SCHEME : K

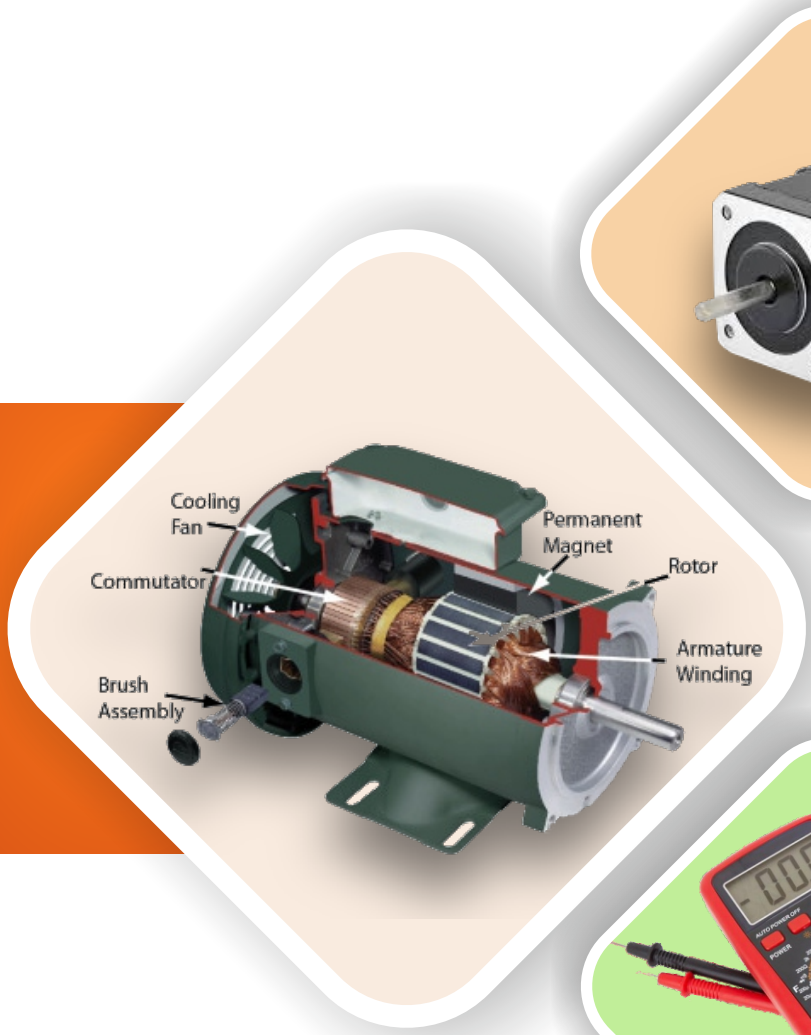
Name : _____

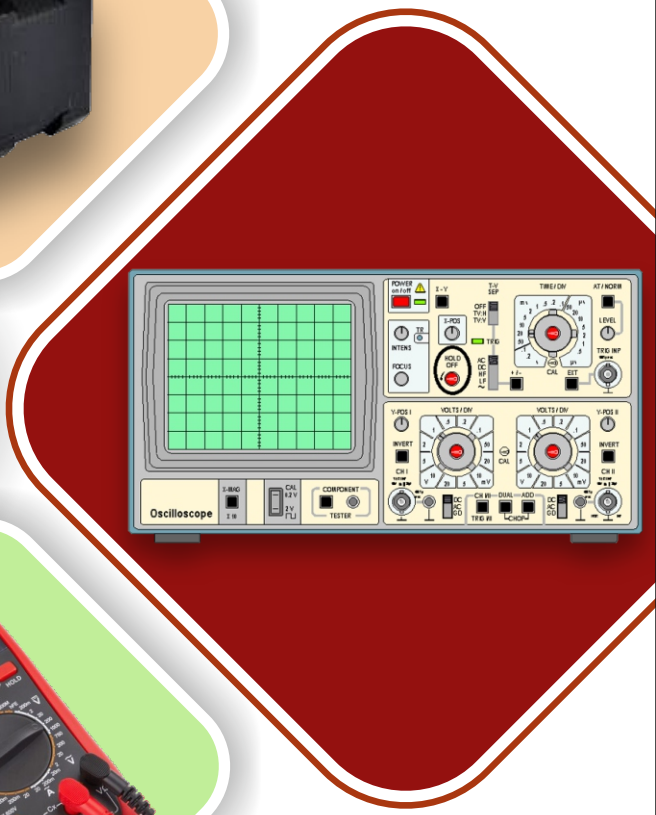
Roll No. : _____ Year : 20___ 20___

Exam Seat No. : _____

LABORATORY MANUAL FOR

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING (312302)





