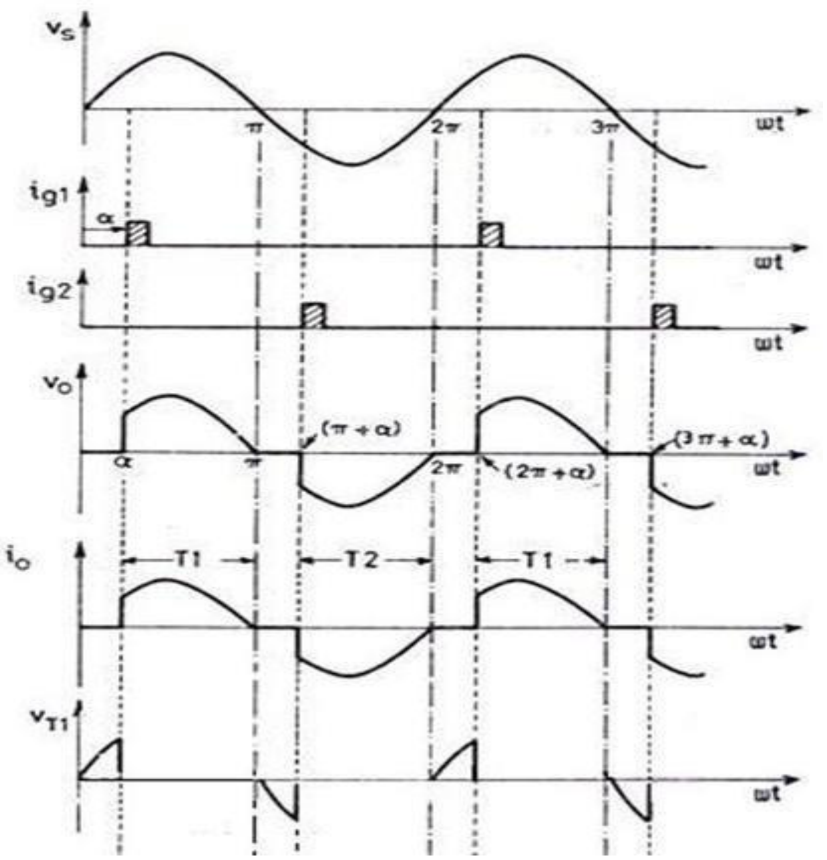
MODEL CALCULATIONS:

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

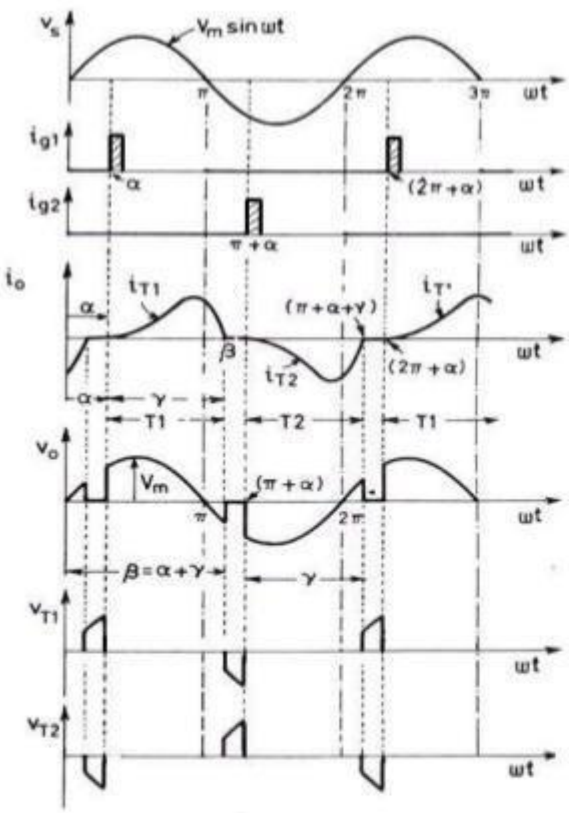
α = Firing Angle

V = RMS Value across transformer output

MODEL GRAPH:



Single Phase AC Voltage controller with R - Load



Single Phase AC voltage controller with RL Load

RESULT:

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?

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?

