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Department of Electrical and Electronics Engineering

LAB MANUAL

Name of the Faculty : Mr. T. Papi Naidu & Mr. T. Karthik

Name of the laboratory : POWER ELECTRONICS

Regulation : R20

Subject Code : R20EEE-PC3105 (C313)

Branch : Electrical and Electronics Engineering

Year & Semester : III B.Tech- I Semester

INSTITUTE

VISION

Produce globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

Department of Electrical and Electronics Engineering

VISION

To be a center of excellence in imparting knowledge, skills, and ethical values, while fostering innovation, sustainability and globally competent to make exemplary contributions to the field of Electrical and Electronics Engineering

MISSION

- To impart technical education using state-of-the-art infrastructure, laboratories, and instructional methods, ensuring students acquire comprehensive knowledge and skills.
- To foster industry-oriented learning by facilitating internships, industrial visits, collaborative projects with industries.
- To create a congenial environment for higher education, employment, and entrepreneurship by delivering quality education, enhancing professional skills and promoting research and innovation.
- To promote societal commitment and ethical leadership by instilling moral values and encouraging responsible engineering practices among students.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will possess a strong foundation in core and interdisciplinary areas of Electrical and Electronics Engineering along with analytical and computational skills, enabling them to tackle global challenges through innovative and critical problem-solving.

PEO2: Graduates will actively engage in research, entrepreneurship, and innovation to address contemporary challenges in Electrical and Electronics Engineering while promoting sustainable and inclusive technological development for the betterment of society.

PEO3: Graduates will exhibit effective communication skills, collaborative abilities, and ethical values, preparing them for successful careers, higher education, and leadership roles in a rapidly evolving competitive environment.

PROGRAM OUTCOMES (POs)

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, 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 modelling 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: Capable of design, develop, test, verify and implement electrical and electronics engineering systems and products.

PSO2: Succeed in national and international competitive examinations for successful higher studies and employment.

COURSE OUTCOMES

S. No.	DESCRIPTION
C313.1	Discuss the characteristics of various power electronic devices
C313.2	Analyze the performance of single–phase bridge converters, Dual Converters and Cyclo converters
C313.3	Design the Buck converter and Boost converter
C313.4	Develop the single phase and three phase AC voltage regulator
C313.5	Describe the functionality of a single-phase square wave inverter utilizing PWM

COURSE INFORMATION SHEET

PROGRAM: **ELECTRICAL AND ELECTRONICS ENGINEERING**	DEGREE: **B.TECH**
COURSE: **POWER ELECTRONICS Lab**	SEMESTER: **III-I** CREDITS: **1.5**
COURSE CODE**: R20EEE-PC3105** REGULATION: **R20**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **Power Electronics**	CONTACT HOURS**: 3 hours/Week**.
CORRESPONDING LAB COURSE CODE (IF ANY):	LAB COURSE NAME (IF ANY):

Experiment	DETAILS	HOURS
I	Introduction and Demonstration of the Experiments	**3**
II	Design of Circuits	**3**
III	Study of Characteristics of Thyristor, MOSFET & IGBT.	**3**
IV	Design and development of a firing circuit for Thyristor.	**3**
V	Single -Phase Half controlled converter with R and RL load.	**3**
VI	Single -Phase fully controlled bridge converter with R and RL load.	**3**
VII	Single Phase Dual Converter with R Load	**3**
VIII	Practice session	**3**
IX	Verification of voltages ripple in buck converter in CCM operation.	**3**
X	Single -Phase AC Voltage Regulator with R and RL Load.	**3**
XI	Three-phase AC-AC voltage regulator with R-load.	**3**
XII	Single-Phase Cyclo-converter with R load	**3**
XIII	Single-phase Square-wave bridge inverter with R and RL load	**3**
XIV	Single-phase PWM inverter with Sine triangle PWM Technique	**3**
XV	Practice Session	**3**
TOTAL HOURS		**45**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T_1	Power Electronics: Circuits, Devices and Applications – by M. H.Rashid, Prentice Hall of India, 2nd edition, 1998.
T_2	Power Electronics: Essentials & Applications by L.Umanand, Wiley, Pvt. Limited, India, 2009
R_1	Power Electronics – by P.S.Bhimbra, Khanna Publishers.
R_2	Power Electronics: Converters, applications & design –by Nedmohan, Tore M. Undeland, Robbins by Wiley India Pvt. Ltd.

COURSE OBJECTIVES:

1	To study the characteristics of various power electronic devices and analyze firing circuits and commutation circuits of SCR
2	To analyze the performance of single–phase bridge converters with both resistive and inductive loads.
3	To understand the operation of AC voltage regulator with resistive and inductive loads.
4	To understand the working of Buck converter, Boost converter and inverters.
5	To understand the operation of dual converter and cyclo converter.

COURSE OUTCOMES:

S. No.	DESCRIPTION	PO(1..12) MAPPING	PSO(1,2) MAPPING
C313.1	Discuss the characteristics of various power electronic devices	PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12	PSO1,PSO2
C313.2	Analyze the performance of single–phase bridge converters, Dual Converters and Cyclo converters	PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12	PSO1,PSO2
C313.3	Design the Buck converter and Boost converter	PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12	PSO1,PSO2
C313.4	Develop the single phase and three phase AC voltage regulator	PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12	PSO1,PSO2
C313.5	Understand single–phase square wave inverter with PWM technique	PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12	PSO1,PSO2
COURSE OVERALL PO/PSO MAPPING: PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12/ PSO1,PSO2			

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

SNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
C313.1	3	3	2	2	-	2	2	2	3	2	1	2	3	2
C313.2	3	3	2	2	-	2	2	2	3	2	1	2	3	2
C313.3	3	3	2	2	-	2	2	2	3	2	1	2	3	2
C313.4	3	3	2	2	-	2	2	2	3	2	1	2	3	2
C313.5	3	3	2	2	-	2	2	2	3	2	1	2	3	2
CO*	3	3	2	2	-	2	2	2	3	2	1	2	3	2

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop, test, verify and implement Electrical and Electronics Engineering systems and products.
PO2	Problem Analysis	PO8	Ethics	PSO2	Succeed in national and international competitive examinations for successful higher studies and employment.

PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

COs VS POs MAPPING JUSTIFICATION:

SNO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
C3105.1	PO1	3	Apply the fundamentals of Electronics highly to draw the characteristics of various power semiconductor devices.
	PO2	3	Analyze slightly the switching operation of Power semiconductor devices with snubber circuit
	PO3	2	Explain switching operation of Power semiconductor devices highly using any simulation software
	PO4	2	Examine moderately the characteristics of SCR, PMOSFET and Power IGBT
	PO6	2	Design switching operation of Power semiconductor devices moderately using any simulation software
	PO7	2	Discussing the characteristics of various power electronic devices moderately develops problem-solving skills
	PO8	2	analysis of device behavior in different circuits and applications. It enhances analytical skills
	PO9	3	primary focus is individual understanding and application, thus contributing moderately to communication and teamwork.
	PO10	2	The topic highly contributes to design capabilities as understanding device characteristics.
	PO11	1	Examine moderately the characteristics of SCR, PMOSFET and Power IGBT with team work.
	PO12	2	Recognize a new kind of power semiconductor devices for our problem as per the technological changes in Power electronics areas
	PSO1	3	Evaluate the performance of different circuitry configurations by selecting suitable power semiconductor devices
	PSO2	2	The Knowledge of power semiconductor devices moderately required to succeed in many competitive examinations like GATE, IES, State electricity board examinations.
C3105.2	PO1	3	Apply the fundamentals of Power electronics highly to convert single phase ac to dc for dc loads.

	PO2	3	Analyse the operations of single phase AC-DC converter for different electrical loads
	PO3	2	Develop,Design simulation circuit of single phase rectifier using any simulation software
	PO4	2	Examine the operation of the converters and its characteristics for various firing angles and for different loads
	PO6	2	Design single phase AC-DC converter for different loads highly using any simulation software
	PO7	2	Analyzing the performance of single-phase bridge converters, dual converters, and cyclo-converters strongly develops problem-solving skills
	PO8	2	Enhances analytical skills through the interpretation of waveforms, calculation of performance parameters and comparison of different converter topologies.
	PO9	3	Design single phase AC-DC converter for different loads highly using any simulation software with individual and team work.
	P010	2	analysis significantly contributes to design capabilities as understanding converter performance is essential for selecting the right converter for a specific application.
	PO11	1	Discussing the controlled converters of various power electronic circuits contributes slightly to lifelong learning
	PO12	2	Recognize a new kind of power semiconductor devices for our problem as per the technological changes in Power electronics areas
	PSO1	3	Develop a single phase AC-DC converter for Electric vehicle applications
	PSO2	2	The Knowledge of Single phase AC-DC converters moderately required to succeed in many competitive examinations like GATE, IES, State electricity board examinations.
C3105.3	PO1	3	Apply the fundamentals of electrical circuit analysis is highly required in analyzing the DC-DC converters
	PO2	3	Analyze the DC-DC converter for Photovoltaic applications
	PO3	2	Design of DC-DC converter for integrating with a PV module
	PO4	2	Evaluate the performance of converter in conjunction with Electric vehicle/ PV modules
	PO6	2	Design DC-DC converter for different applications Highly using any simulation software
	P07	2	Designing Buck and Boost converters moderately develops problem-solving skills
	PO8	2	analysis slightly for circuit behavior, and

			simulation of converter performance
	PO9	3	Analyze the DC-DC converter highly for Photovoltaic applications with team work.
	PO10	2	design process contributes moderately by providing practical experience in applying theoretical concepts to create functional converter circuits
	PO11	1	designing DC-DC converters contributes slightly to lifelong learning
	PO12	2	Recognize a new kind of DC-DC converter technological changes in solar, PV and Battery areas.
	PSO1	3	Design of DC-DC converter is highly required in the application of Renewable energy sources and Electric vehicles
	PSO2	2	The Knowledge of DC-DC converters highly required to succeed in many competitive examinations like GATE, IES, State electricity board examinations.
C3105.4	PO1	3	Apply the fundamentals of Power electronics highly to convert AC to AC
	PO2	3	Analyze the operations of AC-AC converter for different electrical loads
	PO3	2	Develop, Design simulation circuit of AC voltage controller for AC loads using any simulation software
	PO4	2	Examine the operation of the converters and its characteristics for various firing angles and for different loads
	PO6	2	Design single phase AC-AC converter for different loads Moderately using any simulation software
	PO7	2	Developing single-phase and three-phase AC voltage regulators moderately develops problem-solving skills.
	PO8	2	enhances analytical skills through calculations moderately analysis of circuit behavior, and simulation or testing of regulator performance.
	P09	3	Apply the fundamentals of Power electronics moderately to convert AC to AC with team work.
	PO10	2	development process contributes moderately to design capabilities by providing practical experience in building and testing functional voltage regulator circuits
	P011	1	Developing the specific voltage regulators contributes only slightly to lifelong learning.
	PO12	2	Recognize a new kind of ac-ac converter for our problem as per the technological changes in Power electronics areas
	PSO1	3	Develop a single phase AC-AC converter for

			different ac loads.
	PSO2	2	The Knowledge of AC-AC converters slightly required to succeed in many competitive examinations like GATE, IES, State electricity board examinations.
C3105.5	PO1	3	Apply the fundamentals of Engineering Mathematics is highly required in analyzing the DC-AC converters
	PO2	3	Analyze the DC-AC converter for Photovoltaic and Electric vehicle applications
	PO3	2	Design of DC-AC converter for integrating with AC grid
	PO4	2	Investigate the performance parameters of DC-AC converters
	PO6	2	Design DC-AC converter and analyze THD of the converter moderately using any simulation software
	PO7	2	Understanding single-phase square wave inverters with PWM techniques moderately develops problem-solving skills.
	PO8	2	Analyze moderately circuit operation and enhances analytical skills through the interpretation of PWM signals
	P09	3	Analyze the DC-AC converter moderately for Photovoltaic and Electric vehicle applications with team work.
	PO10	2	understanding contributes moderately to design capabilities as it provides a foundation for designing and implementing more complex inverter circuits
	PO11	1	understanding this specific inverter configuration with PWM contributes only slightly to lifelong learning
	PO12	2	Recognize a new kind of DC-DC converter technological changes in solar, PV, and Battery areas.
	PSO1	3	Design of DC-AC converter is highly required in the application of Renewable energy sources and Electric vehicles
	PSO2	2	The Knowledge of DC-AC converters are highly required to succeed in many competitive examinations like GATE, IES, State electricity board examinations.

WEB SOURCE REFERENCES:

1	https://swayam.gov.in/nd1_noc20_ee97/preview
2	https://nptel.ac.in/courses/108/105/108105066/
3	https://www.electrical4u.com/electrical-engineering-articles/power-electronics/

4	https://en.wikipedia.org/wiki/Power_electronics

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑CHALK & TALK	☐ ICT TOOLS	☑ WEB REFERENCES	☐ STUDENT SEMINARS
☐ INDUSTRIAL VISITS	☐ INTERNSHIPS	☑ EXPERIMENTAL LEARNING	☐ MODEL-BASED LEARNING
☐ GUEST LECTURES	☑COLLABORATIVE LEARNING	☐ MINI/MAJOR PROJECTS	☐CASE STUDIES/REAL LIFE EXAMPLES

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ END SEMESTER
☑ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☐STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by
T.Papi Naidu

Approved by
PAC Member

Signature of HoD, EEE

Course Code	Course Title	Hrs./Week L: T: P	Credits
R20EEE-PC3105	Power Electronics Lab	0:0:3	1.5

Course objectives:

- To study the characteristics of various power electronic devices and analyze firing circuits and commutation circuits of SCR.
- To analyze the performance of single–phase bridge converters with both resistive and inductive loads.
- To understand the operation of AC voltage regulator with resistive and inductive loads.
- To understand the working of Buck converter, Boost converter and inverters.
- To understand the operation of dual converter and cyclo converter.

Course outcomes:

- Discuss the characteristics of various power electronic devices. (L2)
- Analyze the performance of single–phase bridge converters, Dual Converters and Cyclo converters. (L3)
- Design the Buck converter and Boost converter. (L3)
- Develop the single phase and three phase AC voltage regulator. (L3)
- Understand single–phase square wave inverter with PWM technique. (L2)

Any 10 of the Following Experiments are to be conducted

1. Study of Characteristics of Thyristor, MOSFET & IGBT.
2. Design and development of a firing circuit for Thyristor.
3. Single -Phase Half controlled converter with R and RL load.
4. Single -Phase fully controlled bridge converter with R and RL load.
5. Single Phase Dual Converter with R Load.
6. Verification of voltages gain of Boost converter in Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode(DCM).
7. Verification of voltages ripple in buck converter in CCM operation.
8. Single -Phase AC Voltage Regulator with R and RL Load.
9. Three-phase AC-AC voltage regulator with R-load.
10. Single-Phase Cyclo-converter with R load.
11. Single -Phase square wave bridge inverter with R and RL Load.
12. Single -phase PWM inverter with sine triangle PWM technique.

