I

Name _____

Roll No. _____ Year 20____20____

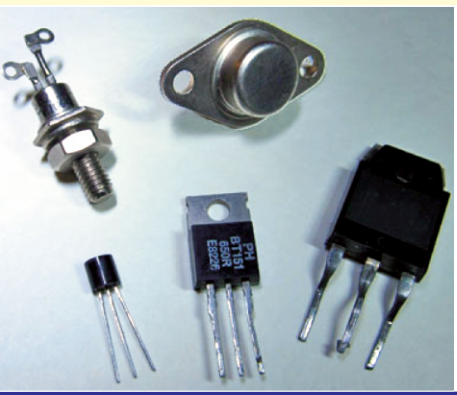
Exam Seat No. _____

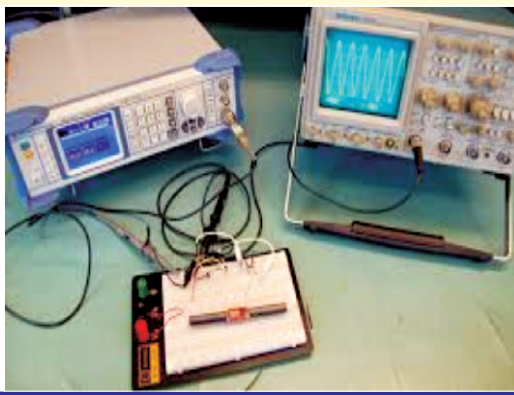
ELECTRICAL GROUP | SEMESTER - III | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

FUNDAMENTALS OF POWER ELECTRONICS (22326)





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 changing technological and 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 followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

for

Fundamentals of Power Electronics

(22326)

Semester-III

(EE/EP/EU/IE)

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)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on June, 2018)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms. ……..…… Roll No. ……..…., of Third Semester of Diploma in ……..…… of Institute, ……..…….……..… (Code: ……...) has completed the term work satisfactorily in course **Fundamentals of Power Electronics (22326)** for the academic year 20…….. to 20…….. as prescribed in the curriculum.

Place: …… Enrollment No:.……

Date: …… Exam. Seat No: ……

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

Seal of Institution

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 curricula for engineering diploma programmes with outcome-base 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 practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals 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 pre-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.

Power electronic devices and circuits play a major role in nearly all industries. By virtue of their operating characteristics; for which study of these devices is very essential for the electrical and electronic technician to handle them. This course aims to impart the knowledge and skills related to handling in terms of the applications and maintenance of these devices.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practicals of this Course

1. **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.
2. **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
3. **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO 1. Electrical Equipment: Maintain various types of rotating and static electrical equipment.

PSO 2. Electric Power Systems: Maintain different types of electrical power systems.

Practical- Course Outcome matrix

Course Outcomes (COs)

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.

S. No.	Title of the Practical	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Test the proper functioning of power transistor.	√	-	-	-	-
2.	Test the proper functioning of IGBT.	√	-	-	-	-
3.	Test the proper functioning of DIAC to determine the break over voltage.	√	-	-	-	-
4.	Determine the latching current and holding current using V-I characteristics of SCR.	√	√	-	-	-
5.	Test the variation of R,C in R and RC triggering circuits on firing angle of SCR.	√	√	-	-	-
6.	Test the effect of variation of R, C in UJT triggering technique.	√	√	-	-	-
7.	Perform the operation of Class – A, B, C, turn off circuits.	√	√	√	-	-
8.	Perform the operation of Class –D, E, F turn off circuits.	√	√	√	-	-
9.	Use CRO to observe the output waveform of half wave controlled rectifier with resistive load and determine the load voltage.	√	-	-	√	-
10.	Draw the output waveform of Full wave controlled rectifier with R load, RL load, freewheeling diode and determine the load voltage.	√	-	-	√	-
11.	Determine the firing angle using DIAC and TRIAC phase controlled circuit on output power under different loads such as lamp , motor or heater.	√	-	-	√	√
12.	Simulate above firing angle control on MATLAB / PSIM / SCILAB software.	-	-	-	-	-
13.	Test the performance of given SMPS.	-	-	√	√	√
14.	Test the performance of given UPS.	-	-	√	√	√
15.	Troubleshoot the Burglar's alarm.	-	-	√	-	√
16.	Troubleshoot the Emergency light system.	-	-	√	-	√
17.	Troubleshoot the Speed control system.	-	-	√	-	√
18.	Troubleshoot the Temperature control system.	-	-	√	-	√

List of Industry Relevant Skills

The following industry relevant skills of the competency **'Maintain the proper functioning of power electronic devices'** are expected to be developed in you by undertaking the practicals of this laboratory manual.

1. Analysis of power electronics circuits.
2. Use of Multimeter to test device and measure voltage,current.
3. Use of CRO to measure firing angle and observe the waveform.
4. Read the data sheet of power electronics components.

Brief Guidelines to Teachers

Hints regarding strategies to be used:

1. 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 for assessment to the teacher in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.

Note:

1. Check the connections made by students and then switch ON the power supply.
2. Ensure that all the knobs of the power supplies are at zero value, before switching them ON.
3. Use the power scope or isolation transformer to observe the waveforms.

Instructions for Students

Note:

1. Show the connections to teacher, before turning the circuit ON.
2. Adjust the knobs of power supply to zero, before turning them ON.
3. Use correct / proper power supply.
4. Use the power scope or isolation transformer to observe the waveforms.

Content Page

List of Practicals and Progressive Assessment Sheet

S. No.	Title of the practical	Page No.	Date of performance	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
13.	Test the performance of given SMPS.	66					
14.	Test the performance of given UPS.	71					
15.	Troubleshoot the Burglar's alarm.	76					
16.	Troubleshoot the Emergency light system.	81					
17.	Troubleshoot the Speed control system.	87					
18.	Troubleshoot the Temperature control system.	92					
	Total						

* ***To be transferred to performa of CIAAN -2017.***

Practical No. 1: Power transistor performance

I Practical Significance

Power Bipolar Junction Transistor (BJT) is the first semiconductor device to allow full control over its Turn on and Turn off operations. Power transistors are mainly used in high-power applications like power amplifiers and switched mode power supplies.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results.
iii. Interpret the circuit diagrams.

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications

V Practical Outcome

Test the proper functioning of power transistor

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

Power transistors can be NPN, PNP, Darlington forms. A power transistor has vertically oriented four layer structure. Due to vertical structure it has low on state resistance and hence low power loss in the device. It is physically larger and capable of carrying more current without melting or burning up. The collector of the transistor is connected to a metal base that acts as a heat sink to dissipate excess power.

Typical power ratings range from around 10 - 300 W, with frequency ratings from about 1 - 100 MHz. Maximum collector current(I_C) values ranges between 1 - 100 A.

VIII Practical set-up / Circuit diagram / Work Situation

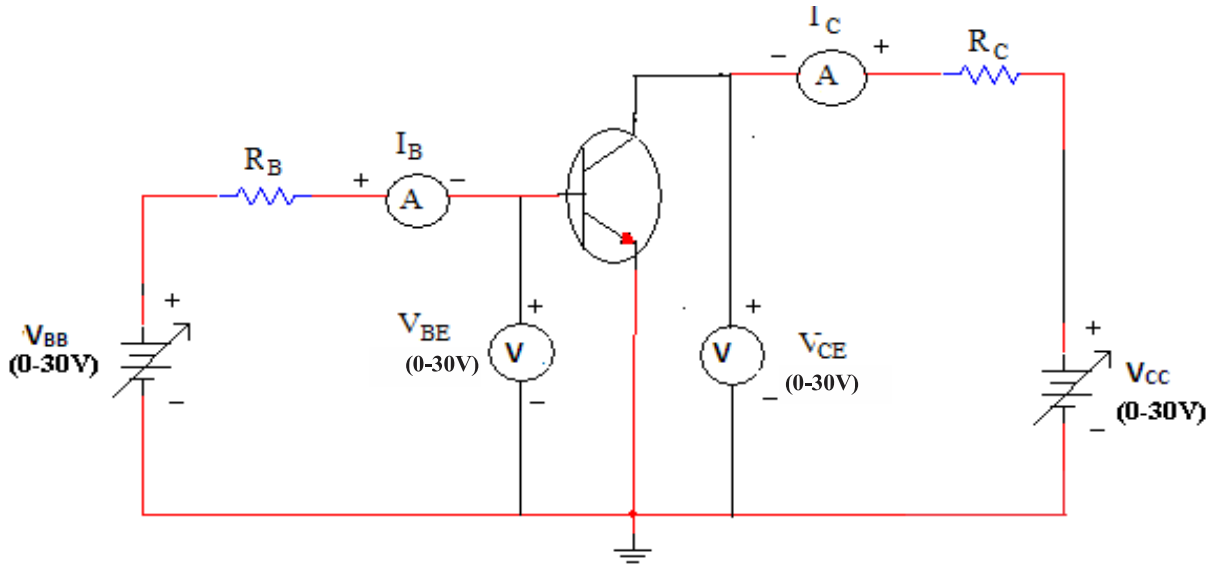


Figure 1 . V/I Characteristics of Power (BJT)

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-30/32 V_{DC}	2 No.
2	Digital Multimeter	0-200 V_{DC} , 0-1A / 10A	2 No.
3	Power Transistor	BD139 ,2N3055 or any other available	1 No.
4	Resistors	R_C = 100 Ω , 5 watt R_B = 3.3 KΩ , 1 watt	1 Each

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. Do not increase the base current more than its rated value.
3. The applied voltage, current should not exceed the maximum rating of the given transistor.
4. If the power transistor is getting heated, either use appropriate heat sink or limit the collector current.
5. Reading should be noted without parallax error.

XI Procedure

1. Make the circuit connection on bread board as per the circuit diagram.
2. Keep knobs of DC supplies to zero.
3. Switch on power supply.
4. Increase V_{BB} power supply gradually to increase I_B to set at the given value by the teacher (say 10 V to 30 V).
5. Keep I_B constant, when increasing V_{CC} in steps of 1volt and record I_C and V_{CE}..
6. Repeat steps 4 to 5 in increasing steps of 10 mA until I_C becomes constant.
7. Plot I_C versus V_{CE} curves for various values of I_B on graph paper.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr. no	I_{B1} =		I_{B2} =		I_{B3} =	
	I_c mA	V_{CE} volts	I_c mA	V_{CE} volts	I_c mA	V_{CE} volts

XV Results

1. Current gain …….
2. ……

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. If R_B is open circuited, state the effect on V_{CE}.
2. If V_{BE} is zero , state the effect on power BJT.
3. Write specifications of power transistor (from data sheet).

[Space for Answers]

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XIX References / Suggestions for further reading

1. Laboratory Manual for Introductory Electronics Experiments, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi, ISBN:9780852265543
2. Transistor database user guide, 2016.
3. https://www.youtube.com/watch?v=IqqNfJdgvlY.

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: (15 Marks)		**60%**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related: (10 Marks)		**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 (25 Marks)		**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….
4. …….