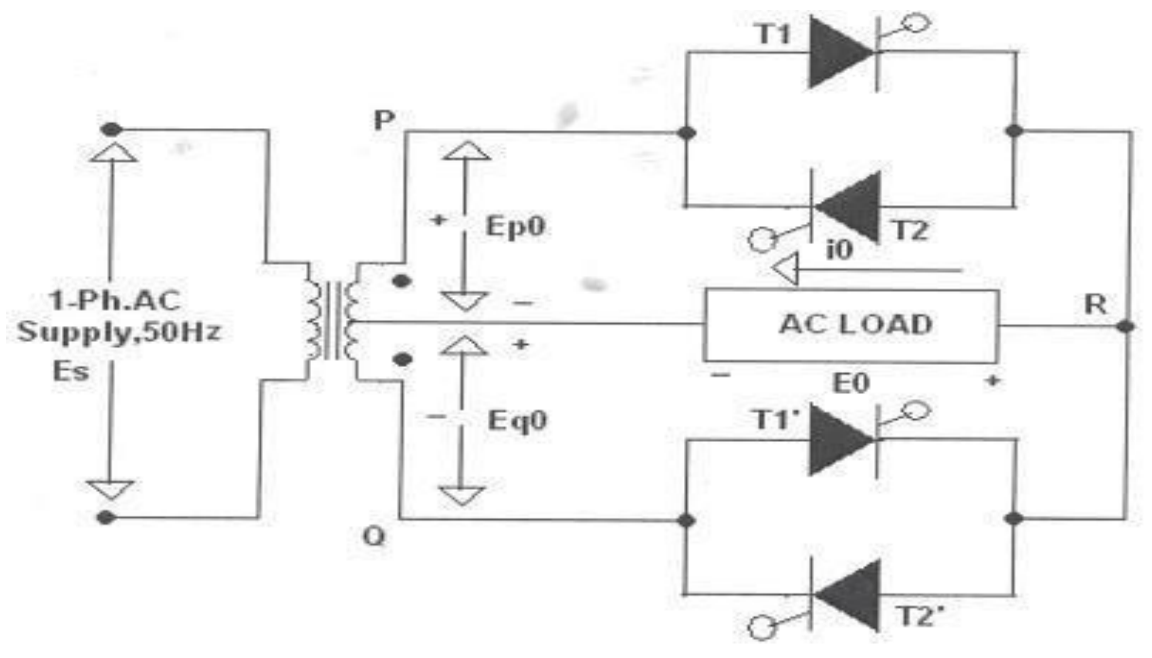
EXPERIMENT – 7

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

APPARATUS:

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

CIRCUIT DIAGRAM :



Circuit Diagram of Single Phase Cyclo – Converter

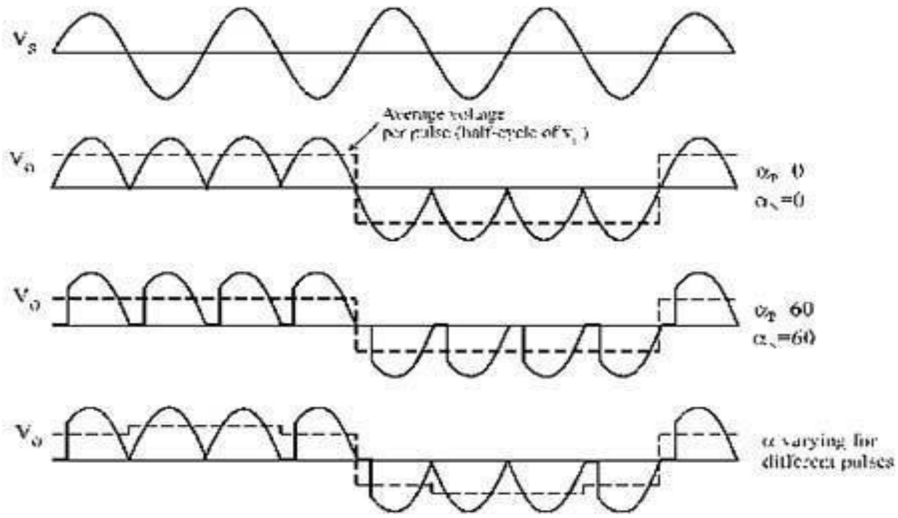
PROCEDURE:

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 andalso 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 allwaveforms and readings as same as above.
11. Observe the various waveforms at different points in circuit by varying the Resistive Loadand Inductive Load.
12. Calculate the output voltage and current by theoretically and compare with it practicallyobtained 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 GRAPH:



Output Wave Forms of Single Phase Cyclo – Converter

RESULT:

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?

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.

