SCHEME : K

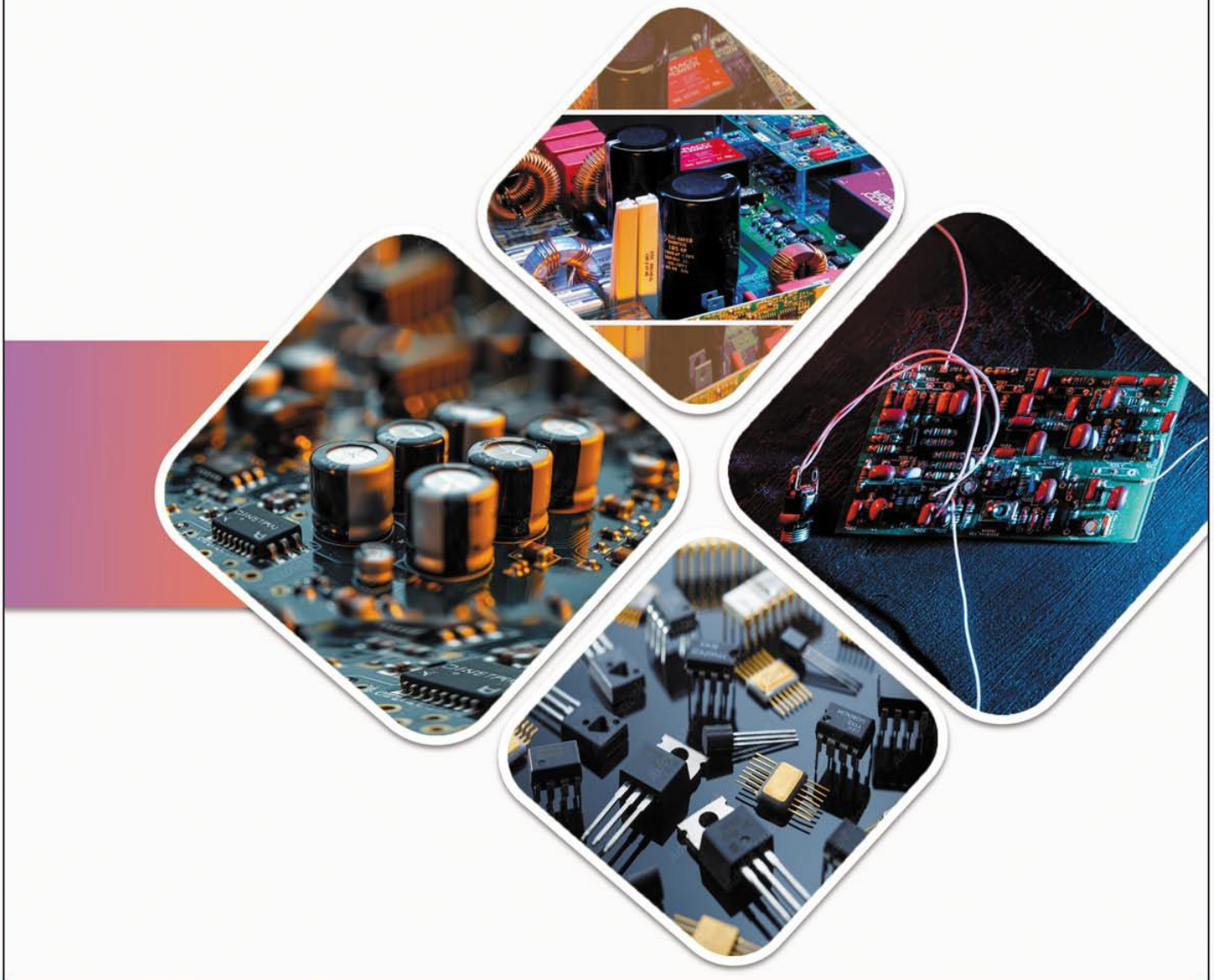
Name : _____

Roll No. : _____ Year : 20___ 20___

Exam Seat No. : _____

LABORATORY MANUAL FOR

BASIC POWER ELECTRONICS (314363)



ELECTRONICS ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF
TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

VISION:

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION:

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following:

- Skill development in line with industry requirements.
- Industry readiness and improved employ ability of Diploma holders.
- Synergistic relationship with industry.
- Collective and Cooperative development of all stake holders.
- Technological interventions in societal development.
- Access to uniform quality technical education..

A Laboratory Manual for

Basic Power Electronics

(314363)

Semester-IV

(DE / EJ / EK / ET/ EX / IC / IE / IS)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION,

MUMBAI

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Address: 4th floor, Govt. Polytechnic Building, 49,

Kherwadi, Bandra (E), Mumbai- 400051

MAHARASHTRA STATE
BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms …….. Roll No.……of Fourth Semester of Diploma in……of **Institute**…….. (**Code:** ……...) has completed the term work satisfactorily in Course **Basic Power Electronics Course (Code:314363)** for the academic year 20….- 20….. as prescribed in the curriculum.

Place: …… Enrollment No: …….

Date: …… Exam. Seat No: …….

Subject Teacher **Head of the Department** **Principal**

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curriculum for engineering diploma programs with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a 'vehicle' to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age old practice of conducting practical to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the per-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Basic Power Electronics course provides platforms for students to understand working of Thyristors devices such as SCR, LASCR, TRIAC, GTO, SCS and Industrial applications of power electronic devices. Electronic control circuits play major role in industries. In this era of automation in industry and manufacturing sector, the mechanical controls are largely replaced by power electronic devices. In this context this course aims at acquainting the pass outs with the basic principles and applications of basic power electronics devices, so that they can maintain the control circuits used in the field. Hence this course has been designed to achieve this aim.

Although all care has been taken to check for mistakes in this laboratory manual, yet It is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Program Outcomes (POs) to be achieved through Practical of this Course

Following programme outcomes are expected to be achieved through the practical of the course

PO1. Basic and Discipline knowledge: Apply knowledge of basic mathematics, science and basic engineering to solve the broad-based Electronics related problems.

P02. Problem Analysis: Electronics and Telecommunication engineering knowledge To solve broad-based Electronics and Telecommunications engineering related problems

P03. Design Development and Solution: Plan to design experiments and develop to use the results to solve broad-based Electronics related problems.

P04. Engineering tools: Apply relevant Electronics and Telecommunications technologies and tools with an understanding of the limitations.

PO5. Engineering Practices for Society, Sustainability and Environment: Assess social, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Electronics. Apply Electronics and Telecommunication engineering solutions also for sustainable development practices in social and environmental contexts.

P06. Project Management : Function effectively as a leader and team member in the diverse/ multidisciplinary teams. Apply ethical principles for commitment to professional ethics, Responsibilities and norms of the practice also in the field of Electronics and Telecommunication engineering.

PO7. Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the Electronics and Telecommunication engineering and allied industry.

List of Relevant Skills

- The following industry relevant skills of the competency 'Maintain power electronic devices in electronic circuits. are expected to be developed in students by undertaking the practicals of this laboratory manual.

1. Identify the power electronic component.
2. Test power electronic component.
3. Select the proper power electronic component of proper value as per the requirement.
4. Select the appropriate component with the help of data sheet.
5. Use the heat sink for relevant active component.
6. Mount the power electronic component as per circuit diagram.
7. Test the power circuit for the given application.
8. Compare the observed output with the expected output.
9. Find faults and trouble shoot the given circuit.
10. Use appropriate EDA tool for simulation of power electronic circuit.

Practical- Course Outcome matrix

Course Outcomes (COs)

CO1 - Identify power semiconductor devices used in Power Electronics circuit.
CO2 - Maintain SCR Triggering and Commutating Circuits.
CO3 - Use phase controlled rectifiers in different applications.
CO4 - Analyze power converter circuits.
CO5 - Maintain power electronic circuits used in various domestic and industrial applications.

s. No.	Practical Outcomes(PrO)	co a.	co b.	co c.	co d.	co e.
1.	*Performance of SCR using IC 2N4103 or any other equivalent IC.	√	-	-	-	-
2.	*Performance of IGBT using IC BUP 402 or any other equivalent IC	√	-	-	-	-
3.	*Performance of DIAC using IC DB3/DB4 or any other equivalent IC through its V-I curve	√	-	-	-	-
4.	Measurement of output voltage by changing firing angle through variation in resistor, capacitor in R and RC triggering circuits of SCR.		√	-	-	-
5.	*Synchronized UJT triggering circuit.	-	√	-	-	-
6.	*Class C-Complimentary type commutation circuit	-	√	-	-	-
7.	* Half wave controlled rectifier	-	-	√	-	-
8.	Performance of full wave controlled rectifier with R, RL load and measure load voltage.	-	-	√	-	-
9.	Performance of 3- phase half wave controlled rectifier	-	-	√	-	-
10.	Performance of step-up chopper for different values of duty cycles	-	-	-	√	-
11	*Step-down chopper for R and RL load	-	-	-	√	-
12.	Performance of parallel inverter	-	-	-	√	-
13.	Single phase midpoint Cyclo-converter with R load.	-	-	-	√	-
14.	*Light dimmer circuit using DIAC-TRIAC	-	-	-	-	√
15.	Emergency Light circuit using SCR	-	-	-	-	√
16. .	Temperature controller using SCR	-	-	-	-	√

Guidelines to Teachers

1. Teacher is expected to refer complete curriculum document and follow guidelines for implementation before start of curriculum.
2. Teacher should provide the guideline with demonstration of practical to the students with all features.
3. Teacher shall explain prior concepts to the students before starting of each practical
4. Involve students in performance of each practical.
5. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
6. Teachers should give opportunity to students for hands on experience after the demonstration.
7. Teacher is expected to share the skills and competencies to be developed in the students.
8. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
9. If practical is in two parts -Part I and Part II it should be conducted in two turns.
10. Assess the skill achievement of the students and COs of each unit.
11. At the beginning Teacher should make the students acquainted with any of the simulation software environment as few experiments are based on simulation.

Instructions for Students

1. Listen carefully the lecture given by teacher about course, curriculum, learning structure, skills to be developed.
2. Before performing the practical student shall read lab manual of related practical to be conducted.
3. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit/or assessment to the teacher.***
4. Organize the work in the group and make record of all observations.
5. Students shall develop maintenance skill as expected by industries.
6. Student shall attempt to develop related hand-on skills and gain confidence.
7. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual.
8. Student shall refer technical magazines, IS codes and data books.
9. Student should develop habit to submit the practical on date and time.
10. Student should well prepare while submitting write-up of exercise,

Content Page

List of Practical's and Progressive Assessment Sheet

Sr. No.	Title of the practical	Page No.	Date of performance	Date of submission	Assessment marks(25)	Dated signature of teacher	Remarks (if any)
1.	*Performance of SCR using IC 2N4103 or any other equivalent IC.	1					
2.	*Performance of IGBT using IC BUP 402 or any other equivalent IC.	11					
3.	*Performance of DIAC using IC DB3/DB4 or any other equivalent IC through its V-I curve	19					
4.	Measurement of output voltage by changing firing angle through variation in resistor, capacitor in R and RC triggering circuits of SCR.	25					
5.	*Synchronized UJT triggering circuit.	32					
6.	*Class C-Complimentary type commutation circuit	38					
7.	* Half wave controlled rectifier	44					
8.	Performance of full wave controlled rectifier with R, RL load and measure load voltage.	50					
9.	Performance of 3- phase half wave controlled rectifier	58					
10.	Performance of step-up chopper for different values of duty cycles	64					
11.	*Step-down chopper for R and RL load	72					
12.	Performance of parallel inverter	79					
13.	Single phase midpoint Cyclo- converter with R load.	86					
14.	*Light dimmer circuit using DIAC-TRIAC	94					
15.	Emergency Light circuit using SCR	100					
16.	Temperature controller using SCR	107					
Total							

Note:
- '*'Marked Practicals (LLOs) are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes

Practical No.1: *Performance of SCR using IC 2N4103 or any other equivalent IC.

I. Practical Significance

Performance of SCR can be decided by understanding the holding current (IH) and latching current (IL). If any one of the current is not appropriately defined by the manufacturer, then it will not make the system efficient or usable for the defined applications like to control the motor speed, battery charging and power conversions. In this practical students will be able to determine switching voltage of the SCR.

II. Industry / Employer Expected outcome(s):

This practical is expected to develop the following skills for the industry identified Expected outcome **'Maintain the proper functioning of power electronic devices':**

Use a multimeter to measure various electrical parameters.
Interpret the circuit diagrams.
Use the power supply for various practicals.

III. Course Level Learning outcome(s)

Use relevant SCR in Electronics circuits.

IV. Laboratory Learning outcome(s)

LLO 1.1 Test the SCR in forward conduction state and measure holding current (IH) and latching current (IL).

V. Relevant Affective Domain related outcome(s)

Follow safe practices.
Follow ethical practices.
Demonstrate working as a leader/a team member

VI. Relevant Theoretical Background (with diagrams if required)

The SCR choice does not depend only on the V_{80} voltage, but it also depends on the rated current an the sensitivity of SCR. Gate triggering is most commonly used method by applying positive signal at gate terminal of SCR it can be trigger much before the specified breakover voltage. The voltage at which SCR turns on with gate current is called switching voltage. The switching voltage of SCR is inversely proportional to gate current.

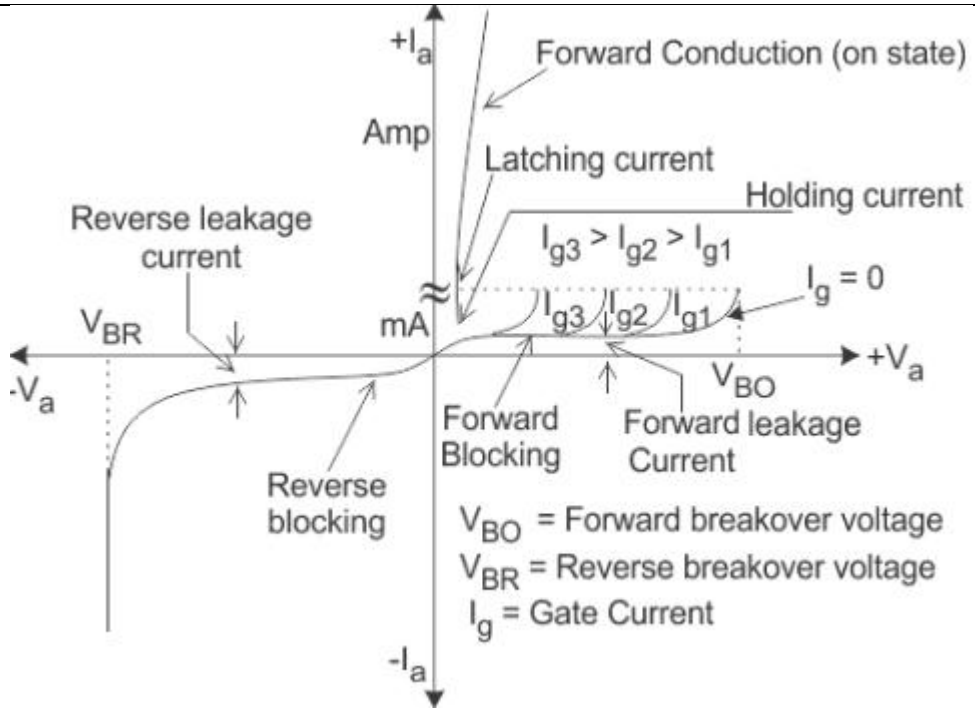


Fig 1.1: V-I characteristics of SCR

VII. Actual Circuit diagram used in laboratory with equipment specifications

a) Sample Circuit diagram

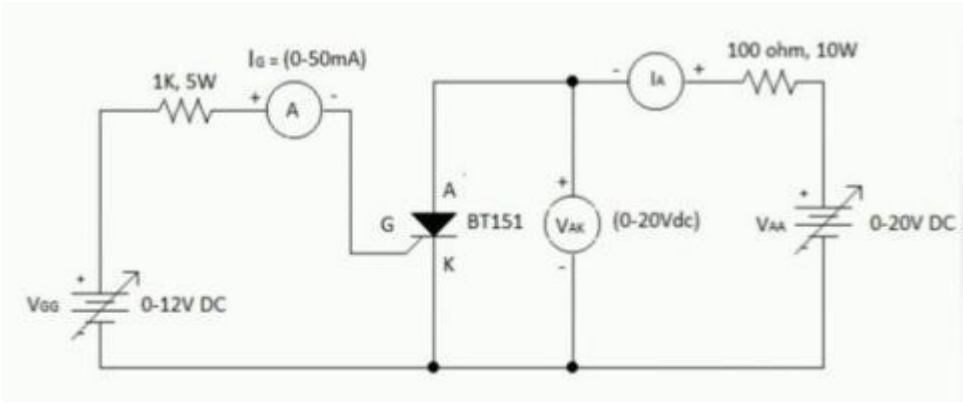


Fig. 1.2 Circuit diagram of V-I characteristics of SCR

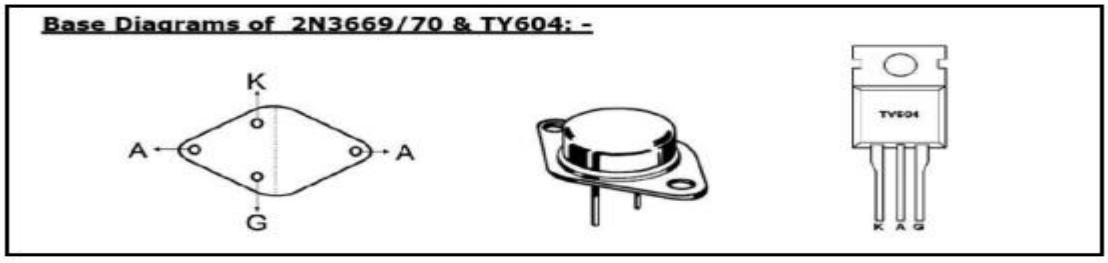


Fig. 1.3 Base Diagrams of SCR 2N3669/70 & TY604

b) Actual Circuit diagram

VIII. Required Resources/apparatus/equipment with specifications

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Digital Multimeter (Ammeter/Voltmeter)	Digital Multimeter: 3 1/2 digit display.	2
2	DC power supply	Variable power supply(0-30)V	2
3	SCR	IC 2N4103 Or any Other as per availability	1
4	Potentiometer	100 Ω, 10 W	1
5	Resistor	1 K Ω, 5W	1
6	Breadboards	General Purpose Breadboards	1
7	Connecting wires	Single strand 0.6 mm Teflon Coating	As per requirement

IX. Precautions to be Followed

Ensure proper connections are made to the equipment.
Ensure the power switch is in 'off' condition initially.
The applied voltage, current should not exceed the maximum rating of the given SCR.

X. Procedure

Forward Characteristics

1. Make the connection as per circuit diagram given in Fig. 1.2.
2. Initially keep the gate current at zero value.
3. Increase V_{AK} stepwise and note down Anode current (I_A)- (In OFF state of SCR)
4. Fixed V_{AK} at particular value. Now increase gate current slowly till SCR trigger and note down the gate current.
5. Increase V_{AK}. Note down anode current. (In ON state of SCR)
6. Repeat the step 4 and 5 for different value of V_{AK}.
7. Draw the forward V-I characteristics of SCR on graph paper.

To determine Holding current

1. Set the V_{AK} at any suitable value.
2. Apply sufficient gate current and tum on SCR.
3. After SCR has tum on remove the gate current.
4. Increase the value of R, I_A will go on decreasing. Find lowest value of I_A at which SCR remains on.
5. The lowest value of I_A is the latching current.

XI. Observations and Calculations (use blank sheet provided if space not sufficient)

Table 1.1

Sr. No.	**Ig1 = 0 mA**		**Ig_2 = mA**		**Ig_3 = mA**	
	$V_F=V_{AK}$ (Volts)	I_A (mA)	$VR=V_{AK}$ (Volts)	I_A (mA)	$VR=V_{AK}$ (Volts)	I_A (mA)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

XII. Results

- Holding current.....
- Switching voltage for Ig_2 = ……, Ig_3 = …….

XIII. Interpretation of Results

……..

……..

……..

XIV. Conclusions and Recommendation

……..

……..

……..

XV. Practical Related Questions (On the basis of observation table 1.1 answer the question 1 to 3)

1. Write the range of anode current in the cut-off region of the SCR.
2. Write the voltage VAK as soon as SCR turns on.
3. Write the minimum voltage for the Gate terminal?
4. Write the various packages of SCR (Explore internet).