INDEX

Experiment - 1

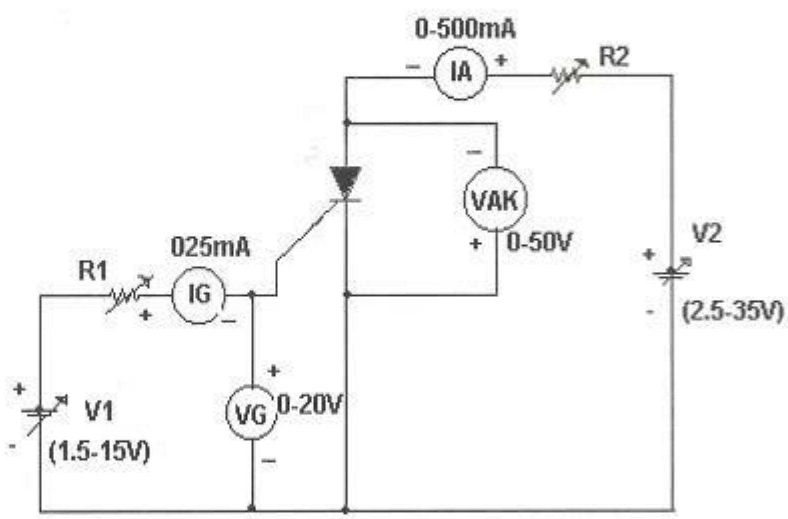
(a). STUDY OF SCR CHARACTERISTICS

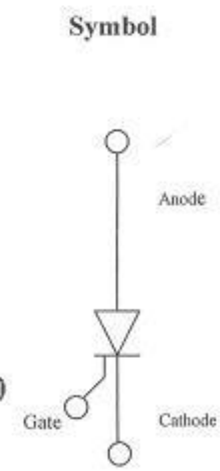
1.AIM: To study the V-I Characteristics of SCR. Finding the value of Latching current, Holding current, Gate voltage and gate current.

2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Qty
01	SCR characteristics Trainer	-	01
02	DC Voltmeter	0V-20V 0V-50V	01 01
03	DC Ammeter	0-25mA 0-500mA	01 01
04	Patch chords	-	Adequate

3.CIRCUIT DIAGRAM:





4.THEORY:

The silicon control rectifier (SCR) consists of four layers of semiconductors, which form NPNP or PNPN structures, having three P-N junctions labeled J1, J2 and J3, and three terminals. The anode terminal of an SCR is connected to the p-type material of a PNPN structure, and the cathode terminal is connected to the n-type layer, while the gate of the SCR is connected to the p-type material nearest to the cathode.

An SCR consists of four layers of alternating p- and n-type semiconductor materials. Silicon is used as the intrinsic semiconductor, to which the proper dopants are added. The junctions are either diffused or alloyed (alloy is a mixed semiconductor or a mixed metal). The planar construction is used for low-power SCRs (and all the junctions are diffused). The mesatypeconstruction is used for high-power SCRs. In this case, junction J2 is obtained by the diffusion method, and then the outer two layers are alloyed to it, since the PNPN pellet is required to handle large currents

Modes of operation:

There are three modes of operation for an SCR depending upon the biasing given to it:

1. Forward blocking mode (off state)
2. Forward conduction mode (on state)
3. Reverse blocking mode (off state)

Forward blocking mode:

In this mode of operation, the anode(+ve) is given a positive voltage while the cathode(-ve) is given a negative voltage, keeping the gate at zero(0) potential i.e. disconnected. In this case junction J1 and J3 are forward-biased, while J2 is reverse-biased, due to which only a small leakage current exists from the anode to the cathode until the applied voltage reaches its breakover value, at which J2 undergoes avalanche breakdown, and at this breakover voltage it starts conducting, but below breakover voltage it offers very high resistance to the current and is said to be in the off state.

Forward conduction mode:

SCR can be brought from blocking mode to conduction mode in two ways: either by increasing the voltage across anode to cathode beyond breakover voltage or by applying positive pulse at gate. Once SCR starts conducting, no more gate voltage is required to maintain it in the on state. There are two ways to turn it off: 1. Reduce the current through it below a minimum value called the holding current and 2. With the gate turned off, short out the anode and cathode momentarily with a push-button switch or transistor across the junction.

Reverse blocking mode:

SCRs are available with reverse blocking capability, which adds to the forward voltage drop because of the need to have a long, low-doped P1 region. (If one cannot determine which region is P1, a labeled diagram of layers and junctions can help). Usually, the reverse blocking voltage rating and forward blocking voltage rating are the same. The typical application for reverse blocking SCR is in current-source inverters.

SCRs incapable of blocking reverse voltage are known as asymmetrical SCR, abbreviated ASCR. They typically have a reverse breakdown rating in the tens of volts. ASCRs are used where either a reverse conducting diode is applied in parallel (for example, in voltage-source inverters) or where reverse voltage would never occur (for example, in switching power supplies or DC traction choppers).

Asymmetrical SCRs can be fabricated with a reverse conducting diode in the same package. These are known as RCTs, for reverse conducting thyristors.

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 Ig to some constant (2.5/5.0mA) by varying the V_1 or R_1.
4. Now slowly vary V_2 and observe Anode to Cathode voltage V_{AK} and Anode current I_A.
5. Tabulate the readings of Anode to Cathode voltage V_{AK} and Anode current I_A.
6. Repeat the above procedure for different Gate current I_g.

GATE TRIGGRING AND FINDING V_G AND I_G:

1. Keep all positions at minimum.
2. Set Anode to Cathode voltage V_{AK} to some volts say 15V.
3. Now slowly vary the V_1 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 V_1 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 V_1. If the Anode current is greater than the latching current of the device, the device says ON even after switch OFF S_1, 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 S_1 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 $I_H < I_L$

6.PRECAUTIONS:

1. Avoid loose connections

7.TABULAR FORM:

I_g=5 mA

V_{AK}(volts)	I_A(mA)
0.6	0
0.8	3
0.81	4
0.84	5
0.86	6
0.88	9
0.89	10

8.RESULT: Study of characteristics of a SCR is conducted experimentally and graph is plotted from tabulated readings.

9.OUTCOMES: By doing this experiment CO1,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

10. APPLICATIONS:

1. Motor control.
2. Power regulators

11.VIVA QUESTIONS:

1. Define latching current.
2. Define holding current.
3. Define forward break over voltage.

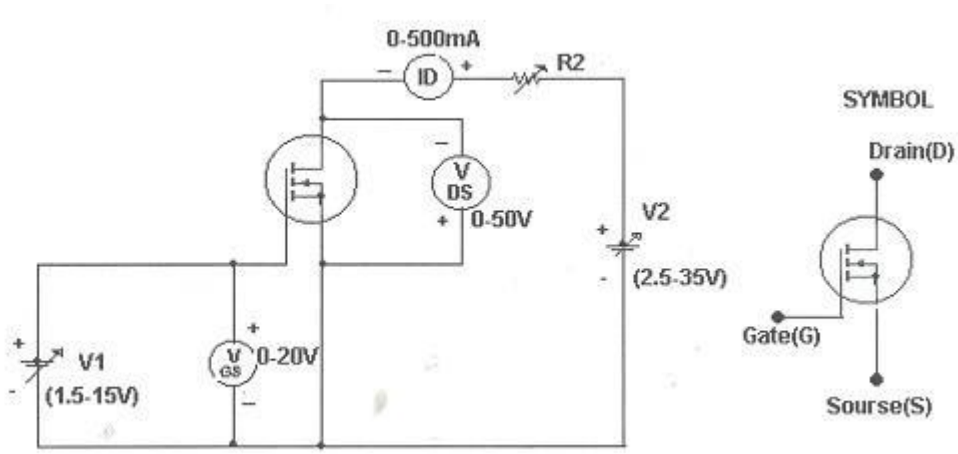
(b). STUDY OF MOSFET CHARACTERISTICS

1.AIM: To study the Output and Transfer Characteristics of MOSFET.

2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Type	Qty
1.	MOSFET characteristics Trainer	-	-	01
2.	Meter Unit	-	-	01
3.	Patch chords	-	-	Adequate

3.CIRCUIT DIAGRAM:



4.THEORY:

Metal-oxide-semiconductor structure:

The traditional metal-oxide-semiconductor (MOS) structure is obtained by growing a layer of silicon dioxide (SiO_2) on top of a silicon substrate and depositing a layer of metal or polycrystalline silicon (the latter is commonly used). As the silicon dioxide is a dielectric material, its structure is equivalent to a planar capacitor, with one of the electrodes replaced by a semiconductor.

When a voltage is applied across a MOS structure, it modifies the distribution of charges in the semiconductor. If we consider a p-type semiconductor (with the density of acceptors, *p* the density of holes; $p = N_A$ in neutral bulk), a positive voltage from gate to body (see figure) creates a depletion layer by forcing the positively charged holes away from the gate-insulator/semiconductor interface, leaving exposed a carrier-free region of immobile, negatively charged acceptor ions (see doping (semiconductor)) . Conventionally, the gate voltage at which the volume density of electrons in the inversion layer is the same as the volume density of holes in the body is called the threshold voltage. When the voltage between transistor gate and source (VGS) exceeds the threshold voltage (V_{th}), the difference is known as overdrive voltage. This structure with p-type body is the basis of the n-type MOSFET, which requires the addition of n-type source and drain regions.

Structure and channel formation:

A MOSFET is based on the modulation of charge concentration by a MOS capacitance between a body electrode and a gate electrode located above the body and insulated from all other device regions by a gate dielectric layer. If dielectrics other than an oxide are employed, the device may be referred to as a metal-insulator-semiconductor FET (MISFET). Compared to the MOS capacitor, the MOSFET includes two additional terminals (source and drain), each connected to individual highly doped regions that are separated by the body region. These regions can be either p or n type, but they must both be of the same type, and of opposite type to the body region. The source and drain (unlike the body) are highly doped as signified by a "+" sign after the type of doping.

If the MOSFET is an n-channel or nMOSFET, then the source and drain are n+ regions and the body is a p region. If the MOSFET is a p-channel or pMOS FET, then the source and drain are p+ regions and the body is a n region. The source is so named because it is the source of the charge carriers (electrons for n-channel, holes for p-channel) that flow through the channel; similarly, the drain is where the charge carriers leave the channel.

The occupancy of the energy bands in a semiconductor is set by the position of the Fermi level relative to the semiconductor energy-band edges. With sufficient gate voltage, the valence band edge is driven far from the Fermi level, and holes from the body are driven away from the gate.

At larger gate bias still, near the semiconductor surface the conduction band edge is brought close to the Fermi level, populating the surface with electrons in an *inversion layer or n-channel* at the interface between the p region and the oxide. This conducting channel extends between the source and the drain, and current is conducted through it when a voltage is applied between the two electrodes. Increasing the voltage on the gate leads to a higher electron density in the inversion layer and therefore increases the current flow between the source and drain. For gate voltages below the threshold value, the channel is lightly populated, and only a very small sub threshold leakage current can flow between the source and the drain.

When a negative gate-source voltage (positive source-gate) is applied, it creates a *p-channel* at the surface of the n region, analogous to the *n-channel* case, but with opposite polarities of charges and voltages. When a voltage less negative than the threshold value (a negative voltage for the p-channel) is applied between gate and source, the channel disappears and only a very small sub threshold current can flow between the source and the drain. The device may comprise a silicon on insulator device in which a buried oxide is formed below a thin semiconductor layer. If the channel region between the gate dielectric and the buried oxide region is very thin, the channel is referred to as an ultrathin channel region with the source and drain regions formed on either side in or above the thin semiconductor layer. Other semiconductor materials may be employed. When the source and drain regions are formed above the channel in whole or in part, they are referred to as raised source/drain regions.

5.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 at middle position.

3. Set V_{DS} to 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 V_1.
2. Slowly vary V_2 and note down I_D and V_{DS}
3. At particular value of V_{GS} there a pinch off voltage between drain and source.
4. If $V_{DS} < V_P$ device works in the constant resistance region and I_0 is directly proportional to $V_{DS.}$
5. If $V_{DS} > V_P$ device works in the constant current region.
6. Repeat above procedure for different values of V_{GS} and draw graph between I_D VS $V_{DS.}$

6.PRECAUTIONS:

1. Avoid loose connections

7.TABULAR COLUMN:

V_{DS}= 10V	
V_{GS} (V)	**I_D(mA)**
3.5	5.3
3.57	8.6
3.66	16.4
3.9	71.0
4.10	94.3

V_{DS} = 20V	
V_{GS} (V)	**I_D(mA)**
2.98	0.1
3.24	0.8
3.55	7.7
4.01	109.7
4.5	205

8.MODEL GRAPH:

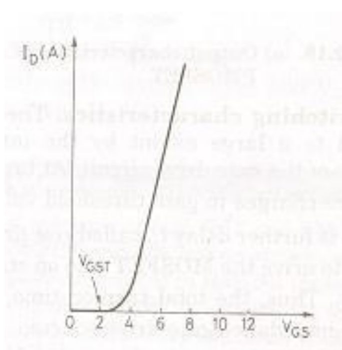


Fig: Transfer Characteristics

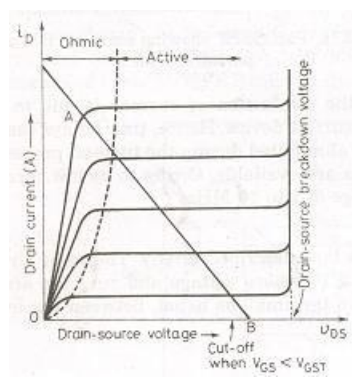


Fig: Output Characteristics

9.RESULT: Study of characteristics of a MOSFET is conducted experimentally and graph is plotted from tabulated readings.

10.OUTCOMES: By doing this experiment CO1,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

11.APPLICATIONS:

1. MOSFET as an analog switch.
2. It is widely used for switching and amplifying electronic signals in the electronic devices.

12.VIVA QUESTIONS:

1. What are the Terminals of MOSFET?
2. Differentiate between N-channel MOSFET and P-channel MOSFET.

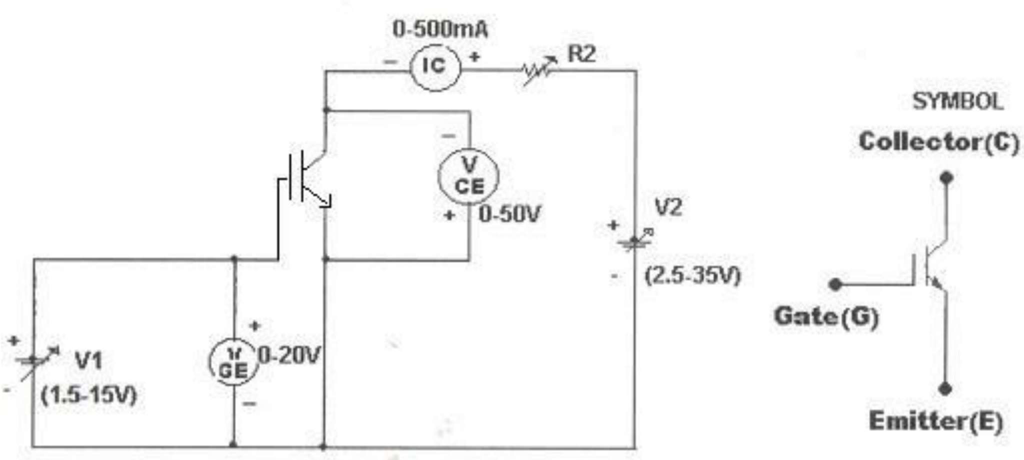
(c). STUDY OF IGBT CHARACTERISTICS

1.AIM: To study the Output and Transfer Characteristics of IGBT.