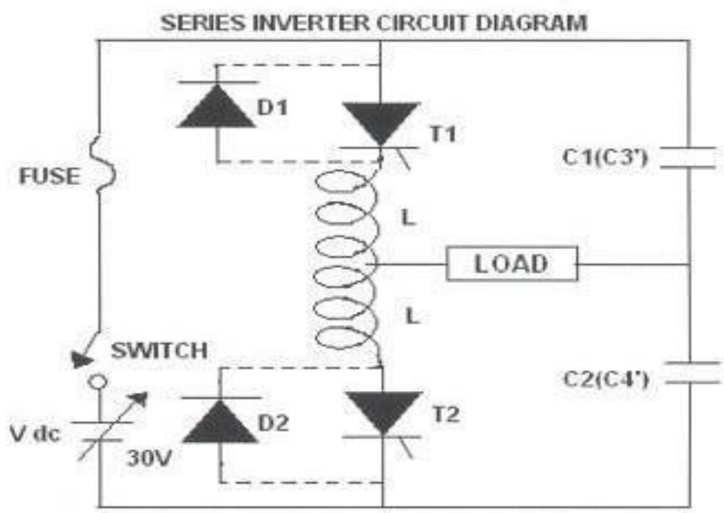
EXPERIMENT – 8

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 MODEL			
3	Patch chords and probes			
4	Regulated dc power supply			
5	Variable Rheostat			
6	Inductor			

CIRCUIT DIAGRAM:



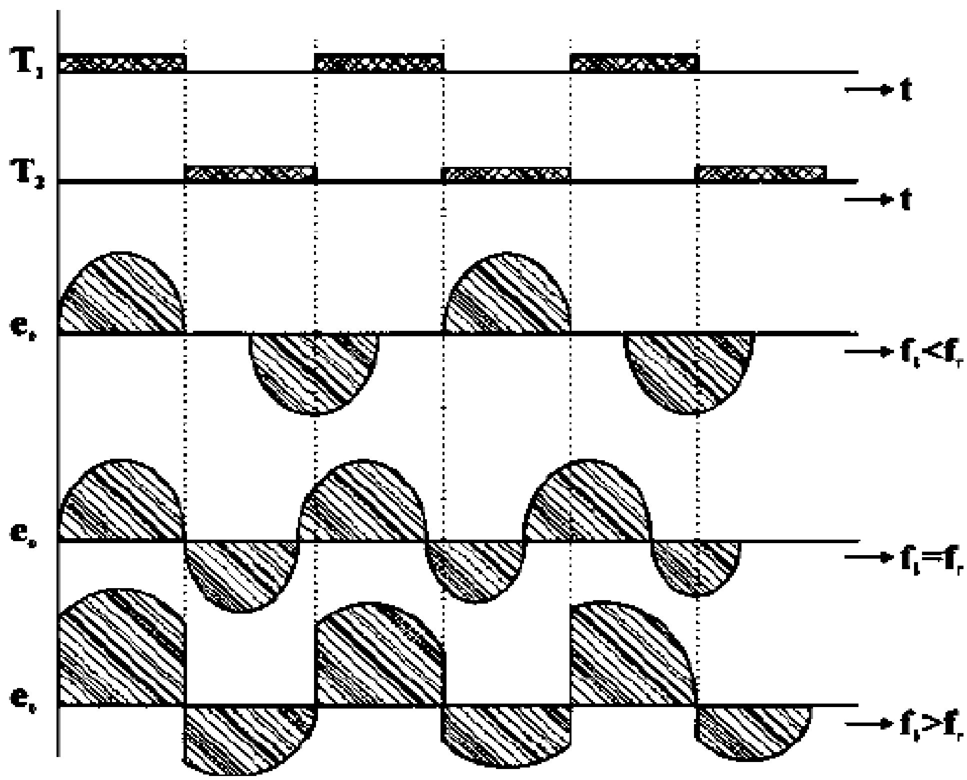
Circuit Diagram Single Phase Series Inverter

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 IRSswitch 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 tryagain.
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:



Output Wave Forms of Single Phase Series Inverter

RESULT:

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?

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?

Department of EEE 2024-25

Experiment No. 9

Objective:-Simulation of single phase half wave and full wave diode rectifier with R and R-L load onMATLAB

Software used:- MATLAB/Simulink

Theory:-

Single phase half wave rectifier:-

The circuit diagram of a single phase half wave rectifier is shown in figure (a). During the positive half cycle, diode is forward biased, it therefore conduct from ωt = 0 to Π. During the positive half cycle, output voltage v_o = source voltage v_s and load current $i_o = {v_o}/{R}$.At ωt = M, $v_o = 0$ and for R load,i_0 is also zero. As soon as v_s tends to become negative after wt = Π, diode D is reverse biased, it is therefore turned off and goes into blocking state .Output voltage as well as output current, are zero from $\omega t = M\ to\ 2M$. After $\omega t = M\ to\ 2M$. After ωt = 2Π, diode is again forward biased and conduction begins.