[Space for Answers]

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XVI. References / Suggestions for further reading

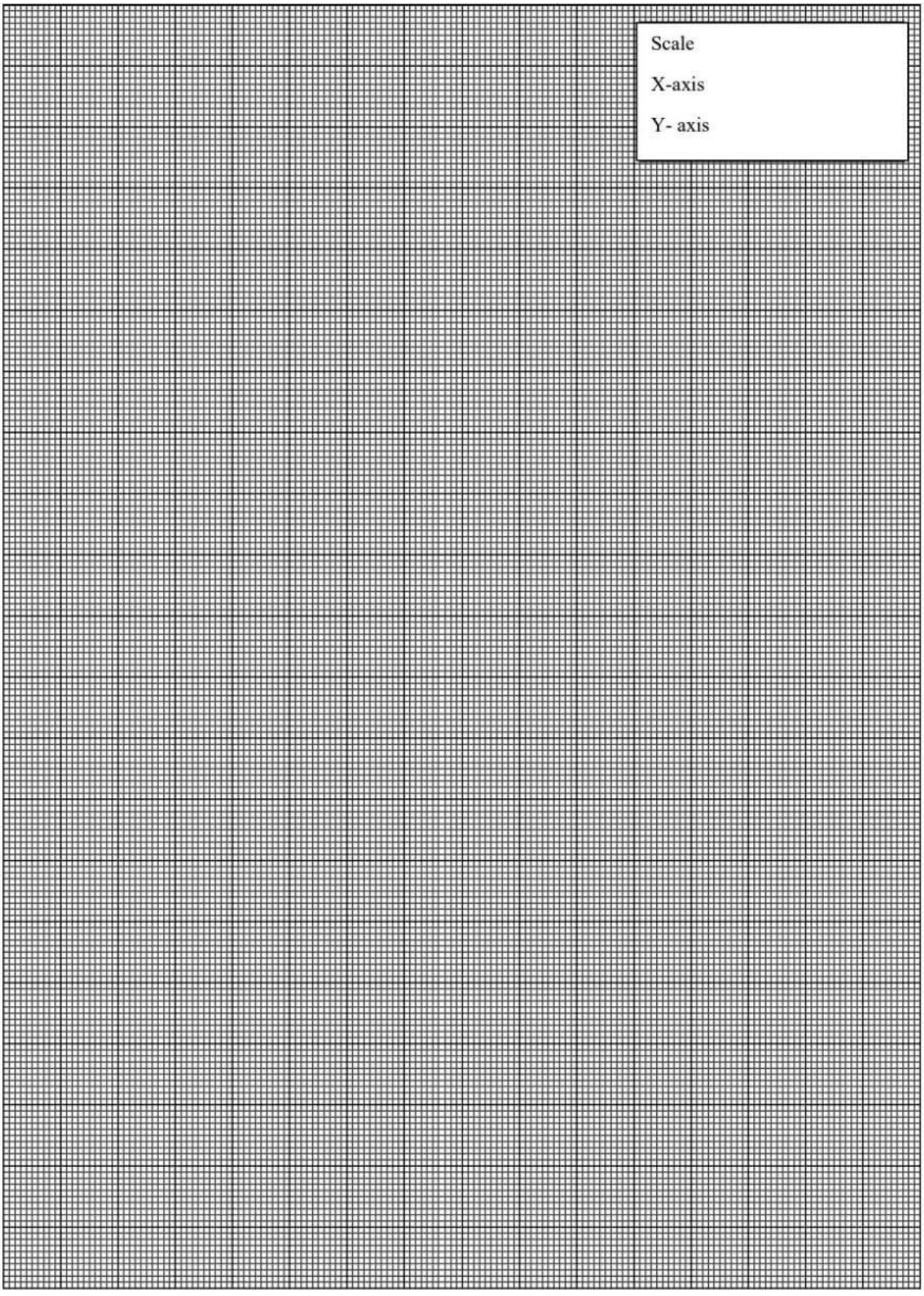
1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics

3. A text - Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 0070727937, 9780070727939.
4. http://bitsavers.trailing-edge.com/components/ge/l 972_GE_SCR_Manual_5ed.pdf

Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	


Scale
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Silicon Controlled Rectifiers

2N3668-2N3670, 2N4103

File Number **116**

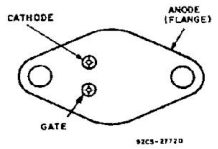
12.5-A Silicon Controlled Rectifiers

For Low-Cost Power-Control and Power-Switching Applications

Features:

- *Low switching losses*
- *High di/dt and dv/dt capabilities*
- *Low leakage currents, both forward and reverse*
- *Low forward voltage drop at high current levels*
- *Low thermal resistance*

TERMINAL DESIGNATIONS



JEDEC TO-204AA

RCA 2N3668*, 2N3669*, 2N3670*, and 2N4103* are all-diffused, three-junction, silicon controlled-rectifiers (SCR's). They are intended for use in power-control and power-switching applications requiring a blocking voltage capability of up to 600 volts and a forward-current capability of 12.5 amperes (rms value) or 8 amperes (average value) at a case temperature of 80°C.

The 2N3668 is designed for low-voltage power supplies, the 2N3669 for direct operation from 120-volt line supplies, the 2N3670 for direct operation from 240-volt line supplies, and the 2N4103 for high-voltage power supplies.

The 2N3668, 2N3669, 2N3670 and 2N4103 SCR's employ the hermetic JEDEC TO-204AA package.

*Formerly Dev. Types TA2621, TA2598, TA2618, and TA2775, respectively.

Absolute-Maximum Ratings, for Operation with Sinusoidal AC Supply Voltage at a Frequency between 50 and 400 Hz, and with Resistive or Inductive Load

RATINGS	CONTROLLED-RECTIFIER TYPES 2N3668	2N3669	2N3670	2N4103	UNITS
Transient Peak Reverse Voltage (Non-Repetitive), V_{RM}(non-rep)	150	330	660	700	volts
Peak Reverse Voltage (Repetitive), V_{RM} (rep)	100	200	400	600	volts
Peak Forward Blocking Voltage (Repetitive), V_{FBOM}(rep)	100	200	400	600	volts
Forward Current:					
For case temperature (T_C) of +80°C					
Average DC value at a conduction angle of 180°, I_{FAV}	8	8	8	8	amperes
RMS value, I_{FRMS}	12.5	12.5	12.5	12.5	amperes
For other conditions, (See Fig. 4)					
Peak Surge Current, i_{FM} (surge):					
For one cycle of applied voltage	200	200	200	200	amperes
For one cycle of applied principal voltage					
60 Hz (sinusoidal), T_C = 80°C	200	200	200	200	amperes
50 Hz (sinusoidal), T_C = 80°C	170	170	170	170	amperes
For more than one cycle of applied voltage	See Fig. 1	See Fig. 1	See Fig. 1	See Fig. 1	
Fusing Current (for SCR protection):					
T_J = -40 to 100°C, t = 1 to 8.3 ms, I^2t	170	170	170	170	ampere² second
Rate of Change of Forward Current, di/dt	200	200	200	200	amperes/ microsecond
$V_{FB} = V_{BOO}$ (min. value)					
I_{GT} = 200 mA, 0.5 ns rise time					
Gate Power*:					
Peak, Forward or Reverse, for 10 ns duration, P_{GM} (See Figs. 7 and 9)	40	40	40	40	watts
Average, P_{GAV}	0.5	0.5	0.5	0.5	watt
Temperature:					
Storage, T_{stg}•	-40 to +125	-40 to +125	-40 to +125	-40 to +125	°C
Operating (Case), T_C	-40 to +100	-40 to +100	-40 to +100	-40 to +100	°C

*Any values of peak gate current or peak gate voltage to give the maximum gate power is permissible.
•Temperature reference point is within 1/8 in. (3.17 mm) of the center of the underside of unit.

Silicon Controlled Rectifiers

2N3668-2N3670, 2N4103

ELECTRICAL CHARACTERISTICS

Characteristics at Maximum Ratings (unless otherwise specified), and at Indicated Case Temperature (T_C)

CHARACTERISTICS	CONTROLLED-RECTIFIER TYPES												UNITS
	2N3668			2N3669			2N3670			2N4103			
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Peak Repetitive Blocking Voltage, V_{DROM} At T_C = +100°C	100	—	—	200	—	—	400	—	—	600	—	—	volts
Peak Blocking Current, at T_C = +100°C: Forward, I_{DOM}	—	0.2	2	—	0.25	2.5	—	0.3	3	—	0.35	4	mA
$V_D = V_{DROM}$ Reverse, I_{ROM}	—	0.05	1	—	0.1	1.25	—	0.2	1.5	—	0.3	3	mA
$V_R = V_{RROM}$ Forward Voltage Drop, v_F At a Forward Current of 25 amperes and a T_C = +25°C (See Fig. 2)	—	1.5	1.8	—	1.5	1.8	—	1.5	1.8	—	1.5	1.8	volts
DC Gate-Trigger Current, I_{GT}: At T_C = +25°C (See Fig. 9)	1	20	40	1	20	40	1	20	40	1	20	40	mA (dc)
Gate-Trigger Voltage, V_{GT}: At T_C = +25°C (See Fig. 9)	—	1.5	2	—	1.5	2	—	1.5	2	—	1.5	2	volts (dc)
Holding Current, I_{HO}: At T_C = +25°C	0.5	25	50	0.5	25	50	0.5	25	50	0.5	25	50	mA
Critical Rate of Applied Forward Voltage, Critical dv/dt V_{FB}=V_{BOO}(min. value), exponential rise, T_C = +100°C	10	100	—	10	100	—	10	100	—	10	100	—	volts/ micro-second
Turn-On Time, t_{on} (Delay Time + Rise Time) $V_D = V_{DROM}$ i_T = 8 amperes, I_G = 200 mA, 0.1 μs rise time, T_C = +25°C	—	1.25	—	—	1.25	—	—	1.25	—	—	1.25	—	micro-seconds
Turn-Off Time, t_{off}, (Reverse Recovery Time + Gate Recovery Time) I_F = 8 amperes, 50 ns pulse width, dv_{FB}/dt = 20 v/μs, di_r/dt = 30 A/μs, I_{GT} = 200 mA, T_C = +80°C	—	20	50	—	20	50	—	20	50	—	20	50	micro-seconds
Thermal Resistance, Junction-to-Case	—	—	1.7	—	—	1.7	—	—	1.7	—	—	1.7	°C/W

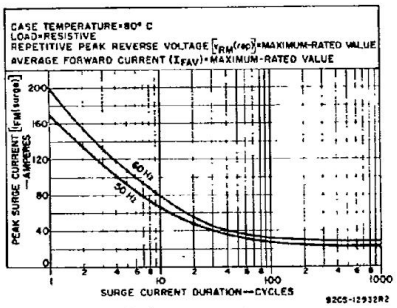


Fig. 1 — Peak surge current vs. surge current duration.

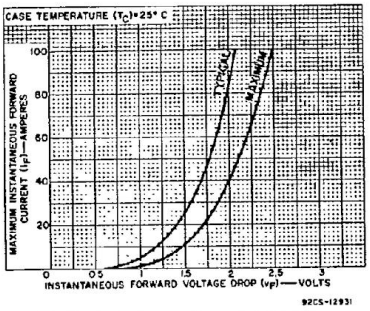


Fig. 2 — Instantaneous forward current vs. instantaneous forward voltage drop.

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Practical No. 2: *Performance of IGBT using IC BUP 402 or any other equivalent IC.

I. Practical Significance

Main features of Insulated Gate Bipolar Transistor over other types of transistor devices are its high voltage capability, low ON-resistance, ease of drive, relatively fast switching speeds and combined with zero gate drive current makes it a good choice for moderate speed, high voltage applications such as in pulse-width modulated (PWM), variable speed control, switch-mode power supplies or solar powered DC-AC inverter and frequency converter applications operating in the hundreds of kilohertz range. In this practical students will be able to determine dynamic input impedance of IGBT from its transfer characteristics

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II. Industry / Employer Expected outcome(s)

This practical is expected to develop the following skills for the industry identified competenc

'Maintain the proper functioning of power electronic devices':

1. Use a multimeter to measure various electrical parameters.
2. Interpret the circuit diagrams.
3. Use the power supply for various practicals.

III. Course Level Learning outcome(s)

- **Identify power electronic devices in circuits.**

IV. Laboratory Learning Outcome(s)

LLO 2.1 Test the forward and transfer characteristics of given IGBT

V. Relevant Affective Domain related Outcome(s)

1. Follow safe practices.
2. Follow ethical practices.
3. Demonstrate working as a leader/a team member

VI. Relevant Theoretical Background (with diagrams if required)

The Insulated Gate Bipolar Transistor also called an **IGBT** for short, is something of a cross between a conventional *Bipolar Junction Transistor,* (BJT) and a *Field Effect Transistor,* (MOSFET) making it ideal as a semiconductor switching device. It combines the simple gate-drive characteristics found in the MOSFET with the high-current and low- saturation-voltage capability of a bipolar transistor. It does this by using an isolated gate field effect transistor for the control input, and a bipolar power transistor as a switch.

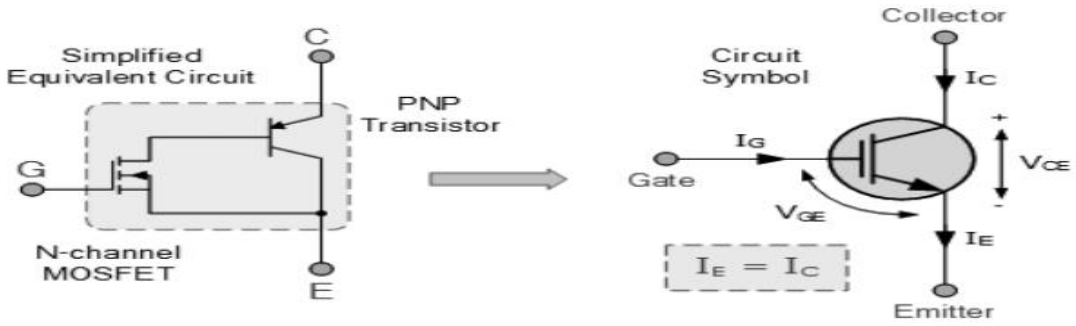

Fig.2.1 IGBT equivalent circuit and Symbol

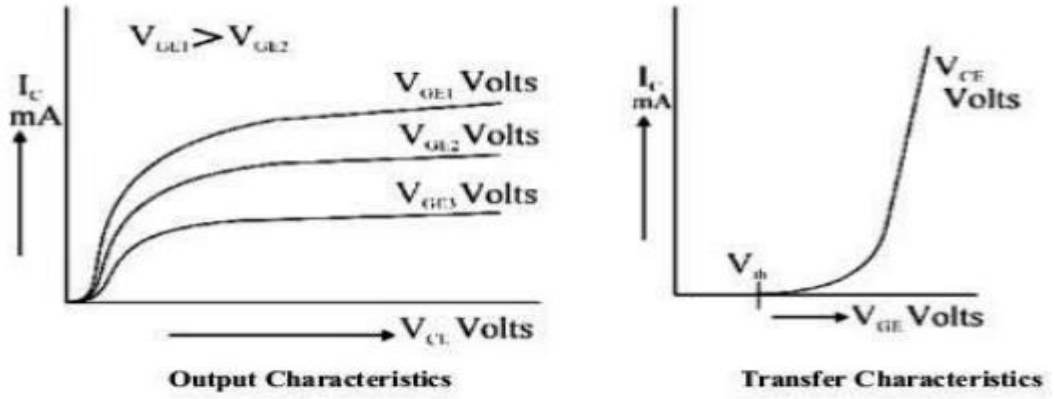

Fig.2.2 IGBT typical characteristics

VII. Actual Circuit diagram used in Laboratory with equipment specifications

Practical Circuit diagram :

a) Sample Circuit diagram

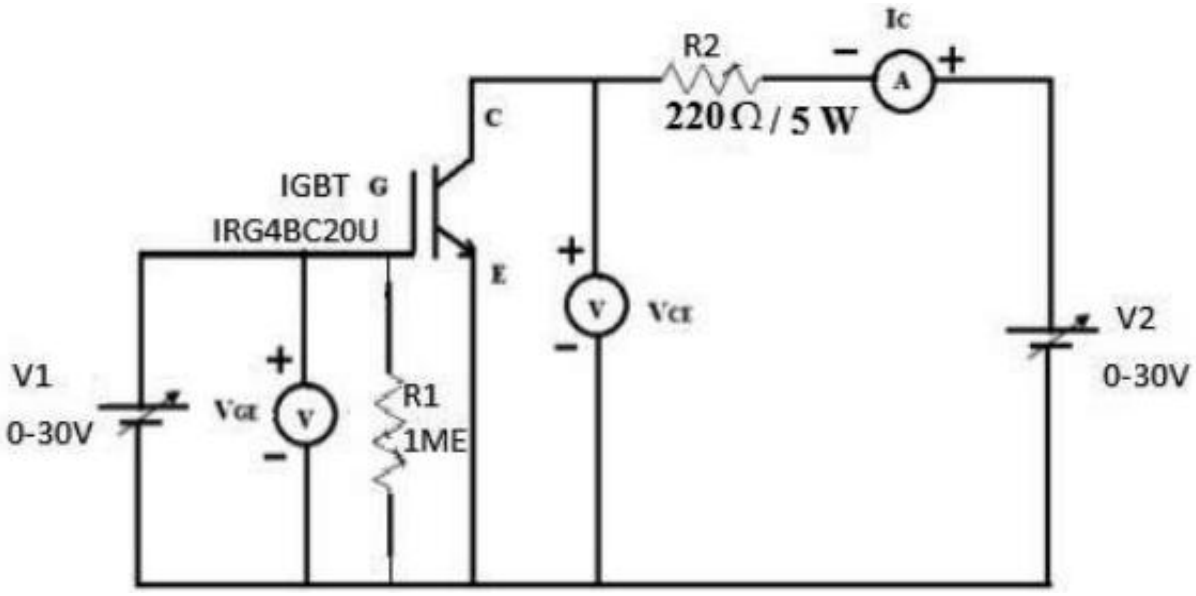

Fig. 2.3 Circuit diagram for V-1 characteristics of IGBT

b) Actual Circuit diagram

VIII. Required Resources/apparatus/equipment with specifications

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Digital Multimeter (Ammeter/Voltmeter))	Digital Multimeter: 3 1/2 digit display.	2
2	DC power supply	Variable power supply(0-30)V 2A With SC protection Digital meters	2
3	IGBT	IRG4BC20U	1
4	Resistor	lMΩ ,220Ω	**1** each
5	Breadboards	5.5 cm X 17cm	1
6	Connecting Wires	Single strand 0.6 mm Teflon coating	As Per Required

IX. Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off condition initially.
3. Ensure the use of proper settings of CRO.

X. Procedure

- **Transfer characteristics**

1. Initially Keep V_{CE} and VGG to minimum voltage.
2. Set VcE =**1**V and gradually vary VGE in steps of 1V and note down le and VGE•
3. The minimum gate voltage VGE required for conducting of IGBT is called the Threshold voltage VGE(Th)• Note Threshold voltage of IGBT in the given practical.

4. After VGE(Th),increase VGE stepwise, take at least 5 reading and note the values in table 2.1
5. Plot the transfer characteristics on graph paper.

- **Output Characteristics**

1. Select VGE gate voltage which gives some suitable value of le and record in the observation table no. 2.2.
2. Keeping VGE at the set value, increase VCE stepwise and note down le in table no2.2.
3. Repeat steps 1,2 for two more values of VGE·
4. Plot graph of VCE versus I_E.

Resources Used

Sr.No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

Actual Procedure Followed (use blank sheet provided if space not sufficient)

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Precautions Followed (use blank sheet provided if space not sufficient)

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XI. Observations and Calculations (use blank sheet provided if space not sufficient)

Table 2.1: Transfer Characteristics

Sr. No.	VCE = 1 V	
	VcE **(Volts)**	**le (mA)**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Table 2.2: Output Characteristics

Sr. No.	VcEI	Volts	VcE2	Volts
	VeE (Volts)	le (mA)	VeE (Volts)	le (mA)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

XII. Results

- For Transfer characteristics, Threshold value $V_{GE\ (TH)}$• ....., IE=.....
- For Output characteristics, V_{CE} = ..., IE =....., (For $V_{GEi)}$ at conducting point.

XIII. Interpretation of Results (Give meaning of the above obtained results)

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XIV. Conclusions and Recommendation

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XV. Practical Related Questions (Refer table 2.1 and 2.2 for question no. 1 to 3).

1. Write the threshold value of VCE for VGE2
2. Write the specification of IGBT used in practice.
3. Calculate dynamic input impedance from transfer characteristics.

[Space for Answers]

XVI. References / Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics

2. www.books.google.co.in/books/about/Power_Electronics

3. A text - Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 0070727937, 9780070727939.

Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical 3:* Performance of DIAC using IC DB3/DB4 or any other equivalent IC through its V-I curve

I. Practical Significance

DIAC is a full-wave or bi-directional semiconductor switch because of its symmetrical bidirectional switching characteristics. These are widely used as triggering devices in triac phase control circuits employed for lamp dimmer, heat control, and universal motor speed control. In this practical students will be able to find break over voltage of given DIAC

II. Industry / Employer Expected outcome(s):

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use a multimeter to measure various electrical parameters.
- Interpret the circuit diagrams.
- Use the power supply for various practicals.

III. Course Level Learning Outcome(s)

- Identify power electronic devices in circuits.

IV. Laboratory Learning Outcome(s)

LLO 3.1 Test the performance of DIAC and plot its V-I characterstics

V. Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI. Relevant Theoretical Background (with diagrams if required)

The DIAC is a bidirectional, two terminal semiconductor device which can be turned on by either (Positive or Negative) polarity of alternating supply voltage. When the terminal MTI is made positive with respect to MT2 and applied voltage less than the break over voltage, only leakage current flows through the device. It conducts only when the voltage applied to its terminal is equal to break over voltage.

VII. Practical Circuit diagram :

a. Sample Circuit diagram

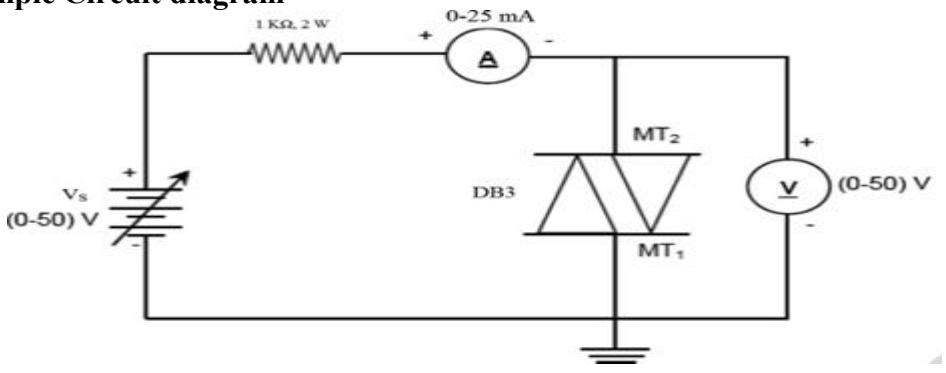

Fig. 3.1 Circuit diagram of V-I characteristics of DIAC

b. Actual Circuit diagram

VIII. Resources Required

SR.no.	Name of Resource	Suggested Broad Specification	Quanti ty
1	Digital Multi-meter (Arnmeter/Voltmeter)	Digital Multi-meter: 3 1/2 digit display.	2
2	DC power supply	Variable power supply (0-50)V 2 A with SC protection and digital meters	1
3	DIAC	DB3/DB4 SSD3A Or any Other as per availability	1
4	Resistor	1 KΩ	1
5	Connecting Wires	Single strand 0.6 mm Teflon coating	As Per requirec
6	Breadboards	5.5 cmX 17cm	1

IX. Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off condition initially.