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

Practical No. 2: Insulated gate bipolar transistor performance

I Practical Significance

This device is designed to make use of the benefits of both BJT and MOSFET devices. This device is suitable for several applications in power electronics, particularly in UPS (Uninterruptible Power Supplies), SMPS (Switched-Mode Power Supplies), induction heating, etc. It increases the efficiency, dynamic performance and reduces the level of the audible noise (typically operated at high frequency more than 20 KHz).

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice**: An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools**: Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the power supply to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications

V Practical Outcome

Test the proper functioning of IGBT

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

IGBT is a hybrid MOS gated turn-on/turn-off bipolar transistor that combines the attributes of MOSFET, BJT and thyristor. It has an input characteristics of a MOSFET and an output characteristics of a bipolar transistor. That means it has high input impedance and low on state conduction loss. But it has no second breakdown problem like BJT. It has simple drive circuit, wide safe operating area, peak current capability, ruggedness and bipolar voltage blocking capability like a thyristor. It has three terminals, Collector (C), Emitter (E), source(S),and gate(G),according to a MOSFET model or emitter(E),collector(C),and gate(G), according to a BJT model.

VIII Practical set-up / Circuit diagram / Work Situation

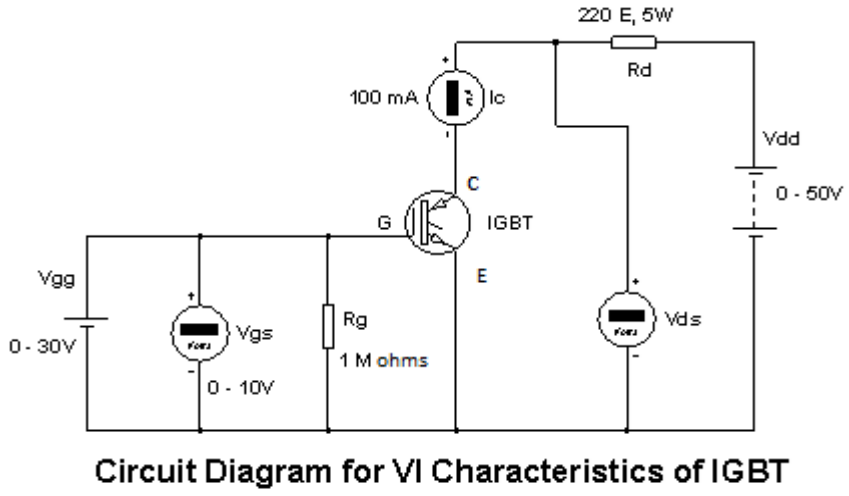

Figure 1 ..IGBT characteristics..

Note : Students should trace the circuit from the available kit and then draw the circuit diagram. Also refer the datasheet for IGBT and then use relevant Power supplies,Voltmeter and Ammeter .

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-50 V DC	2 No.
2	Digital Voltmeter	0-50V DC	2 No.
3	Digital Ammeter	0-500 mA	1 No
4	IGBT	IRG4BC20U	1 No.
5	Resistors	Rg = 1 MΩ Rd = 220 Ω	2 Nos.

Note : Students should trace the circuit from the available kit /kit manual and then draw the circuit diagram. Also refer the datasheet for IGBT and then use relevant IGBT ,Powersupplies,Voltmeter, and Ammeter .

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. Identify Gate, Collector, and Emitter terminals of the given IGBT and make the connections as shown in the circuit diagram.
3. The applied voltage, current should not exceed the maximum rating of the given IGBT.
4. If the IGBT is getting heated , either use appropriate heat sink or limit the Collector current.
5. Reading should be noted without parallax error .

XI Procedure

a) Transfer Characteristic :

1. Make the circuit connection as per the circuit diagram.
2. Keep knobs of DC supplies to zero
3. Switch on power supply.
4. Set V_{CE} = 10V and gradually vary power supply V_{gg} in steps of 1V and note down I_c and V_{ge}.
5. The minimum gate voltage V_{ge} required for conduction of IGBT is called the threshold voltage $V_{ge(TH).}$
6. Plot the transfer characteristics (I_c versus V_{ge}) on graph paper.

b) Output Characteristics:

1. Switch on power supply V_{gg} and set $V_{ge} \geq V_{ge(TH).}$
2. Now increase power supply V_{dd} gradually in steps of 2V from zero and record V_{ce} and $I_{c.}$
3. Repeat step 2 for two more values of V_{ge}.
4. Plot the output characteristics (I_c versus V_{ce}) on graph paper.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

A) Transfer Characteristics :

Sr. no	V_{ce} =10 V	
	V_{ge} volts	Ic mA

B) Output Characteristics :

Sr. no	V_{ge1} = V		V_{ge2} = V	
	V_{ce} volts	I_c mA	V_{ce} volts	I_c mA

XV Results

1. Threshold voltage of the given IGBT $V_{ge(TH).}$=……V
2. When $V_{ge} < V_{ge(TH)}$, I_c =……mA, V_{ce} =……V and the IGBT switch is ……(ON/OFF)

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. Write number of three IGBTs and their specifications.
2. Comment on gate to source voltage greater and threshold voltage of the given IGBT to turn ON.
3. State the requirement of pulse triggering levels for IGBT.

[Space for Answers]

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XIX References / Suggestions for further reading

1. Laboratory Manual for introductory electronics experiments, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi, ISBN:9780852265543
2. Transistor database user guide,2016.
3. https://www.youtube.com/watch?v=IqqNfJdgvlY

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: (15 Marks)		**60%**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related: (10 Marks)		**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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 3: DIAC Performance

I Practical Significance

It is a member of the Thyristor family. It can be used mainly in the TRIAC triggering circuit, lamp dimmer circuit, fan regulator, temperature controller etc . The advantage of using this device is that it can be turned on or off simply by controlling the applied voltage level about its breakover voltage.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the Power supply to get the desired results.
iii. Interpret the circuit diagrams.

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications.

V Practical Outcome

Test the proper functioning of DIAC to determine the break over voltage.

VI Relevant Affective domain related Outcome(s)

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

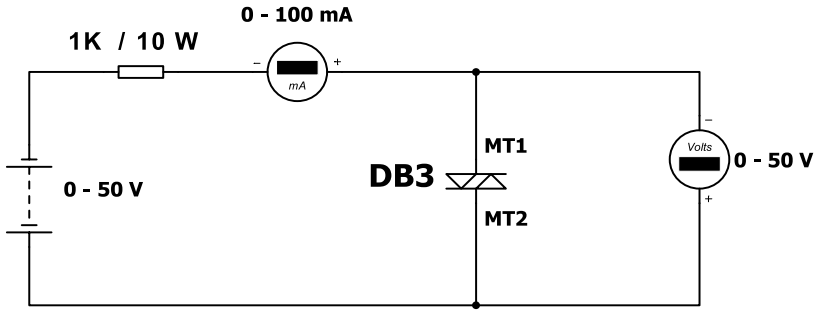
VII Minimum Theoretical Background

It is a device which consists of three layers and two terminals. The construction is almost same as that of the transistor. But there are certain points which deviate from the construction of the transistor. The differentiating points are-

1. There is no base terminal in the DIAC.
2. The three regions have almost the same level of doping.
3. It gives symmetrical switching characteristics for either polarity of voltages.

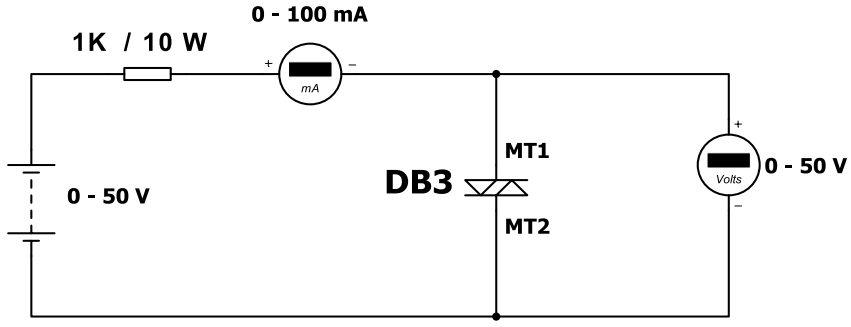
Also, it can be either turned on or off for both the polarity of voltages. This device works when avalanche breakdown occurs.

VIII Practical set-up / Circuit diagram / Work Situation



MT2 Positive w.r.t. MT1 (First Quadrant Operation)

Fig 1..



MT1 Positive w.r.t. MT2 (Third Quadrant Operation)

Fig 2..

Note: Students should trace the circuit from the available kit/kit manual, then draw the circuit diagram. Also refer the data sheet for DIAC and then use relevant DIAC , Power supplies, voltmeter, ammeter.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-50 V DC	1 No.
2	Voltmeter	0-50 V	1 No.
3	Ammeter	0-100 mA	1 No.
4	DIAC	DB3/DB4 or any other available	1 No.
5	Resistor	1 KΩ , 10 watt	1 No.

Note: Also refer the data sheet for DIAC available on the Trainer Kit and then use relevant DIAC , Power supplies, voltmeter, ammeter and resistor.

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them ON.
2. The applied voltage, current should not exceed the maximum rating of the given DIAC.
3. Reading should be noted without parallax error .

XI Procedure

a) MT_2 positive wrt MT_1(First Quadrant operation):

1. Make the circuit connection as per the circuit diagram.
2. Keep knobs of DC supplies to zero.
3. Switch on power supply.
4. Increase voltage of DC power supply(V_s) in a steps of 2V and note down V and I of DIAC.
5. Increase V_s till I increases with sudden drop in V. The maximum voltage at which DIAC turns on is called the breakover voltage $V_{BO.}$
6. Measure V_{BO} precisely.
7. Take at least four more reading of Voltage and Current after breakover voltage

b) MT_1 positive wrt MT_2(Third Quadrant operation):

1. Reverse the polarity of power supply and meters or reverse the DIAC Terminals
2. Repeat steps 3 to 7 (from a procedure).
3. Plot the V-I characteristics of DIAC on graph paper.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr. no	(MT_2 is positive wrt MT_1) 1st Quadrant		(MT_1 is positive wrt MT_2) 3rd Quadrant	
	V (Volts)	I (mA)	V (Volts)	I (mA)
1				
2				
3				
4				
5				
6				

XV Results

1. 1st Quadrant Breakover Voltage V_{BO} ……..
2. 3rd Quadrant Breakover Voltage V_{BO} ……

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

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.....
.....

XVII Conclusions (Actions/decisions to be taken based on the interpretation of results)

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.....
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XVIII Practical Related Questions

1. If resistance 1K is open circuited , state the effect on Voltage across DIAC.
2. If AC voltage (0-50V) is applied to DIAC, whether it conducts or not ?
3. Write specifications of the given DIAC (from data sheet).