For a Resistive load, output current i_o has the same waveform as that of the output voltage v_0.Diode voltage $v_D$is zero when diode conducts.Diode is reverse biased from ωt =M to 2Π as shown. The waveform of $v_s, v_0\ and$ i_o .Here source voltage is sinusoidal i.e. $v_s = v_m$sinωt.

Rms value of output voltage,

$$V_{or} = [\frac{1}{2M}\int_0^M V_m^2 sin^2\omega t.d(\omega t)]$$

$$= \frac{V_m}{2}$$

Average Value of load current,

$$I_o = {V_o}/{R} = {V_m}/{MR}$$

Rms value of load current,

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

Single phase full wave rectifier:-

Primary function of full wave diode rectifier simulation is to establish a dc level from a sinusoidal input voltage that has zero voltage. Single phase supply, is a fully controlled bridge- circuit .In the bridge circuit, diagonally opposite pairs of diodes are made to conduct, and are commutated, simultaneously.

During the first positive half-cycle, diodes D1 and D2 are forward biased and if they are triggered simultaneously, then current flows through the path L-D1-R-D2-N. Hence, in the positive cycle, diodes D1 and D2 are conducting.

During the negative half cycle of the a.c. input, diodes D3 and D4 are forward biased and if they are triggered simultaneously, current flows through the path N-D3-R-D4-L. Diodes D1, D2 and D3, D4 are triggered at the same firing angle α in each positive and negative half-cycles of the supply voltage, respectively.

When the supply voltage falls to zero, the current also goes to zero. Hence, diodes D1 and D2 in positive half cycle and D3, D4 in negative half cycle turn off by natural commutation.

The related voltage and current waveforms for the circuit are shown in the figure given below the circuit diagram;

Procedure:-

1) Start the Matlab software.
2) Open a new simulation window by clicking on simulink button.
3) Window that appears in simulink library browser the window contains component that can be plotted into simulink or design window.
4) Drag & drop the components from library.
5) Run the simulation.