X. Procedure

- MT2 positive with respect to MTl

1. Make the connection as per circuit diagram in Fig. 3.1.
2. Set the voltage knob at zero value.
3. Switch on the de power supply.
4. Increase the voltage of de power supply in steps and note down voltage across DIAC and current.

5. Take at least four more reading of voltage and current after breakover voltage (VBo).

• MTl positive with respect to MT2

1. Repeat the step 2 to 5.
2. Plot the V-I characteristics ofDIAC on graph paper.

XI. Observation Table

Observations and Calculations (use blank sheet provided if space not sufficient)
Table 3.1

Table 3.1

Sr. No.	MT2 is positive		MT1 is positive	
	V (Volts)	I (mA)	V (Volts)	I (mA)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

XII. Result(s)

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XIII. Interpretation of Results (Give meaning of the above obtained results)

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XIV. Conclusions and Recommendation

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XV. Practical Related Questions

1. DIAC is device. (Unidirectional / Bidirectional)
2. Write the current value of DIAC in this practical at VBo-
3. Write the specification of DIAC used in this practical.
4. Check whether the break over voltage in first quadrant and third quadrant is same? (Refer plotted characteristics).

[Space for Answers]

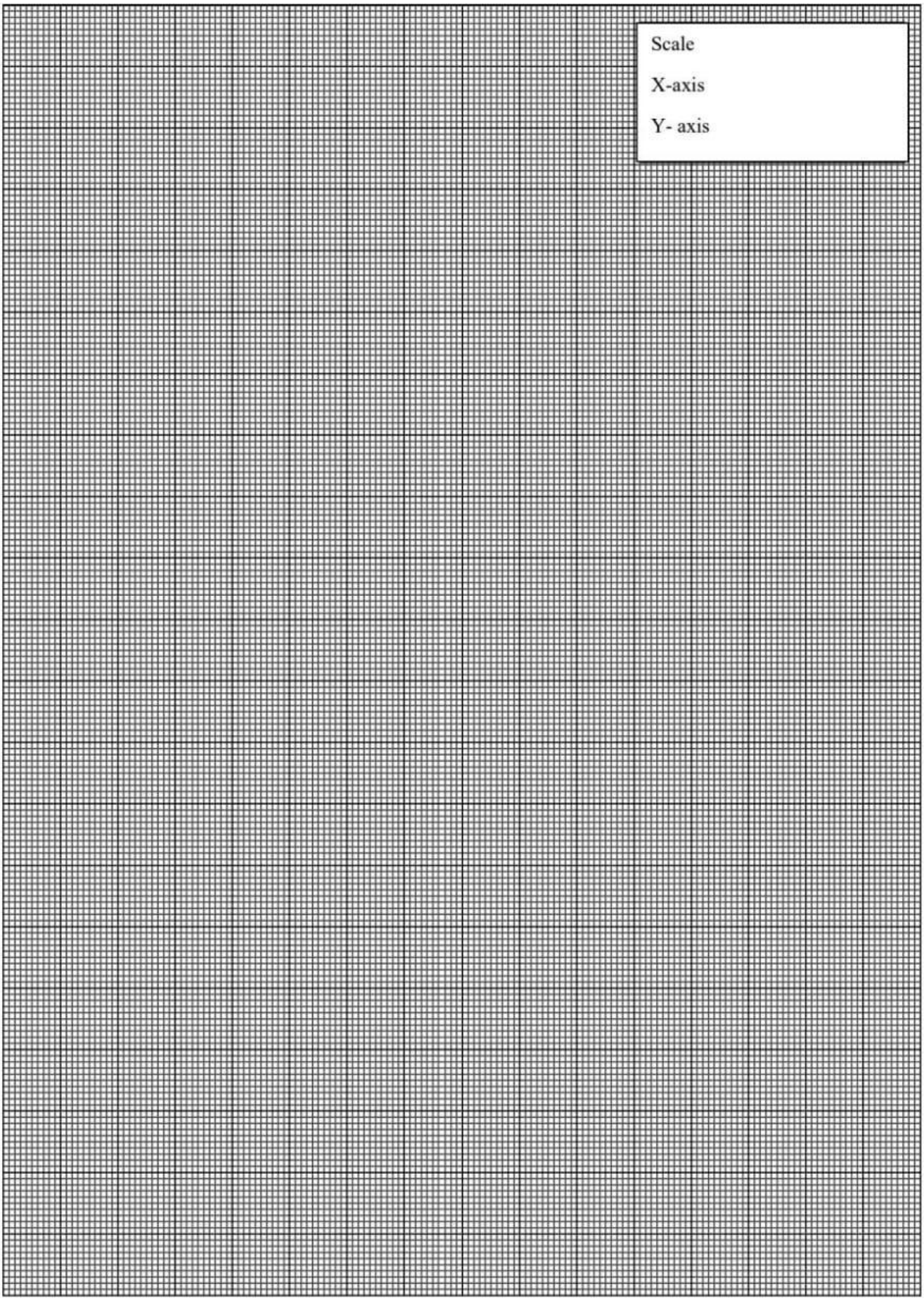
XVI. References / Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text - Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 0070727937, 9780070727939.

Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	


Scale
X-axis
Y- axis

Practical 4: Measurement of output voltage by changing firing angle through variation in resistor, capacitor in R and RC triggering circuits of SCR.

I. Practical Significance

The output power deliver to load is controlled through triggering circuit. Resistance 'R' triggering is the simplest and economical type of triggering but limited for few applications. In R triggering circuit firing angle is limited to 90° only and the RC triggering circuit which provides the firing angle control from 0 to 180°.In this practical student will able to turn on the SCR under the gate triggering.

II. Industry / Employer Expected outcome(s)

This practical is expected to develop the following skills for the industry identified competency 'Maintain the proper functioning of power electronic devices':

- Use multimeter to measure various electrical parameters.
- Use the CRO to observe the waveform.
- Interpret the circuit diagrams.

III. Course Level Learning Outcome(s)

- Maintain triggering and commutation circuits.

IV. Laboratory Learning Outcome(s)

- LLO 4.1 Test the R and RC triggering circuits of SCR.

V. Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member.

VI. Relevant Theoretical Background (with diagrams if required)

The key factor in use of SCR for controlling power is their ability to switch from non-conducting to conducting states. The basic requirement for the firing of SCR is the current supplied to the gate should be adequate. SCR can be turned on by gate triggering method with this triggering method SCR can be triggered much below the breakover voltage.

VII. Actual Circuit diagram used in laboratory with equipment specification

a. Sample Circuit diagram

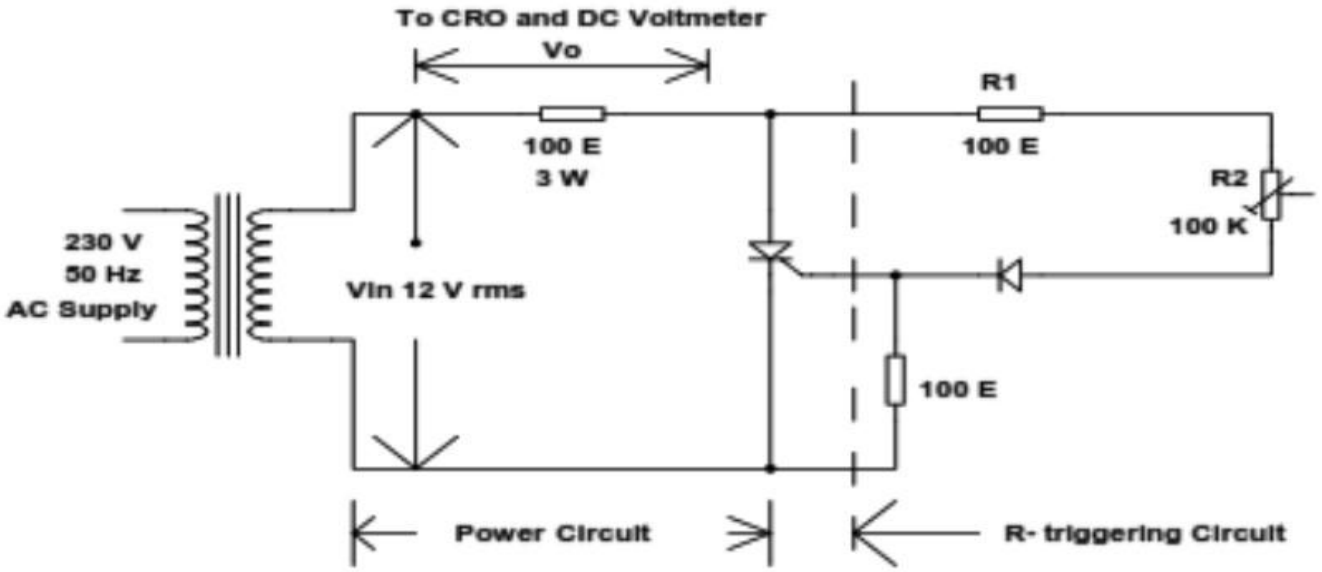


Fig. 4.1 R-triggering Circuit

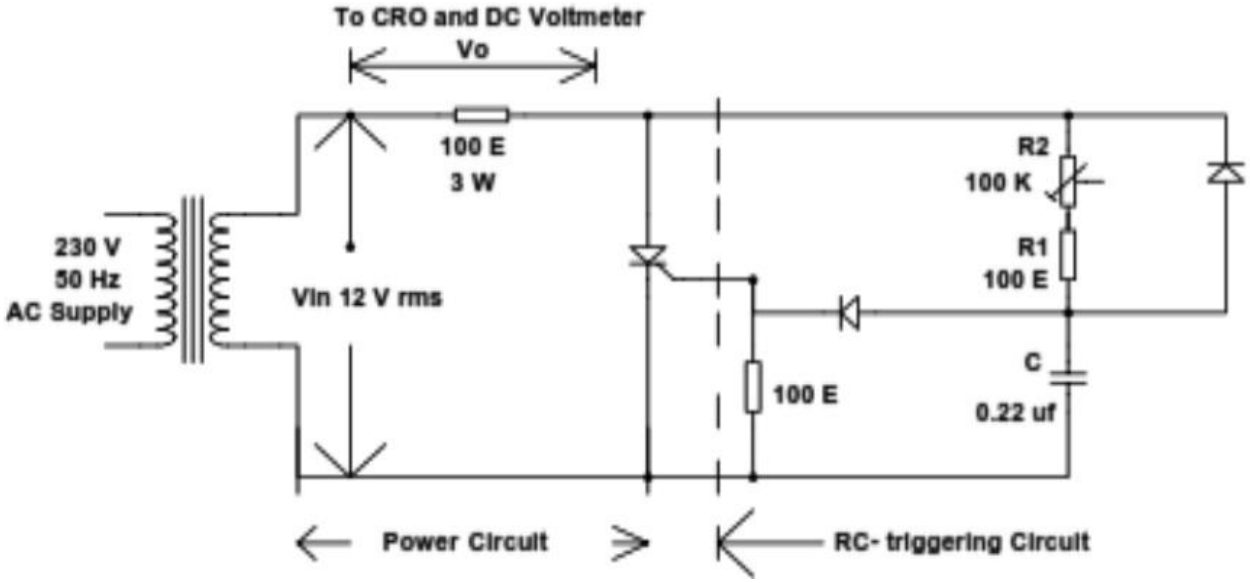


Fig. 4.2 RC-triggering Circuit

b. Actual Circuit diagram

VIII. Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	AC power supply	230 V, 50 Hz	1 No.
2	Voltmeter	0-30 V	1 No.
3	CRO	20MHz	1 No.
4	Transformer	0-12V 500 Ma	1 No.
5	SCR	TYN 612 or any other available	1 No.
6	Diode	D1 and D2	2No.
7	Capacitor	0.22µF	1 No.
8	Resistors	R1 = 100 Ω, R2 , potentiometer = 100KΩ, Ro=l00 Ω,, RL= 100 Ω,, 3watts	1 Each

IX. Precaution

IX. Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off condition initially.
3. Ensure the use of proper settings of CRO.

X. Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig.4.1
2. Keep Potentiometer R at maximum value.
3. Switch on Mains supply.
4. Decrease the resistance R2 of Potentiometer in steps, note down the corresponding values of output voltage.
5. Also record the corresponding firing angle by measuring in time period from CRO.
6. Calculate firing angle in degree.
7. Draw the corresponding wave form on Graph Paper for any two firing angles.

XI. Observations and Calculations (use blank sheet provided if space not sufficient)

Table 4.1: R -triggering:

Vin= Vrms

Sr. No.	Resistance	Firing angle in time	Firing angle $\alpha(^0)$	Average output voltage (V)
1				
2				
3				
4				
5				

Table 4.2: RC - triggering:

Vin= Vrms

Sr. No.	Resistance	Firing angle in time	Firing angle α(^{0})	Average output voltage (V)
1				
2				
3				
4				
5				

XII. Results

a) R-triggering

• For high resistance R= .....0, a(^{0})= .....

• For low resistance R= .....0, a(^{0})= .....

b) RC-triggering

• For high resistance R= .....0, a(^{0})= .....

• For low resistance R= .....0, a(^{0})= .....

XII. Interpretation of Results (Give meaning of the above obtained results)

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XIII. Conclusions and Recommendation

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XIV. Practical Related Questions

1. Refer fig. 4.1 and 4.2; state the effect on load voltage if diode is open.
2. Refer fig. 4.1 and 4.2; state the effect on load voltage if Rl and R2 are short circuited.
3. State the range of firing angle with R, RC- triggering circuit (refer observation table 4.1 and 4.2).

[Space for Answers]

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XV. References / Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text - Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 0070727937, 9780070727939.

Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical 5: *Synchronized UJT triggering circuit.

I. Practical Significance

To control the power UJT is used in synchronized type triggering circuit where firing angle can be change from 0° to 180°. In this practical students will able to tum on the Thyristor under the gate triggering through UJT.

II. Industry / Employer Expected outcome(s)

This practical is expected to develop the following skills for the industry identified competency 'Maintain the proper functioning of power electronic devices':

- Use multimeter to measure various electrical parameters.
- Use the CRO to observe waveforms.
- Interpret the circuit diagrams.

III. Course Level Learning outcome(s)

- **Maintain triggering and commutation circuits.**

IV. Laboratory Learning outcome(s)

- **LLO 5.1 Measure output voltage by changing firing angle in synchronized UJT triggering circuit.**

V. Relevant Affective Domain related outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI. Relevant Theoretical Background (with diagrams if required)

A Unijunction transistor (UJT) is an electronic semiconductor device that has only one junction. The UJT has three terminals: an emitter (E), Base 1(B1) and Base 2 (B2). The capacitor is connected between Emitter and Base 1. Charging time constant of capacitor decides the firing angle. Signal at B1 is connected to the gate terminal of SCR.

VII. Actual Circuit diagram used in laboratory with equipment specifications.

a) Sample Circuit diagram

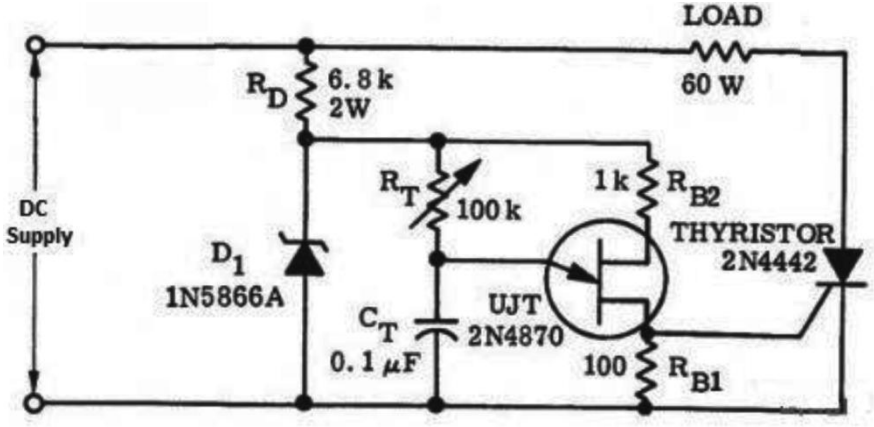

Fig. 5.1 UJT triggering Circuit

b) Actual Circuit diagram

VIII. Required Resources/apparatus/equipment with specifications

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-30 V 2 A with SC protection	1 No.
2	UJT	2N4870 or any other	1 No.
3	Capacitor	CT= 0.1 μF	1 No.
4	Resistors	RBI= 100 Ω, RB2= 1 K Ω, R_T(pot) = 100 K Ω, RD=6.8 K Ω, Lamp Load= 60 W	1 Each
5	Connecting wires	As per kit requirement.	As per requirement
6	AC supply	230 V, 50 Hz	1 No.

IX. Precautions to be followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off condition initially.
3. The applied voltage, current should not exceed the maximum rating of the given UJT.
4. Ensure the use of proper settings of CRO.

X. Procedure

1. Make the circuit connection as per the circuit diagram in Fig. 5.1.
2. Switch on power supply.
3. Increase RT in steps till waveform observe across capacitor CT and resistor RB Ion CRO
4. Observe the output voltage across the load.
5. Measure the firing angle (in time) for various value of resistance RT,
6. Calculate firing angle in degree.
7. Draw the waveform across the load and SCR for different value of firing angle.

XI. Observation table

Sr. No.	Firing angle in time	Firing angle **α(°)**	Average output voltage (V)
1			
2			
3			
4			
5			

XII. Result(s)

- **For high resistance R= ..... Ω, α(°)= .....**
- **For low resistance R= ..... Ω, α(°)= .....**

XIII. Interpretation of results

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XIV. Conclusions and recommendation

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XV. Practical related questions (Provide space for answers)

1. Note down the voltage across zener diode used in fig. 5.1.
2. Write the procedure of testing of UJT.
3. Write the effect on intensity of lamp load with respect to variation of RT in between maximum and minimum position.

[Space for Answers]

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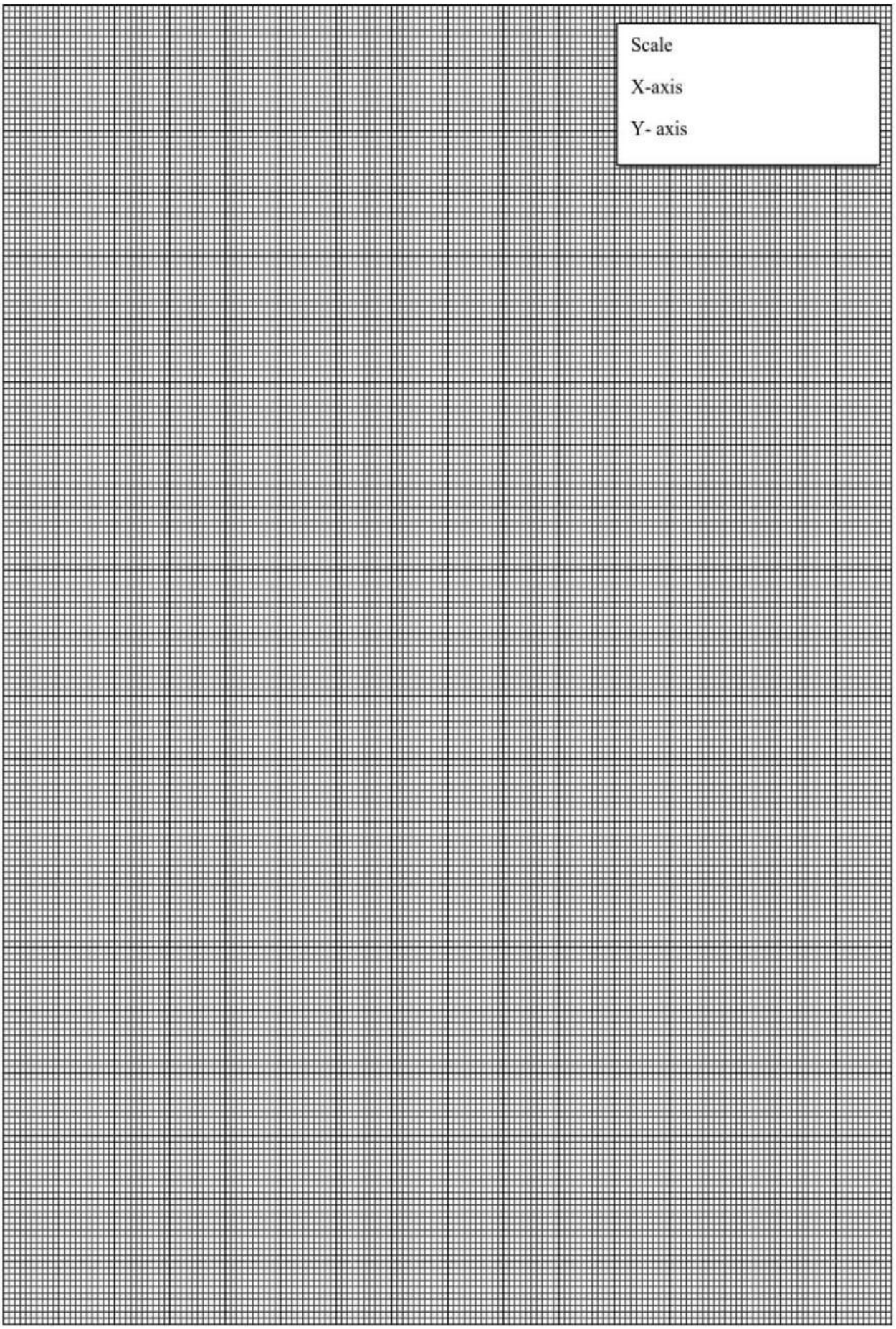
XVI. References/Suggestions for further reading: include websites/links

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text-Lab Manual, Zbar,, Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN:0070727937,9780070727939

Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
		100%

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	
Total (25 Marks)			


Scale
X-axis
Y- axis

Practical 6: *Class C-Complimentary type commutation circuit.