2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range		Qty
01	IGBT characteristics Trainer	-	-	01
02	Meter Unit	-	-	01
03	Patch chords	-	-	Adequate

3.CIRCUIT DIAGRAM:



4.THEORY:

The insulated gate bipolar transistor is a three terminal semiconductor device and these terminals are named as gate, emitter and collector. Emitter and collector terminals of the IGBT are associated with a conductance path & gate terminal is associated with its control. The calculation of amplification is attained by the IGBT is a radio b/n its i/p & o/p signal. For a conventional BJT, the sum of gain is nearly equivalent to the radio to the output current to the input current which is termed as beta. The insulated gate bipolar transistors are mainly used in amplifier circuits such as MOSFETS or BJTs. The IGBT is mainly used in small signal amplifier circuits like BJT or MOSFET. When the transistor combines the lower conduction loss of an amplifier circuit, then an ideal solid state switch occurs which is perfect for in many applications of power electronics. An IGBT is simply turned “ON” & ”OFF” by activating and deactivating its Gate terminal. A constant voltage positive input signal across the gate and emitter terminals will maintain the device in active state, while assumption of the input signal will cause it to turn “OFF” similar to BJT or MOSFET.

5.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 at 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:

1. Initially set V_{GE} to some value say 5V by varying V_1.
2. Slowly vary V_2 and note down I_C and V_{CE} readings.
3. At particular value of V_{GS} there a pinch off voltage V_P between Collector and Emitter.
4. If $V_{CE} < V_P$ device works in the constant resistance region and I_C is directly proportional to $V_{CE.}$
5. If $V_{CE} > V_P$ device works in the constant current region.
6. Repeat above procedure for different values of V_{GE} and draw graph between I_C VS $V_{GE.}$

6.PRECAUTIONS:

1. Avoid loose connections.

7.TABULAR COLUMN:

V_{GE}= 5V	
V_{CE}	I_C
0.4	0.09
0.5	1.3
0.6	3.3
0.7	4.1
0.9	4.3
1.1	4.4
2	4.4

V_{GE}= 8.1V	
V_{CE}	I_C
0.5	1.6
0.6	5.6
0.7	7.5
1.1	8.7
2.2	8.8
3.8	8.8
7.5	8.9

8.MODEL GRAPH:

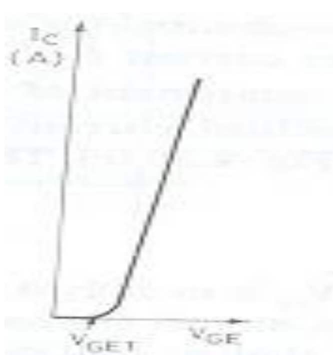


Fig: Transfer Characteristics

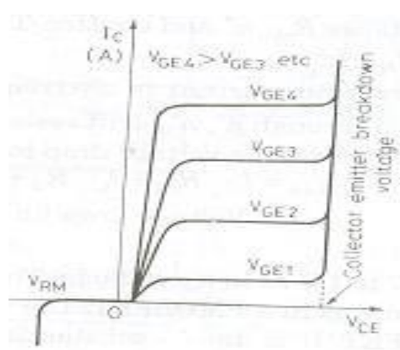


fig: Output Characteristics

9.RESULT: Study of characteristics of a IGBT is conducted experimentally and graph is plotted from tabulated readings.

10.OUTCOMES: By doing this experiment CO1,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

11.APPLICATIONS:

1. IGBT is used in medium to high power applications like switched mode power supplies, traction motor control and induction heating.

12.VIVA QUESTIONS:

1. What are the Terminals of IGBT
2. Explain about transistor working.

Experiment - 2

DESIGN AND DEVELOPMENT OF A FIRING CIRCUIT FOR THYRISTOR.

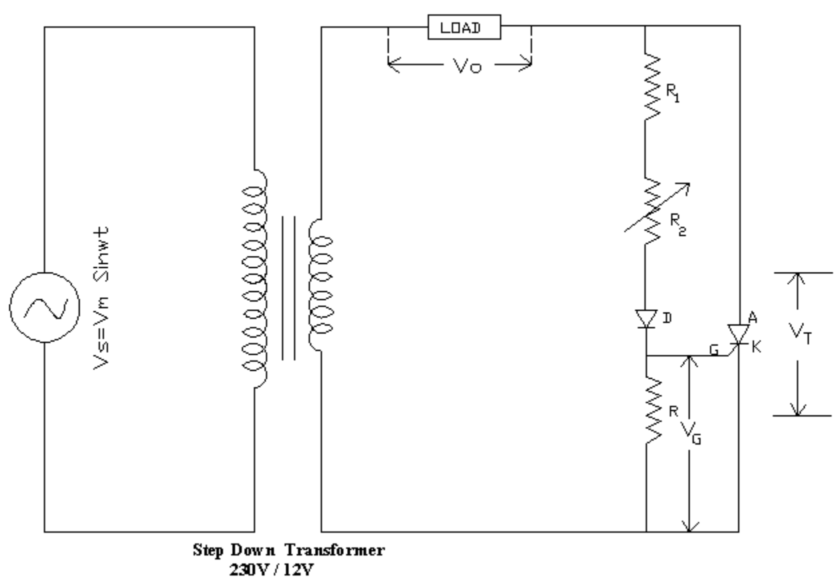
1.AIM: To trigger an SCR by using R, RC triggering circuits and observe the output waveforms for different firing angles.

2. APPARATUS REQUIRED:

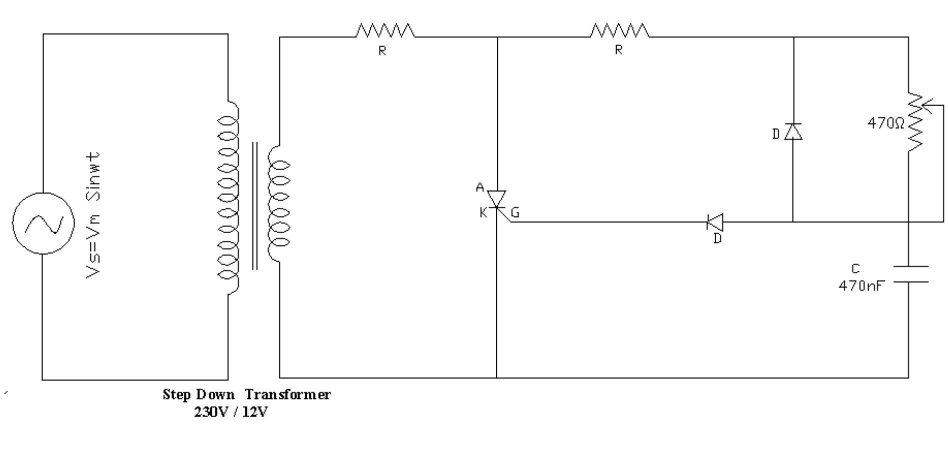
S.No.	Name of the equipment	Range	Type	Qty
01	Triggering Circuit Kit	-	-	1
02	CRO	-	-	1
03	Connecting Probes	-	-	1

3. CIRCUIT DIAGRAM

R-Triggering



RC-Triggering



4. PROCEDURE:

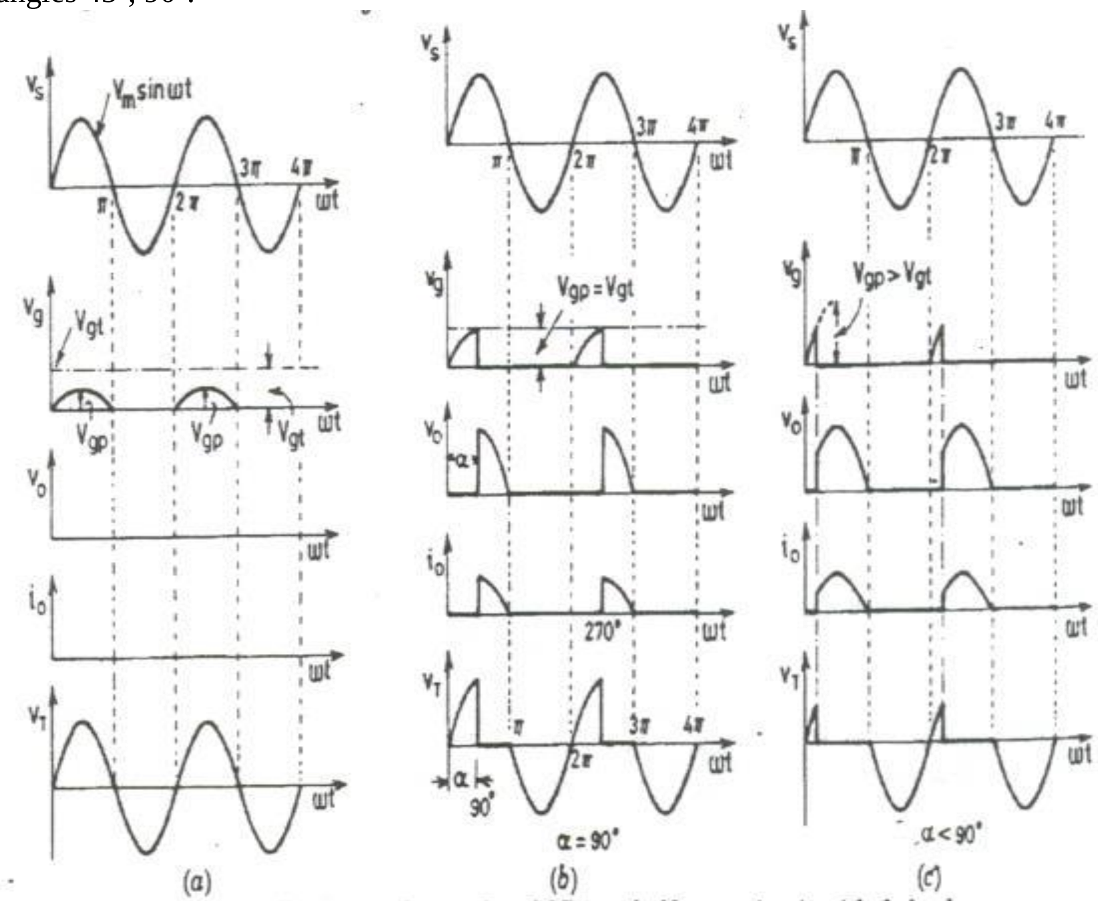
Resistance firing circuit:

(1) Apply 12V of AC input to the anode and cathode of SCR terminals from a step down transformer.

(2) Connect the anode, cathode & gate terminals of SCR to the corresponding A, K, G terminals in the R – Triggering circuit.

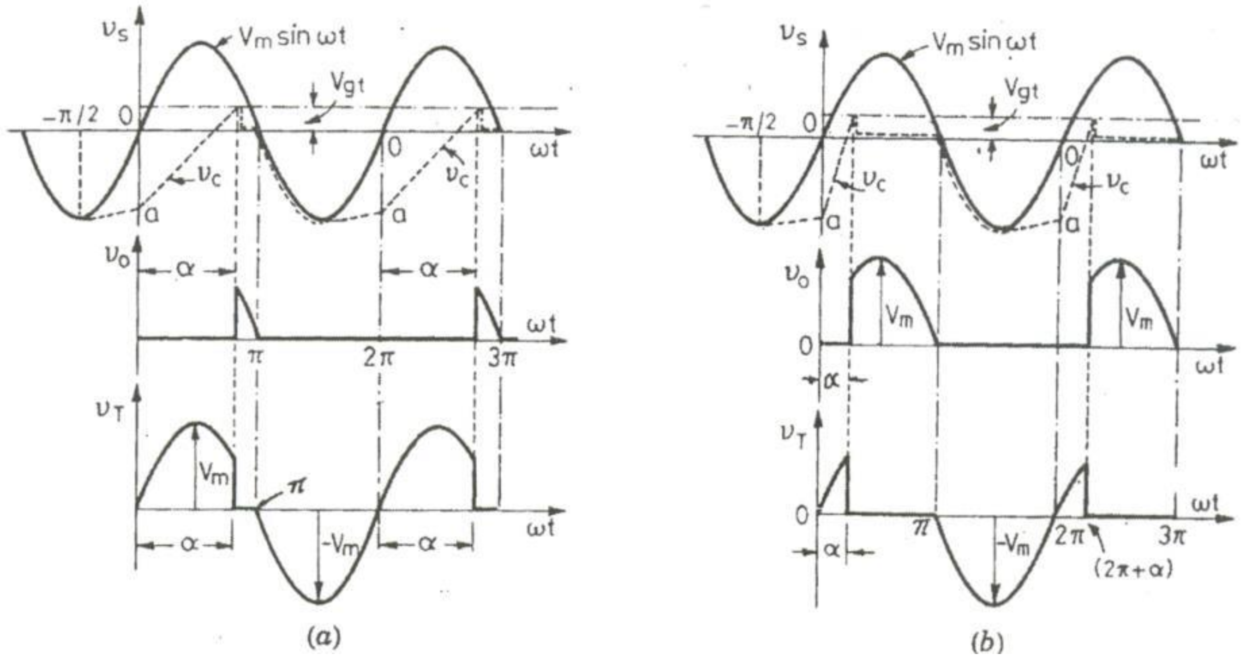
(3) Connect the load of 50Ω/2A between the load terminals.

(4) Observe the variations in the voltage across the load for different firing angles (by varying potentiometer) with the help of CRO, plot waveforms of firing signals &output voltage for firing angles 45^0, 90^0.



RC firing circuits:

1. Apply 12V of AC input to the anode and cathode of SCR terminals from a step down transformer.
2. Connect the anode, cathode & gate terminals of SCR to the corresponding A, K, G terminals in the R – Triggering circuit.
3. Connect the load of 50Ω/2A between the load terminals.
4. Observe the variations in the voltage across the load for different firing angles (by varying potentiometer) with the help of CRO, plot waveforms of firing signals & output voltage for firing angles 45^0, 180^0.



5. PRECAUTIONS:

(1) Initially the potentiometer should be in minimum resistance position.
(2) Vary the Potentiometer gradually.
(3) Observe the output waveforms carefully on the CRO

6. RESULT: The output waveforms of an SCR by using R, RC triggering circuits at different firing angles are observed.

7.OUTCOMES: By doing this experiment CO1,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

8.APPLICATIONS: Produce a gate signal of suitable magnitude and sufficiently short rise time.

9.VIVA QUESTIONS:

1. What are the different turn-on methods of SCR?
2. What are the salient features of gate Turn-On?

Experiment - 3

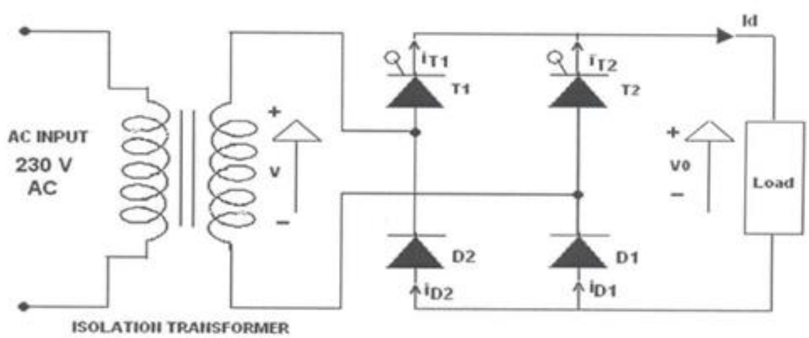
SINGLE -PHASE HALF CONTROLLED CONVERTER WITH R AND RL LOAD

1.AIM: To control the output voltage of single phase half controlled bridge converter with R Load and R-L Load.