Figure:-

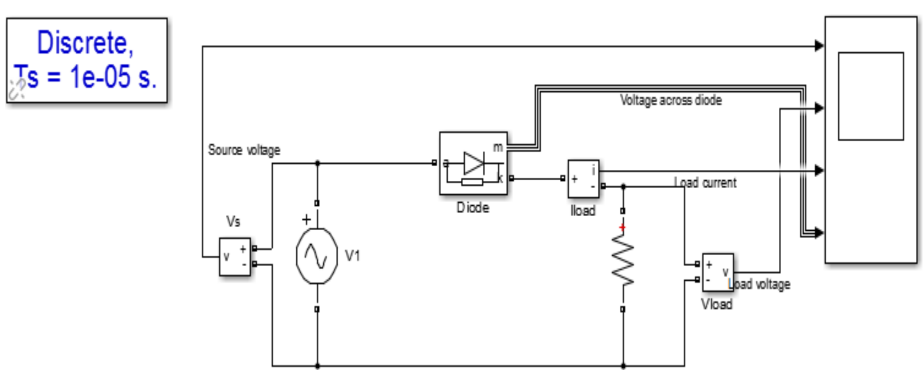


Figure 1 simulink model of half wave rectifier

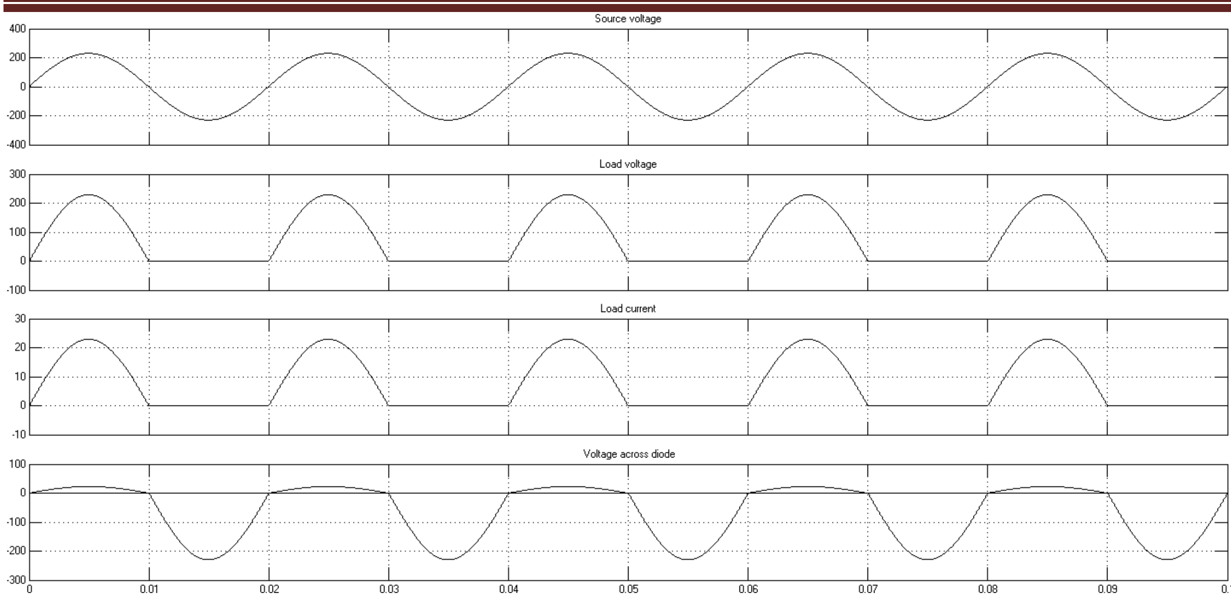


Figure 2 wave forms of half wave rectifier in terms of input voltage ,load voltage ,load current and voltage across diode

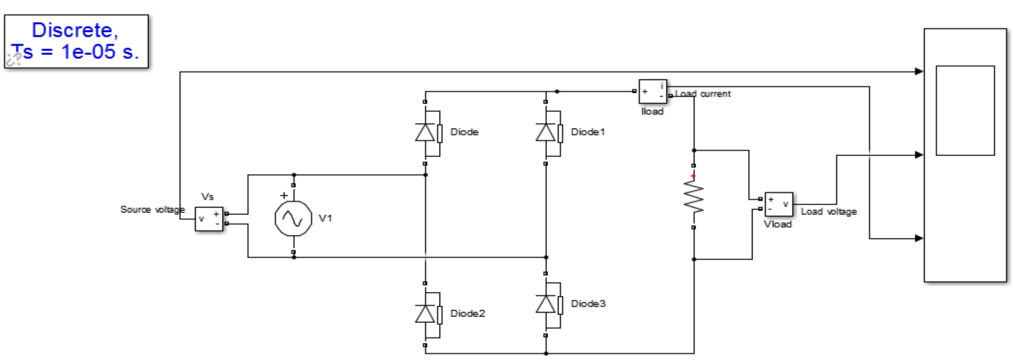
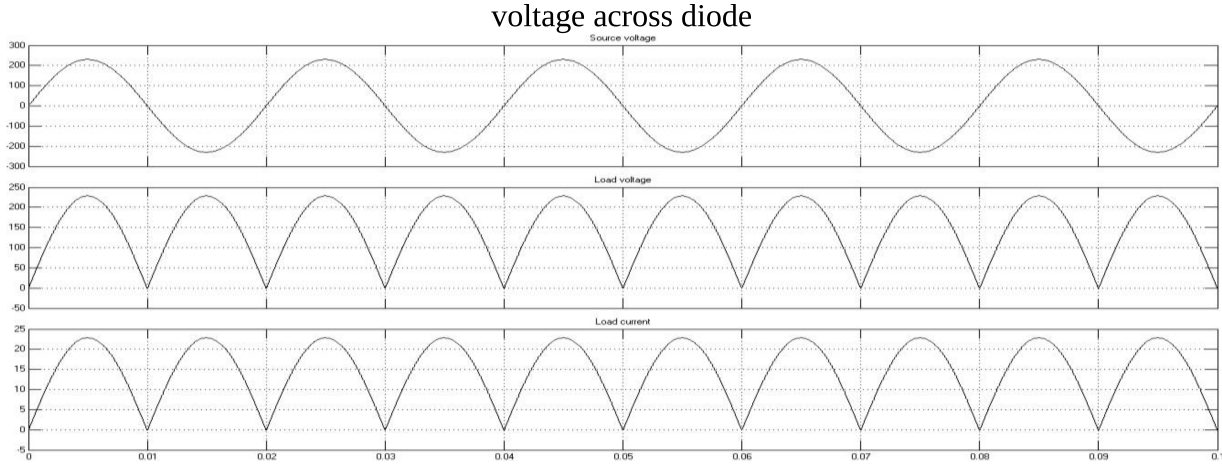


Figure 2 wave forms of half wave rectifier in terms of input voltage ,load voltage ,load current and voltage across diode

Figure 2 wave forms of half wave rectifier in terms of input voltage ,load voltage ,load current and voltage across diode



RESULT:-

Single phase Half wave and full wave diode rectifier has been studied.

Precautions:-

1) Connections must be properly alone.
2) Don't forget to drag powergui beside circuit diagram.