I. Practical Significance

The process of turning OFF a SCR by using external circuits is one type of Commutation known as Forced Commutation By selecting appropriate method students will be able to understand turning off process for SCR .Commutation method plays important role in developing SCR based applications. In this practical student will be able to commutate the SCR.

I. Industry / Employer Expected outcome(s)

This practical is expected to develop the following skills for the industry identified competency 'Maintain the proper functioning of power electronic devices ':

- Use multimeter to measure various electrical parameters.
- Use the CRO to observe waveforms.
- Interpret the circuit diagrams.

II. Course Level Learning outcome(s)

• Maintain triggering and commutation circuits.

III. Laboratory Learning outcome(s)

LLO 6.1 Observe and verify Input-Output waveforms of Class C-Complimentary type commutation circuit.

IV. Relevant Affective Domain related outcome(s)

• Follow safe practices.
• Follow ethical practices.
• Demonstrate working as a leader/a team member.

V. Relevant Theoretical Background (with diagrams if required)

The term commutation means the transfer of currents from one path to another. So the commutation circuit does this job by reducing the forward current to zero so as to tum OFF the SCR or Thyristor. To tum OFF the conducting SCR the below conditions must be satisfied. The anode or forward current of SCR must be reduced to zero or below the level of holding current and then, a sufficient reverse voltage must be applied across the SCR to regain its forward blocking state.

VI. Actual Circuit diagram used in laboratory with equipment specifications.

a) Sample Circuit diagram

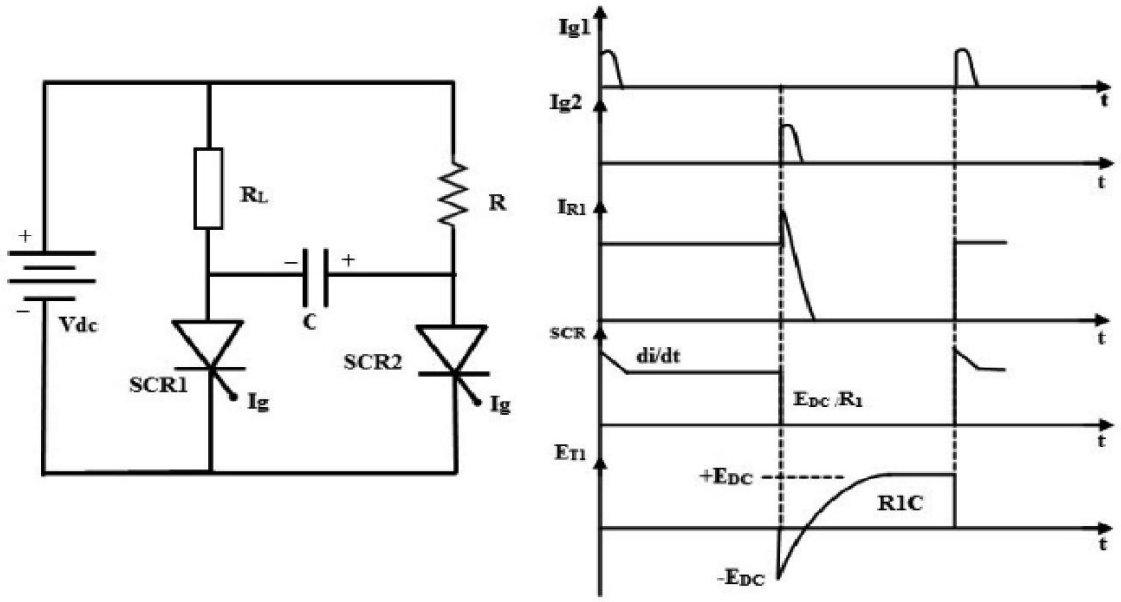


Fig. 6.1 Class C commutation circuit

b) Actual Circuit diagram

VII. Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Regulated power supply	Variable DC power supply 0-30V, 2A with SC protection and digital meters suitable for trainer kit	1 No.
2.	Practical Kit	Trainer kit for Class C Commutation of SCR	1 No.
3.	CRO /Power scope	30 MHz Dual trace	1 No.
4.	Connecting wires	As per kit requirement.	

VIII. Precautions to be followed

1. Ensure proper connections are made to the equipment.
2. Ensure the power switch is in 'off' condition initially.
3. The applied voltage, current should not exceed the maximum rating of the given SCR.
4. Ensure the use of proper settings of CRO.

IX. Procedure

1. Make the circuit connection as per the circuit diagram shown in fig. 6.1.
2. Switch on power supply.
3. Observe the output voltage waveform across the load and SCR on CRO.
4. Measure and note down the amplitude and time period in ON and OFF condition the SCR.
5. Draw the waveform across the load and SCR on graph paper.

X. Observation table

Table 6.1

Sr. No.	Observation	Amplitude	Time period	
			T_{ON}	T_{OFF}
1	Voltage across SCR			
2	Voltage across load			
3				
4				
5				

XI. Result(s)

a. Voltage across SCR when it is in ON condition= .....

b. Voltage across SCR when it is in OFF condition= .....…

XII. Interpretation of results

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XIII. Conclusions and recommendation

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XIV. Practical related questions

1. Write the specification of SCR used in Practical kit.
2. State the effect on class C commutation circuit if capacitor is short circuited.
3. Measure the voltage across SCR1 when SCR2 is in ON state.
4. Measure the voltage across capacitor in working condition of trainer kit.

[Space for Answers]

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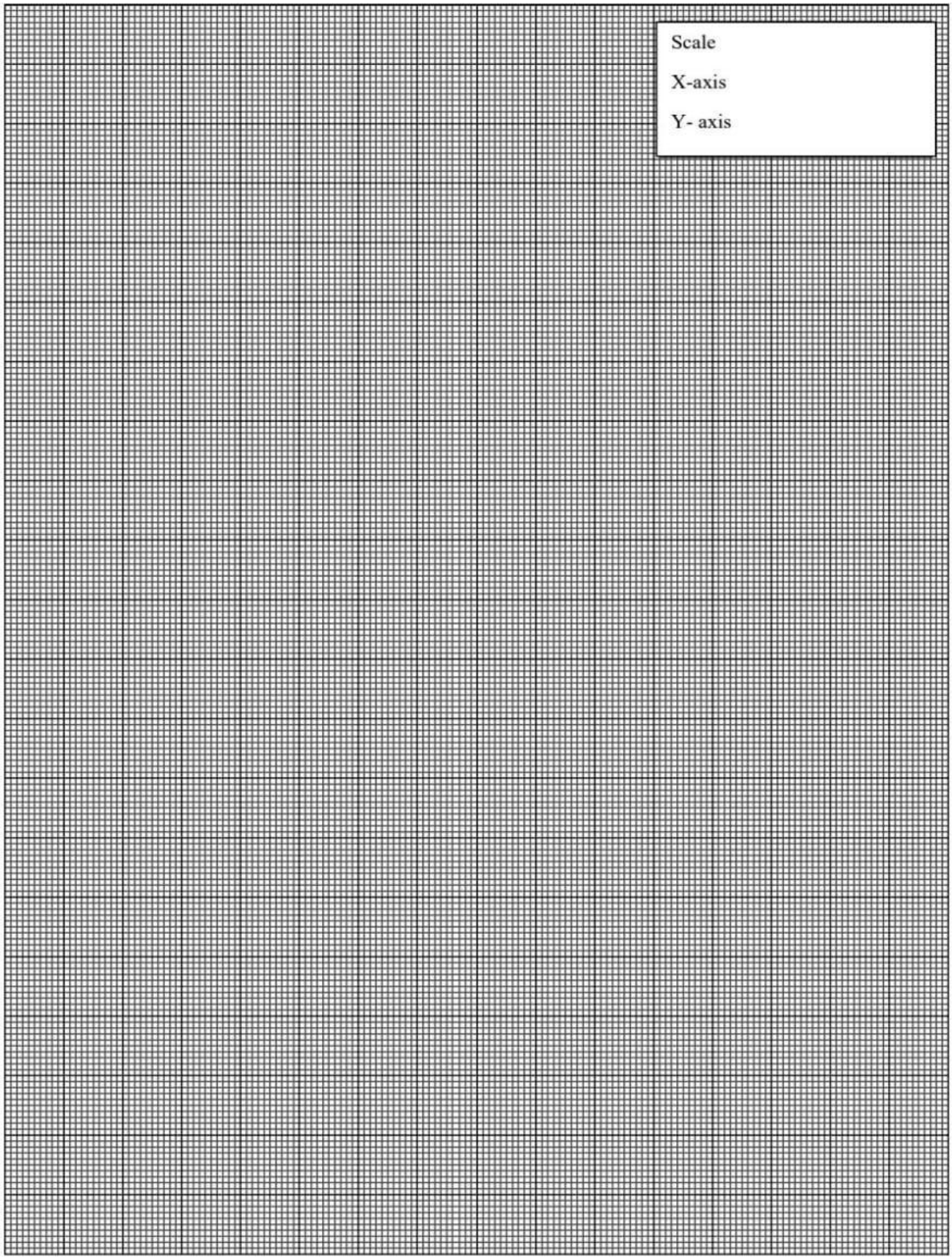
XV. References/Suggestions for further reading: include websites/links

1. www.books.google.co.in/books/about/Power_Electronics
2. A text - Lab Manual, Z bar, , Paul B. McGraw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 0070727937, 9780070727939
3. http://bitsavers.trailing-edge.com/components/ge/l972_GE_SCR_Manual_5ed.pdf

Assessment Scheme

Performance Indicators		Weightage
Process related: 15 Marks		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	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X-axis
Y- axis

Practical No.7: *Test the performance of half wave controlled rectifier with R and RL load and measure load voltage

I. Practical Significance

To run the DC motor on high DC power, controlled rectifier circuit is used. Controlled rectifier circuit plays important role for converting AC power to DC power. It is also used in Battery charger circuit, high voltage DC transmission. In this practical student will able to control the output power deliver to the load.

II. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency

'Maintain the proper functioning of power electronic devices':

- Use multimeter to measure various electrical parameters.
- Use the CRO to observe waveforms.
- Interpret the circuit diagrams.

III. Relevant Course Outcome(s)

- Use Phase controlled rectifier in different applications.

IV. Practical Outcome

- Test the performance of half wave controlled rectifier with R and RL load and measure load voltage.

V. Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI. Minimum Theoretical Background

Controlled rectifier is a circuit which converts constant AC input voltage into controlled DC output voltage using controlled device like SCR by varying firing angle i.e., phase angle can be controlled. In half wave controlled rectifier, output voltage can be controlled in only one half cycle of the input AC voltage. It gives unidirectional output.

VII. Practical Circuit diagram :

a) Sample Circuit diagram

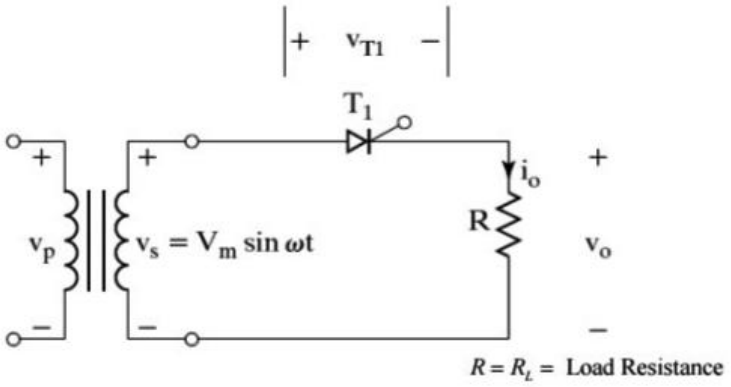

Fig. 7.1 Half wave controlled rectifier for R load

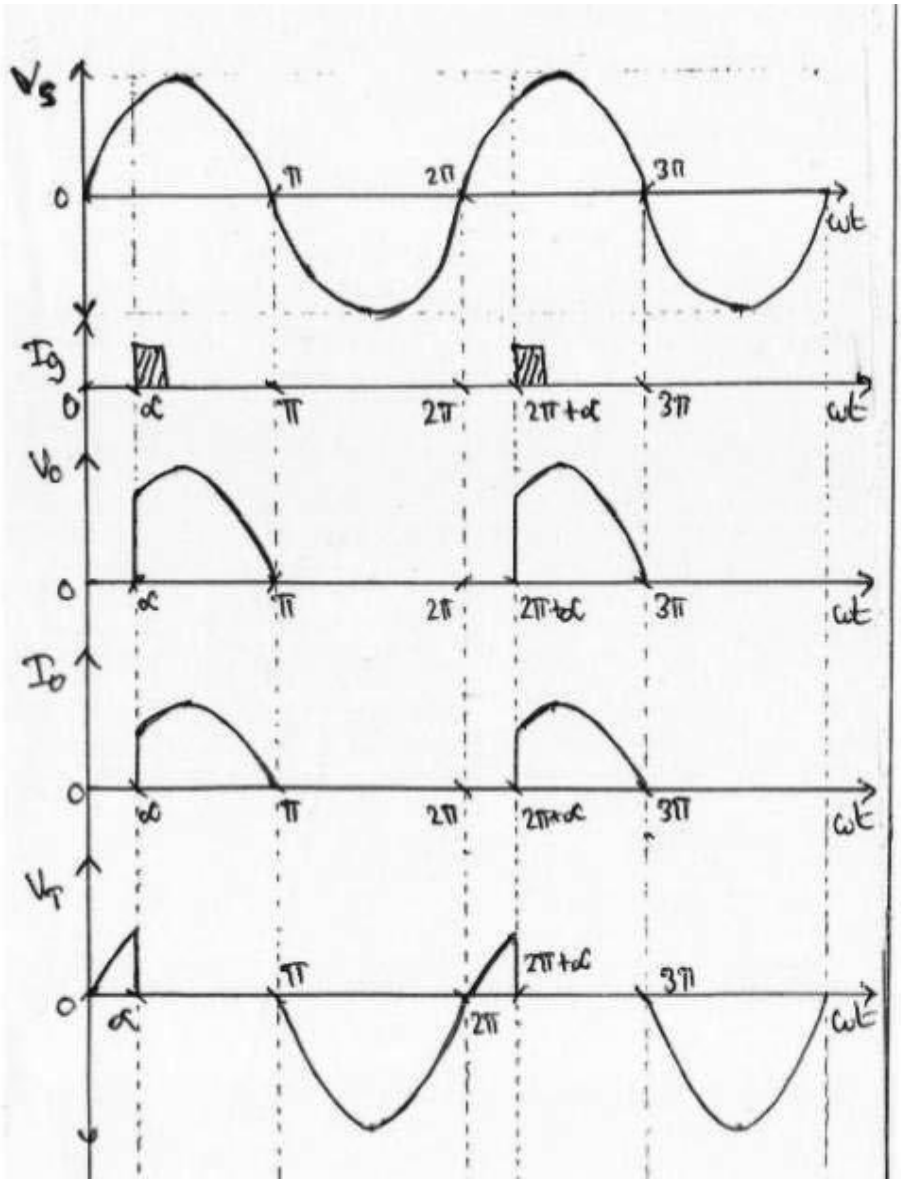

Fig. 7.2 Half wave controlled rectifier waveform (R-load)

b) Actual Circuit diagram

VII. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	AC power supply	230 V, 50 Hz	1 No.
2.	Voltmeter	0-30 V	1 No.
3.	CRO /Power Scope	20MHz	1 No.
4.	Practical kit	Trainer kit of Half wave controlled rectifier with Rand RL load with various test point	1 No.
5.	Connecting wires	As per kit requirement	

VIII. Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. The applied voltage, current should not exceed the maximum rating of the given SCR
3. Reading should be noted without parallax error.

IX. Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig. 7.1.
2. Switch on power supply.
3. Measure the AC input voltage by the meter at secondary of transformer.
4. Connect CRO across the input to observe the input waveform.
5. Connect CRO to measure the voltage across the load.
6. Observe the output waveforms for different firing angles.
7. Calculate the average output voltage. VL = Vm / 2Ju: (1 + cos α)
8. Draw input and output waveform on graph paper for different firing angle.
9. Make the circuit connections as per diagram shown in 7.2.
10. Repeat the same procedure from step 2 to 7 for RL Load.
11. Calculate the average output voltage VL = Vm / 2Ju (cos α) and draw waveform for the same.

X. Observations and Calculations (use blank sheet provided if space not sufficient)

Table 7.1

Vin= Vm

Sr. No.	Firing angle in time	Firing angle α(o)	Measured output voltage (V)	Calculated output voltage (V)
1				
2				
3				
4				
5				

XI. Results

a) For firing angle at (a =30 °), Output voltage ,
b) For firing angle at (a =90 °), Output voltage .....…

XII. Interpretation of Results (Give meaning of the above obtained results)

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XIII. Conclusions and Recommendation

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XIV. Practical Related Questions(Refer practical kit for question 1 to 3)

1. State the effect on output if no gate pulse is applied.
2. State the effect on output if gate pulse is applied at 180°.
3. Write the value of output voltage at o^0 firing angle and draw the waveform across the load.

[Space for Answers]

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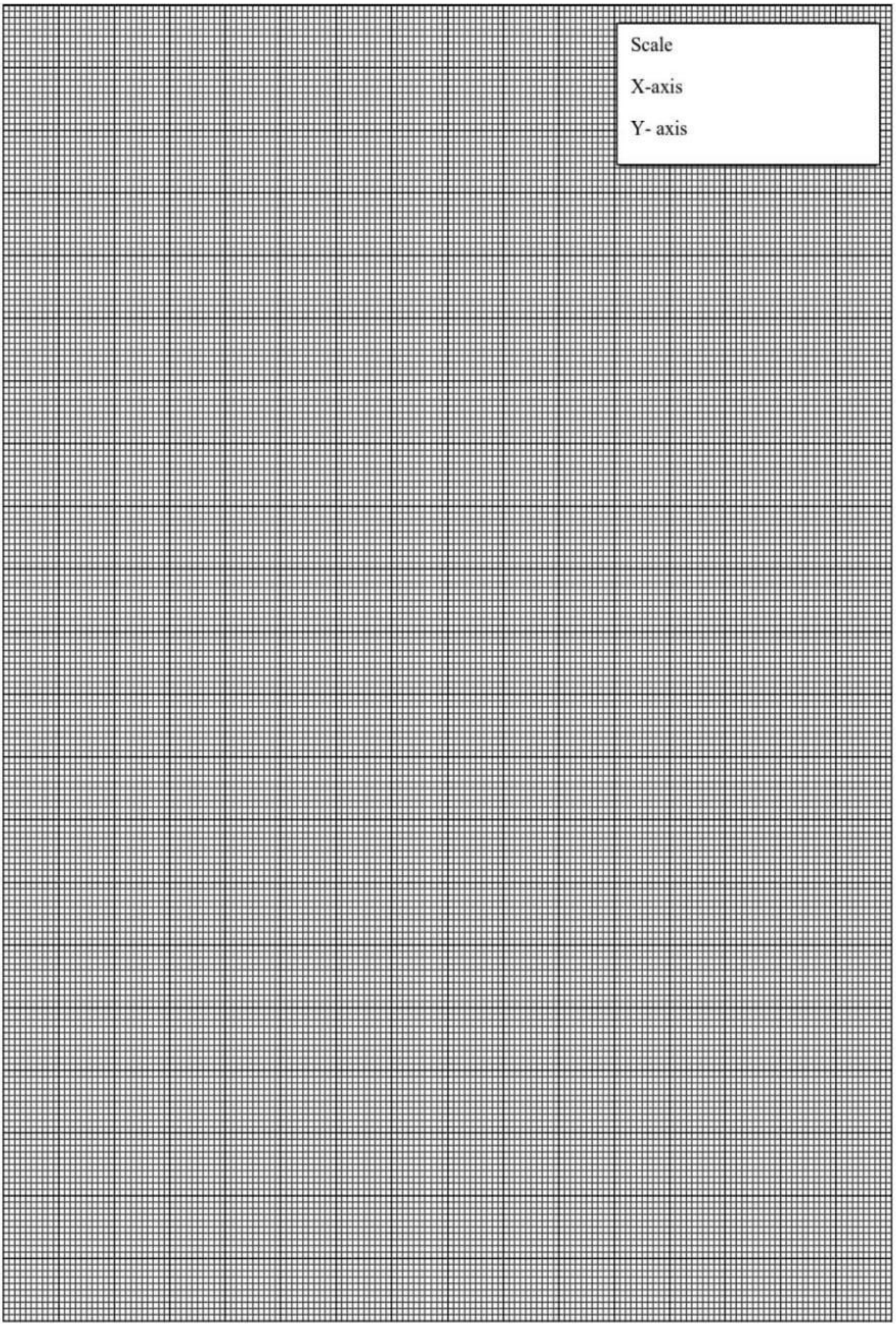
XV. References / Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text - Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 0070727937, 9780070727939

Assessment Scheme

	Performance Indicators	Weightage
	Process related: 15 Marks	**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
	Product related: 10 Marks	**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total (25 Marks)	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	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Y- axis

Practical No.8: Performance of full wave controlled rectifier with R, RL load and measure load voltage.