2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Type	Qty
01	Single phase half controlled bridge converter power circuit and firing Circuit	-	-	01
02	Isolation Transformer	Tapping from 30V-230V / 5A	-	01
03	Variable Rheostat	0-200Ω / 5A	-	01
04	Loading Inductor	25mH to 150 mH	-	01
05	DSO	-	-	01
	Patch chords and probes	-	-	Adequate

3.CIRCUIT DIAGRAM:



4.THEORY:

A semi converter uses two diodes and two thyristors and there is a limited control over the level of dc output voltage. A semi converter is one quadrant converter. A one-quadrant converter has same polarity of dc output voltage and current at its output terminals and it is always positive. It is also known as two pulse converter. Figure shows half controlled rectifier with R load. This circuit consists of two SCRs T_1 and T_2, two diodes D_1 and D_2. During the positive half cycle of the ac supply, SCR T_1 and diode D_2 are forward biased when the SCR T_1 is triggered at a firing angle $\omega t = \alpha$, the SCR T_1 and diode D_2 comes to the on state. Now the load current flows through the path L - T_1- R load –D_2 - N.

During this period, we output voltage and current are positive. At $\omega t = \pi$, the load voltage and load current reaches to zero, then SCR T_1 and diode D_2 comes to off state since supply voltage has been reversed. During the negative half cycle of the ac supply, SCR T_2 and diode D_1 are forward biased. When SCR T_2 is triggered at a firing angle $\omega t = \pi + \alpha$, the SCR T_2 and diode

D_1 comes to on state. Now the load current flows through the path N - T_2- R load – D_1 -L. During this period, output voltage and output current will be positive. At $\omega t = 2\pi$, the load voltage and load current reaches to zero then SCR T_2 and diode D_1 comes to off state since the voltage has been reversed. During the period ($\pi + \alpha$ to 2π) SCR T_2 and diode D_1 are conducting.

5.PROCEDURE:

1. Make all connections as per the circuit diagram.
2. Connect 30V AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Connect DSO probes and observe waveforms in DSO, Ch-1 or Ch-2, across load and device in single phase half controlled bridge converter.
6. By varying firing angle gradually up to 180^0 and observe related waveforms
7. Measure output voltage by connecting voltmeter.
8. Tabulate all readings for various firing angles.
9. Calculate the output voltage by theoretically and compare with it practically obtained values.

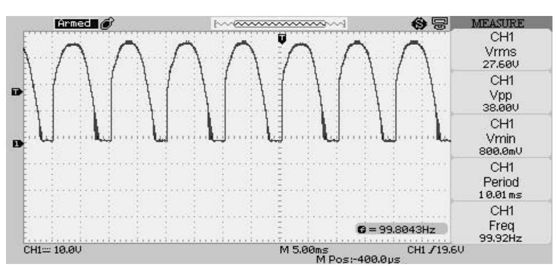
6.PRECAUTIONS:

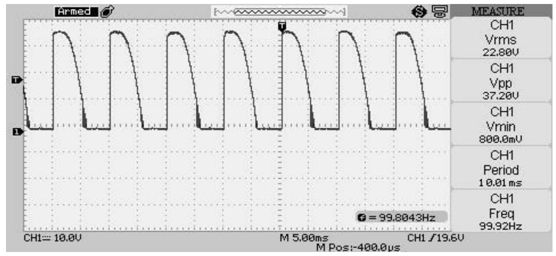
1. Avoid loose connections

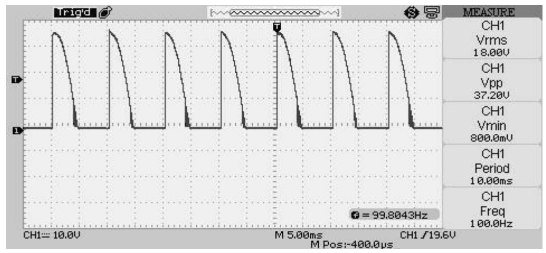
7.TABULAR COLUMN:

S.No.	Input Voltage (V)	Firing angle (Degrees)	Output voltage (V)
1	30	0	26.8
2	30	45	24.4
3	30	60	20.0
4	30	120	7.20
5	30	150	2.00
6	30	180	0.00

8.MODEL GRAPH:







9.MODEL CALCULATIONS:

V_0 = $(\sqrt{2}V / \pi) * (1 + \cos\alpha)$
I_0 = $(\sqrt{2}V / \pi R) * (1 + \cos\alpha)$
α = Firing Angle
V = RMS Value across transformer output

10.RESULT: The control of the output voltage using single phase half controlled converter with R-load is obtained practically

11.OUTCOMES: By doing this experiment CO2,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

12.APPLICATIONS:

1. Battery charging.
2. Speed control of DC motors

13.VIVA QUESTIONS:

1. Differentiate between half wave converter and half controlled converter
2. Derive the average output voltage equation for single phase half controlled converter

Experiment – 4

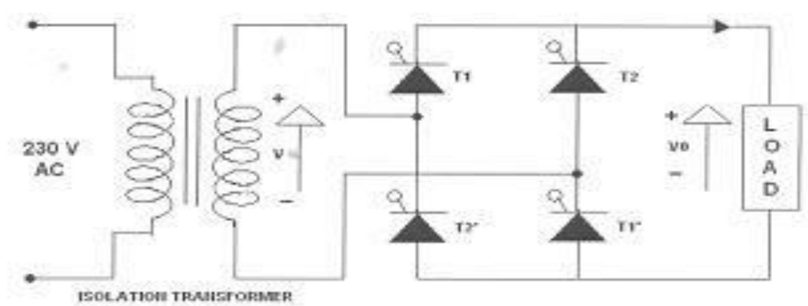
SINGLE -PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R AND RL LOAD

1.AIM: To study the single phase fully controlled bridge converter with R and RL Loads.

2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Type	Qty
01	Single phase full controlled bridge converter power circuit and firing Circuit	-	-	01
02	Isolation Transformer	Tapping from 30V to 230V / 5A	-	01
03	Variable Rheostat	0-200Ω / 5A	-	01
04	Loading Inductor	25 mH to 150 mH	-	01
05	DSO with deferential module	-	-	01
06	Patch chords and probes	-	-	Adequate

3.CIRCUIT DIAGRAM:



4.THEORY:

The single phase fully controlled rectifier allows conversion of single phase AC into DC. Normally this is used in various applications such as battery charging, speed control of DC motors and front end of UPS (Uninterruptible Power Supply) and SMPS (Switched Mode Power Supply).

All four devices used are thyristors. The turn-on instants of these devices are dependent on the firing signals that are given. Turn-off happens when the current through the device reaches zero and it is reverse biased at least for duration equal to the turn-off time of the device.

In positive half cycle thyristors T_1 & T_2 are fired at an angle α. In negative half cycle of input voltage, SCR's T_3 & T_4 are triggered at an angle of (π+α).

5.PROCEDURE:

1. Make all connections as per the circuit diagram.

2. Connect firstly 30V AC supply from Isolation Transformer to circuit.
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit.
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Connect DSO probes and observe waveforms in DSO, CH-1 or CH-2, across load and device in single phase half controlled bridge converter.
6. By varying firing angle gradually up to 180^0 and observe related waveforms.
7. Measure output voltage by connecting voltmeter.
8. Tabulate all readings for various firing angles.
9. Calculate the output voltage by theoretically and compare with it practically obtained values.

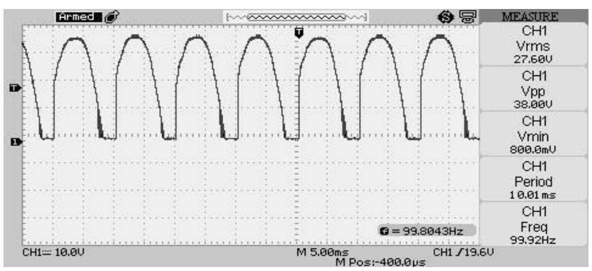
6.PRECAUTIONS:

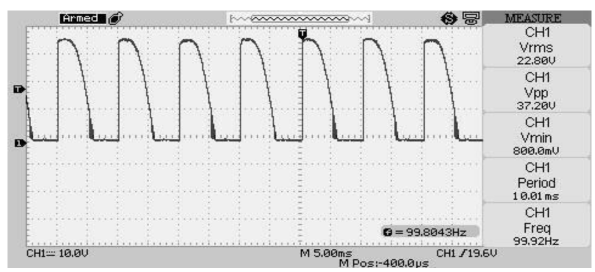
1. Avoid loose connections

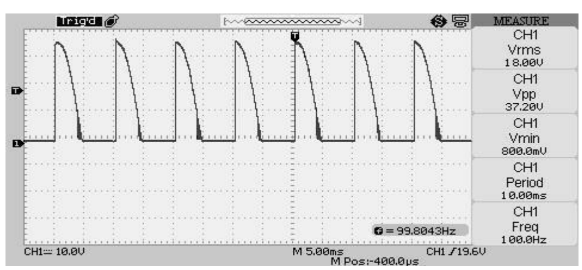
7.TABULAR COLUMN:

S.No.	Input Voltage (V_{in})	Firing angle (Degrees)	Output voltage (V_0)
1	30	0	24
2	30	45	22
3	30	65	17.6
4	30	90	11.2
5	30	120	6

8.MODEL GRAPH:







9.MODEL CALCULATIONS:

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

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

V= RMS Value across transformer output

10.RESULT: Single phase fully controlled converter loaded with R and RL loads is conducted experimentally and output waveforms are traced at different firing angles.

11.OUTCOMES: By doing this experiment CO2,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

12.APPLICATIONS:

1. Battery charging.
2. Speed control of DC motors

13.VIVA QUESTIONS:

1. Differentiate between full wave converter and fully controlled converter.
2. Derive average output voltage equation for single phase fully controlled converter.

Experiment - 5

DESIGN AND VERIFICATION OF VOLTAGES GAIN OF BOOST CONVERTER IN CONTINUOUS CONDUCTION MODE(CCM) AND DISCONTINUOUS CONDUCTION MODE(DCM).

1.AIM: To study working of Boost converter using MOSFET**.**

2.APPARATUS REQUIRED:

a) MOSFET based Boost Converter kit.

b) DC Regulated Power supply-0-30V/2A (single)

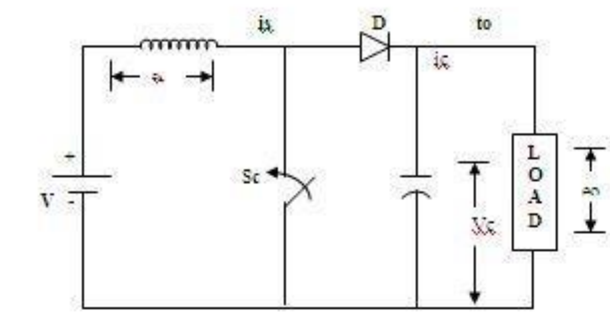
c) DSO

d) probe & patch chords

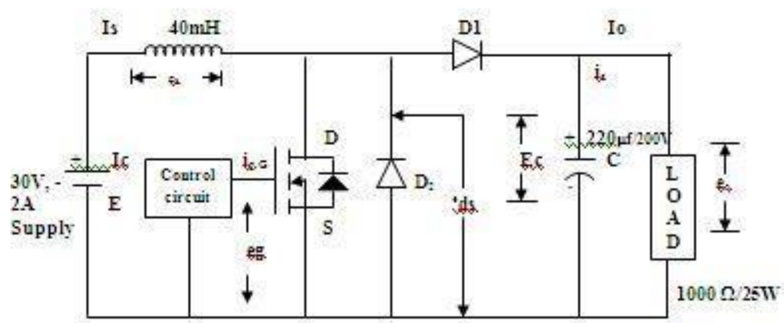
e) R-Load

3.THEORY:

In the basic boost converter, The energy is stored in the inductor in the on-period of the switch S_c. The current flows in the inductor L through the switch during T_{on} period and the voltage e_L across inductor in equal to V. when switch S_c is opened, the stored energy in the inductance discharged into the capacitor C and the load.



BASIC CIRCUIT DIAGRAM OF THE BOOST CONVERTER



4.PROCEDURE:

1. Switch ON the mains by the control circuit and observe the output by varying the frequency duty cycle, potentiometer.
2. Then connect the driver Output to Gate and Source of POWER MOSFET**.**
3. Make the Boost converter power circuit as shown in figure.
4. Check all the connections and confirm connections made are correct before switching on the equipment.
5. Connect DC input from Regulated power supply (0-30V / 2A) to the input terminal. Apply small Voltage (10Volts) Connect R –Load of 25W Resistor provided in the unit.
6. Switch ON the input switch in series with the DC input.
7. Apply driver output Pulses to the POWER MOSFET and observe the wave form at different points like across Load, Inductor, across capacitor and across Device with R – Load. And observe the effect of changing in t_{on} and t_{off} periods of the Power MOSFET (At particular frequency) by varying the Duty cycle potentiometer.
8. Note down the voltage wave form across the load, POWER MOSFET, and across inductor.
9. Change the frequency and repeat the experiment.
10. Bring the duty cycle and frequency to minimum, switch off driver outputs, switch off DC power supply and finally switch off mains supply to the unit. Remove connections.

5. PRECAUTIONS:

1. Avoid loose connections.

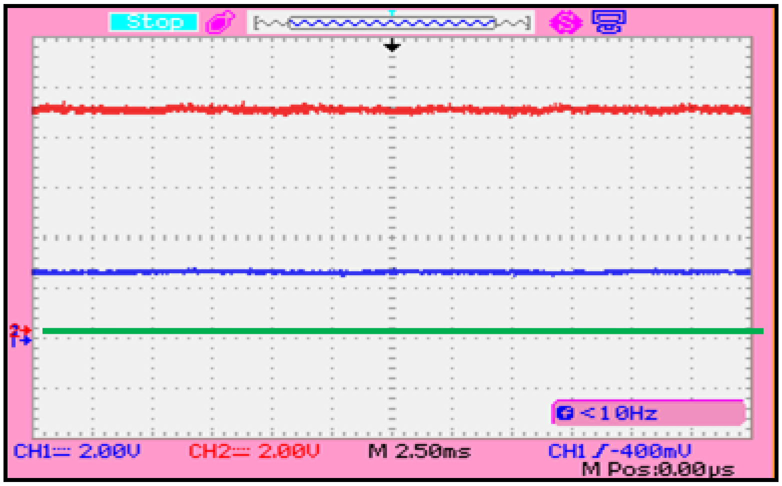
6.TABULAR COLUMN: f=100 HZ

S. No.	**V_{DC}**	**V_L**	T_{ON} (mS)	T_{OFF} (mS)	Duty Cycle (%)
1	10	13.3	2.5	7.5	25
2	10	20	5	5	50
3	10	40	7.5	2.5	75

7.MODEL GRAPH:

Vout

Vin



8.MODEL CALCULATIONS:

$$\text{Duty cycle} = \frac{T_{ON}}{T_{ON} + T_{OFF}} \times 100 \qquad V_0 = \frac{V_S}{1 - \text{D.cycle}}$$

For Input of 10 V, If Duty cycle is 50% V_0= 10/(1-0.5)= 20V.