[Space for Answers]

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XIX References / Suggestions for further reading

1. A text – Lab Manual, Zbar, Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 9780070728226.
2. Datasheet of DIAC from any website or www.radiotechnika.hu/images/DB3.pdf.
3. https://www.youtube.com/watch?v=D8njxLbmRmQ

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 4: Silicon controlled rectifier performance

I Practical Significance

The SCRs are capable to control the power given to the load. Due to its ability to turn ON and OFF , the SCRs are used for home appliance control include lighting, temperature control, fan speed regulator , etc and for industrial applications, SCRs are used to control the motor speed, battery charging and power conversions.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the power supply to get the desired results.
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications

V Practical Outcome

Determine the latching current and holding current using V-I characteristics of SCR.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

Silicon Controlled Rectifier (SCR) is a unidirectional semiconductor device made of silicon. SCR is a three terminal, four-layer as p-n-p-n and three junctional device.

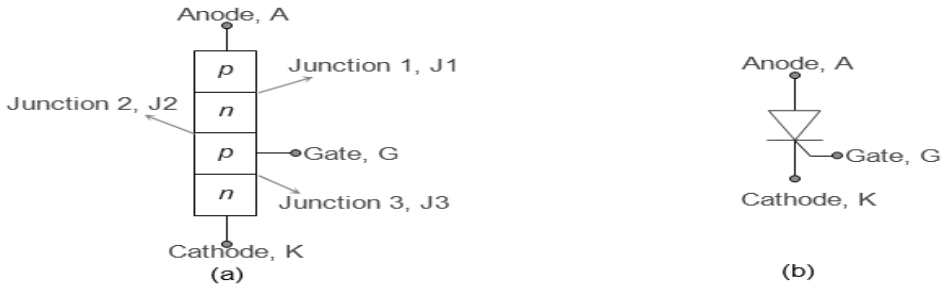
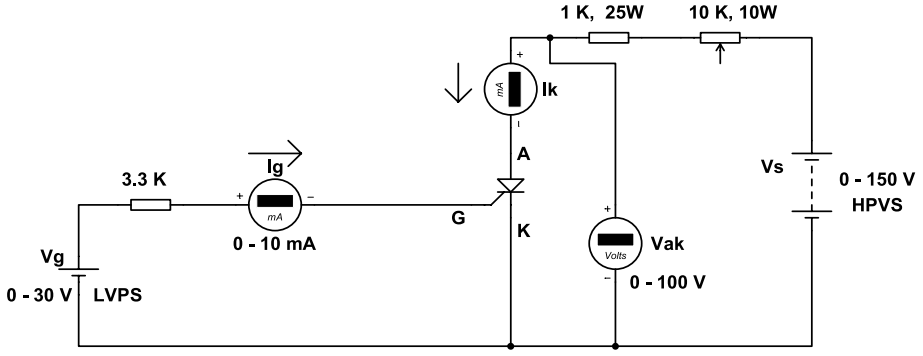


Figure 1 Silicon Controlled Rectifier (a) Layered Structure (b) Symbol

VIII Practical set-up / Circuit diagram / Work Situation



Circuit Diagram for Forward Characteristics of SCR

Figure 1 : Forward characteristics of SCR

Note : Students should trace the circuit from the available KIT / kit manual , then draw the circuit diagram. Also, go through the data sheet for the SCR and then,use relevant SCR, power supplies,voltmeter,ammeters.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-150 V_{DC} , 0-30 V_{DC}	2 No.
2	Ammeters	0-30 mA , 0-150 mA	2 No.
3	Voltmeter	0-100 V	1 No.
4	SCR	TYN604 / TYN612 or any other available	1 No.
5	Resistors	R_L = 10 KΩ , 10 watt R_G = 3.3 KΩ , 0.25 watt	1 Each

Note : Also, go through the data sheet of the SCR available on the Kit and then,use relevant power supplies,voltmeter,ammeters and resistors.

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. Do not increase the voltage, current more than its rated value.
3. Reading should be noted without parallax error.

XI Procedure

A) For forward characteristics :

1. Make the circuit connection as per the circuit diagram.
2. Keep knobs of DC supplies to zero
3. Switch on power supply.
4. Set I_G= 0 mA.
5. Increase V_{AK} power supply gradually and when I_A flows, then this V_{AK} is called as $V_{BO.}$
6. Set I_{G1} = 2 mA , increase V_{AK} power supply gradually till SCR turns ON and record the readings of V_{AK} and JA.
7. Set I_{G2} , I_{G3} (I_{G3}> I_{G2} > I_{G1}) and repeat step 6.
8. Record I_A for I_{G1} , I_{G2} , I_{G3} respectively.
9. Plot I_A versus V_{AK} curves for various values of I_G on graph paper.

B) To determine Latching current :

1. Set V_{AK} to any suitable value given by the teacher.
2. Apply sufficient gate current and turn ON the SCR.
3. After the SCR has turned ON, remove gate current.
4. If SCR remains ON , then switch off $V_{AK.}$
5. Increase the value of resistor (R_L) and turn ON the SCR at lower I_A.
6. As the value of R_L is increased, I_A will go on decreasing, record lowest value of I_A at which SCR remains ON even after gate current is removed.
7. The lowest value of I_A is the latching current.

C) To determine holding current :

1. Set V_{AK} to suitable value and increase gate current gradually to turn the SCR on and absolutely small I_A flows through it.
2. Now remove gate current if the SCR turns off, then as per step no1 for minimum Ig if a Min I_A flows through the SCR, then it is called I_H note it down.
3. Gradually increase R which will decrease I_A.
4. Record the lowest value of I_A at which SCR turns OFF. This is the holding current.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr. no	I_{G1} = mA		I_{G2} = mA		I_{G3} = mA	
	V_{AK}	I_A mA	V_{AK}	I_A mA	V_{AK}	I_A mA
1						
2						
3						
4						
5						
6						

XV Results

1. V_{BO} =
2. Holding Current, I_H =
3. Latching current, I_L =

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. If resistance 3.3 KΩ is open circuited, state the effect on SCR.
2. In a DC circuit, during ON state of SCR, if gate terminal becomes open, state the effect on the working of SCR.
3. Write specifications of SCR (from data sheet).

[Space for Answers]

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XIX References / Suggestions for further reading

1. Industrial Electronics : A Text –Lab manual, Zbar,Paul B., McGraw Hill Publishing Co. Ltd. ,New Delhi,1990, ISBN:9780070728226.
2. Data sheet of SCR from any website.
3. www.nptel.ac.in – module 4.

XX Suggested 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 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 (25 Marks)	**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 5: SCR Triggering Circuits Performance

I Practical Significance

It is the simplest and economical type of triggering but limited for few applications. In R triggering circuit firing angle is limited to 90^0 only and the RC triggering circuit which provides the firing angle control from 0 to 180^0. These are the most commonly used method of triggering.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications

V Practical Outcome

Test the variation of R,C in R and RC triggering circuits on firing angle of SCR.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

SCR can be turned on by gate signal at any phase angle with respect to applied ac voltage. Firing angle is the phase angle of ac voltage at which SCR is turned ON. A positive signal is applied between the gate and cathode terminal of SCR.

With the gate triggering SCR can be triggered much before the breakover voltage V_{BO} . Three types of signals can be used for this purpose i) DC signal ii) AC signal iii) Pulse signal.

VIII Practical set-up / Circuit diagram / Work Situation

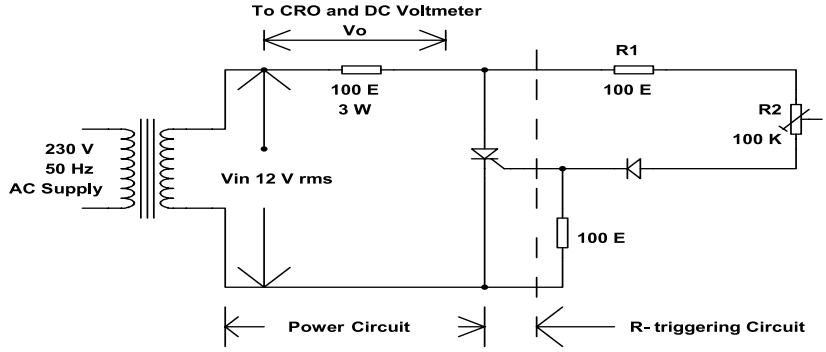

Fig 5.1 …Circuit diagram for R triggering...

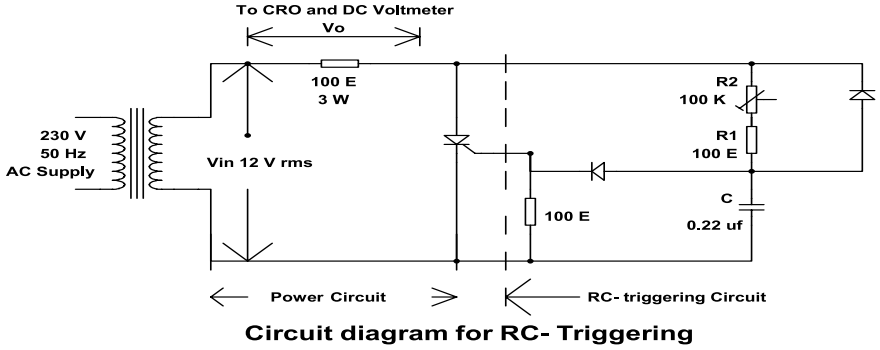

Fig 5.2 ..Circuit diagram for RC triggering…

Note: Students should trace the circuit from the available kit/kit manual, then draw the circuit diagram. Also refer the data sheet for SCR and then use relevant SCR, Power supplies, voltmeter ,CRO.

IX 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	20 MHz	1 No.
4	Transformer	0-12V 500 mA	1 No.
5	SCR	TYN 612 or any other available	1 No.
6	Diode	D_1 and D_2	2 No.
7	Capacitor	0.22µF	1 No.
8	Resistors	R_1 = 100 Ω , R_2 , potentiometer = 100KΩ, R_G=100 Ω, R_L= 100 Ω, 3watts	1 Each

Note: Also refer the data sheet for SCR available on the Kit and then use relevant voltmeter.

X Precautions to be Followed

1. Connection to the mains should be done carefully.
2. The applied voltage, current should not exceed the maximum rating of the given SCR.
3. Reading should be noted without parallax error.

XI Procedure

a) R- triggering :

1. Make the circuit connection as per the circuit diagram.
2. Keep Potentiometer R2 at maximum value.
3. Switch on Mains supply.
4. Decease the resistance R_2 of Potentiometer in steps , note down the corresponding values of output voltage.
5. Also measure / record the corresponding firing angle on CRO.
6. Draw the corresponding wave form on Graph Paper for any two firing angles.

b) RC- Trigerring :

1. Make the circuit connection as per the circuit diagram.
2. Keep Potentiometer R_2 at maximum value.
3. Switch on Mains supply.
4. Decrease the resistance R_2 of Potentiometer in steps , note down the corresponding values of output voltage.
5. Also measure / record the corresponding firing angle on CRO.
6. Draw the corresponding wave form on Graph Paper for any two firing angles.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

a) R –triggering :

Vin = …. Vrms

Sr. no	Firing angle $\alpha(^o)$	Average output Voltage(V)
1		
2		
3		
4		
5		

2. RC – triggering :

Vin = …. Vrms

Sr. no	Firing angle $\alpha(^o)$	Average output Voltage(V)
1		
2		
3		
4		
5		

XV Results

a) R-triggering

- For high resistance R= ……Ω, $\alpha(^o)$= …….
- For high resistance R= ……Ω, $\alpha(^o)$= …….

b) RC-triggering

- For high resistance R= ……Ω, $\alpha(^o)$= …….
- For high resistance R= ……Ω, $\alpha(^o)$= …….