I. Practical significance

To run the DC motor on high DC power controlled rectifier circuit is used. Controlled rectifier circuit plays important role for converting AC power to DC power. Average output voltage is controlled by controlling the SCR firing angle in both the half cycles of ac input voltage. It also used in Battery charger circuit, high voltage DC transmission. In this practical student will able to convert ac input power to pulsating de output power.

II. Industry / Employer Expected outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Use the CRO to observe waveforms.
- Interpret the circuit diagrams.

III. Course Level Learning outcome(s)

- **Use Phase controlled rectifier in different applications.**

IV. Laboratory Learning outcome(s)

LLO 8.1 Observe and verify the Input-output waveforms of full wave controlled rectifier with R, RL load and measure load voltage.

V. Relevant Affective Domain related outcome(s)

- **Follow safe practices.**
- **Follow ethical practices.**
- **Demonstrate working as a leader/a team member.**

VI. Relevant Theoretical Background (with diagrams if required)

It is an AC to DC converter circuit which converts an AC input voltage to a controllable DC output voltage using SCR the basic principle of phase controlled rectifier is to control the point in time at which the SCRs are allowed to conduct during each AC cycle and hence average output voltage is controlled.

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VII. Actual Circuit diagram used in laboratory with equipment specifications.

a) Sample Circuit diagram

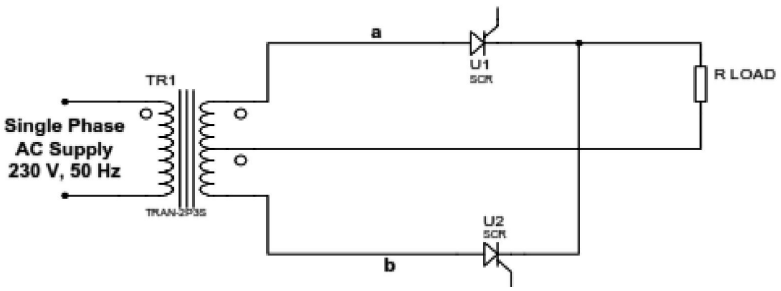

Fig. 8.1 Full wave controlled rectifier with R load

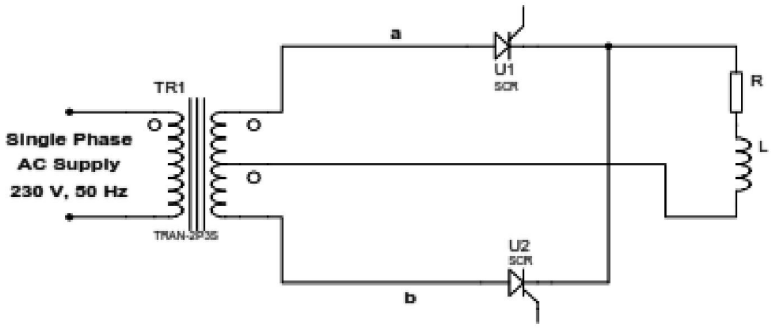

Fig. 8.2 Full wave controlled rectifier with Rl load

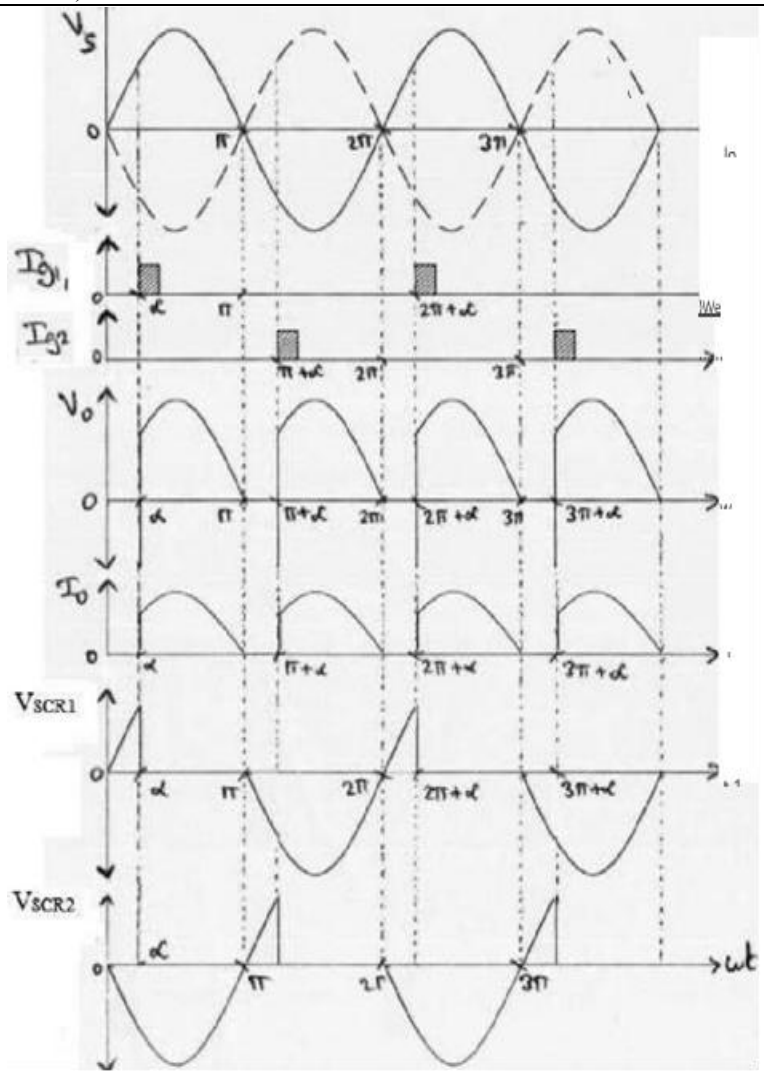

Fig. 8.3 Full wave controlled rectifier with R load waveform

b) Actual Circuit Diagram

VIII. Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Full wave controlled rectifier trainert kit	With center tap transformer (12-0- 12), connecting facility for i) R Load ii)RL Load	1 No.
2	Triggering circuit for full wave rectifier	Synchronized UJT triggering circuit with pulse Transformer for isolation	1 No.
3	Multimeter	0-200V, 0-200mA, IA	1 No.
4	Connecting Wires	As per kit requirement	

IX. Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. The applied voltage, current should not exceed the maximum rating of the given SCR.
3. Reading should be noted without parallax error

X. Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig. 9.1.
2. Switch on power supply.
3. Measure the AC input voltage by the multimeter at secondary of transformer.
4. Connect CRO across the input to observe the input waveform.
5. Connect CRO to measure the voltage across the load (Vm)-
6. Observe the output waveforms at different firing angles for R and RL load.
7. Calculate the average output voltage. $V_L = V_m / n\ (1 + \cos \alpha)$.
8. Draw input and output waveform on graph paper for different firing angle.

XI. Observation table

Table 8.1: For R load

Vin= Vm

Sr. No.	Firing angle in time	Firing angle α(o)	Measured output voltage (V)	Calculated output voltage (V)
1.				
2.				
3.				
4.				
5.				

Table 8.2: For RL load

Vin=……..Vm

Sr. No.	Firing angle in time	Firing angle α(o)	Measured output voltage (V)	Calculated output voltage (V)
1				
2				
3				
4				
5				

XII. Result(s)

a. For firing angle at (a =30°, R load), Output voltage ,

b. For firing angle at (a =30°, RL load), Output voltage .....

XIII. Interpretation of results

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XIV. Conclusions and recommendation

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XV. Practical related questions

1. Find whether the output voltage is more in R or RL load, for 90° firing angle.
2. Write the value of output voltage at o^0 in this practical.
3. Write the effect on output voltage if load is changed from R to RL.
4. Write the effect of freewheeling diode on observed output waveform and draw the waveform.

[Space for Answers]

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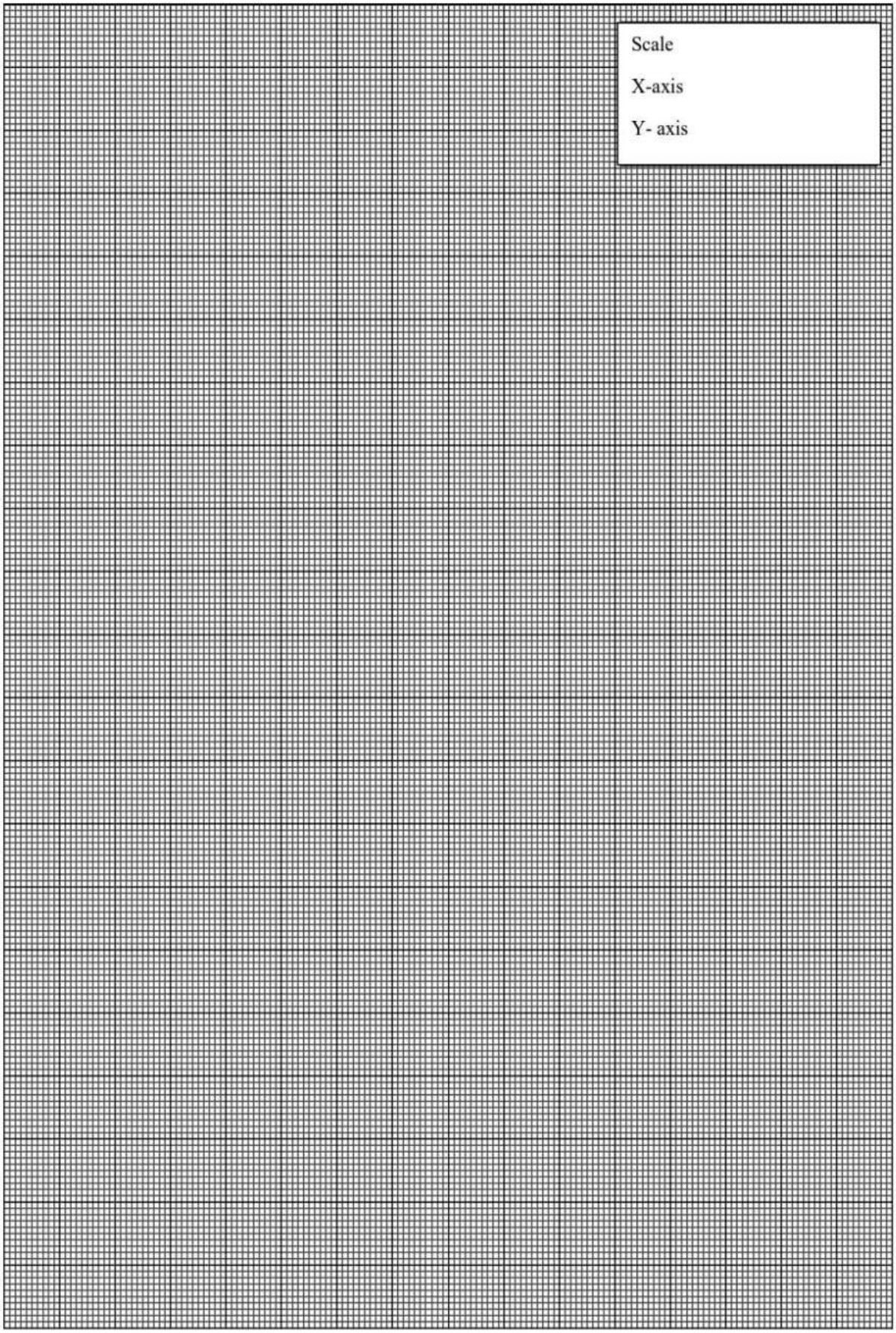
XVI. References/Suggestions for further reading: include websites/links

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text - Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 0070727937, 9780070727939
4. http://bitsavers.trailing-edge.com/components/ge/l972_GE_SCR_Manual_5ed.pdf

Assessment Scheme

Performance Indicators	Weightage
Processrelated:15Marks	**60%**
1 Handling of equipment	10%
2 Identification of component	10%
3 Measuring value using suitable instrument	30%
4 Working in team	10%
Productrelated:10Marks	**40%**
5 Calculate the firing angle	10%
6 Interpretation of result	05%
7 Conclusions	05%
8 Practical related questions	15%
9 Submitting the journal in time	05%
Total(25Marks)	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	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Practical No.9: Performance of 3-phase Half wave controlled Rectifier

I Practical Significance

Three phase rectifier circuits convert 3 phase ac voltage to pulsating de voltage with the help of SCR. Which provide higher average output voltage and power, have low ripple factor, high efficiency, high transformer utilization factor. Output voltage controlled through firing angle. In this practical student will able to convert 3-phase AC voltage to pulsating DC voltage

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course Level Learning Outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Interpret the circuit diagrams
- Use the CRO to observe waveforms.

IV Laboratory Learning Outcome(s)

- Determine firing angle and output voltage of 3-phase half wave controlled rectifier using Delta-Star transformer.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

Three phase controlled rectifier converts either positive or negative half cycle of three phase ac voltage to pulsating dc voltage using three SCRs. The maximum conduction angle of each SCR is 120°.The filtering requirement for smoothing out the load current and load voltage are simpler.

VII Actual Circuit diagram used in laboratory with specification

a) Sample circuit diagram

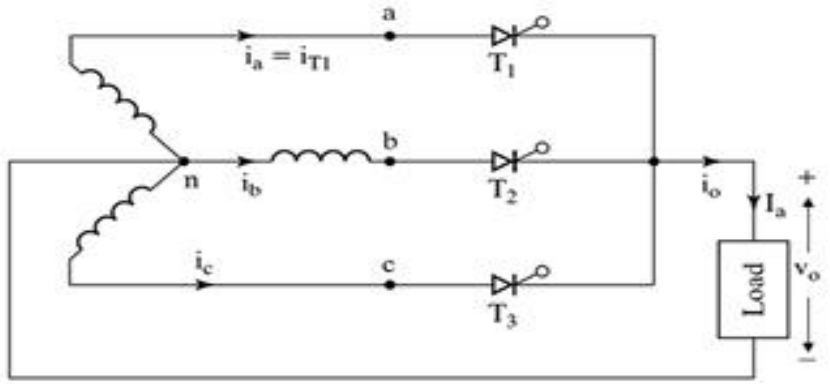

Fig.9.1Three-phase Half wave controlled rectifier circuit

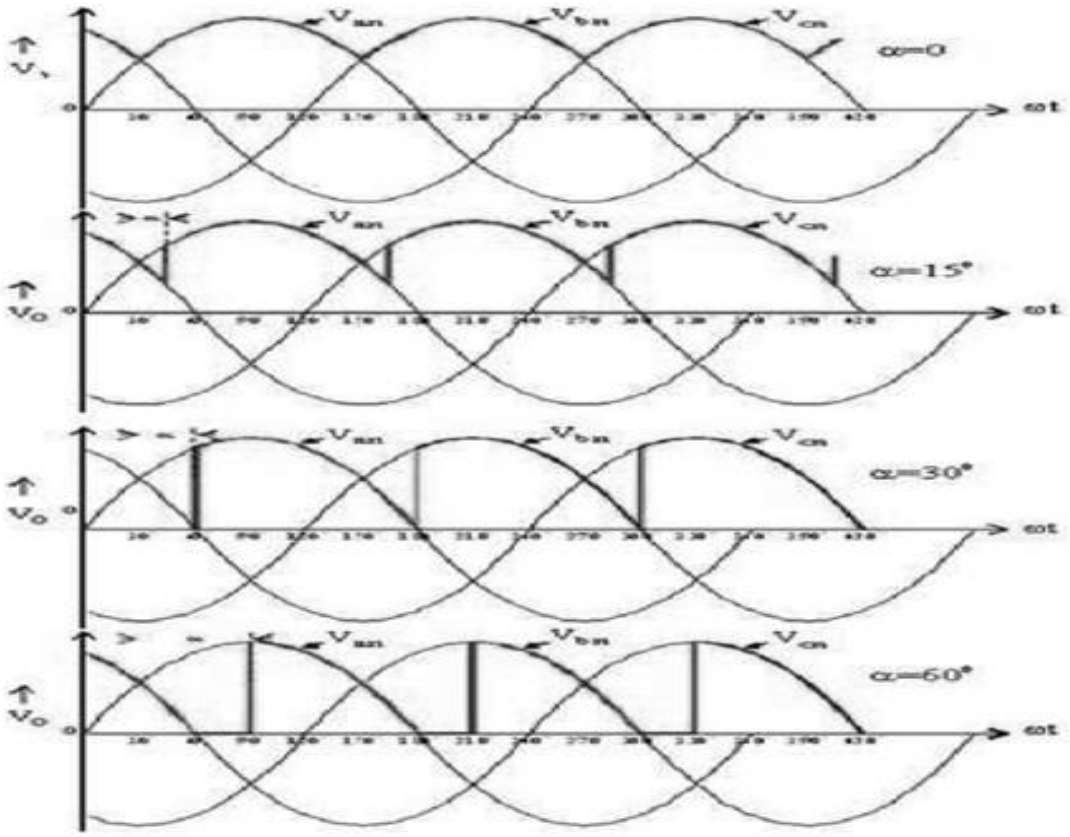

Fig.9.2 Three-phase Half wave controlled rectifier waveform (R-load)

b) Actual circuit diagram:-

VIII Resources Required with specification

SR. No.	Name of Resource	Suggested Broad Specification	Quantity
1	3-phase AC power supply	230 V, 50Hz	1 No.
2	Voltmeter	0 to 230 V	1 No.
3	CRO/Power scope	20 MHz	1 No.
4	Practical Kit	Trainer kit for 3-phase half wave controlled rectifier with various test points	1 No.
5	Connecting Wires	As per kit requirement	

IX Precautions to be Followed

1. Ensure proper connections are made to the equipment as per 3-phase supply.
2. The applied voltage, current should not exceed the maximum rating of the given SCR
3. Reading should be noted without parallax error.

X Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig 9.1.
2. Switch on three phase power supply.
3. Measure the AC input voltage by the meter at secondary of transformer.

4. Connect CRO across the input to observe the input waveform.
5. Connect CRO to measure the voltage across the load.
6. Observe the output waveforms for different firing angles.
7. Draw input and output waveform on graph paper for different firing angle.

XI Observation Table and Calculations

Table 9.1

Vin=……Vm

Sr.No.	Firing angle In time	Firing angle α(°)	Measured Output voltage (V)	Calculated Output voltage (V)
1				
2				
3				
4				
5				

XII Result(s)

- For firing angle at (α=30°), Output voltage ,
- For firing angle at (α=90°), Output voltage.....

XIII Interpretation of Result(s) (Give meaning of the above obtained results)

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XIV Conclusions and Recommendation

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XV Practical Related Questions (Refer table 9.1 for question 1 to 3)

1. Write the effect on output if firing angle increases.
2. Write the output voltage at firing angle $\alpha=0^0$
3. Calculate the conduction angle of each SCR when firing angle α=30°.
4. Write any four electrical specifications of transformer used in practical kit.

[Space for Answers]

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XVI References/Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text- Lab Manual, Z bar, Paul B. McGraw Hill Publishing Co. Ltd, New Delhi, 1990, ISBN: 0070727937, 97800707279

Assessment Scheme

Performance Indicators	Weightage
Processrelated:15Marks	**60%**
1 Handling of equipment	10%
2 Identification of component	10%
3 Measuring value using suitable instrument	30%
4 Working in team	10%
Productrelated:10Marks	**40%**
5 Calculate the firing angle	10%
6 Interpretation of result	05%
7 Conclusions	05%
8 Practical related questions	15%
9 Submitting the journal in time	05%
Total(25Marks)	**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.10: Performance of step-up chopper for different values of duty cycles.

I Practical Significance

To improve controllability of the equipment a constant DC voltage is varied and controlled with the help of a **chopper.** It is a high speed switch which connects and disconnects the load from source at a high rate to get variable or chopped voltage at the output for applications like subway cars, trolley and buses etc. In this practical student will able to calculate output voltage of the chopper.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course Level Learning Outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use Multimeter to measure various electrical parameters.
- Interpret the circuit diagrams.
- Use the CRO to observe waveforms.

IV Laboratory Learning Outcome(s)

- Find output voltage of step-up chopper for different values of duty cycles.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member.

VI Relevant Theoretical Background (with diagrams if required)

Chopper known as DC Transformer is a static device that converts fixed de input voltage to variable de output voltage directly. It is high speed ON-OFF switch. It connect source to load and disconnect the load from the source at very fast speed. In this chopper the large inductor used in series with source voltage. In a step up chopper output voltage is more than input chopper.