9.RESULT: MOSFET based Boost converter is constructed and its performance is studied

10.OUTCOMES: By doing this experiment CO3,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

11.APPLICATIONS:

1. Step up chopper principle is utilized in the regenerative breaking of a DC motor.

12.VIVA QUESTIONS:

1. Explain about choppers.
2. Derive the output voltage equation for step up chopper.

Experiment - 6

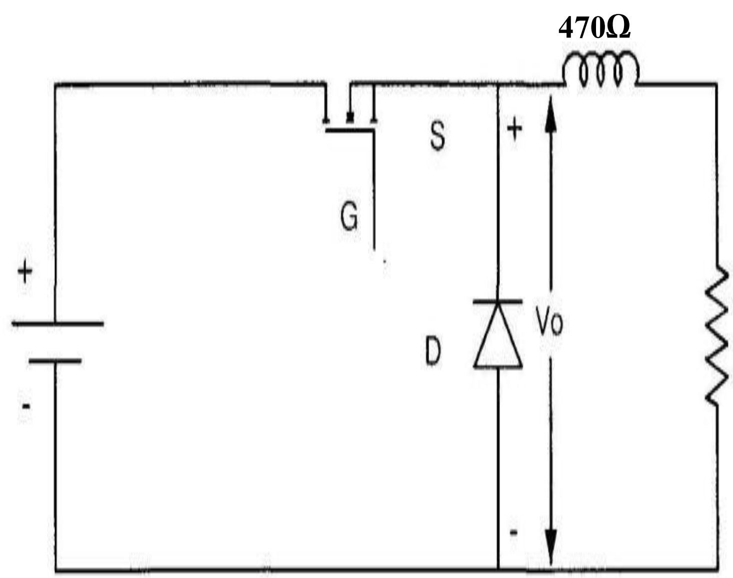
DESIGN AND VERIFICATION OF VOLTAGES RIPPLE IN BUCK CONVERTER IN CCM OPERATION

1.AIM: To study working of Buck converter using MOSFET.

2.APPARATUS REQUIRED :

a) MOSFET based Buck Converter kit.
b) DSO
c) connecting wires
d) Multi meter
e) DC Regulated Power supply-0-30V/2A (single)

3.CIRCUIT DIAGRAM:



4.THEORY:

A Chopper is a high speed on/off semiconductor switch. It connects source to load and disconnects the load from source at a fast speed. A step down chopper using MOSFET is shown in Fig. During T_{ON} chopper is ON and load voltage is equal to source voltage V_s. During the interval T_{off}, chopper is off, load current flows through freewheeling diode and load voltage is zero during T_{off}. In this manner chopper load voltage is produced at the load terminals.

In Buck converter the average output voltage V_0 is less than the Input voltage V_s. Hence the name “BUCK” a popular converter. The circuit diagram using POWER MOSFET is shown in Fig. and this is like a step down converter. The Buck converter requires only one MOSFET, is simple and has high efficiency greater than 90%. The di/dt of the load current is limited by inductor L. However, the input current is discontinuous and a smoothing input filter is normally required. It provides one polarity of output voltage and unidirectional output current.

5.PROCEDURE:

1. Switch on the mains supply for control circuit. And observe the Driver output by Varying the frequency, and duty cycle potentiometer.
2. Make the Buck power circuit as shown in figure.
3. Then connect the driver Output to Gate and Source of POWER MOSFET as shown in figure. Connect R –Load of 25W Resistor provided in the unit..
4. Connect DC input from Regulated power supply (0-30V / 2A) to the input terminal. Apply small Voltage (10 Volts)
5. Check all the connections and confirm connections made are correct before switching on the equipments.
6. Switch ON the input switch in series with the DC input.
7. Apply driver output pulses to MOSFET and observe the load voltage waveform by varying frequency and duty cycle.
8. Increase the input Voltage to rated voltage (30V) and observe the Voltage Waveform across LOAD and the MOSFET by varying frequency and duty cycle.
9. Output voltage & Current can be measured using DC voltmeter or digital multimeter across Load points and DC ammeter or digital multi meter in series with load points.
10. Bring the duty cycle and frequency to minimum, switch off driver outputs, switch off DC power supply and finally switch off mains supply to the unit. Remove connections.

6.PRECAUTIONS:

1. Avoid loose connections.

7.TABULAR COLUMN:

S. No.	Input voltage (V)	Load voltage (V)	T_{ON} msec	T_{OFF} msec	Duty Cycle%
1	30	9.69	2.27	4.75	0.323
2	30	10.2	5.06	9.85	0.34

3	30	15.39	5.05	4.79	0.513
4	30	18.33	7.85	5.01	0.611
5	30	18.96	4.43	2.58	0.632
6	30	21.75	6.92	2.62	0.725

8.MODEL GRAPH:

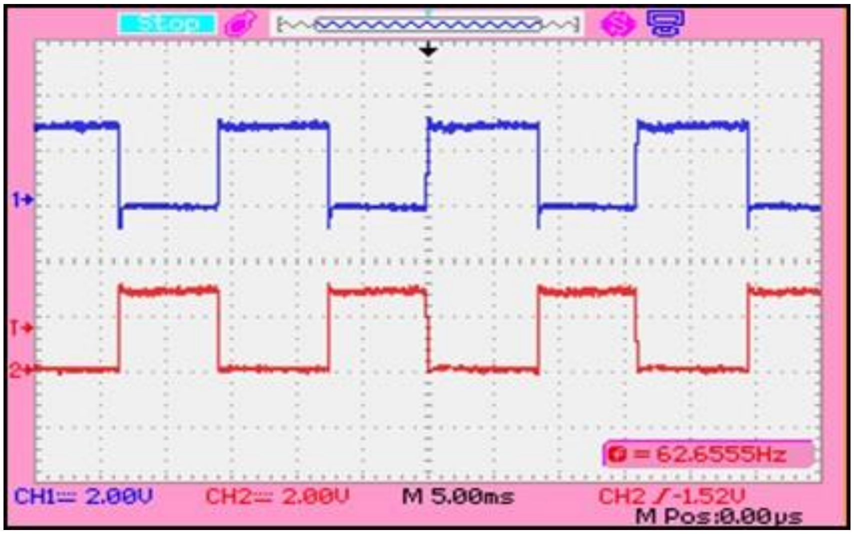


Fig:Voltage waveforms across V_{Ds} and V_{Load}

9.MODEL CALCULATIONS:

V_0 =Duty Cycle x V_s

For Input voltage= 30 Volts,

If Duty cycle is 50% V_0= 0.5x30 = 15V.

Duty Cycle = $[T_{ON} / (T_{ON} + T_{OFF})] \times 100$

10. RESULT: MOSFET based Buck converter is constructed and its performance is studied.

11.OUTCOMES: By doing this experiment CO3,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

12.APPLICATIONS:

1. These are used in electric cars, airplanes and spaceships.
2. These are used as power supplies in computers, electronic instruments.

3. These are used for DC motor control, solar energy conversion and wind energy conversion.

13.VIVA QUESTIONS:

1. Explain the operation of chopper.
2. Explain the difference between step down chopper and step up chopper.

Experiment - 7

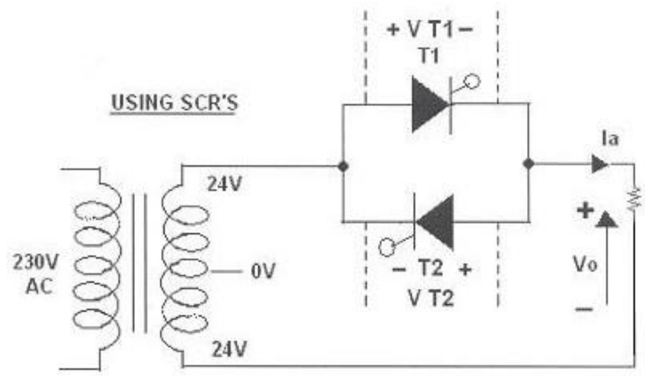
SINGLE -PHASE AC VOLTAGE REGULATOR WITH R AND RL LOAD

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

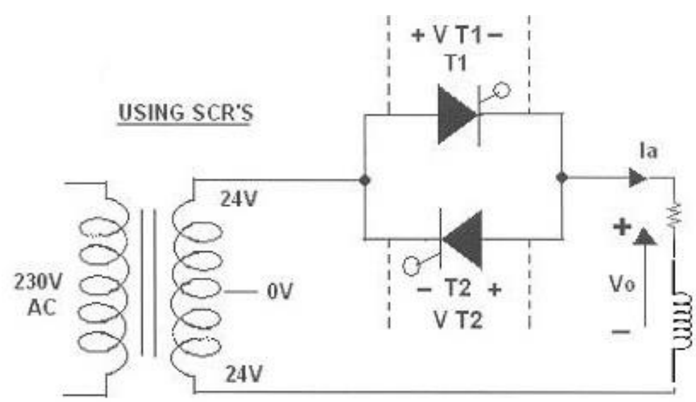
2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Qty
01	Single phase AC voltage controller power circuit and firing circuit	-	01
02	Step down Transformer	230V / 24V, 5A	01
03	Variable Rheostat	0-200Ω / 5A	01
04	DSO	-	01
05	Patch chords and probes	-	Adequate

3.CIRCUIT DIAGRAM:



Single Phase Full Wave AC Voltage Controller with R Load



Single Phase Full Wave AC Voltage Controller with RL Load

4.THEORY:

AC voltage controllers (ac line voltage controllers) are employed to vary the RMS value of the alternating voltage applied to a load circuit by introducing Thyristors between the load and a constant voltage ac source. The RMS value of alternating voltage applied to a load circuit is controlled by controlling the triggering angle of the Thyristors in the ac voltage controller circuits. In phase control the Thyristors are used as switches to connect the load circuit to the input ac supply, for a part of every input cycle. That is the ac supply voltage is chopped using Thyristors during a part of each input cycle.

The thyristor switch is turned on for a part of every half cycle, so that input supply voltage appears across the load and then turned off during the remaining part of input half cycle to disconnect the ac supply from the load. By controlling the phase angle or the trigger angle 'α' (delay angle), the output RMS voltage across the load can be controlled. The trigger delay angle 'α' is defined as the phase angle (the value of ωt) at which the thyristor turns on and the load current begins to flow.

5.PROCEDURE:

1. Make all connections as per the circuit diagram
2. Connect firstly 30V AC supply from Isolation Transformer to circuit
3. Connect firing pulses from firing circuit to Thyristors as indication in circuit
4. Connect resistive load 200Ω / 5A to load terminals and switch ON the MCB and IRS switch and trigger output ON switch.
5. Observe waveforms in DSO, across load by varying firing angle gradually up to 180^0.
6. Measure output voltage by connecting voltmeter.
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 angles in circuit by varying the Resistive Load and Inductive Load.
10. Calculate the output voltage by theoretically and compare with it practically obtained values.

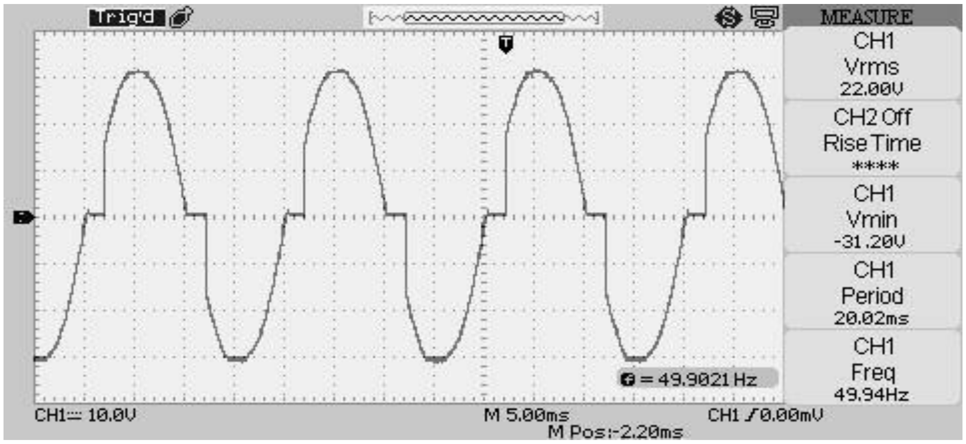
6.PRECAUTIONS:

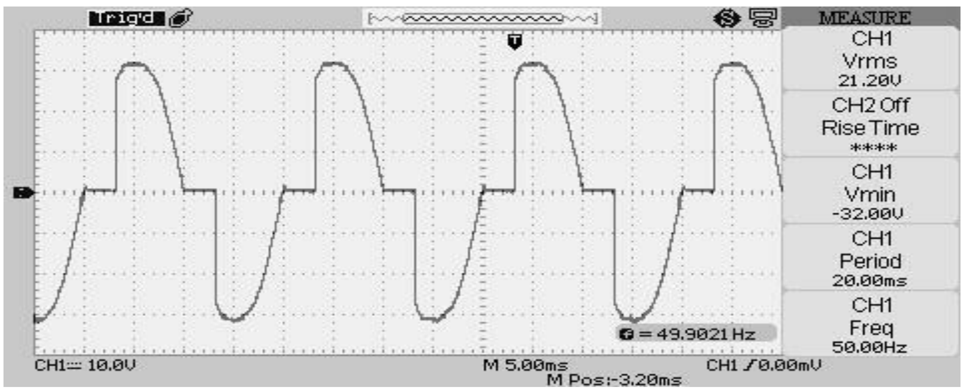
1. Avoid loose connections.

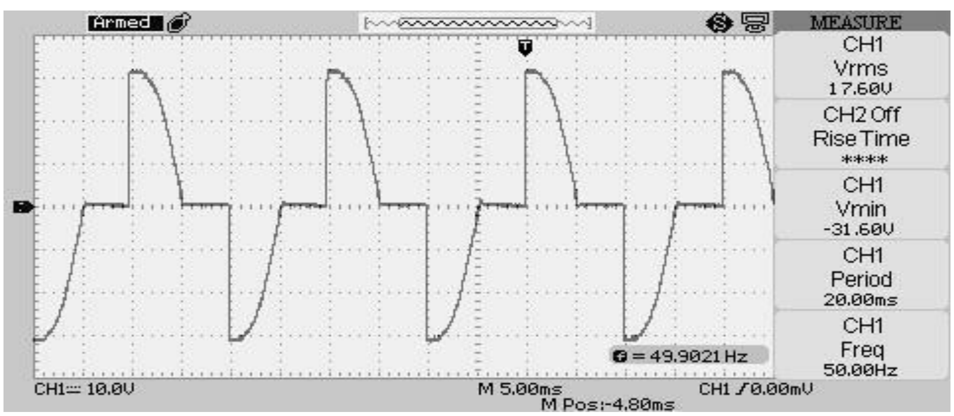
7.TABULAR COLUMN:

S.No.	Input Voltage (V_{in})	Firing angle in Degrees	Output voltage(V_0)
1	24	0	24
2	24	30	22.3
3	24	90	16.97
4	24	120	13.8

8.MODEL GRAPHS:







9.MODEL CALCULATIONS:

V_{0r} = $(V / \sqrt{\pi}) * [(\pi - \alpha) + (\sin 2\alpha)/2]$
I_{0r} = V_{0r} / R
α = Firing Angle
V = RMS Value across transformer output.

10.RESULT: The output AC voltage is controlled by using Single phase AC voltage controller.

11.OUTCOMES: By doing this experiment CO4,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

12.APPLICATIONS:

1. Lighting and fan control.
2. Starting of induction motor.
3. Transformer tap changing

13.VIVA QUESTIONS:

1. Explain about TRIAC
2. Explain about difference between single phase variac and single phase ac voltage controller.

Experiment - 8

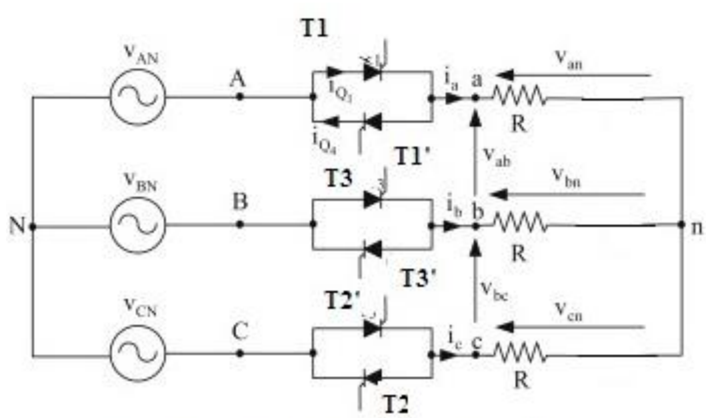
THREE- PHASE AC-AC VOLTAGE REGULATOR WITH R –LOAD.