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

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Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVII Practical Related Questions

1. If diode is open circuited , state the effect on Voltage across Load.
2. If R1 and R2 are short circuited , state the effect on load vpltage.
3. State the range of firing angle with R , RC- triggering circuit.

[Space for Answers]

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XVIII References / Suggestions for further reading

1. A text – Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 9780070728226.
2. Datasheet of SCR from any website.

XIX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……
4. …….

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

Practical No. 6: UJT Triggering Techniques

I Practical Significance

One common application of the Unijunction Transistor (UJT) is the triggering device of the other power control devices such as the SCR, Triac etc.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired waveform results
iii. Interpret the circuit diagrams and waveforms.

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications

V Practical Outcome

Test the effect of variation of R, C in UJT triggering technique.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

A unijunction transistor (UJT) is an electronic semiconductor device that has only one junction. The UJT has three terminals: an emitter (E) and two bases (B1 and B2). The base is formed by lightly doped n-type bar of silicon. Two ohmic contacts B1 and B2 are attached at its ends. The emitter is of p-type and it is heavily doped. The resistance between B1 and B2, when the emitter is open-circuit is called interbase resistance.

Now the capacitor discharges through minimum emitter base resistance of the device and o/p resistance RB1.

VIII Practical set-up / Circuit diagram / Work Situation

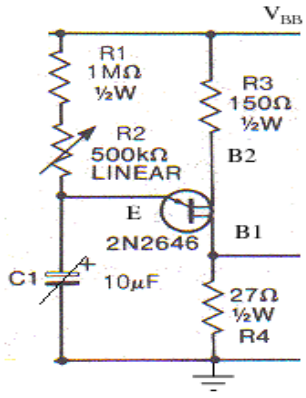

Figure 1 …

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-30 V DC	1 No.
2	UJT	2N2646 or any other	1 No.
3	Capacitor (variable)	C1 = 100 μF or any other available	1 No.
4	Resistors	R1 = 10K, 1/4 watt R2 (pot) = 500 KΩ R3 = 150 Ω , 0.25 watt R4 = 27 Ω , 0.25 watt	1 Each

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. The applied voltage, current should not exceed the maximum rating of the given UJT.
3. Reading should be noted without parallax error .

XI Procedure

1. Make the circuit connection as per the circuit diagram.
2. Keep knobs of DC supplies to zero
3. Switch on power supply.
4. Increase V_{BB} power supply gradually to increase I_B to set at the given value by the teacher (say 10 V to 15 V).
5. Keep R2 at maximum value.
6. Keep C1 constant, while decrease R2 in steps till waveform observed on CRO at B1 and across C1.
7. Measure the values of R2.
8. Measure the time period of charging and discharging of capacitor (a saw tooth waveform).

9. Repeat step 6 for 2 /3 values of R2.
10. Now, keep R2 constant and vary C1 till waveform observed on CRO at B1.
11. Measure the time period of charging and discharging of capacitor (a saw tooth waveform).
12. Repeat steps 10 and 11 for 2 / 3 values of C1.
13. Draw the waveforms for different values of R2 and C1.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr. No	R2	C1	T measured	T calculated
1				
2				
3				
4				
5				

$f = \frac{1}{RC \ln(1/(1-\eta))}$ ……η= 0.65 to 0.8 ….. formula

XV Results

1. ……...
2. ……

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect on controlled output from a controlled rectifier, if fixed dc supply is given to UJT relaxation oscillator.
2. Comment on the range of firing angle that can be obtained using UJT triggering.

[Space for Answers]

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XIX References / Suggestions for further reading

1. https://www.allaboutcircuits.com/textbook/semiconductors/chpt-7/unijunction-transistor-ujt/
2. Industrial Electronics : A Text –Lab manual, Zbar, Paul B., McGraw Hill Publishing Co. Ltd. ,New Delhi,1990, ISBN:9780070728226.

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. …….
4. …….

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

Practical No. 7: Class A, B, C commutation Performance

I Practical Significance

Continuous conduction causes problems in choppers, inverters and cyclo converters. By the commutation process the thyristor operating mode is changed from forward conducting to forward blocking mode. In Class A, B and C commutation, thyristor can be turned OFF by reducing the anode current below the holding current with the help of active and passive components.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course 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.

V Practical Outcome

Perform the operation of Class – A, B, C turn off circuits.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

Thyristor current can be reduced to a value below the value of holding current. Since, the thyristor is turned off forcibly it is termed as a forced commutation process.

Class A Commutation

This is also known as commutation, or load commutation. In this commutation, the source of commutation voltage is in series with SCR. The load must be an under damped R-L-C supplied with a DC supply so that natural zero current is obtained at the ringing frequency.

Class B Commutation

This is also a self commutation circuit in which commutation of SCR is achieved automatically by L and C components, once the SCR is turned ON. In this, the LC resonant circuit is connected across the SCR but not in series with load as in case of class A commutation and hence the L and C components do not carry the load current.

Class C Commutation

In this commutation method, main SCR that is to be commutated gets connected in series with the load and an additional or complementary SCR is connected in parallel with main SCR. This method is also called as complementary commutation.