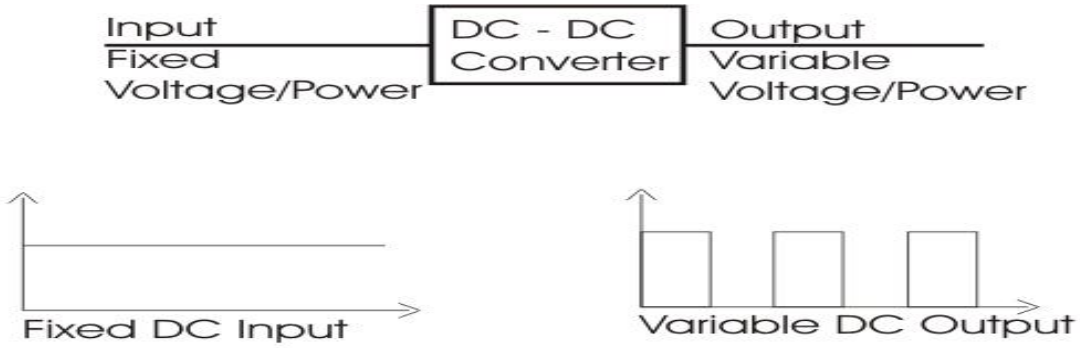

Fig10.1 Block diagram of Chopper

VII Actual Circuit diagram used in laboratory with specification

a) Sample Circuit diagram:

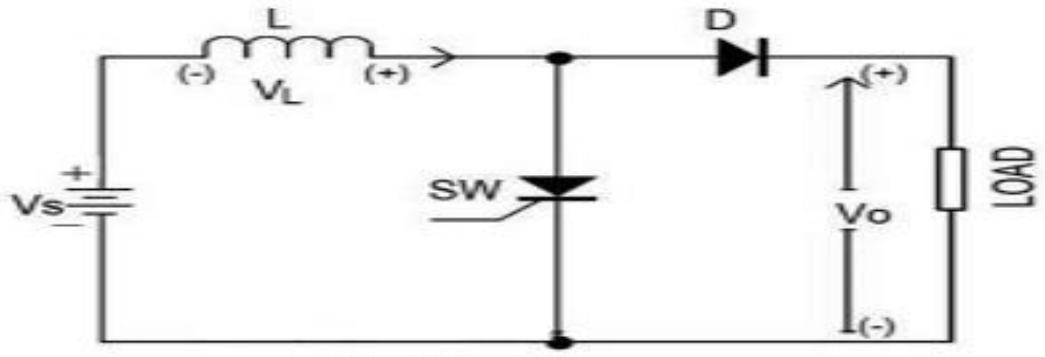

Fig. 10.2 Step up chopper

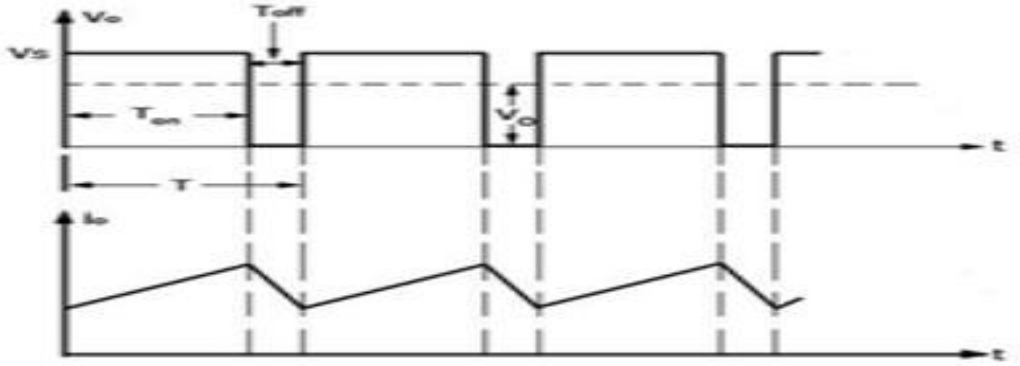

Fig. 10.3 Output voltage and current waveform

b) Actual Circuit diagram

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	1phase DC to DC converter Practical kit (step-up chopper)	Trainer kit of step-up SCR based Chopper with various test points.	1No.
2	CRO	30MHz	1No.
3	Multimeter	0-200V	1No.
4	Connecting wires	As per kit requirement.	

IX Precautions to be Followed

1. Check all the connection before switching on the connections.
2. Do not touch live wires.
3. The applied voltage, current should not exceed the maximum rating of the given SCR.
4. Reading should be noted without parallax error.

X Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig.10.2.
2. Switch on power supply.
3. Set duty cycle below 50% and observe the output waveform on the CRO.
4. Measure the RMS value of output with multimeter.

5. Observe the output waveforms across the load.
6. Change the duty cycle above 50%.
7. Repeat the steps 4 and 5.
8. Draw the output waveform across load for different duty cycle.

XI Observation Table and Calculations (use blank sheet provided if space not sufficient)

Table10.1:-

Sr. No.	Input DC voltage (V)	Output voltage (V)	Time period (ms)	
			T_{ON}	T_{OFF}
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

XII Result(s)

- Output voltage ,
- Duty Cycle ……..

XIII Interpretation of Results (Give meaning of the above obtained results)

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XIV Conclusions and Recommendation

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XV Practical Related Questions

1. Write the relation between duty cycle and output voltage.
2. Write the specification of SCR used in practical kit.
3. Find whether the load voltage of a chopper can be controlled by varying the duty cycle or firing angle.
4. (SCR/diode) used in a chopper circuit?

[Space for Answers]

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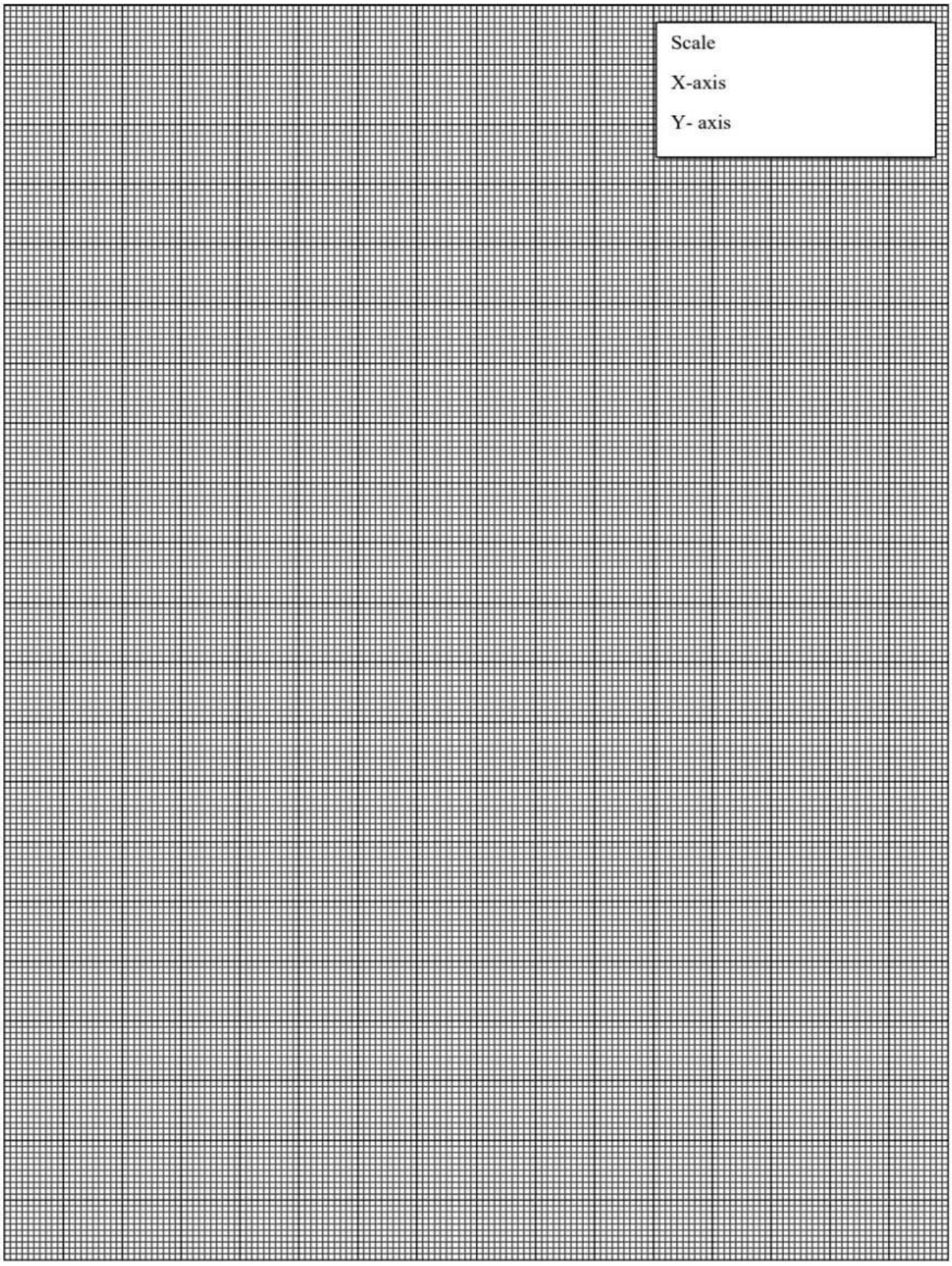
XVI References/Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text-Lab Manual, Zbar, Paul B. McGraw Hill Publishing Co.Ltd, New Delhi,1990, ISBN: 0070727937, 9780070727939
4. http://bitsavers.trailing-edge.com/components/ge/1972_GE_SCR_Manual_5ed.pdf

Assessment Scheme

Performance Indicators	Weightage
Processrelated:15Marks	**60%**
1 Handling of equipment	10%
2 Identification of component	10%
3 Measuring value using suitable instrument	30%
4 Working in team	10%
Productrelated:10Marks	**40%**
5 Calculate the firing angle	10%
6 Interpretation of result	05%
7 Conclusions	05%
8 Practical related questions	15%
9 Submitting the journal in time	05%
Total(25Marks)	**100%**

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	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X-axis
Y- axis

Practical No.11: *Step-down chopper for R and RL load

I Practical Significance

Choppers are very much useful as many industrial applications are dependent upon DC voltage source. The performance of this application will be improved if variable DC supply is used. It will help to improve controllability of equipment. Examples of such applications are subway cars, trolley buses, battery operated vehicles. In this practical student will able to convert fixed input DC voltage to variable DC output voltage.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course Level Learning Outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Interpret the circuit diagrams
- Use the CRO to observe waveforms.

IV Laboratory Learning Outcome(s)

- Use choppers and inverters in different applications.
- Measure output voltage of step-down chopper for different values of duty cycles.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI Relevant Theoretical Background (with diagrams if required)

Chopper is a static device that converts fixed dc input voltage to variable dc output voltage directly. It is high speed ON-OFF switch. It connect source to load and disconnect the load from the source at very fast speed. In this chopper the large inductor used in series with source voltage. In a step up chopper output voltage is more than input chopper.

VII Actual circuit diagram used in laboratory with equipment specification:-

a) Sample Circuit diagram

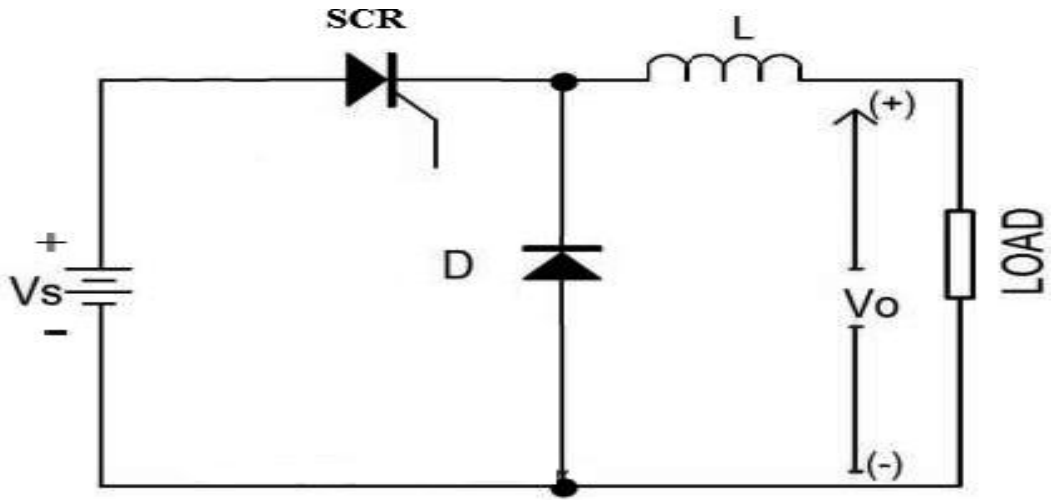

Fig.11.1 Step down chopper with RL load

b) Actual Circuit Diagram:-

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	**1** phase DC to DC converter Practical kit (step down chopper)	Trainer kit of Chopper	1No.
2	CRO	30MHz	1No.
3	Multimeter	0-200V	1No.
4	Connecting wires	As per kit requirement.	

IX Precautions to be Followed

1. Check all the connection before switching on the connections.
2. Do not touch live wires.
3. The applied voltage, current should not exceed the maximum rating of the given SCR.
4. Reading should be noted without parallax error.

X Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig.12.1.
2. Switch on power supply.
3. Set duty cycle below 50% and observe the output waveform on the CRO.
4. Measure the RMS value of output using multimeter.
5. Observe the output waveforms across the load.
6. Change the duty cycle above 50%.
7. Repeat the steps 4 and 5.
8. Draw the output waveform across load for different duty cycle.

XI Observation Table and Calculations

Table11.1

Sr. No.	Input DC voltage (V)	Output voltage (V)	Time period (ms)		Duty Cycle(%) =ToN/(ToN+ToFF)
			ToN	ToFF	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

XII Result(s)

- Output voltage ,
- Duty cycle.....

XIII Interpretation of Results (Give meaning of the above obtained results)

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XIV Conclusions and Recommendation

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XV Practical Related Questions

1. Write the value of output voltage at 50% duty cycle refer table 12.1.
2. State the function of diode used in practical kit.
3. Write the relation between duty cycle and output voltage.
4. Write the specification of SCR used in practical kit.

[Space for Answers]

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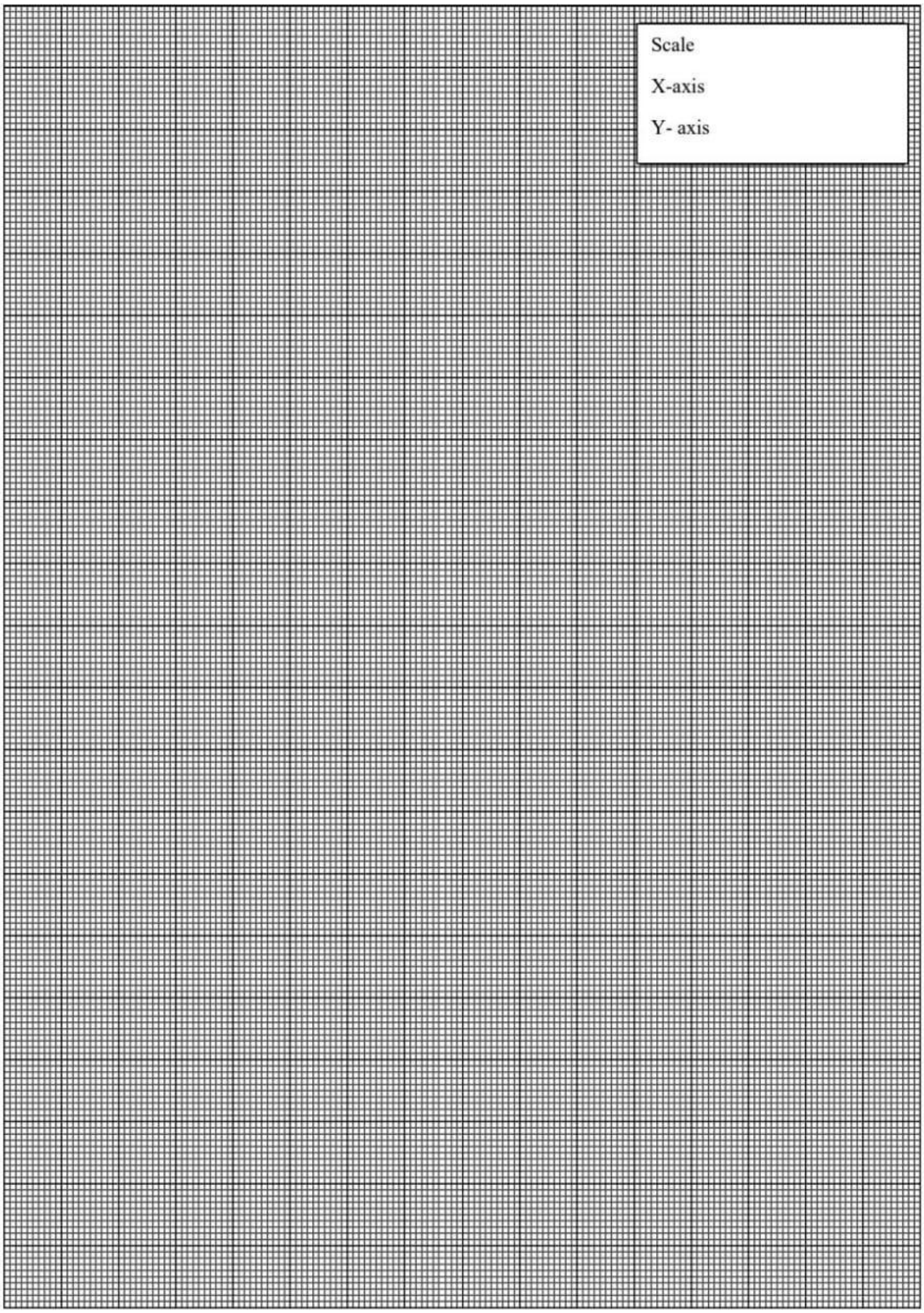
XVI References/Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text-Lab Manual, Z bar, Paul B. McGraw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 0070727937, 9780070727939
4. http://bitsavers.trailing-edge.com/components/ge/l972_GE_SCR_Manual_5ed.pdf

XVII Assessment Scheme

Performance Indicators	Weightage
Processrelated:15Marks	**60%**
1 Handling of equipment	10%
2 Identification of component	10%
3 Measuring value using suitable instrument	30%
4 Working in team	10%
Productrelated:10Marks	**40%**
5 Calculate the firing angle	10%
6 Interpretation of result	05%
7 Conclusions	05%
8 Practical related questions	15%
9 Submitting the journal in time	05%
Total(25Marks)	**100%**

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	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X-axis
Y- axis

Practical No.12: Performance of Parallel Inverter

I Practical Significance

An inverter has the capability to convert the DC power into AC power that are useful for generating equipment like household items, computers, power tools and much more by simply plugging typically equipment into the inverter. In this practical student will be able to convert DC input voltage to AC output voltage.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course Level Learning Outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Interpret the circuit diagrams
- Use the CRO to observe waveforms.

IV Laboratory Learning Outcome(s)

- Use choppers and inverters in different applications
- Test parallel inverter to the measure frequency and output voltages.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

The function of an inverter is to convert de input voltage to symmetrical ac voltage of desired magnitude or frequency. The output voltage could be fixed or variable frequency. The frequency of output waveform depends upon inductance (L) and Capacitance (C) used in the circuit. A variable output voltage can be obtained by varying the input de voltage.

VII Actual circuit diagram used in laboratory with equipment specification:-

a) Sample Circuit diagram

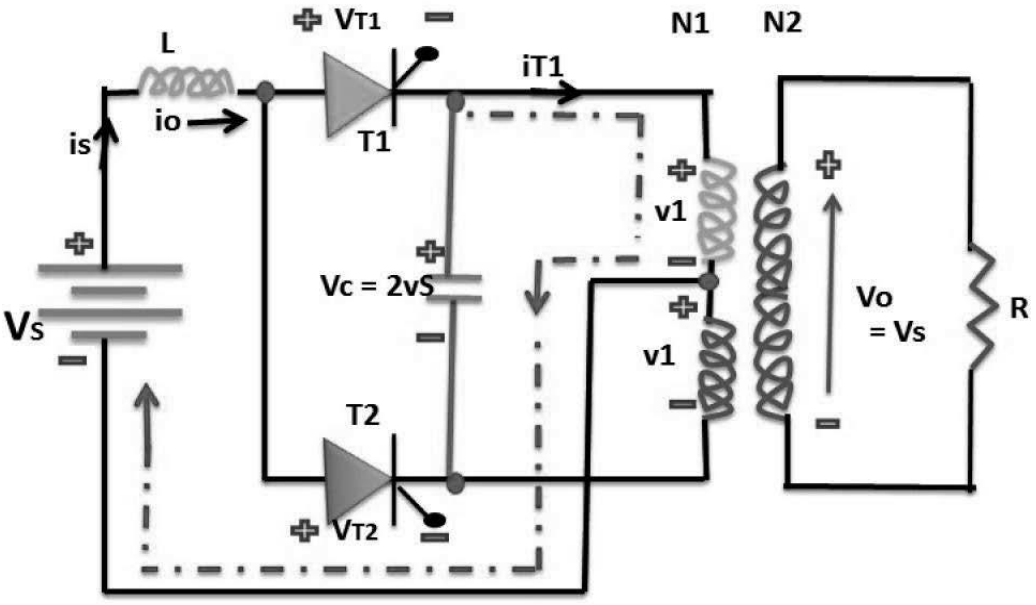

Fig.12.1Parallel inverter

b) Actual Circuit diagram

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Parallel inverter circuit Trainer kit	Trainer kit of Parallel inverter based On SCR with various test points	**1**No.
2	CRO	30MHz	**1**No.
3	Multimeter	0-600VAC	**1**No.
4	Connecting wires	As per kit requirement	

IX Precautions to be Followed

1. Ensure proper connections are made to the equipment.
2. The applied voltage, current should not exceed the maximum rating of the given SCR.
3. Reading should be noted without parallax error

X Procedure

1. Make the circuit connection as per the circuit diagram shown inFig.12.1.
2. Switch on power supply.
3. Observe the output waveforms across the load.
4. Measure the output voltage and time period of output waveform.
5. Calculate the frequency of output waveform.

XI Observation Table and Calculations

Table12.1

Sr. No.	Input DC voltage (V)	Output voltage(V)	Time period (ms)	Frequency (Hz)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

XII Results

- Output voltage ,
- Frequency.....

XIII Interpretation of Results (Give meaning of the above obtained results)

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XIV Conclusions and Recommendation

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XV Practical Related Questions

1. Write the value of capacitors used in the practical kit.
2. Write the effect on amplitude of output voltage waveform with increase input voltage in the given practical.
3. Write the specification of 2N6394 SCR.