1. AIM: To obtain the output waveforms of three-phase full wave full-controlled bridge rectifier with R load.

2.APPARATUS:

S.No.	Name of the equipment	Range	Qty
01	Three phase AC voltage controller power circuit and firing circuit	-	01
02	Step down Transformer	230V / 24V, 5A	01
03	Three-phase Resistive load	415V/4.5 kW	01
04	DSO	-	01
05	Patch chords and probes	-	Adequate

3. **Circuit Diagram:**

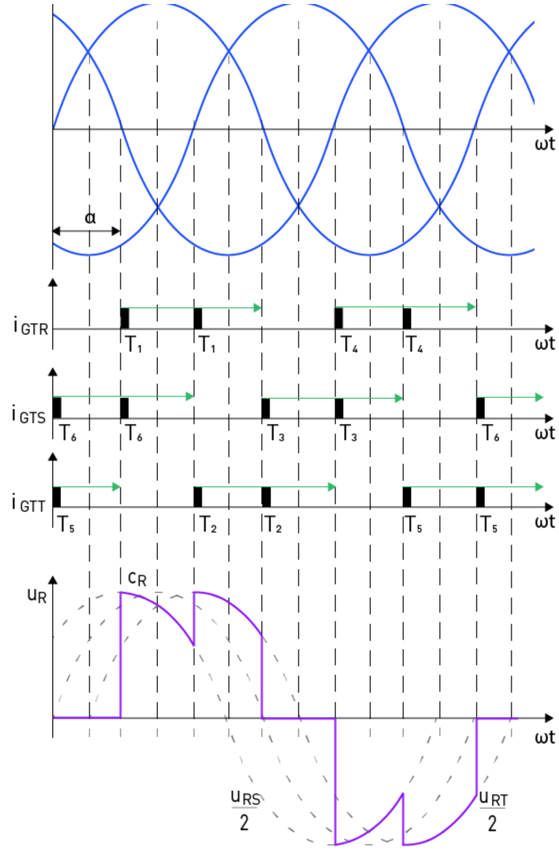


Three Phas AC Voltage Controller with R Load

4. Procedure:

1. Make the connections as per the circuit diagram.
2. Verify the connections before simulating.
3. Set the value of resistance.
4. Connect the scope and simulate the circuit.
5. Observe output voltage waveform.
6. Note down readings of firing angle and output voltage.
7. Also calculate theoretical and practical values of output voltages and compare.
8. Repeat above steps for various firing angles.
9. For RL-load connect Inductance in series with resistance.
10. Repeat the above steps.

5. Model Graph:



6. TABULAR COLUMN:

S.No.	Firing angle in Degrees	Maximum Output voltage (V_{Max})	Output voltage (V_0)
1	60	3.0	16.4
2	120	3.0	4.2

7. Result: The output waveforms of a three phase fully controlled converter are obtained for R load.

8.OUTCOMES: By doing this experiment CO4,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

9.APPLICATIONS:

1. Light dimming circuits for street lights.
2. Industrial & domestic heating.
3. Induction heating.

10.VIVA QUESTIONS:

1. Explain about difference between three phase variac and three phase ac voltage controller.
2. Explain the impact of firing range on operation of three phase ac voltage controller.

Experiment - 9

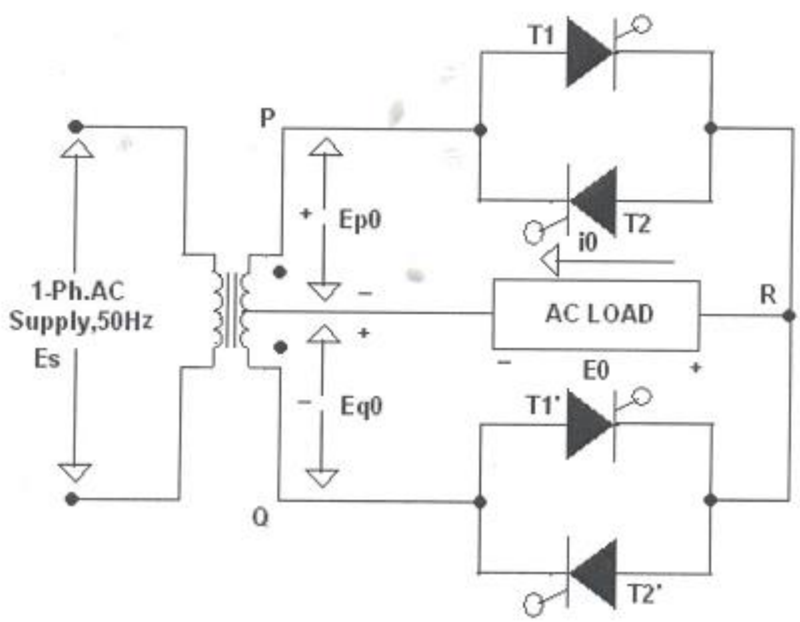
SINGLE-PHASE CYCLO-CONVERTER WITH R LOAD

1.**AIM:** To study the single phase Cyclo-converter with R Load.

2.APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Type	Qty
01	Single phase Cyclo converter power circuit and firing circuit	-	-	01
02	CRO with deferential module	-	-	01
03	Patch chords and probes	-	-	Adequate
04	Isolation Transformer (centre-tapped)	230V-0-230V / 5A (with tappings)	-	01
05	Variable Rheostat	0-200Ω / 5A	-	01

CIRCUIT DIAGRAM:



3.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.

4.TABULAR COLUMN:

Sl. No	Input Voltage (V_{in})	Firing angle in Degrees	Frequency Division	V_o (V)
1	30	0	1	28.2
2	30	90	1	20.7
3	30	0	2	28.4
4	30	90	2	20.2
5	30	0	3	28.6
6	30	90	3	20.09

5.MODEL CALCULATIONS:

$V_0 = V_s \sqrt{[1 - \frac{3\alpha}{2\pi} + \frac{3}{4\pi} sin2\alpha]}$

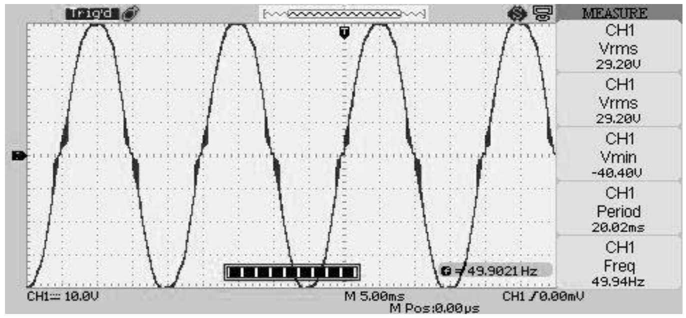
$I_0 = V_0 / R$

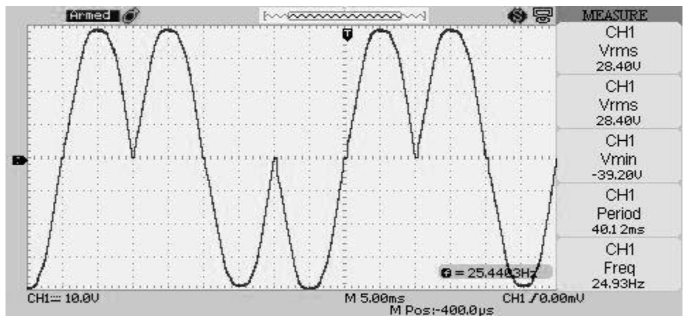
α = Firing Angle

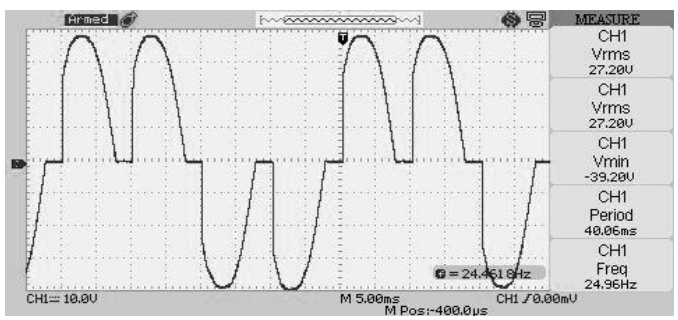
V = RMS Value across transformer output

6.MODEL GRAPH:

CYCLO CONVERTER







7.PRECAUTIONS: Avoid loose connections

8.RESULT: The output voltage and frequency has been controlled using cyclo-converter experimentally.

9.OUTCOMES: By doing this experiment CO2,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

10.APPLICATIONS:

1. Aircraft or shipboard power supplies.
2. Speed control of high power AC drives.
3. Grinding mills.
4. Cement mill drives.

11.VIVA QUESTIONS:

1. Explain about difference between three phase variac and three phase ac voltage controller.
2. Explain the impact of firing range on operation of three phase ac voltage controller.

Experiment - 10

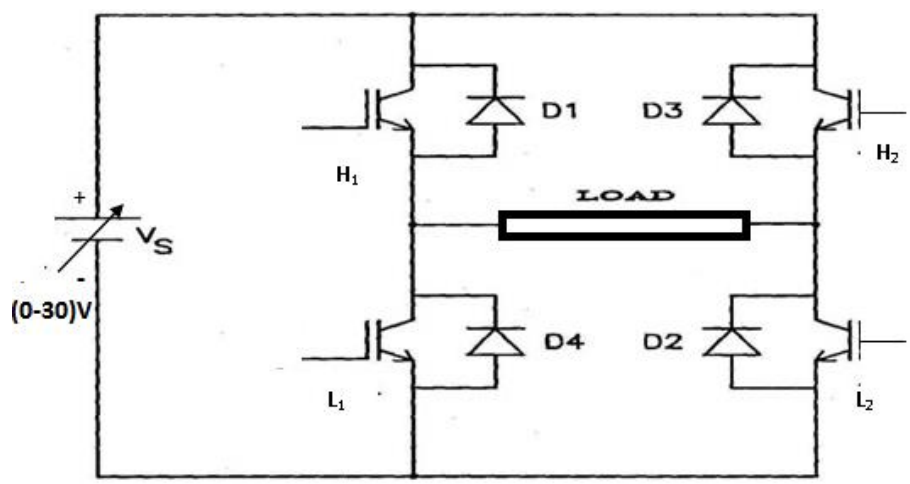
SINGLE -PHASE SQUARE WAVE BRIDGE INVERTER WITH R AND RL LOADS

1. AIM: To study Single phase square wave bridge inverter –IGBT based.

2.APPARATUS REQUIRED:

a) Single phase square wave bridge inverter –IGBT based.
b) DC regulated power supply-0-30V/2A(single)
c) Resistive load-100 Ohms/2A.Rheostat
d) DSO

3.CIRCUIT DIAGRAM:



4.THEORY:

The power circuit is IGBT based full bridge inverter shown in figure. When H1, L2 conduct, load voltage is +Vs and when H2, L1 conduct load voltage is –Vs. The frequency of the output voltage can be controlled by varying the time period. For inductive loads the diodes connected in anti parallel with devices. These diodes are called feedback diodes. The modulation techniques used is Stair case modulation.

5.PROCEDURE:

1. Switch ON the mains supply to the controller unit. The LCD display shows 1-ph PWM inverter with modulation type and M- (Duty cycle or modulation index) 00 and F-100 Hz and in OFF position.
2. Now M-00 Blinks. Press INC key to set the modulation index from 00- 1.0.
   Now Press FRQ/DTY key. Now F-100blinks.
3. Now use INC and DEC key to increase or decrease the frequency from 20Hz to

100Hz. After setting the duty cycle and frequency, press RUN/STOP key. Now the driver O/Ps pulses are available at O/Ps are comes to OFF with soft stop.

4. Now set the modulation type to staircase type and check the driver outputs for different modulation indices. Make sure that the driver outputs are proper before connecting to the power circuit.
5. Now make the connections as given in the circuit diagram for 1phase IGBT based square wave inverter.
6. Connect DC supply from a Regulated DC power supply unit (30V/2A).
7. Connect a resistive load, (R-load) – 100 Ω/2 Amps Rheostat at load terminals.
8. Connect driver output signals to the Gate and Emitter of corresponding IGBTs.
9. Check all the connections and confirm connections made are correct before switching on DC supply.
10. Switch ON the DC supply. Now use INC and DEC key to increase or decrease the frequency from 20Hz to 100Hz. After setting the duty cycle (Modulation index) and frequency, press RUN/STOP key to RUN and observe the output voltage waveform across the load.
11. Measure the AC voltage across load using AC volt meter (True RMS) or True RMS digital Multi-meter by varying modulation index.
12. Tabulate the reading.
13. Change the load to series RL load of R= 100 Ω/2 A and L = 50 mH and repeat the procedure.
14. Bring the driver outputs to OFF by press RUN/STOP key to STOP.
15. Switch off DC supply in the power circuit and switch off the mains supply to the unit.

6.PRECAUTIONS:

1. Avoid loose connections.

7.TABULAR COLUMN:-

For R load: 100 Ω/2A

Frequency = 100 Hz

Input DC voltage= 10V

S. No.	Modulation Index	AC peak voltage, V_{Max} (V)	AC Load voltage, $V_{o, rms}$ (V)
1	0.2	9.2	3
2	0.5	9.2	4.4
3	0.8	9.2	5.4
4	1	9.2	6.0

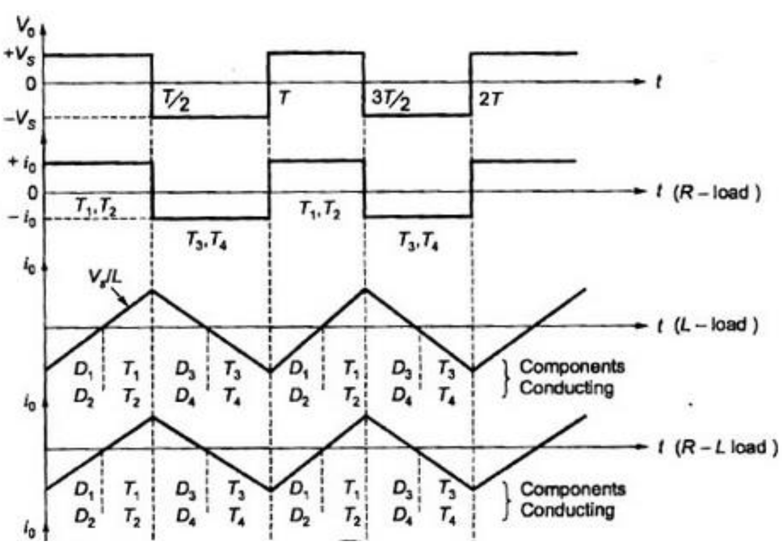
For RL load: 100 Ω/2A and 50 mH

Frequency = 100 Hz

Input DC voltage= 10V

S. No.	Modulation Index	AC peak voltage, V_{Max} (V)	AC Load voltage, $V_{o, rms}$ (V)
1	0.2	9.2	1.6
2	0.5	9.2	3
3	0.8	9.2	4
4	1	9.2	4.6

8.MODEL GRAPH:



9.RESULT: Single phase IGBT based Square wave inverter circuit is constructed and performance is studied.