VIII Practical set-up / Circuit diagram / Work Situation

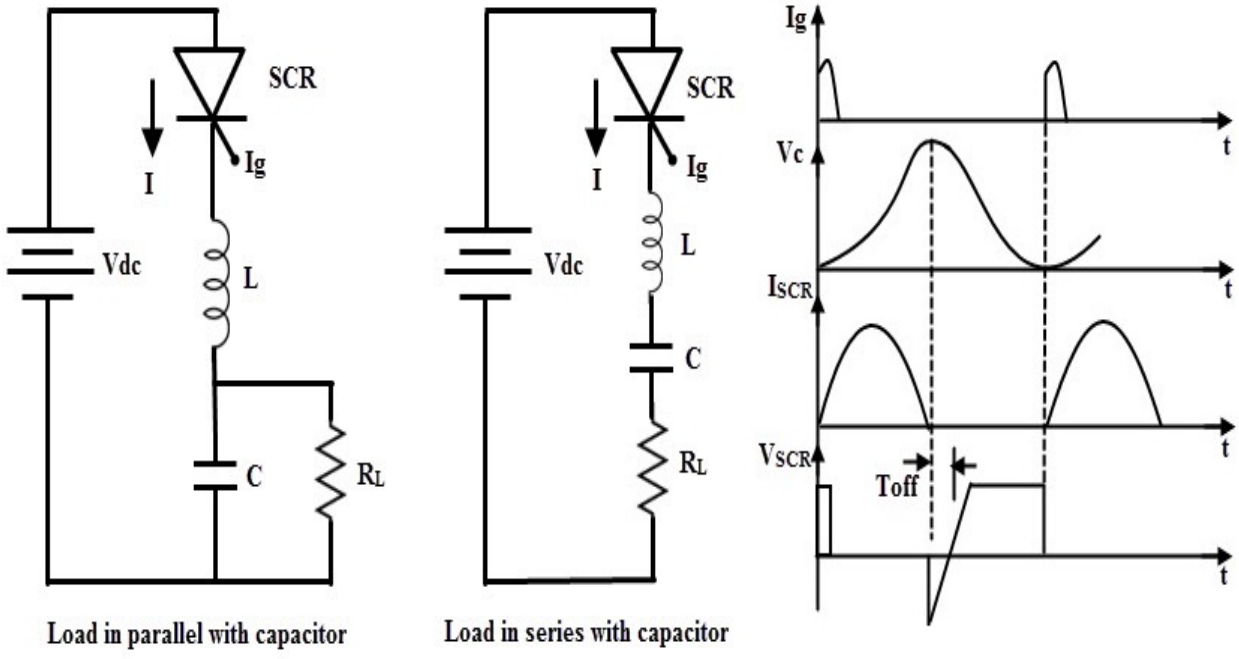

Figure 1 Class A Commutation

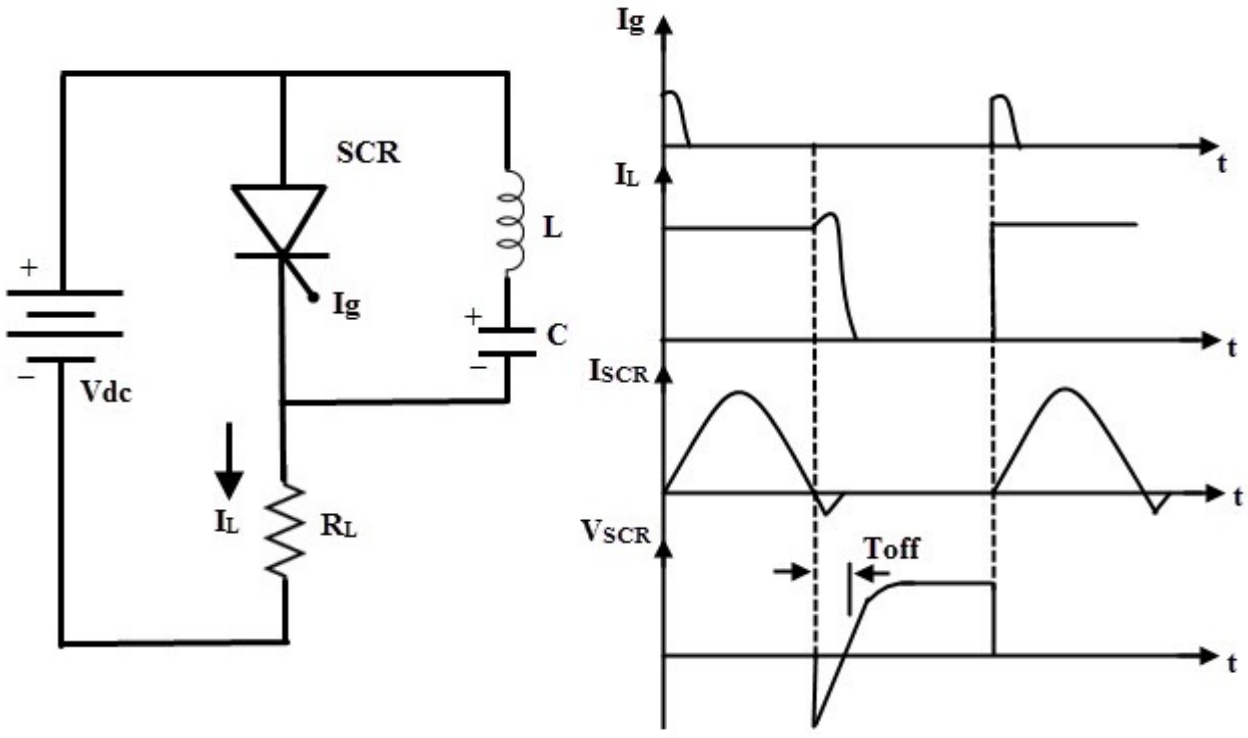

Figure 2 Class B Commutation

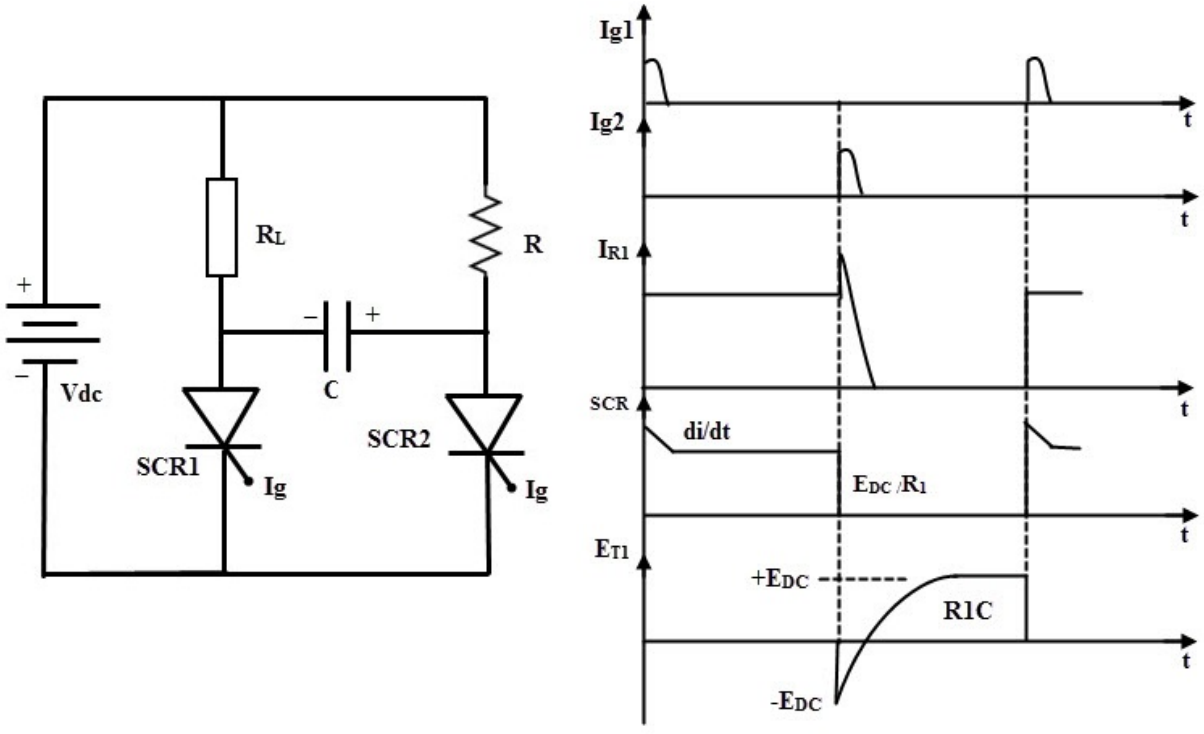

Figure 3 Class C Commutation

Note : Students should trace the circuit from the available kit and then draw the circuit diagram.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Regulated power supply	0-300/32 V DC	1 No.
2	Dual Trace CRO	20 MHz	2 No.
3	SCR	2N6394 / TYN612 or any other available	2 No.
4	Resistors	1 KΩ or any other available	1 No.
5	Inductor	5 mH or any other available	1 No.
6	Capacitor	1 μF or any other available	1 No.
7	UJT triggering circuit		1 No.

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. The applied voltage, current should not exceed the maximum rating of the given SCR.
3. Reading should be noted without parallax error.

XI Procedure

1. Make the circuit connection as per the circuit diagram.
2. Switch on the power supply.
3. Observe and note output V_{AK} if gate voltage is not applied.
4. Now apply gate signal to the SCR .
5. Observe the change in output with respect to gate pulse.
6. Observe and record the load voltage and $V_{AK.}$
7. Draw the waveforms on graph paper.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

1. Time period of gate signal-…….
2. Amplitude of gate signal-……....
3. V_{AK} when gate is not applied-…….
4. V_{AK} when gate is applied-……

XV Results

1. Voltage across SCR when it is in ON condition =……..
2. ……

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect on class C commutation circuit if capacitor is short circuited.
2. State the effect if an inductor is disconnected in class B commutation.

[Space for Answers]

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XIX References / Suggestions for further reading

1. www.electronics-tutorial.net/thyristor/thyristor-commutation/index.html
2. www.youtube.com/watch?v=q8EAyQLjA
3. www.youtube.com/watch?v=81RHn0eOVBI

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: (15 Marks)		**60%**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related: (10 Marks)		**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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……
4. ……..

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

Practical No. 8: Class D, E, F commutation Performance

I Practical Significance

Continuous conduction causes problems in choppers, inverters and cyclo converters. By the commutation process the thyristor operating mode is changed from forward conducting to forward blocking mode. In Class D and E ,thyristor can be turned off by applying reverse voltage across SCR and external pulse respectively. In class F commutation, thyristor is turned off due to negative half cycle of applied ac voltage.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results.
iii. Interpret the circuit diagrams.

IV Relevant Course 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.

V Practical Outcome

Perform the operation of Class – D, E, F turn off circuits.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

Thyristor current can be reduced to a value below the value of holding current. Since, the thyristor is turned off forcibly it is termed as a forced commutation process. No separate commutation components are required in class F commutation. Due to negative half cycle of ac input ,thyristors are turned off. Hence controlled rectifiers are also called as line commutated converters.

Class D Commutation

This is also known as auxillary commutation. The source of commutation voltage is in the commutating capacitor. The load current flows through main SCR. Auxillary SCR is used for initial charging of commutating capacitor and to turn of the main SCR. Reverse voltage across this capacitor is used to turn off the main SCR.

Class E Commutation

This is also known as external pulse commutation circuit in which a reverse voltage is applied across the SCR. Load current flowing through the SCR becomes zero when reverse voltage of equal magnitude to that of supply voltage is applied across the SCR .

Class F Commutation

AC input is given to the controlled rectifier circuits. In single phase half wave controlled rectifier SCR conducts in positive half cycle and turned of naturally due to reverse voltage in negative half cycle. Turn off time of converter grade SCRs is in the range of 200 to 300 μsec and duration of negative half cycle for 50 Hz frequency is 10 msec. As turn off time of SCR is very less and duration of negative half cycle is too large with compared to turn off time, SCR is turned off during each negative half cycle. Hence controlled rectifiers are also called as line commutated converters. This type of commutation is called as class F or natural commutation.

VIII Practical set-up / Circuit diagram / Work Situation

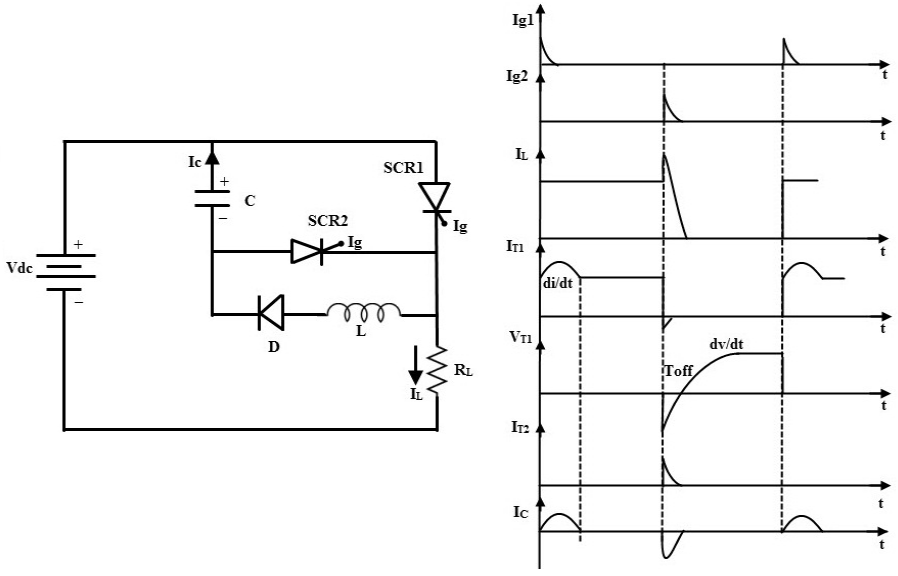

Figure 1 ..Class D Commutation..

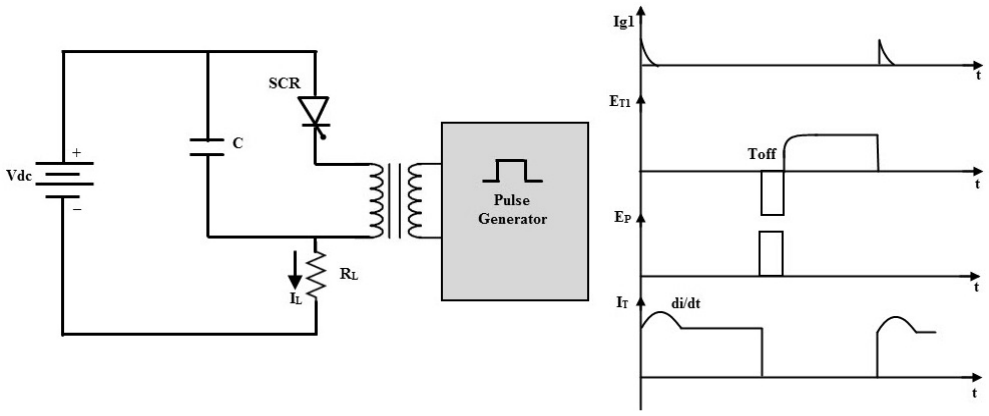

Figure 2 Class E Commutation

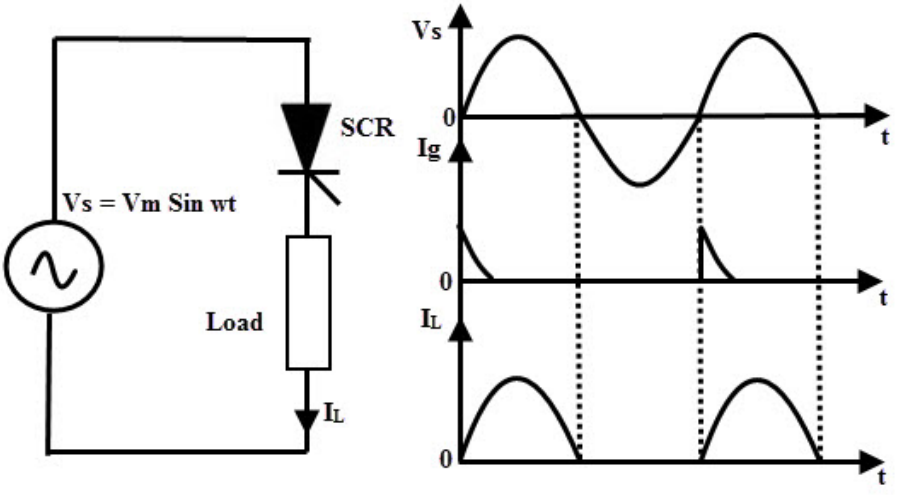

Figure 3 Class F Commutation

Note : Students should trace the circuit from the available kit and then draw the circuit diagram.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Power supply	0-50 V_{DC} , AC power supply	1 No.
2	Dual Trace CRO	20 MHz	2 No.
3	SCR	2N6394 / TYN612 or any other available	2 No.
4	Resistors		1 No.
5	Inductor		1 No.
6	Capacitor		1 No.
7	UJT triggering circuit		1 No.