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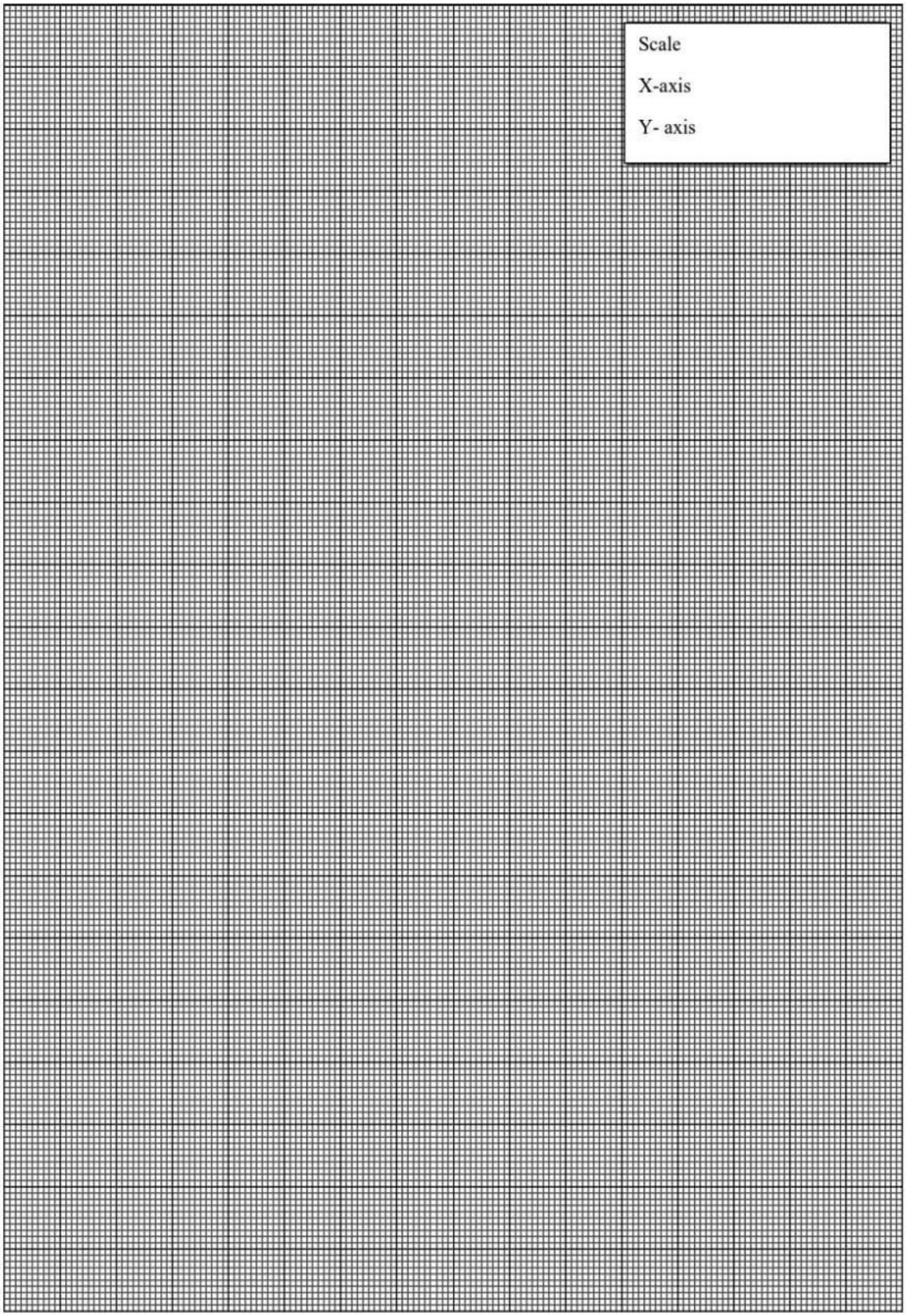
XVI References/Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text-Lab Manual, Z bar, Paul B. McGraw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 0070727937, 97800707279

XVII Assessment Scheme

Performance Indicators	Weightage
Processrelated:15Marks	**60%**
1 Handling of equipment	10%
2 Identification of component	10%
3 Measuring value using suitable instrument	30%
4 Working in team	10%
Productrelated:10Marks	**40%**
5 Calculate the firing angle	10%
6 Interpretation of result	05%
7 Conclusions	05%
8 Practical related questions	15%
9 Submitting the journal in time	05%
Total(25Marks)	**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	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Practical No.13: Single phase midpoint Cyclo-converter with R load

I Practical Significance

Intensity of the lamp can be varied over wide range by TRIAC. It is a bidirectional device which requires triggering pulse at its gate terminal during both half cycles. The intensity of lamp depends upon the value firing angle of the TRIAC. Less the value offering angle more will be the intensity of lamp. In this practical student will able to control intensity of lamp.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course level learning outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Interpret the circuit diagrams
- Use the CRO to observe waveforms.

IV Laboratory Learning Outcome(s)

- Study the operation of cyclo-converter and observe the output waveforms

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member

VI Relevant Theoretical Background

In the cyclo-converter one group of thyristors produce positive polarity of the load voltage and the other group produces the other polarity. One group of SCRs are gated together. Depending on the polarity of the input only one of them will conduct. When P is positive w.r.t. O then SCR1 will conduct otherwise SCR2 will conduct. Thus in both half cycles of the input the load voltage will be positive. The SCRs get turned OFF by natural commutation at the end of every half cycle.

Depending on the desired frequency, gating pulses to positive group of SCRs will be stopped and SCRs 3 & 4 will be gated SCR 3 conducts when p is +ve and SCR4 conducts when P is–ve.

VIII Actual circuit diagram used in laboratory with equipment specification:-

a) **Sample Circuit diagram**

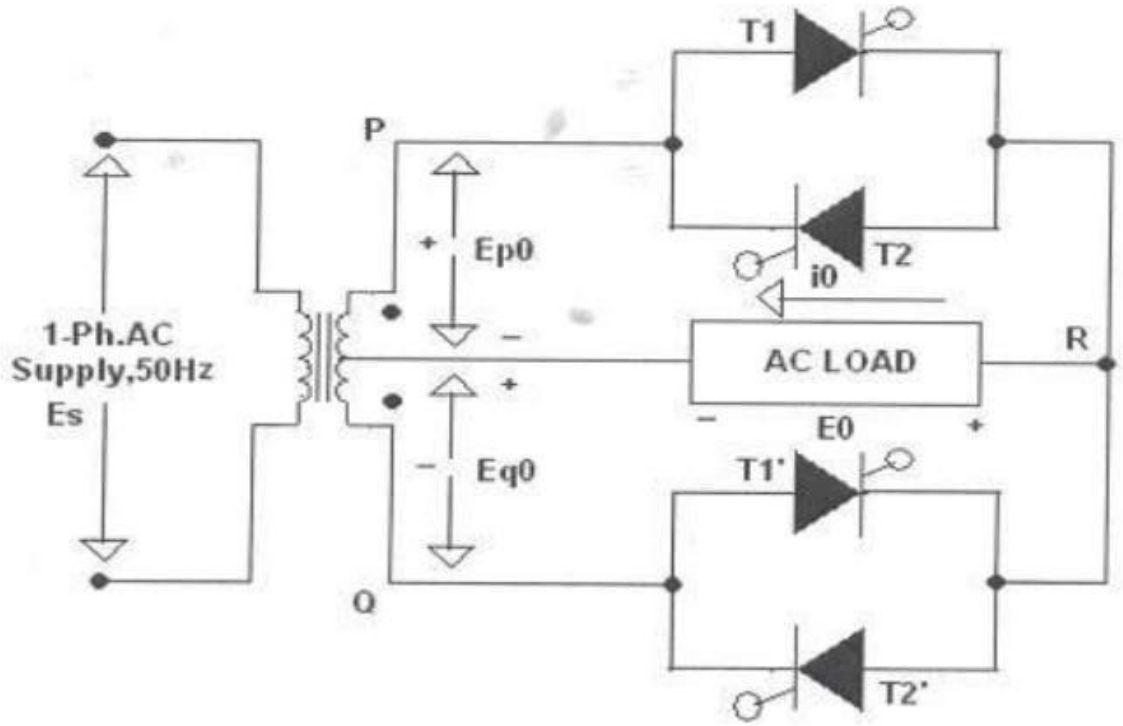

Fig. 13.1 Single phase midpoint Cyclo-converter

b) Actual circuit diagram:-

IX Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Cyclo-converter Kit	Trainer kit of cyclo-converter based On SCR with various test points	**1** No.
2	CRO	30MHz	**1** No.
3	Isolation Transformer	Center tapped	**1** No**.**
3	Multimeter	0-600VAC	**1** No.
4	Patch Cords	As per kit requirement	

X 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 2002/5A 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" 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.

XI Observation Table & Calculations:-

Sr. No.	Input Voltage (Vin)	Firing angle in degrees	Frequency Division	Vo (v)	Io (A)	Input Frequency (fs)	Output Frequency (fo)	fo/fs
1.								
2.								
3.								
4.								
5.								
6.								
7.								

XII Results:

- **Vor =**
- **Ior =**
- **Ɵ =**
- **V = RMS Value across transformer output=**

XIII Interpretation of Results (Give meaning of the above obtained results)

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XIV Conclusions and Recommendation

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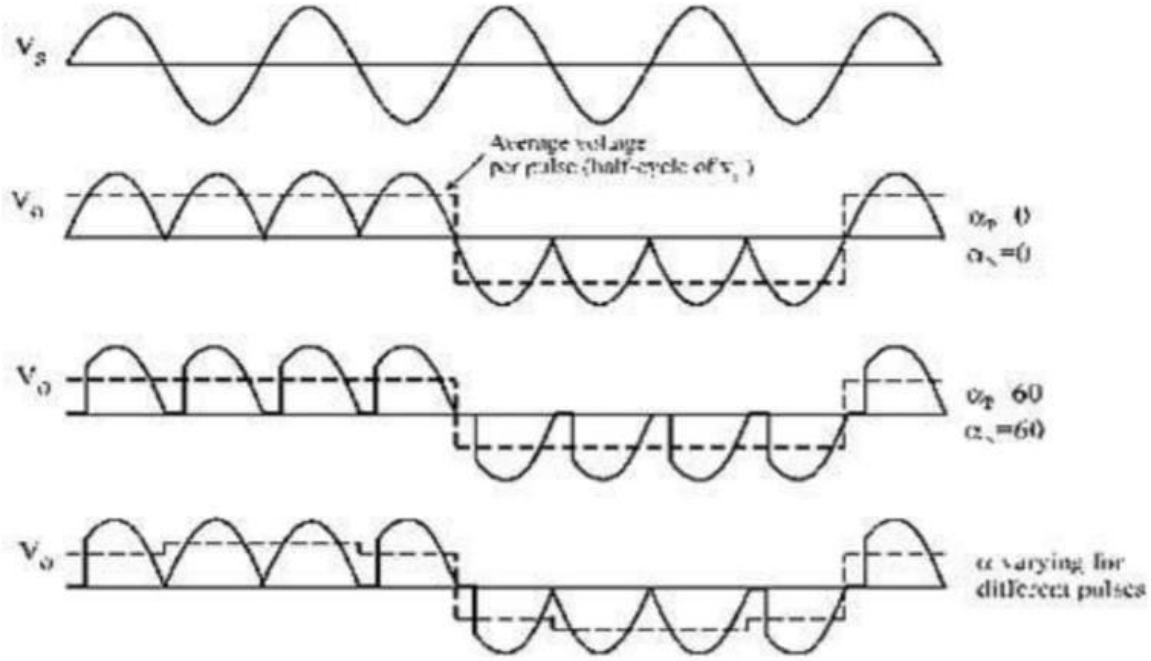
Expected Graph:-



Output Wave Forms of Single Phase Cyclo – Converter

XV Practical Related Questions

1) **What is the principle of single-phase cyclo-converter?**
2) **What is the cyclo-converter mainly used to change?**
3) **Write advantages of cyclo-converter.**

[Space for Answers]

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XVI References/Suggestions for further reading

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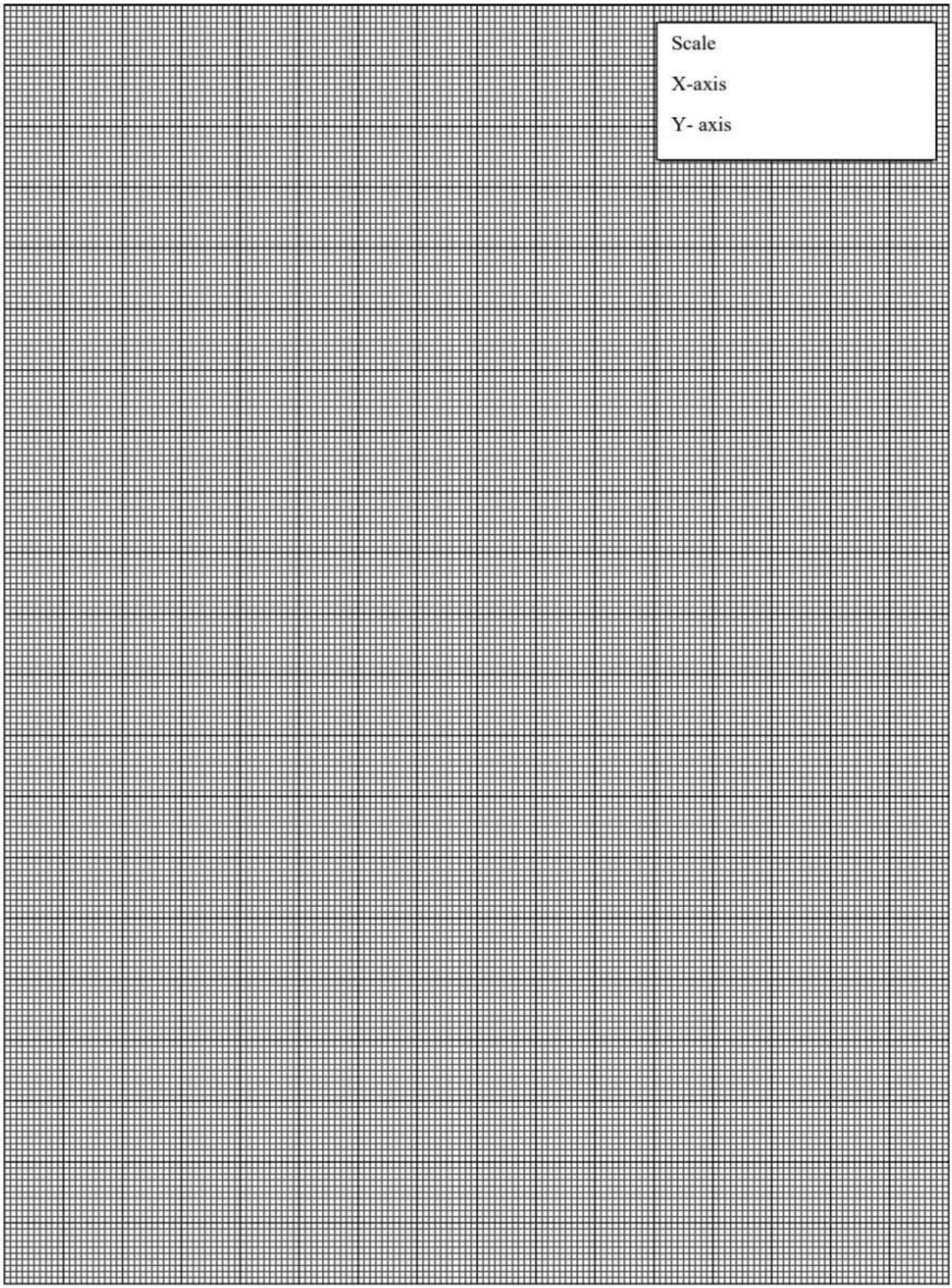
4. http://bitsavers.trailing-edge.com/components/ge/l972_GE_SCR_Manual_5ed.pdf

XVII Assessment Scheme

Performance Indicators	Weightage
Processrelated:15Marks	**60%**
1 Handling of equipment	10%
2 Identification of component	10%
3 Measuring value using suitable instrument	30%
4 Working in team	10%
Productrelated:10Marks	**40%**
5 Calculate the firing angle	10%
6 Interpretation of result	05%
7 Conclusions	05%
8 Practical related questions	15%
9 Submitting the journal in time	05%
Total(25Marks)	**100%**

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	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X-axis
Y- axis

Practical No.14: *Light dimmer circuit using DIAC-TRIAC.

I Practical Significance

Intensity of the lamp can be varied over wide range by TRIAC. It is a bidirectional device which requires triggering pulse at its gate terminal during both half cycles. The intensity of lamp depends upon the value firing angle of the TRIAC. Less the value offering angle more will be the intensity of lamp. In this practical student will able to control intensity of lamp.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course Level Learning Outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Interpret the circuit diagrams.
- Use the CRO to observe waveforms.

IV Laboratory Learning Outcome(s)

- Maintain control circuits consisting of power electronic devices.
- Build Light dimmer circuit using TRIAC. Test the effect of resistance variation on intensity of lamp.

V Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Follow ethical practices.
- Demonstrate working as a leader/a team member.

VI Relevant Theoretical Background

In this circuit a lamp acts as load, a potentiometer(P) is used for varying the firing angle of the TRIAC and a fixed resistor (R) at which the potentiometer is at zero resistance value. The resistance value by the potentiometer decides the charging time constant which required by the capacitor. If the resistance is low, the firing angle

as well as the charging time of the capacitor is low and if the resistance is high, then it will take more time to charge. The intensity of lamp will depend upon the value of firing angle of the TRIAC. Less the value of the firing angle (a) of the TRAIC, more will be the voltage across the lamp and hence more will be its intensity of illumination and vice-versa.

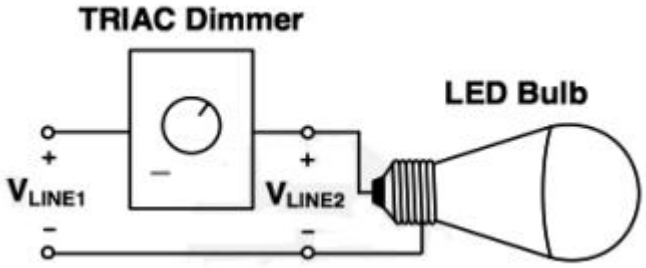

Fig14.1 Schematic diagram of Light Dimmer

VII Actual circuit diagram used in laboratory with equipment specification:-

a) Sample Circuit diagram

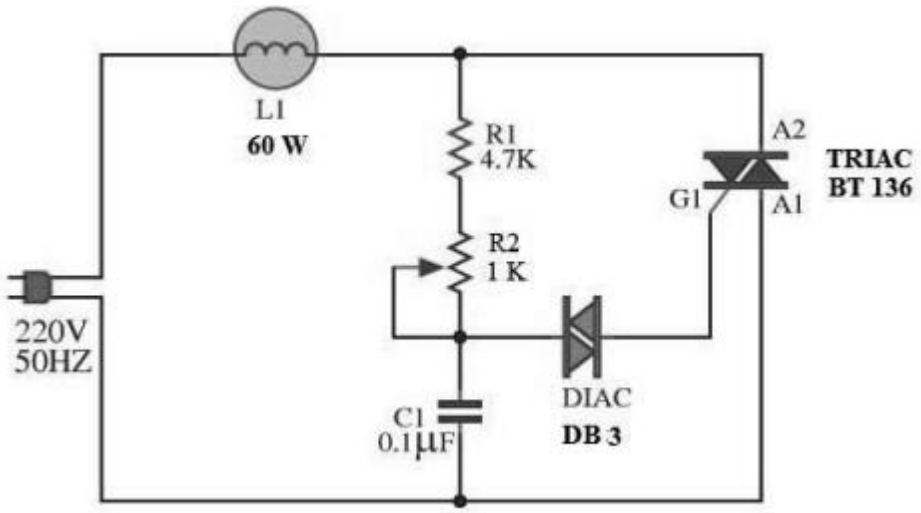

Fig14.2 Light Dimmer using TRIAC

b) Actual Circuit diagram:

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	TRIAC	BT136	1No.
2	DIAC	DB3	1No.
3	Lamp (Ll)	60W	1No.
4	Resistors, capacitor	Rl=4.7KΩ, R2=1KΩ, Cl=0.1μF	1Each
5	Multimeter	0-200V	1No.
6	Connecting wires	As per requirement	

IX Precautions to be Followed

1. Check all the connection before switching on the connections.
2. Do not touch live wires.
3. Keep potentiometer at minimum position.

X Procedure

1. Make the circuit connection as per the circuit diagram shown in Fig.16.2
2. Switch on power supply.
3. Vary the potentiometer R_2 slowly and observe its effect on the load-lamp/bulb.
4. Measure the voltage across lamp and TRIAC at different value of R_2.

XI Observations and Calculations

Table 14.1

Sr. No.	Intensity of Lamp	Resistance R2 (Ω)	Voltage across TRIAC (V)	Voltage across Load (Lamp) (V)
1	Low			
2	Moderate			
3	High			

XII Results

At high intensity

- Resistance= ,
- Voltage across load=.....

XIII Interpretation of Results (Give meaning of the above obtained results)

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XIV Conclusions and Recommendation

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VII Practical Related Questions

1. Find whether the minimum intensity of lamp is at higher or lower conduction angle.
2. Measure and note down voltage across TRIAC and lamp at high intensity.
3. Write the specification of triggering device used in this practical circuit.