Experiment No. 10

Objective: Simulation of single-phase half wave phase controlled converter with R and R-L loadon MATLAB.

Apparatus Required: MATLAB/SIMULINK installed on PC.

Theory:

The phase-controlled rectifiers using SCRs are used to obtain controlled dc output voltages from the fixed ac mains input voltage. A single-phase half wave-controlled converter only has one SCR is employed in the circuit. The performance of the controlled rectifier very much depends upon the type and parameters of the output (load) circuit.

For R load:

The output voltage is varied by controlling the firing angle of SCR. The simulation circuit of the half wave converter is shown in fig (1). During the positive half-cycle of input voltage, the thyristor anode voltage is positive with respect to cathode and the thyristor is said to be forward biased. When thyristor T_1 is fired at wt=α, thyristor T_1 **i**s conducts and input voltage appears the load. When the input voltage starts to be negative at wt=∏, the thyristor anode is negative with respect to cathode and thyristor is said to be reverse biased; and it is turned off. The time after the input voltage starts to go positive until the thyristor is fired is called the delay or firing angle α. If the load is resistive, the load voltage and load current are similar.Average output voltage is half controlled converter with Rload is given by.

$$V_{dc\ (av)} = \frac{Vm}{2M}[1+\cos\alpha] \text{ (volts)}$$

where

Vm is the maximum input voltage α is the firing angle of the SCR

The simulation waveforms for half wave phase controlled converter with R load for firing angle(30^0&60^0) in terms firing pulse, input voltage, output voltage and load current are shown in figure 2&figure3 respectively .

For RL load:

When the load is resistive, SCR1 conduct from α to π. The nature of the load current depends on the values of R and L in the inductive load. The simulation circuit of the half wave converter with RL load is shown in fig (4). Because of the inductance, the load current keeps on increasing and becomes maximum at π. At π, the supply voltage reverses but SCRs 1 does not turn off. This is because the load inductance does not allow the current to go to zero instantly. Thus the energy stored in the inductance flows against

Where

Vm is the maximum input voltageα is the firing angle of the SCR

$V_{dc\ (av)} = \frac{Vm}{2M}$ [cosβ -cosα] (volts)

The simulation waveforms for half wave phase-controlled converter with RL load for firing angle (30^0&60^0) in terms firing pulse, input voltage, output voltage and load current are shown in figure 5&figure6 respectively. This converter is not used in industrial applications because its output has high ripple content and low ripple frequency

Procedure:

1. Make the connections as per circuit diagram with elements taken from the MATLAB library for both R & RL load.
2. Simulate them.
3. Observe the waveform carefully on scope.

Result:

Simulation of half wave-controlled rectifier with R & RL load have been simulated.

Circuit Diagram:

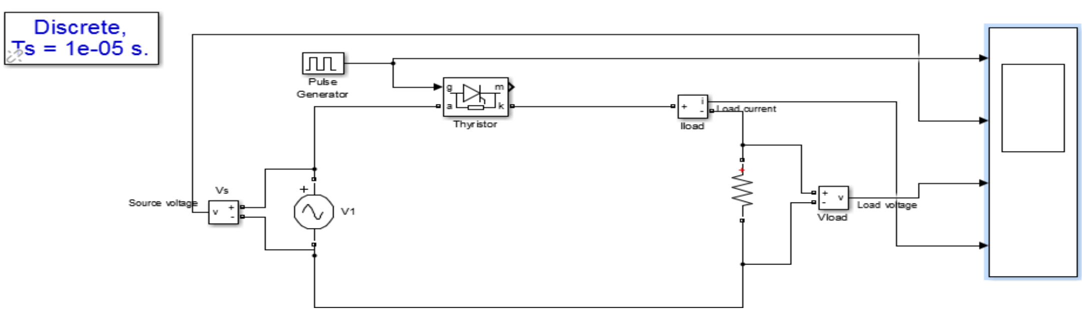


Figure1Simulink model of single phase half wave with R load

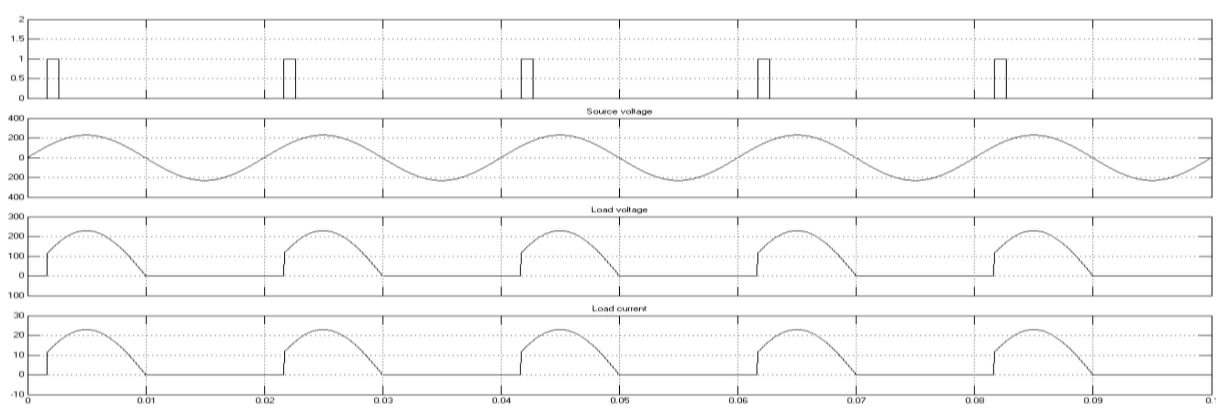


Figure2 Wave forms of gate pulse, input voltage, output voltage and load current of single phase half wave with R load with firing angle $30^{\mathbf{0}}$

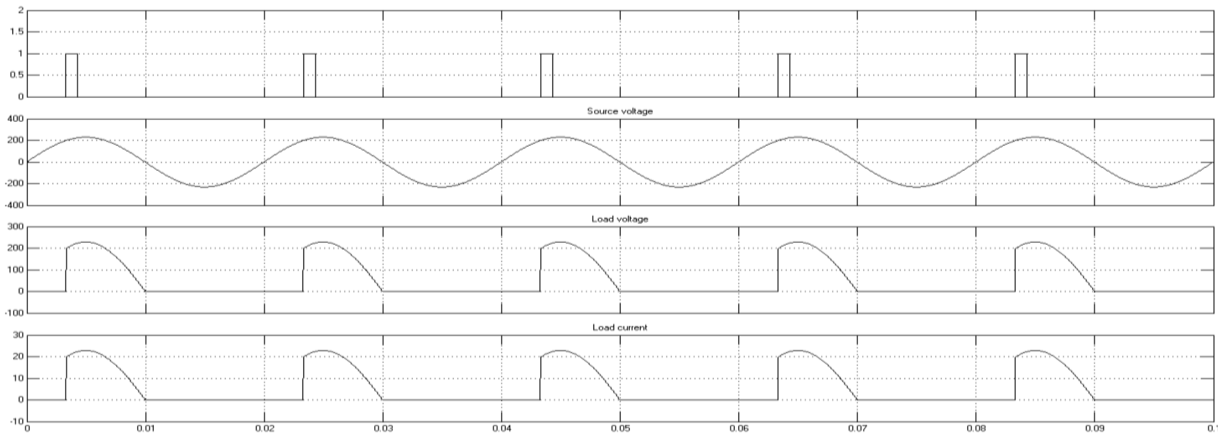


Figure3Wave forms of gate pulse, input voltage, output voltage and load current of single phase half wave with R load with firing angle 60^0