X Precautions to be Followed

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. The applied voltage, current should not exceed the maximum rating of the given SCR.
3. Reading should be noted without parallax error.

XI Procedure

1. Make the circuit connection as per the circuit diagram.
2. Switch on the power supply.
3. Observe and note output V_{AK} if gate voltage is not applied.
4. Now apply gate pulse to the SCR .
5. Observe and record $V_{AK.}$
6. Draw the waveforms on graph paper.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

1. V_{AK} when gate is not applied……..
2. V_{AK} when gate is applied…….
3. Time period of gate signal (class E)…….
4. Amplitude of gate signal (class E)……...
5. AC input voltage (class F)……
6. Average load voltage (class F)…….

XV Results

1. Voltage across SCR when it is in ON condition ……..
2. ……

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect on class D commutation circuit if trigger pulse is not available to auxillary SCR.
2. State the effect on class E commutation if pulse width of external pulse is smaller than turn off time of SCR.

[Space for Answers]

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XIX References / Suggestions for further reading

1. www.nptel.ac.in – module 3, Lesson 19.
2. https://www.youtube.com/watch?v=pU_0pDIBvGk – class D.
3. https://www.youtube.com/watch?v=CG31r6_bPF8 – class F.

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: (15 Marks)		**60%**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related: (10 Marks)		**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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. …….
4. …….

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

Practical No. 9: Half Wave Controlled Rectifier Performance

I Practical Significance

Phase controlled rectifier has its main applications in Paper mills, Textile mills and Steel mills which uses DC motor drives. It is also used in Portable handheld instruments, Flexible speed controlled industrial drives, Battery charger, and High voltage DC transmission (HVDC).

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications.
b. Maintain the performance of Thyristors.
c. Maintain phase controlled rectifiers.

V Practical Outcome

Use CRO to observe the output waveform of half wave controlled rectifier with resistive load to determine the load voltage.

VI Relevant Affective domain related Outcome(s)

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

VII 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 ie., 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.

VIII Practical set-up / Circuit diagram / Work Situation

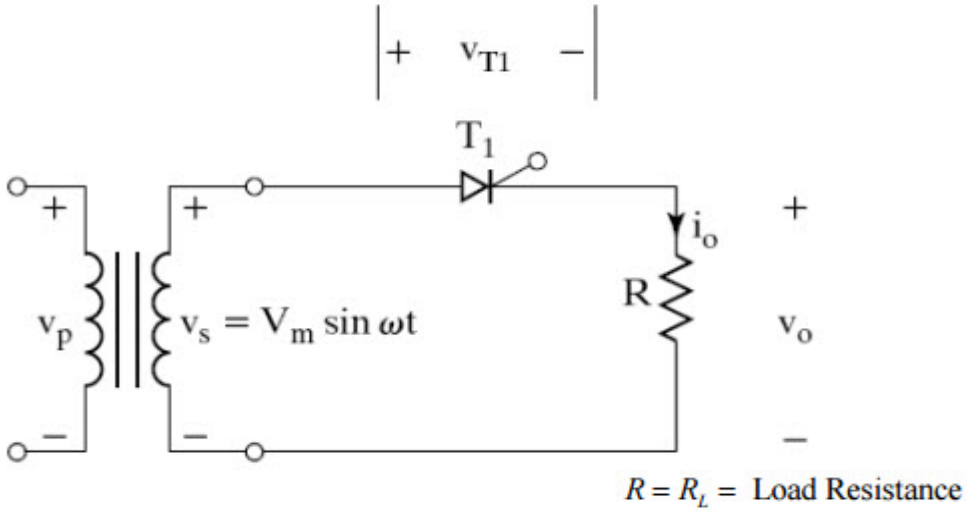

Figure 1 ..Half wave controlled rectifier with R load..

Note : Students should draw the circuit diagram from the available kit.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Transformer	12-0-12V/500mA	1No.
2	Digital Multimeter	$20V_{DC}$	2 No.
3	SCR	2N 6394 / TYN 612 or any other available	1 No.
4	Resistor	1 KΩ / 2.2 KΩ	1 No.
5	Synchronized UJT triggering circuit		1 No.
6	Power scope	Dual trace 20MHz	1 No.

X Precautions to be Followed

1. The applied voltage, current should not exceed the maximum rating of the given SCR.
2. Reading should be noted without parallax error.

XI Procedure

1. Make the circuit connection as per the circuit diagram.
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. Draw input and output waveform on graph paper.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr.No.	Firing angle	Measured output voltage	Calculated output voltage
1			
2			
3			
4			

Formula for V_{oav} =

XV Result

1. For firing angle $\alpha = 30^0$…….,Output voltage=……
2. For firing angle $\alpha = 90^0$…….,Output voltage=……

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect on output if there is no gate pulse is applied.
2. State the effect on output if gate pulse is applied at 180^0 .

[Space for Answers]

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XIX References / Suggestions for further reading

1. Power Electronics and its Applications by Jain, Alok Penram International Publishing (India) Pvt. Ltd, Mumbai, 2006 ISBN: 978-8187972228.
2. https://www.youtube.com/watch?v=Uc4yr-w03qk

1.

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 10: Performance of Full Wave Controlled Rectifier For R and RL Load

I Practical Significance

The single phase fully controlled rectifier allows conversion of single phase AC into DC. This is used in various applications such as battery charging, speed control of DC motors.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications.
b. Maintain the performance of Thyristors.
d. Maintain phase controlled rectifiers.

V Practical Outcome

Test the proper functioning of full wave controlled rectifier for R and RL Load.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

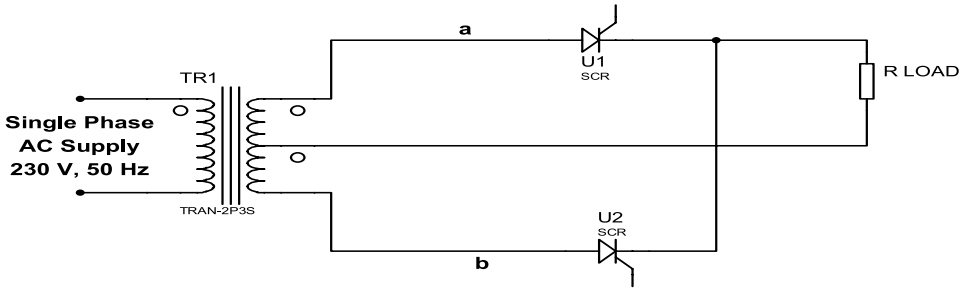
For full-wave rectification , two SCRs are connected across the centre taped secondary, as shown in figure10.1. The gates of both SCRs are supplied from two gate control circuits. One SCR conducts during the positive half cycle and the other during the negative half cycle and thus unidirectional current flows in the load circuit. The

main advantage of this circuit over ordinary full-wave rectifier circuit is that the output voltage can be controlled by varying the firing angle.

Now, if the supply voltage $v = V_{MAX} \sin \omega t$ and the firing angle is α, then average voltage output will be given by the expression

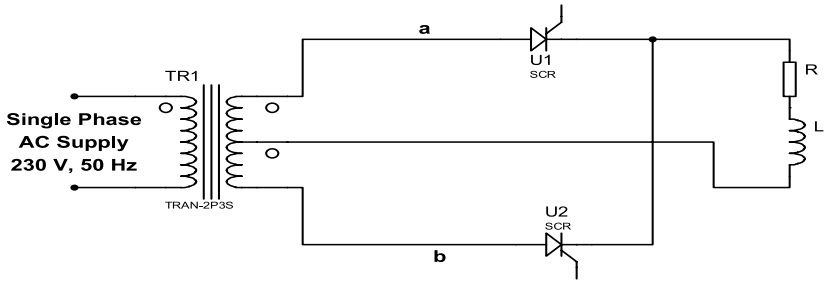
$$V_{av} = (V_{MAX} / \pi) (1 + \cos \alpha)$$

VIII Practical set-up / Circuit diagram / Work Situation



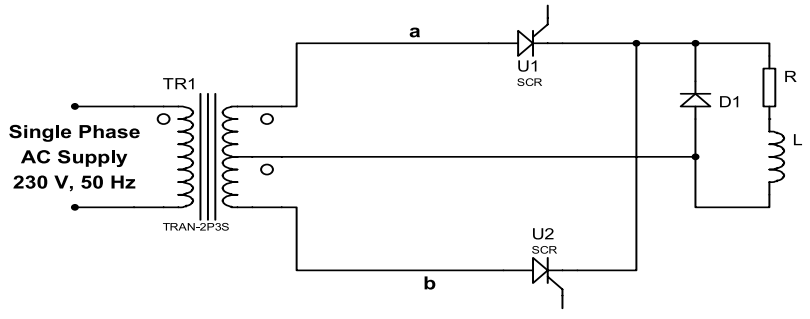
Full Wave Controlled Rectifier with Resistive Load

Fig 10.1



Full Wave Controlled Rectifier with RL Load

Fig 10.2



Full Wave Controlled Rectifier with RL Load and freewheeling Diode

Fig 10.3

Note : Trace the Kit available in the laboratory and draw the circuit in the manual.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Full wave rectifier circuit kit	With center tap transformer(12-0-12), connecting facility for i) R Load ii)RL Load iii) Freewheeling diode	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, 1A	1 No
4	Powerscope	Dual Trace , 20 MHz	1 No

X Precautions to be Followed

1. Ensure that the variable R of triggering circuit should be at maximum value.
2. Do not increase the gate current more than its rated value.
3. The applied voltage, current should not exceed the maximum rating of the given Thyristor.
4. Reading should be noted without parallax error .

XI Procedure

1. Make the circuit connection as per the circuit diagram.
2. Switch on power supply.
3. Observe output voltage on CRO by varying the firing angle for
   i) R Load
   ii) RL Load
   iii) RL Load with freewheeling diode
4. Measure output voltage with multimeter across load.
5. Repeat step 3 and 4 for $\alpha_1, \alpha_2, \alpha_3,$ and α_4.
6. Draw observed output voltage waveform on graph paper .

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XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

i) For R Load :

Sr. No.	Firing Angle	Measured output Voltage	Calculated output voltage
1			
2			
3			
4			

ii) For RL Load :

Sr. No.	Firing Angle	Measured output Voltage	Calculated output voltage
1			
2			
3			
4			

iii) For RL Load with Freewheeling diode :

Sr. No.	Firing Angle	Measured output Voltage	Calculated output voltage
1			
2			
3			
4			

XV Results

1. Output voltage across R Load =…… V
2. Outpuvoltage across RL Load =…… V
3. Output voltage across RL Load with freewheeling diode =…… V

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect on output voltage of rectifier if trigger pulse is not given to one of the Thyristor of controlled rectifier.
2. State the effect on output voltage if freewheeling diode is open circuited.
3. Write specifications of Thyristor used in full wave controlled rectifier.