10.OUTCOMES: By doing this experiment CO5,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

11. APPLICATIONS:

1. Using high-speed power semiconductor devices, the harmonic contents at the output can be reduced.
2. Other applications like AC variable motor, heating induction device, standby power supply

12.VIVA QUESTIONS:

1. What are the advantages of bridge configuration?
2. What are the disadvantages of bridge configuration?
3. What is the significance of conduction angle in the operation of the inverter?

Experiment - 11

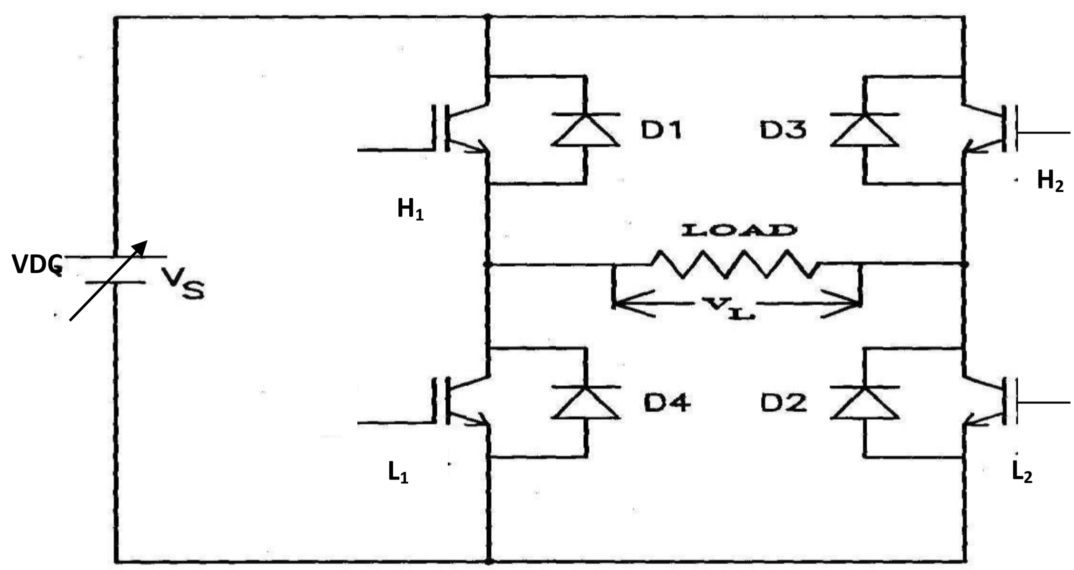
SINGLE -PHASE PWM INVERTER WITH SINE TRIANGLE PWM TECHNIQUE

1.AIM: To study Single phase PWM inverter –IGBT based.

2.APPARATUS REQUIRED:

e) Single phase PWM inverter –IGBT based.
f) DC regulated power supply-0-30V/2A(single)
g) Resistive load-100 Ohms/2A.Rheostat
h) DSO

3.CIRCUIT DIAGRAM:



4.THEORY:

The power circuit is IGBT based full bridge inverter shown in figure. When H1, L2 conduct, load voltage is +Vs and when H2, L1 conduct load voltage is –Vs. The frequency of the output voltage can be controlled by varying the time period. For inductive loads the diodes connected in anti parallel with devices. These diodes are called feedback diodes. The modulation techniques used is a) Single pulse width modulation. b) Multiple pulse width modulation**.**c)Sinusoidal pulse width modulationd) Trapezoidal modulation. e)Stair case modulation.

SINGLE PHASE PWM INVERTERS:

In many industrial applications, it is often required to control the output voltage of inverters to cope with the variations of dc input voltage, for voltage regulation of inverters and

for the constant volts/frequency control requirement. There are various techniques to vary the inverter gain. The most efficient method of controlling the gain (and output voltage) is to incorporate pulse-width- modulation (PWM) control within the inverters. The commonly used techniques are:

1. Single pulse width modulation.
2. Multiple pulse width modulation.
3. Sinusoidal pulse width modulation
4. .Trapezoidal modulation.
5. Stair case modulation.

SINGLE PULSE WIDTH MODULATION*:*

In Single phase width modulation control, there is only one pulse per half-cycle and the width of the pulse is varied to control the inverter output voltage. The generation of gating signals and output voltage of single phase full bridge inverters. The gating signals are generated by comparing a rectangular reference signal of amplitude – Ar, with a triangular carrier wave of amplitude – Ac, the frequency of the carrier wave determines the fundamental frequency of output voltage. By varying Ar from 0 to Ac, the pulse width can be varied from 0 to 100 percent. The ratio of Ar to Ac is the control variable and defined as the modulation index.

MULTIPLE PULSE WIDTH MODULATION*:*

The harmonic content can be reduced by using several pulses in each half – cycle of output voltage. The generation of gating signals for turning ON and OFF of transistors by comparing a reference signal with a triangular carrier wave. The frequency – fc, determines the number of pulses per half cycle. The modulation index controls the output voltage. This type of modulation is also known as uniform pulse- width modulation (UPWM).

SINUSOIDAL PULSE WIDTH MODULATION:

Instead of maintaining the width of all pulses the same as in the case of multiple-pulse modulation, the width of each pulse is varied in proportion to the amplitude of a sine wave evaluated at the center of the same pulse. The distortion factor and lower – order harmonics are reduced – significantly. The gating signals are generated by comparing a sinusoidal reference signal with a triangular carrier wave of frequency – fc. This type of modulation is commonly used in industrial applications and abbreviated as SPWM. The frequency or reference signal – fr, determines the inverter output frequency, and its peak amplitude – Ar, controls the modulation index – M, and rms output voltage – Vo. The number of pulses per half – cycle depends on the carrier frequency. They are 9 pulses are there in each half cycle.

TRAPEZOIDAL MODULATION*:*

This is similar to sinusoidal PWM, here the output is trapezoidal approximation. In this unit since the carrier frequency is 9 pulses in each half cycle, there is very slight difference between sinusoidal modulation.

5.PROCEDURE:

1. Switch ON the mains supply to the controller unit. The LCD display shows 1-ph PWM inverter with modulation type and M- (Duty cycle or modulation index) 00 and F-100 Hz and in OFF position.
2. Now M-00 Blinks. Press INC key to set the modulation index from 00- 1.0.
   Now Press FRQ/DTY key. Now F-100blinks.
3. Now use INC and DEC key to increase or decrease the frequency from 20Hz to 100Hz. After setting the duty cycle and frequency, press RUN/STOP key. Now the driver O/Ps pulses are available at O/Ps are comes to OFF with softstop.
4. Now set the modulation type to other type and check the outputs. Check the driver outputs for different types of modulation. Make sure that the driver outputs are proper before connecting to the power circuit.
5. Now make the connections as given in the circuit diagram for 1phase IGBT based PWM inverter.
6. Connect DC supply from a Regulated DC power supply unit(30V/2A).
7. Connect a resistive load – 100 ohms 2 Amps Rheostat at load terminals.
8. Connect driver output signals to the Gate and Emitter of corresponding IGBTs.
9. Check all the connections and confirm connections made are correct before switching on DC supply.
10. Switch ON the DC supply. Now use INC and DEC key to increase or decrease the frequency from 20Hz to 100Hz. After setting the duty cycle(Modulation index) and frequency, press RUN/STOP key to RUN and observe the output voltage waveform across theload.
11. Measure the AC voltage across load using AC volt meter(True RMS) or True

RMS digital Multimeter by varying modulation index.

12. Tabulate the reading.
13. Change the type of modulation and repeat the procedure.
14. Bring the driver outputs to OFF by press RUN/STOP key to STOP.
15. Switch off DC supply in the power circuit and switch off the mains supply to the unit.

6.PRECAUTIONS:

2. Avoid loose connections.
3. Readings are to be taken without any parallax error.

7.TABULAR COLUMN:-

For R load:

Frequency = 100 Hz.

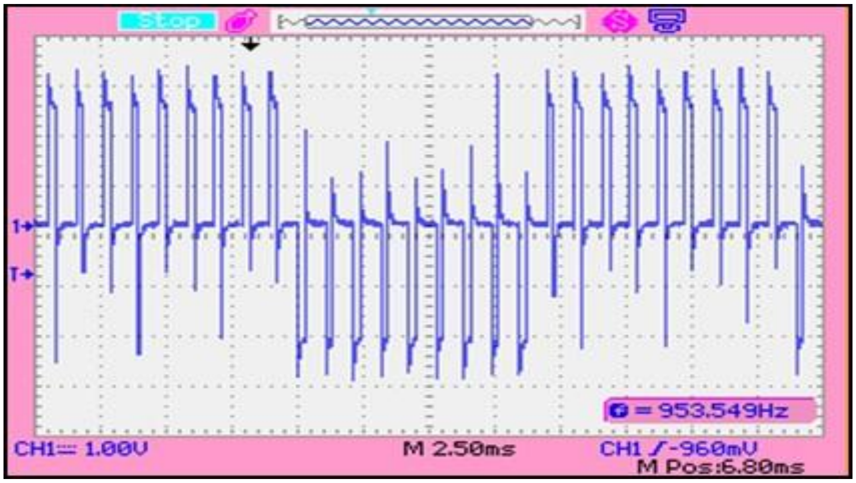
Input DC voltage= 30V

S. No.	Pulse	Modulation Index	Load Voltage AC Volts
1	Single	0.5	6.3
2	Multiple	0.5	5.1
3	trapezoidal	0.5	6.6

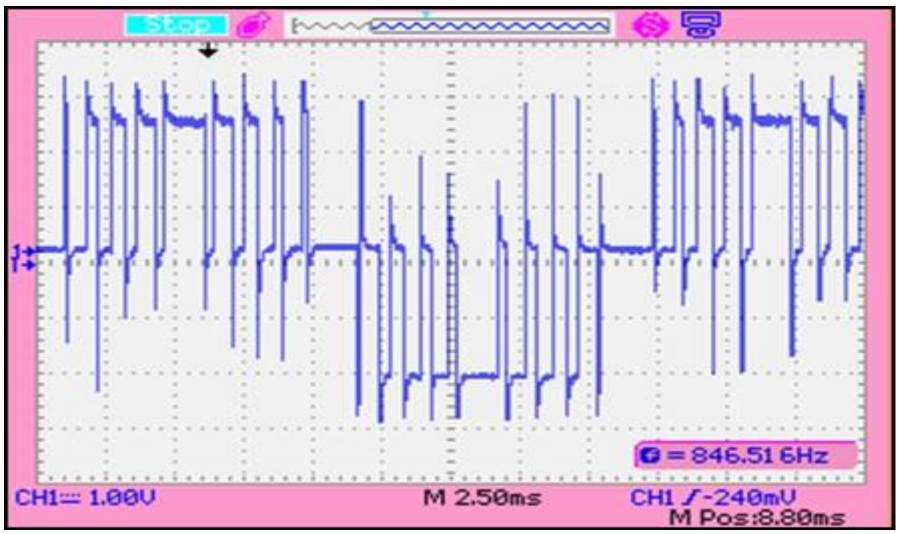
8.MODEL GRAPH:

SINGLE PULSE MODULATION

MULTIPULSE MODULATION



SINUSOIDAL MODULATION



TRAPEZOIDAL MODULATION

STAIRCASE MODULATION

9.RESULT: Single phase IGBT based PWM inverter circuit is constructed and performance is studied.

10.OUTCOME: By doing this experiment CO5,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

11.APPLICATIONS:

1. It is used in static VAR compensation.
2. It is used in variable speed motor drives.
3. It is used in high voltage DC and AC transmission lines.
4. It is used in high voltage system interconnections.

12.VIVA QUESTIONS:

1. Explain the concept of inverter.
2. Explain the concept of PWM technique.
3. Explain the concept of three phase 120 degree mode of operation and three phase 180 degree mode of operation.

ADDITIONAL EXPERIMENTS

1. SINGLE PHASE DUAL CONVERTER WITH R LOAD

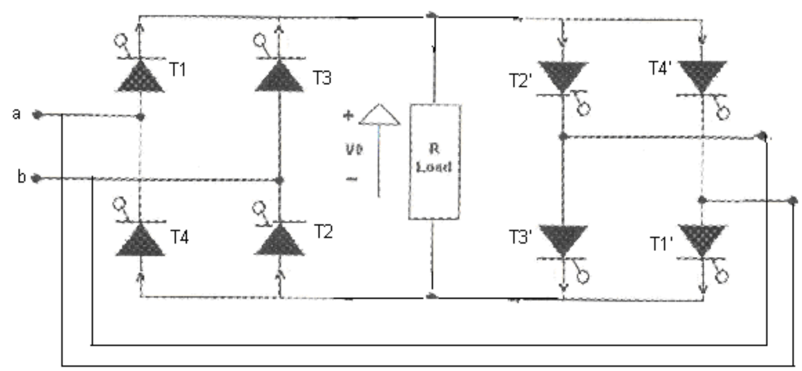
1. AIM: To study the single phase dual converter with R load.

APPARATUS REQUIRED:

S.No.	Name of the equipment	Range	Type	Qty
01	Single phase dual converter.(power circuit & firing circuit.)	-	-	01
02	Patch chords & Probes	-	-	Adequate
03	DSO	-	-	01
04	Isolation transformer(With tapping)	-	-	01
05	R load	0-200 Ohm / 5A	-	01

2.CIRCUIT DIAGRAM:

NON- CIRCULATING CURRENT MODE:



3.PROCEDURE:

NON- CIRCULATING CURRENT MODE:

1. Make all connections as per the circuit diagram.
2. Connect R-load across load terminals.
3. Connect the input AC supply to the power circuit through an Isolating Transformer(take input voltage 30V)
4. Select the NCC mode in firing circuit.
5. Give the firing pulses and keep P-converter in ON position and also put on the MCB switch.
6. By varying the firing angle observe related output waveforms in the CRO. Tabulate all the readings.
7. Repeat all above procedure for RL-load.