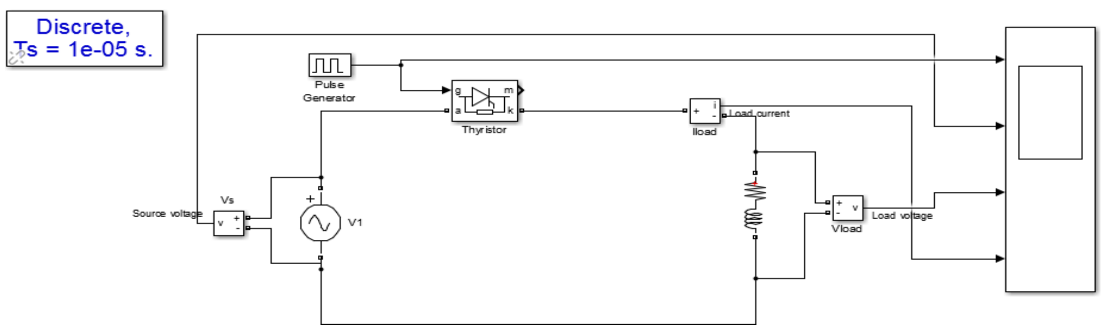


Figure 4Simulink model of single phase half wave with RL load

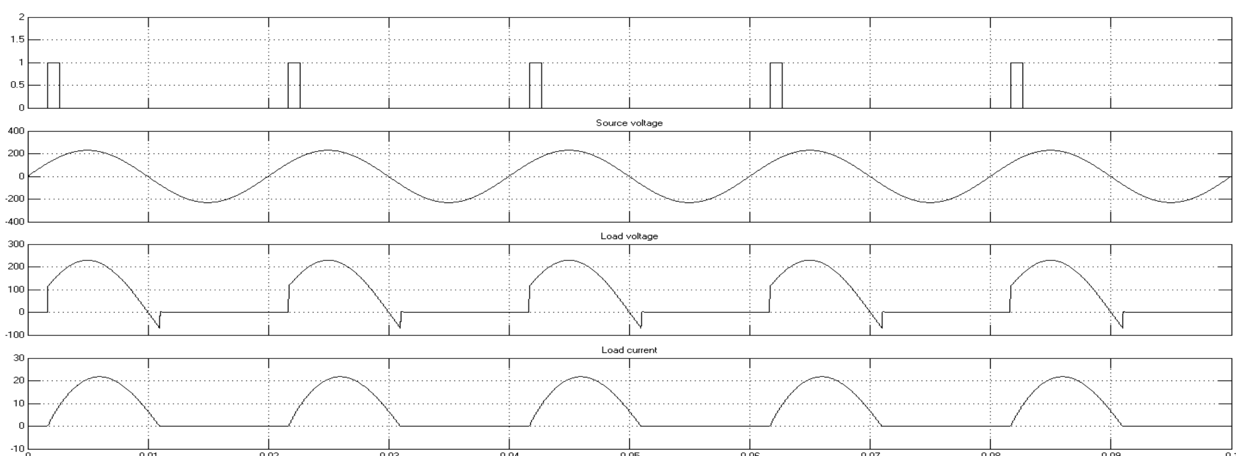


Figure5Wave forms of gate pulse, input voltage, output voltage and load current of single phase half wave with RL load with firing angle 30^0

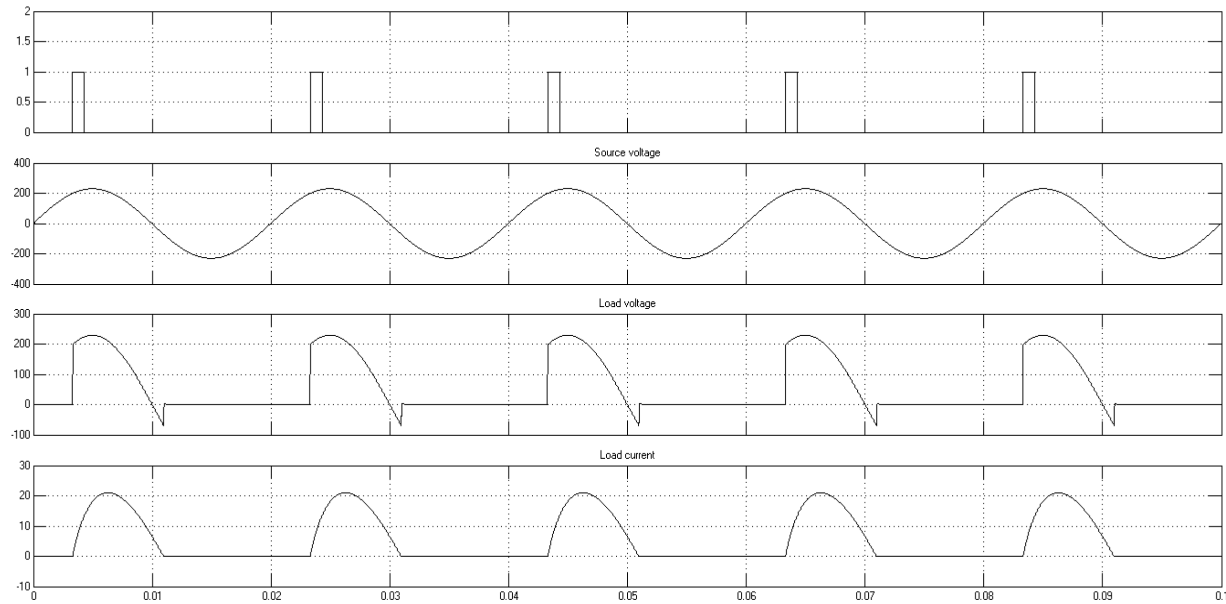


Figure6Wave forms of gate pulse, input voltage, output voltage and load current of single-phase half wave with RL load with firing angle 60^0

Gating Sequence. The gating sequence for the thyristor is as follows:

1. Generate a pulse-signal at positive zero crossing of the supply voltage Vs.
2. Delay the pulse by desired angle α and apply it between the gate and cathode terminal terminals of T1 through a gate-isolating circuit

This lab manual has been updated by

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Crosschecked
By HOD
EEE

Please spare some time to provide your valuable feedback.