[Space for Answers]

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XIX References / Suggestions for further reading

1 Industrial Electronics: A Text –Lab Manual , Zbar, Paul B. McGraw Hill Publishing Co. Ltd. , New Delhi, 1990 ISBN: 978-0070728226.
2 SCR Manual, General electric Prentice Hall; 6th edition, ISBN: 978-0137967636.
3 https://www.youtube.com/watch?v=LijTAhqtIrU.

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….
4. …….

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

Practical No. 11: DIAC and TRIAC Phase control circuit performance

I Practical Significance

Phase controlled circuits are used in domestic light dimmers, electric fan speed control, small motor controls and control of small AC powered domestic appliances. Triac is easy to use and having cost advantage as compared to two thyristors for many low power applications.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications.
b. Maintain the performance of Thyristors.
d. Maintain phase controlled rectifiers.
e. Maintain industrial control circuits.

V Practical Outcome

Determine the effect of firing angle using DIAC and TRIAC phase controlled circuit on output power under different loads such as lamp, motor or heater.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

A TRIAC ,as compared to thyristor , gets limited time to turn off due to bidirectional conduction. As a result, the triacs are operated only at power frequency. Switching characteristics of a triac is similar to that of a thyristor. For phase control application, the triac is switched on and off in synchronism with the mains supply so that only a part of each half cycle is applied across the load. In this circuit, as Vs increases voltage across C increases due to current flowing through load, R_1, VR_1 and C. The voltage drop across Diac increases until it reaches its breakover point. As DIAC conducts, a large current pulse is injected into the gate of the triac. By varying VR_1 the firing can be controlled.

VIII Practical set-up / Circuit diagram / Work Situation

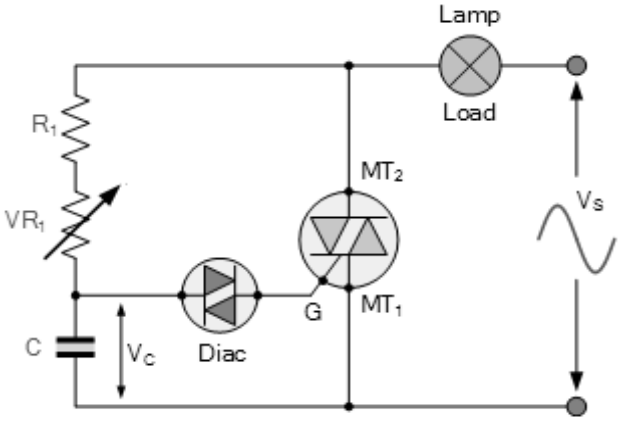

Figure 1 …DIAC-TRIAC phase control circuit…

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	AC mains supply	230 V , 50 Hz	1 No.
2	Triac	BT136 or any other available	1 No.
3	Diac	DB3 or any other available	1 No.
4	Resistors	R_1 = 1 KΩ or 3.3 KΩ , 0.5 watt VR_1(pot)= 470 KΩ or 250 KΩ , 0.5 watt	1 Each
5	Capacitor	C = 0.1 µF	1 No.
6	Powerscope	Dual trace, 20 MHz	1 No.
7	Lamp	40 / 60 watt	1 No.
8	Digital Multimeter	Voltage 500 $V_{ac/dc}$,	1 No.

X Precautions to be Followed

1. Take care while connecting AC mains.
2. Reading should be noted without parallax error .

XI Procedure

1. Make the circuit connection as per the circuit diagram.
2. Keep the VR_1(potentiometer) at a minimum position .
3. Switch on the mains power supply.
4. Vary the potentiometer VR_1 slowly to observe the effect on intensity of the lamp.
5. Measure the voltage across different points for different value of VR_1.
6. Repeat steps 2 to 5 to observe the waveforms at different points on power scope.
7. Switch off the power supply.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr. No.	Intensity of Lamp	Resistance , VR_1	V_{DIAC}	V_{TRIAC}	V_{LOAD}
1	Low				
2	Medium				
3	High				

XV Results

1. ……..
2. ……..
3. ……..

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. If capacitor is shorted , state the effect.
2. Write specifications of DIAC, TRIAC (from data sheet).

[Space for Answers]

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XIX References / Suggestions for further reading

1. http://www.nptel.ac.in/courses/ ….. for triac.

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….
4. …….

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

Practical No. 12: TRIAC Phase controlled circuit computer simulation

I Practical Significance

The graphic interface provides a user-friendly environment where the power circuit and control system are represented in the same diagram. The results are displayed while the simulation is running. The processing power of SCILAB allows the designer to perform complex post-processing on simulation results. The simulation software helps to create fault and its effect in the power electronic circuit.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use simulation software to observe the waveforms and the effects of the circuit, circuit components.
ii. Use the simulation software to create the fault and get the desired results.
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Select power electronic devices for specific applications.
b. Maintain the performance of Thyristors.
c. Maintain industrial control circuits.

V Practical Outcome

Simulate the firing angle control for DIAC and TRIAC phase controlled circuit in SCILAB software.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

In order to trigger triac, we have to give proper triggering pulses to it using a pulse generator. We have to trigger triac using DIAC. So, we have to set phase angle for triac, so that it will trigger accordingly as shown in the Simulation software. We can enter values in the software which is obtained by double clicking pulse generator. This box includes following points which are to be filled.

1. Amplitude
2. Period
3. Pulse Width
4. Phase delay

VIII Practical set-up / Circuit diagram / Work Situation

Student should prepare the circuit/schematic in SCILAB.

Note : Student should attach printout of circuit prepared in SCILAB diagram.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	SCILAB software	Any open source simulation software	--
2			

X Precautions to be Followed

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XI Procedure

1. Open SCILAB software.
2. Open new project/file.
3. Select required components (XCOS GUI).
4. Make connections.
5. Simulate the designed circuit.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

XIII Actual Procedure Followed (Use blank sheet provided if space is not sufficient)

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XIV Observations and Calculations (Use blank sheet provided if space is not sufficient)

Attach print out of simulation waveforms results.

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XV Results

Write the effects on waveforms.

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

State the effect of variation in firing angle on load.

[Space for Answers]

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XIX References / Suggestions for further reading

1. http://www.gcek.ac.in/ece/fdp/materials/2/Dr.Sreekumar/Hand-outs/Handout_Scilab-computing-gcek.pdf
2. https://scilab.in/lab_migration/generate_lab/140/1

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 13: Switching mode power supply performance

I Practical Significance

The majority of electronic DC loads are supplied from standard power sources. Switch-mode power supplies (SMPSs) are frequently used to provide the various levels of DC output power needed for modern applications and are indispensable in achieving highly efficient, reliable DC-DC power-conversion systems.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

a. Examine industrial control circuit.

V Practical Outcome

Test the performance of given SMPS.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

SMPS converts a DC input voltage into multiple DC output voltages, depending on the circuit topology. While there are numerous SMPS topologies used in the engineering world, three are fundamental and seen most often. These topologies are classified according to their conversion function: step-down (buck), step-up (boost), and step-up/down (buck-boost or inverter).

All three fundamental topologies include a MOSFET switch, a diode, an output capacitor and an inductor. The MOSFET, which is the actively controlled component in the circuit, is interfaced to a controller. This controller applies a pulse-width-modulated (PWM) square-wave signal to the MOSFET's gate, thereby switching the device on and off. To maintain a constant output voltage, the controller senses the SMPS output voltage and varies the duty cycle (D) of the square-wave signal. The value of D, which is the ratio of the square wave's on time to its switching period (T_{ON}/T_S), directly affects the voltage observed at the SMPS output.

VIII Practical set-up / Circuit diagram / Work Situation

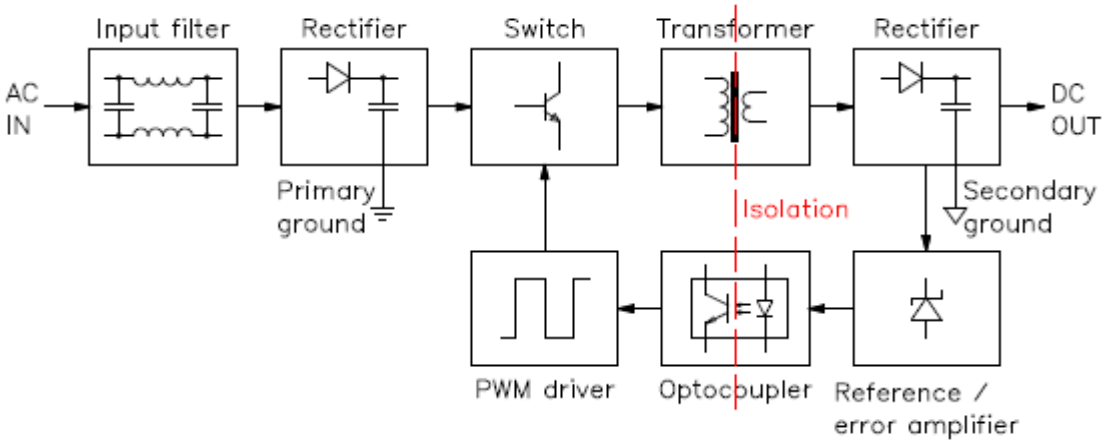

Figure 1 …Reference diagram…

Note : Student should draw the block / circuit diagram of the given SMPS by teacher.

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	SMPS	Input voltage 220 V, Current 5 A, DC output voltage +5V,+12V,+3.3V,-5V , -12 V	1 No.
2	Digital Multimeter	Voltages 600V_{DC}, 600V_{AC}. Current 0-200 mA, 0.2 -200mA , 10A .	2 No.
3	CRO	Dual trace ,20 MHz	1 No.

X Precautions to be Followed

1. Discharge the capacitor completely before touching the circuit by using suitable resistor instead (a few KΩ and a few watts).
2. Measure the voltage and make sure it is zero before starting.

XI Procedure

1. Case1: No output (+ 5V) – Then check the fuse.
2. Case2: No output (+ 5V) – Then check the capacitor.
3. Case3: No output (+ 5V) – Then check the MOSFET.
4. Case4: No output (+ 5V) – Then check the secondary winding of output transformer.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Actual Procedure Followed (Use blank sheet provided if space is not sufficient)

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

Sr. No	Troubleshooting action	Observation / Reading	Remark
1	Visual inspection		
2	No output , good fuse		
3	No output , blown fuse		
4	Capacitor check		
5	Light bulb load		
6			
7			
8			
9			

Note : Teacher can make separate observation table which will be filled by the students.

XV Results

1. Line regulation……..……..
2. Efficieny……..

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect of change in AC line voltage on output voltage.
2. SMPS are based on the ……. (Inverter / chopper) principle.
3. State the effect on output voltage if duty cycle of PWM is changed.