[Space for Answers]

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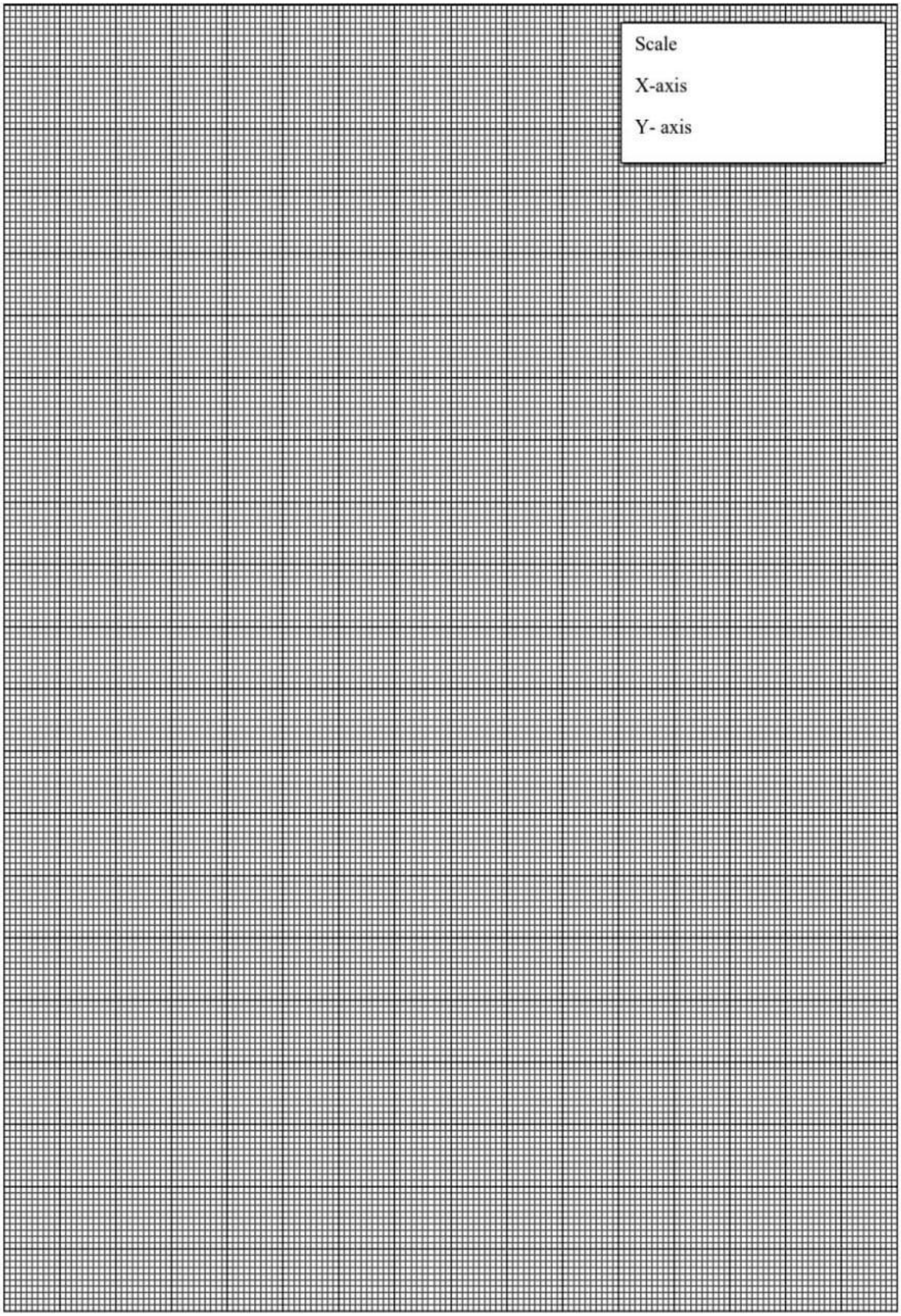
XVI References/Suggestions for further reading

1. www.en.wikibooks.org/wiki/Power_Electronics
2. www.books.google.co.in/books/about/Power_Electronics
3. A text-Lab Manual, Zbar, Paul B. McGraw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 0070727937, 9780070727939
4. http://bitsavers.trailing-edge.com/components/ge/l972_GE_SCR_Manual_5ed.pdf

Assessment Scheme

Performance Indicators		Weightage
Processrelated:15Marks		**60%**
1	Handling of equipment	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Productrelated:10Marks		**40%**
5	Calculate the firing angle	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total(25Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	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Y- axis

Practical No. 15: Emergency Light System using SCR.

I Practical Significance

An emergency light is an illumination device specially designed for operating in the event of power failure. It works on low voltage battery. The lamp glows only when ac power is not available. The duration for which lamp remain ON, depends upon the ampere-rating of the battery.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems.

III Course Level Learning Outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

- Use multimeter to measure various electrical parameters.
- Interpret the circuit diagrams
- Use the CRO to observe waveforms.

IV Laboratory learning Outcome(s)

a. Select power electronic devices for specific applications.

b. Maintain the performance of Thyristors.

c. Troubleshoot turn-on and turn-off circuits of Thyristors.

d. Maintain phase controlled rectifiers.

e. Maintain industrial control circuits.

V Relevant Affective domain related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.

VI Relevant Theoretical Background

During normal operation (mains power present), the SCR is triggered by the gate signal, but the emergency light is not energized since the backup power source is not connected to the SCR cathode. When the mains power fails, the SCR turns off, and the backup power source is connected to the SCR anode through the diode. The capacitor provides a brief delay to ensure the SCR is fully turned off before the backup power source takes over. The SCR then turns on, energizing the emergency light.

VII Actual circuit diagram used in laboratory with specification

a) Sample circuit diagram:-

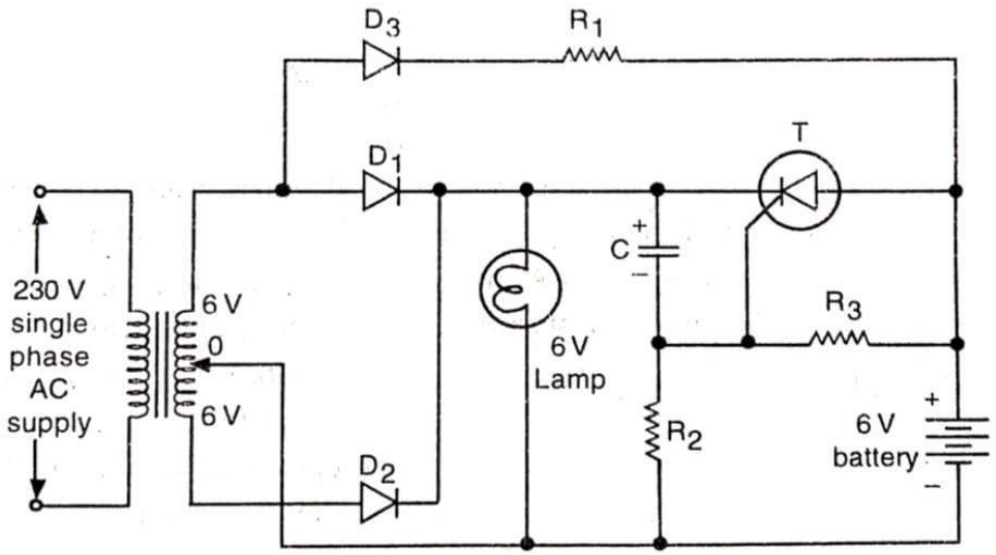

Fig. 15.1 Emergency Light System

b) Actual circuit diagram:-

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	SCR	BT151	**1** No.
2	Transformer Center tapped	Secondary voltage= 12 V	**1** No.
3	Diode	1N4007	**3** No.
4	Resistor	1KΩ	**3** No.
5	Capacitor	100μF	**1** No.
6	Lamp	6 V	**1** No.
7	Backup Power source	6 V DC	**1** No.

IX Precautions to be Followed

1. Wear protective gear like safety glasses, gloves, and a lab coat to prevent injury from electrical shock or component failure.
2. Double-check all connections and wiring to avoid electrical shock or short circuits.
3. Ensure that all components, including the SCR, diode, and capacitor, can handle the voltage and current ratings used in the experiment.
4. Use a reliable power source, such as a DC power supply, to avoid voltage fluctuations or electrical shock.
5. Adhere to standard laboratory procedures and guidelines for conducting electrical experiments.

X Procedure

1. Connect the mains power source and observe the emergency light (should be off).
2. Simulate a power failure by disconnecting the mains power source.
3. Observe the emergency light (should turn on automatically).
4. Reconnect the mains power source and observe the emergency light (should turn off).

XI Observations

1.Mains Power Present | Mains Power Failure |

2. SCR Gate Voltage:- | 5V | 0V |

3. SCR Anode Voltage:- | 12V | 9V |

4. SCR Cathode Voltage:- | 0V | 9V |

5. Emergency Light:- | OFF | ON |

XII Result(s)

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XIII Interpretation of Results

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XIV Conclusions and Recommendation

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XV Practical Related Questions

1. If battery charging is low, state the effect on intensity of lamp.
2. If lamp is not glowing after AC supply failure, state the possible reasons.
3. Write specifications of battery and lamp used in given Emergency Lighting system.

[Space for Answers]

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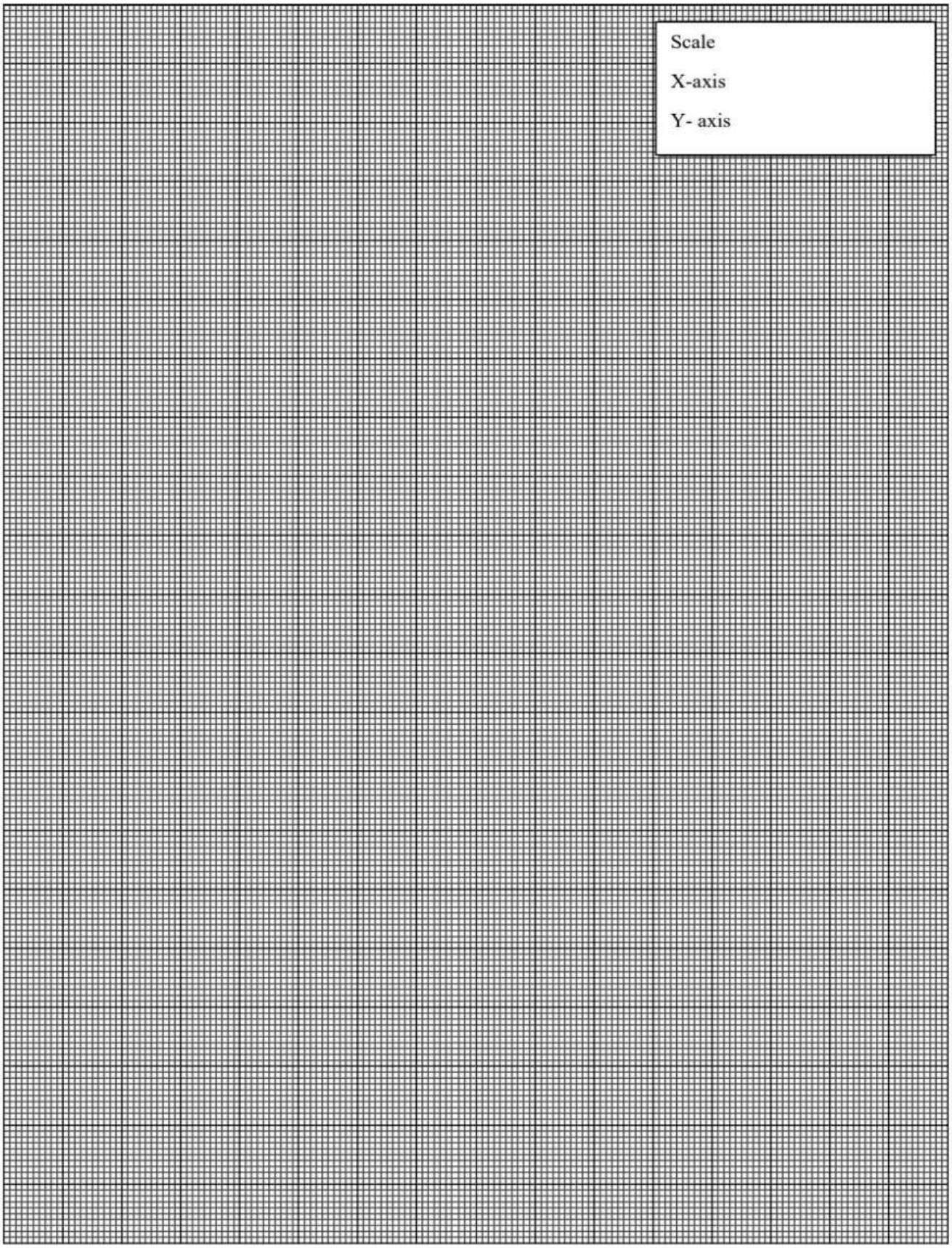
XVI References/Suggestions for further reading

1. A text-Lab Manual, Zbar, Paul B. Mc Graw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 9780070728226.
2. SCR Manual General electricPrenticeHall;6thedition,ISBN978-0137967636
3. https://www.youtube.com/watch?v=KumwNkiK4Gc
4. https://www.youtube.com/watch?v=5lRsrizfWME

Assessment Scheme

Performance indicators		Weightage
Process related:(15Marks)		**60%**
1	Handling of the components	10%
2	Identification of component	10%
3	Measuring value using suitable instrument	30%
4	Working in team	10%
Product related: (10Marks)		**40%**
5	Calculate theoretical values of given component	10%
6	Interpretation of result	05 %
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25Marks)		**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	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Y- axis

Practical No. 16: Temperature Controller using SCR

I Practical Significance

Electronic cutout for temperature control is used in furnace in the Industries. This circuit will tum off the supply given to the heater coils as soon as the desired temperature has been reached. When actual temperature goes slightly above the set temperature, the comparator output becomes low. This will tum off the power transistor or relay i.e. relay contact will become open. This results in disconnecting the heater coil from the ac supply. Thus temperature of the furnace is controlled at desired level.

II Industry/Employer Expected Outcome(s)

- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electronics and Telecommunication engineering problems.
- **Discipline knowledge:** Apply Electronics and Telecommunication engineering knowledge to solve broad-based Electronics and Telecommunications engineering related problems.
- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electronics and Telecommunication engineering problems

III Course level learning outcome(s)

This practical is expected to develop the following skills for the industry identified competency **'Maintain the proper functioning of power electronic devices':**

a. Select power electronic devices for specific applications.

b. Maintain the performance of Thyristors.

c. Troubleshoot tum-on and tum-off circuits of Thyristors.

d. Maintain phase controlled rectifiers.

e. Maintain industrial control circuits.

IV Laboratory Learning Outcome(s)

- Troubleshoot the Temperature control system.

V Relevant Affective domain related Outcome(s)

- Follow safety practices.
- Practice good house keeping.
- Maintain tools and equipment.

VI Relevant Theoretical Background

A temperature controller using SCR (Silicon Controlled Rectifier) theory is a device that regulates temperature using thyristors (SCRs) to control the flow of electrical energy to a heating element.

VII Actual circuit diagram used in laboratory with specification

a) Sample circuit diagram:-

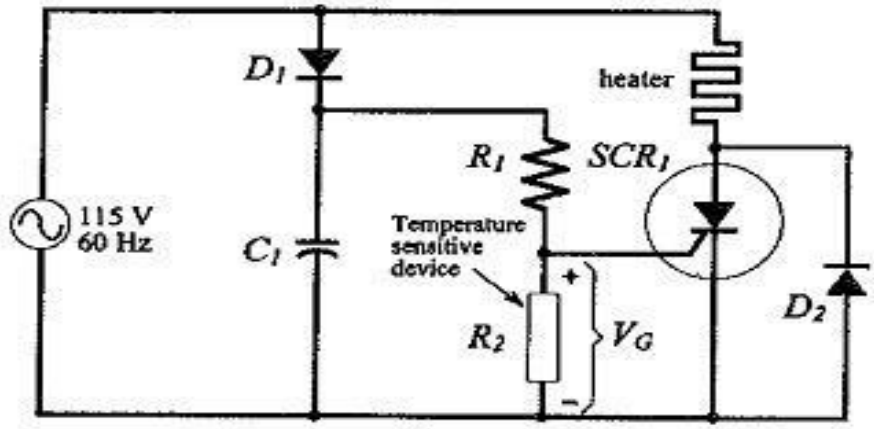

Fig. 16.1 Temperature Controller using SCR

b) Actual circuit diagram:-

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Temperature Sensor	60 degree	**1** No.
2	Heating Element (RTD)	100 Ω	**1** No.
3	Thermistor	10 Ω	**1** No**.**
4	SCR	BT-151	**1** No.
5	AC Power Supply	115V, 60Hz	**1** No.

IX Precautions to be followed

1. Protect yourself from electrical shock
2. Handle heating elements with care
3. Avoid overloading the circuit with excessive current.
4. Maintain a safe distance from combustible materials.
5. Use appropriate measuring instruments (e.g., thermometers, multimeter).
6. Avoid overheating: - Set a maximum temperature limit. Ensure proper heat dissipation.

X Procedure

1. Build the circuit on a breadboard or PCB.
2. Set the desired temperature 60 degree (connected to the reference voltage).
3. Measure the temperature using a thermometer or multimeter.
4. Observe how the SCR switches on/off to maintain the set temperature.
5. Adjust the set point and observe the response.

XI Observations and Calculations

Sr. No.	Temperature (°C)	Thermistor (RTD) Voltage (V)	Error Signal (V)	SCR State
1.	25	1.05	0	OFF
2.	40	1.20	0.5	OFF
3.	50	1.35	1.0	ON
4.	60	1.50	0	ON
5.	65	1.55	-0.5	OFF
6.	70	1.60	-1.0	OFF

XII Result(s)

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XIII Interpretation of result

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XIV Conclusions & Recommendation

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XV Practical Related Questions

1. Write specifications of thyristor, and sensor used in given Temperature control system.
2. State the effect of heater load on thyristor.

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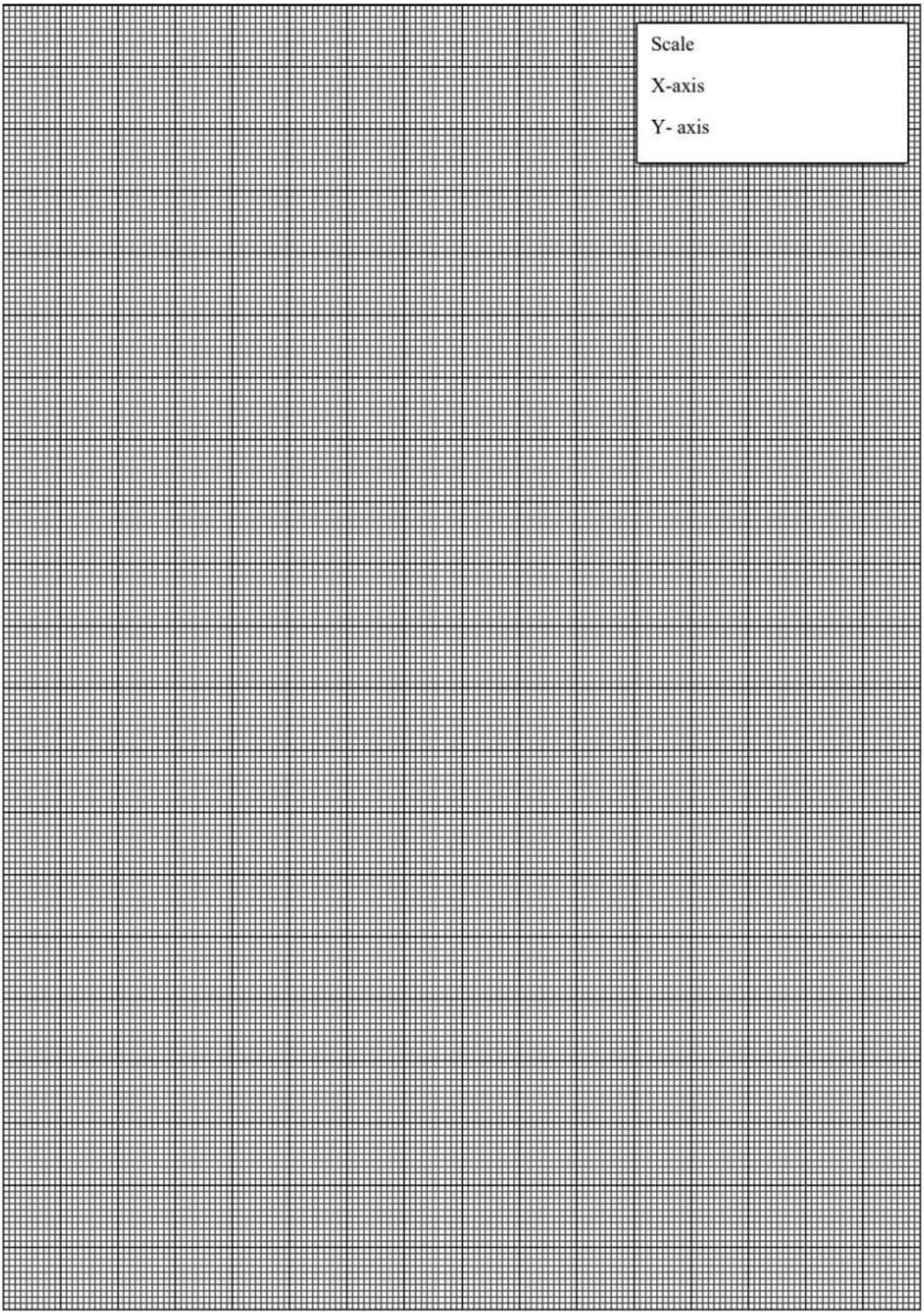
Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	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