4.TABULAR COLUMN:

S.No.	Input Voltage (V_{in})	Firing angle in Degrees	Output voltage (V_0)
1	30	0	26
2	30	60	20
3	30	90	13
4	30	120	7

5.MODEL CALCULATIONS:

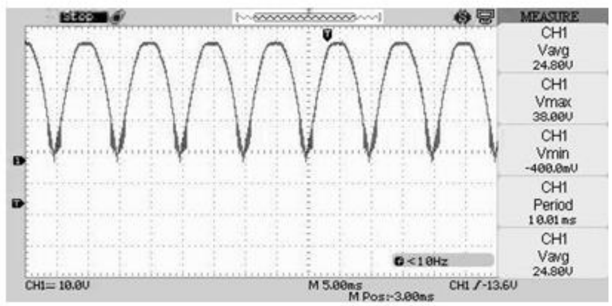
V_0 = $(2\sqrt{2}V / \pi) * (\cos \alpha)$

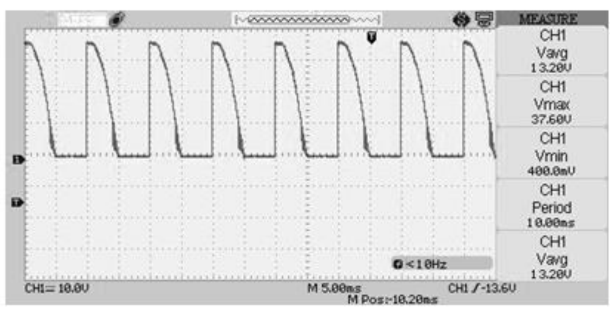
I_0 = $(2\sqrt{2}V / \alpha Z) * (\cos \alpha)$

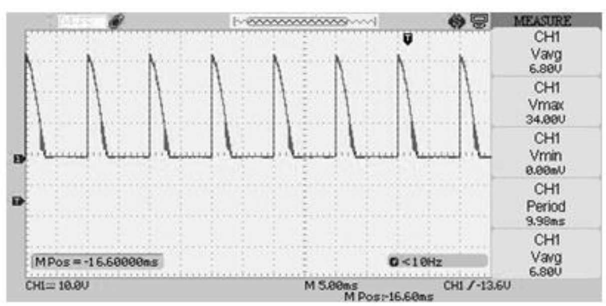
α = Firing Angle

V = RMS Value across transformer output

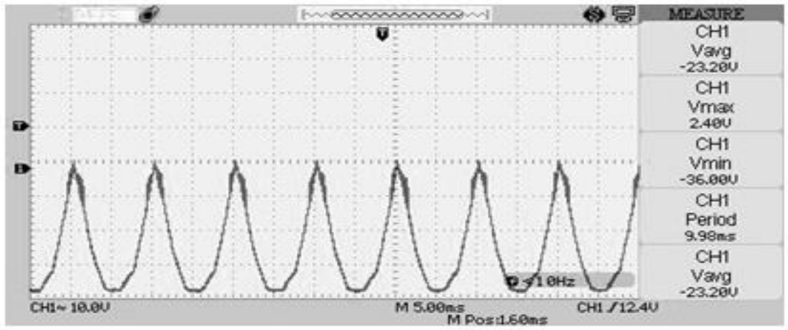
P-CONVERTER

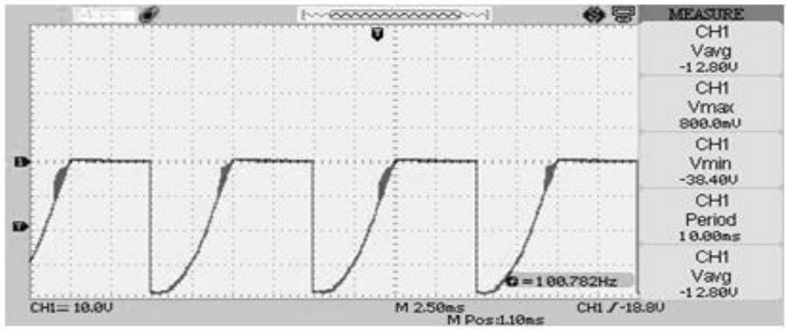


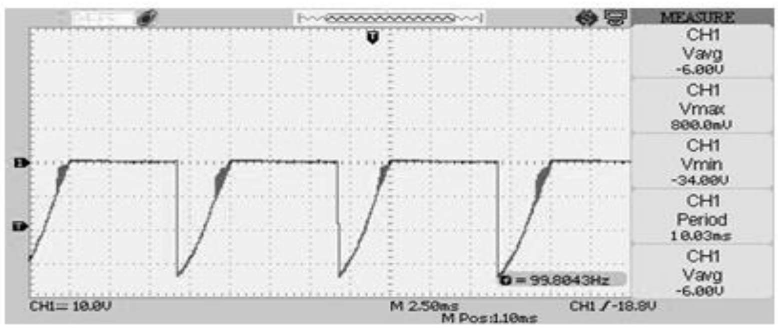




N-CONVERTER







6.PRECAUTIONS:

1. Avoid loose connections

7.RESULT: The single phase dual converter is loaded with R load experimentally and output wave forms are obtained.

8.OUTCOMES: By doing this experiment CO2,PO1,PO2,PO3,PO4,PO6,PO7,PO8, PO9,PO10,PO11,PO12 are attained.

12.APPLICATIONS:

1. Battery charging.
2. Speed control of DC motors

13.VIVA QUESTIONS:

1. Differentiate between full wave converter and fully controlled converter.
2. Derive average output voltage equation for single phase fully controlled converter.

2. JONES CHOPPER

1.AIM:Study of SCR based DC Jones Chopper circuit.

2.APPARATUS REQUIRED:

a) DC- Chopper firing unit.

DC Chopper power circuit 30V/2A(Jones chopper power circuit)

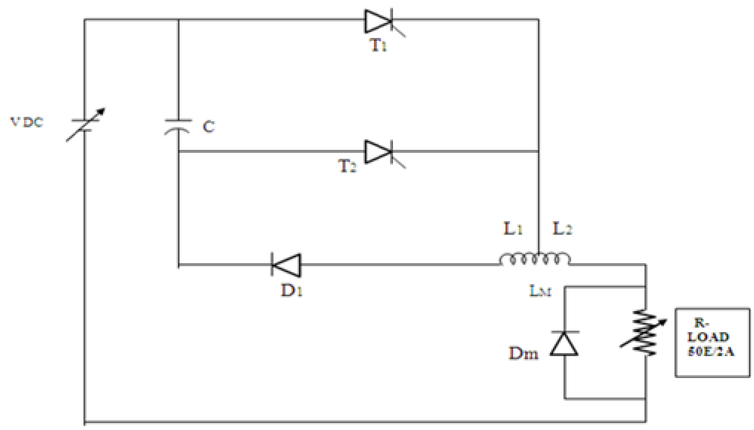
b) Rheostat -50 Ohms/2Amps.

c) Loading Inductor 0-150mH/2A

d) DC Power supply-30V/2Amps.

e) CRO or Power scope

3.CIRCUIT DIAGRAM:



4.THEORY:

Let us assume that the given polarities in the diagram are positive.T1 is the main thyristor and T2 is the auxiliary thyristor. This circuit is an example of voltage commutation. The special feature of this circuit is the tapped auto transformer. Load current flows through some portion of auto transformer winding. The two portions of the auto transformer winding are closely coupled. Because of this auto transformer, commutating capacitor gets sufficient energy to turn off the main thyristor. Load current is assumed constant to simplify the analysis of this chopper. Before turning on the main thyristor T1, load is flowing through free-wheeling diode. In this period capacitor voltage is -Vs.When main thyristor turn on load current shifts from free - wheeling diode to the main SCR. In this period an oscillating circuit is formed with L_r and C. This oscillating current flows through C - T1 - L2 - D1 - C. In this period capacitor gets charged in the reverse direction. By the end of this period Vc = +Vs. When auxiliary thyristor T2 is turned on, the capacitor will appear across T1 as reverse voltage and T1 will get turn off . Now the load current flows through Vs - C - T2 - L1 - load - Vs.When capacitor voltage becomes -Vs, free-wheeling diode will get turn on and the load current shifted to free-wheeling diode.But the inductor L1 has some amount of stored energy. Inductor stored this energy when load current is flowing through it.When load current shifts to free-wheeling diode, the energy stored in inductor L1 is transferred to capacitor through L2 (since it is an auto transformer).Because of this capacitor voltage rises initially and settles down to -Vs.For the next cycle same sequence of steps are repeated.

5.PROCEDURE:

1. To begin with switch ON the DC Chopper firing unit.
2. Observe the test point signals and Trigger output signals by varying Duty cycle and Frequency Potentiometer. Be sure the trigger outputs are proper before connecting to the power circuit.
3. Now make the interconnections in the power circuit as given in the circuit diagram.
4. Connect DC supply from a Regulated DC power suppl-30V/2A.
5. Initially set the input DC supply to 10Volts.
6. Connect a Resistive load (50Ohms/2Amps Rheostat)
7. Connect respective trigger outputs from the firing circuit to the respective SCRs in the Power Circuit.
8. Initially keep the ON/OFF switch in the firing circuit in OFF position.
9. Switch ON the DC supply. Apply Main SCR trigger pulses by pressing the ON/OFF switch to ON position.
10. Observe the voltage waveforms across load.
11. We can observe the chopped DC waveform.
12. If the commutation fails we can see only the DC voltage.
13. In this case switch OFF the DC supply, Switch OFF pulses and check the connections and try again.
14. Observe the voltage across load, across Capacitor, across Main SCR and auxiliary SCR by varying Duty cycle and frequency Potentiometer.
15. Now vary the DC supply up to the rated voltage (30V DC).
16. Draw the wave forms at different duty cycle and at different Frequency.
17. Connect DC Voltmeter or Multi meter across load to measure load voltage and DC Ammeter or Multi meter in series with Load to measure load current and note down values in the table.

18. Connect R-L Load (50 Ohms/2Amps in series with 0-150mH Loading inductor)) and repeat the above procedure for with and without free-wheeling diode.

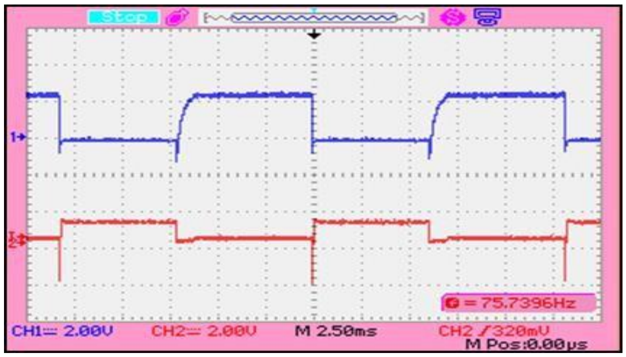
19. Switch off the DC supply, switch off trigger pulses and finally switch off the mains supply to the firing unit.

6.PRECAUTIONS:

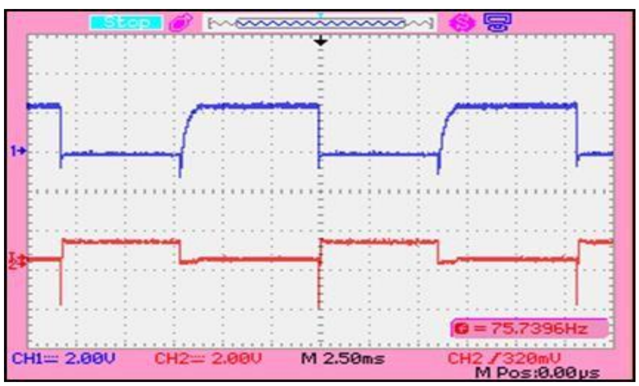
1. Avoid loose connections.
2. Readings are to be taken without any parallax error.

7.MODEL GRAPH:

WAVEFORM ACROSS LOAD (FOR R LOAD)



WAVEFORM ACROSS SCR1 and SCR2 (FOR R LOAD)



8. RESULT: Performance of DC Jones chopper is studied.

9. APPLICATIONS:

1. Speed control of DC motors
2. Battery chargers
3. Railway traction

10.VIVA QUESTIONS:

1. Explain about choppers?
2. Explain about step down choppers and step up choppers?

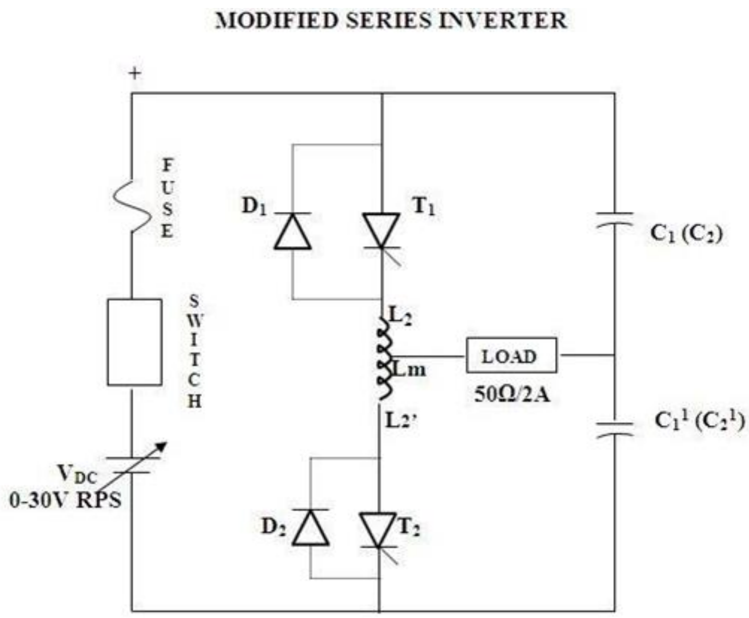
3. SINGLE PHASE SERIES INVERTER

1.AIM: To study working of Seriesinverter.

2.APPARATUS:

1. Series inverterkit.
2. DC powersupp unit – 30V @ 2A
3. Rheostat – 100ohms/2A
4. DSO
5. Probes and patch chords

3.CIRCUIT DIAGRAM:



4.THEORY:

This circuit which converts DC power into AC power is called inverter. If the thyristor commutation circuit of the inverter is in series with the Load, then the inverter is called "Series are tightly coupled. In this circuit, it is possible to turn-on-thyristorT_p before the current through thyristor$T_n$has become zero and vice-versa. Therefore, the Modifed Series Inverter can be operated beyond the resonance frequency (fr) of the circuit. Inverter is operated at the resonance frequency (f_r) if the load current waveform has low frequency and should not have zero current interval. The inverter's resonance frequency depends on the values of L, R and C in the circuit.

5.PROCEDURE:

1. To begin with switch on the power supply to the firing circuit. Check that trigger pulses by varying the frequency.
2. Make the interconnections of the power circuit as shown in the circuit diagram.
3. Now connect trigger outputs from the firing circuits to Gate and Cathode of SCR`s T1 and T2.

4. Connect input from a 30V/2A Regulated power supply. Switch on the input DC supply. Now apply trigger pulses to the SCR`s and observe voltage wave from across load.
5. Vary the frequency and observe the wave forms.
6. If the inverter frequency increases above the resonant frequency of the power
7. Circuit commutation will fail
8. Then switch OFF the DC supply, reduce the inverter frequency and try again if you will not get the result. Check the input fuse and try again.
9. Repeat the same with different values of L , C and load.
10. And also observe the waveforms with and without fly wheel diodes. The output waveform is entirely depending on load.
11. Plot a graph of frequency verses output voltage. (Output voltage varies with frequency)
12. Draw the load voltage waveform. To switch OFF the inverter. Switch OFF the input supply first and then trigger pulses.

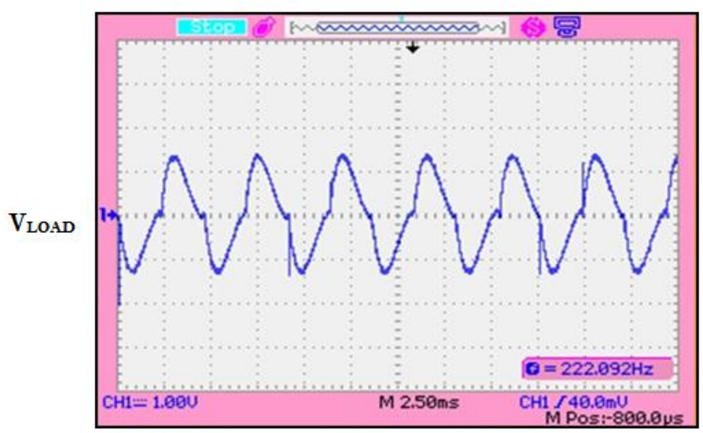
6.PRECAUTIONS:

1. Avoid loose connections.
2. Readings are to be taken without any parallax error.

7.TABULAR COLUMN:

S.NO.	SUPPLY VOLTAGE	FREQUENCY	RMS OUTPUT VOLTAGE
1	23.8	80	6.4
2	23.8	120	7.6
3	23.8	150	8.4
4	23.8	200	9.2
5	23.8	260	9.6

8.MODEL GRAPH:



9.RESULT: Series inverter is constructed and its performance is studied

10.APPLICATIONS:

1. Used In Uninterrupted Power Supply (UPS).

11.VIVA QUESTIONS:

1. Explain about inverters?
2. Explain about differences between series inverter and parallel inverter?