[Space for Answers]

XIX References / Suggestions for further reading

1. https://www.youtube.com/watch?v=NoGl7oeh7eU
2. https://www.youtube.com/watch?v=ZQ6-SbChwgg

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 14: Uninterruptable power supply performance

I Practical Significance

An uninterruptible power supply, UPS is an electrical apparatus that provides emergency power to a load. It is typically used to protect hardware such as computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the stop watch to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course Outcome(s)

e. Maintain industrial control circuit.

V Practical Outcome

Test the performance of given UPS

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

The three general categories of modern UPS systems are on-line, line-interactive and standby. An on-line UPS uses a "double conversion" method of accepting AC input, rectifying to DC for passing through the rechargeable battery (or battery strings), then inverting back to 230 V AC for powering the protected equipment.

A line-interactive UPS maintains the inverter in line and redirects the battery's DC current path from the normal charging mode to supplying current when power is lost.

In a standby ("off-line") system the load is powered directly by the input power and the backup power circuitry is only invoked when the utility power fails.

VIII Practical set-up / Circuit diagram / Work Situation

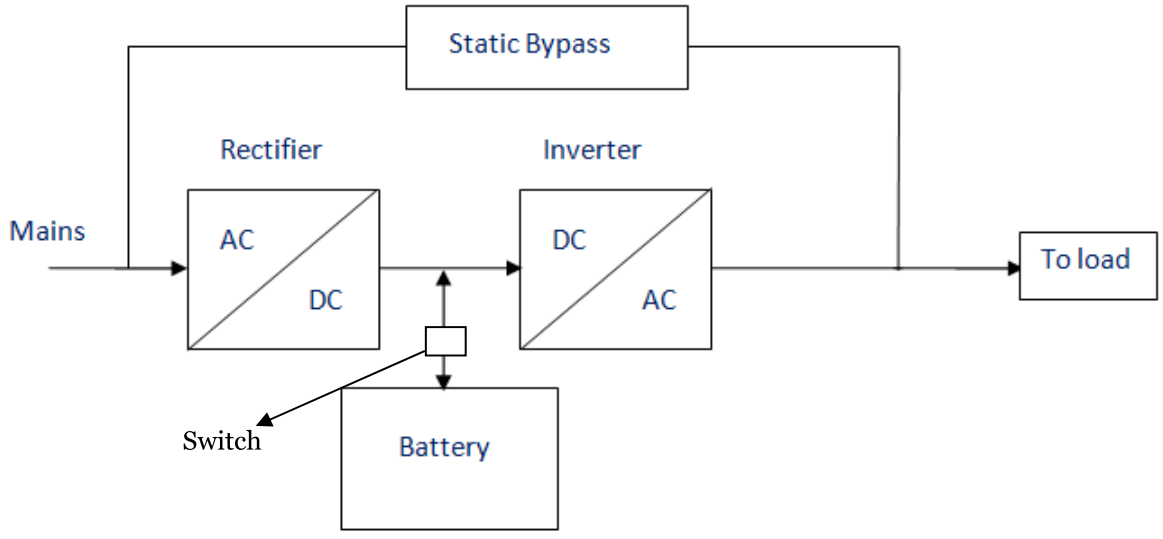

Figure 14 On Line UPS

(Students should draw the block and circuit diagram of the given UPS.)

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	UPS	Input voltage range 145 - 90V,Nominal Output Voltage 230V,Output power Capacity 660Watts / 1.1 kVA	1 No.
2	Digital Multimeter	Voltage 600 V_{DC},600 V_{AC}, current 0-200mA_{AC},0.2-200mA_{DC}, 10A_{AC},10A_{DC}	1No.
3	Digital Stop Watch	Stopwatch/Chronograph mode with 1/100sec resolution, Programmable alarm.	1 No.

X Precautions to be Followed

1. The UPS must be appropriately grounded.
2. Wait for five minutes before opening the UPS to allow the capacitors to discharge.
3. There will be high leakage current, so that the grounding conductor must be connected first.
4. The UPS must be installed on a non-inflammable surface (e.g. concrete).

XI Procedure

a. Mains ON:

1. Measure AC input voltage with the help of multimeter.
2. Measure AC output voltage with the help of multimeter.
3. Measure Battery Full Charge DC Voltage with the help of multimeter.

b. When mains is OFF

1. Measure AC input Voltage with the help of multimeter.
2. Measure AC output Voltage with the help of multimeter.
3. Measure Battery DC voltage with the help of multimeter.

c. When the load is OFF

1. Measure Battery DC voltage with the help of multimeter.
2. Measure Backup time with the help of stop watch.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

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

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XIV Observations and Calculations (Use blank sheet provided if space not sufficient)

When mains is on:

1. AC input Voltage =…… volts
2. AC output Voltage =……volts
3. Battery full charge DC voltage =……volts

When mains is off:

1. AC input Voltage =…… volts
2. AC output Voltage =……..volts
3. Battery DC voltage =…… volts

When the load is off:

1. Battery DC voltage =…… volts
2. Backup time =……min.(Use stop watch)

XV Results

1. Back up time =… ……..
2. ……

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

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. State the effect on back up time of UPS battery, when load gets doubled.
2. Calculate the UPS requirement for load of 3 computers (450 watts),1 fan (60 watts),2 tubes (80 watts).
3. Write the technical specifications of the given UPS.

[Space for Answers]

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XIX References / Suggestions for further reading

1. https://www.renesas.com/en-in/solutions/office/computer-peripherals/ups-online.html
2. http://www.apc.com/salestools/ASTE-6Z8LUA/ASTE-6Z8LUA_R5_EN.pdf
3. https://www.youtube.com/watch?v=E5RKBWhEUAU

XX Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. ……..
4. ……..

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

Practical No. 15: Burglar Alarm System Troubleshooting

I Practical Significance

Burglar alarms are the standard equipment in stores, other businesses offices, private homes for the security purpose.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course 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 Practical Outcome

Troubleshoot the Burglar's alarm.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

VIII Problem Statement

(*Sample given below, teacher should provide different problem to other batches)*

The system is not detecting the person in the coverage area-- Diagnose and rectify the Problem.

IX Provide relevant block diagram/circuit diagram/wiring diagram to the students

Note: Students should draw the circuit diagram of the given SCR based Burglar Alarm system.

X Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1			
2			
3			

XI Precautions to be Followed

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XII Procedure

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XIII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
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5.					

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

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XV Observations and Calculations (Use blank sheet provided if space not sufficient)

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XVI Results

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

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XVIII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XIX Practical Related Questions

1. State the change in the circuit design under variable light conditions.
2. Write specifications of the given Burglar Alarm system.

[Space for Answers]

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XX References / Suggestions for further reading

1. A text – Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 9780070728226.
2. SCR Manual, General electric Prentice Hall; 6th edition, ISBN 978-0137967636
3. http://www.zen22142.zen.co.uk/ronj/scr.html
4. https://www.youtube.com/watch?v=07Fgs2l4_RE

XXI Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……
3. ……
4. ……

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

Practical No. 16: Emergency Lighting System Troubleshooting.

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 Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course 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 Practical Outcome

Troubleshoot the Emergency Lighting system

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

VIII Problem Statement

(*Sample given below, teacher should provide different problems to other batches)*

The intensity of the emergency lamp starts decreasing **---** Diagnose and rectify the Problem.

IX Provide relevant block diagram/circuit diagram/wiring diagram to the students

Note:- Students should draw the circuit diagram of the given Emergency Lighting system.

X Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1			
2			
3			

XI Precautions to be Followed

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XII Procedure

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XIII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

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

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XV Observations and Calculations (Use blank sheet provided if space not sufficient)

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XVI Results

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

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XVIII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XIX 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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XX References / Suggestions for further reading

1. A text – Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 9780070728226.
2. SCR Manual, General electric Prentice Hall; 6th edition, ISBN 978-0137967636
3. http://www.instructables.com/id/Emergency-Lighting-System/
4. https://www.youtube.com/watch?v=9f20R1lLtic

XXI Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

Practical No. 17: Thyristor Speed Control System Troubleshooting

I Practical Significance

Variable speed control of DC motors are widely used within industrial applications such as cranes and machine tool spindles, etc. In industry, skills such as connecting, operating and troubleshooting a motor with Thyristor speed control are required.

II Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course 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 Practical Outcome

Troubleshoot the Speed control system.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

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VIII Problem Statement

(*Sample given below, teacher should provide different problem to other batches)*

The variable speed control training system includes a ¼ HP DC shunt wound motor. If the speed of the motor suddenly drops, when load is applied **---** Diagnose and rectify the Problem.

IX Provide relevant block diagram/circuit diagram/wiring diagram to the students

Note:- Students draw the blocl/circuit diagram of the given Speed control system.

X Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1			
2			
3			
4			

XI Precautions to be Followed

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XII Procedure

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XIII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

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

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XV Observations and Calculations (Use blank sheet provided if space not sufficient)

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XVI Results

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

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XVIII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XIX Practical Related Questions

1. If triggering circuit is not providing firing pulse to the thyristor , what will be the effect on output voltage.
2. If one of the SCR in speed control circuit is open circuited, state the effect on output voltage ?
3. Write specifications of SCR used in motor speed control circuit. (from data sheet).

[Space for Answers]

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XX References / Suggestions for further reading

1. A text – Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd,New Delhi,1990, ISBN: 9780070728226.
2. SCR Manual, General electric Prentice Hall; 6th edition, ISBN 978-0137967636
3. https://www.youtube.com/watch?v=g6b2460fbDM
4. https://www.youtube.com/watch?v=Z2QI52tIkLU

XXI Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. …….
3. …….
4. …….

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

Practical No. 18: Temperature Control System Troubleshooting

I Practical Significance

Electronic cutout for temperature control is used in furnace in the Industries. This circuit will turn 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 turn 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 Relevant Program Outcomes (POs)

- **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad based Electrical engineering related problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices to use the results to solve engineering problems.
- **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

III 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'**

i. Use multimeter to measure various electrical parameters.
ii. Use the CRO to get the desired results
iii. Interpret the circuit diagrams

IV Relevant Course 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 Practical Outcome

Troubleshoot the Temperature control system.

VI Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

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VIII Problem Statement

(*Sample given below, teacher should provide different problem to other batches)*

Diagnose and rectify the problem when sensor is not working properly at set temperature.

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IX Provide relevant block diagram/circuit diagram/wiring diagram to the students

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Note:- Students draw the blocl/circuit diagram of the given Speed control system.

X Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1			
2			
3			

XI Precautions to be Followed

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XII Procedure

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XIII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

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

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XV Observations and Calculations (Use blank sheet provided if space not sufficient)

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XVI Results

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

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XVIII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XIX Practical Related Questions

1. Write specifications of power transistor / thyristor, relay and sensor used in given Temprature control system.
2. State the effect of heater load on thyristor.

[Space for Answers]

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XX References / Suggestions for further reading

1. A text – Lab Manual, Zbar, , Paul B. McGraw Hill Publishing Co. Ltd, New Delhi,1990, ISBN: 9780070728226.
2. SCR Manual, General electric Prentice Hall; 6th edition, ISBN 978-0137967636
3. https://www.youtube.com/watch?v=KumwNkiK4Gc
4. https://www.youtube.com/watch?v=51RsrIzfWME

XXI Suggested 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 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 (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

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

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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