COMPUTER ENGINEERING GROUP

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

VISION:

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

MISSION:

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

QUALITY POLICY

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

CORE VALUES

MSBTE believes in the following:

- 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

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

(312302)

K-SCHEME

Semester-II

(AI/AN/BD/CM/CO/CW/DS/HA/IF/IH)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (1SO:9001:2015) (1SO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai

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

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

MAHARASHTRA STATE
BOARD OF TECHNICAL EDUCATION
Certificate

This is to certify that Mr. /Ms…….. Roll No. ……..…….of Second Semester of Diploma in…...……...of Institute ……..…….(Co de:……) has completed the term work satisfactorily in course **Basic Electrical and Electronics Engineering (312302)** for the academic year 20…….to 20…….. as prescribed in the curriculum.

Place: …….. **Enrollment No: …….**

Date: ……. **Exam Seat No: ……**

Subject Teacher Head of department Principal

Seal of Institute

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 'K' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a 'vehicle' to develop this industry identified competency in every student. The practical skills are difficult to develop through "chalk and duster" activity in the classroom situation. Accordingly, the "K scheme laboratory manual development team designed the practical's to focus on the outcomes, rather than the traditional age old practice of conducting practical's 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 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.

This course deals with the fundamentals of electrical engineering and electronics engineering, working principles of commonly used motors, different electronic components and circuits used. In today's world most of the consumer appliances are based on electronic circuits and devices, working of computer or any of its peripherals are based on electronics. The basic concepts of electrical and electronics engineering in this course will be very useful for understanding and testing simple electrical circuits and electronic circuits. After studying this course students will develop an insight to identify, build and trouble shoot simple electrical and electronic circuits.

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.

Program Outcomes (POs):

- **PO 1. Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.
- **PO 2. Problem analysis:** Identify and analyze well-defined engineering problems using codified standard methods.
- **PO 3. Design/development of solutions:** Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs.
- **PO 4. Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
- **PO 5. Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
- **PO 6. Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
- **PO 7. Life-long learning:** Ability to analyze individual needs and engage in updating in the context of technological changes.

Program Specific Outcomes (PSOs):

- **PSO 1:** Use state-of-the-art technologies for operation and application of computer software and hardware.
- **PSO 2:** Maintain computer engineering related software and hardware systems.

PROGRAM EDUCATIONAL OBJECTIVES (PEO):

- **PEO 1:** Provide socially responsible, environment friendly solutions to Computer engineering related broad-based problems adapting professional ethics.
- **PEO 2:** Adapt state-of-the-art Computer engineering broad-based technologies to work in multidisciplinary work environments.
- **PEO 3:** Solve broad-based problems individually and as a team member communicating effectively in the world of work.

List of Industry Relevant Skills

The following industry relevant skills of the competency "Use electrical equipment in industrial applications" are expected to be developed in you by undertaking the practicals of this laboratory manual.

1. Calculate and measure basic electrical quantities and parameters.
2. Use different electrical machines by making connections.
3. Use electrical safety devices in electrical circuits.
4. Use relevant diode in different electronic circuits.
5. Use BJT and FET in various electronic circuits.
6. Use various types of sensors and transducers.

Brief Guidelines to Teachers.

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each experiment.
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in. the students after the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.

Instructions for Students

1. Listen carefully the lecture given by teacher about subject, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make record all programs.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual.
6. Student shall refer technical magazines.
7. Student should develop habit to submit the practicals on date and time. Student should well prepare while submitting write-up of exercise.
8. Attach /paste separate papers wherever necessary.

Practical course outcome matrix

PRACATICAL COURSE OUTCOME MATRIX

COURSE LEVEL LEARNING OUTCOMES (COS)

CO1 - Calculate and measure basic electrical quantities and parameters

CO2 - Use different electrical machines by making connections.

CO3 - Use electrical safety devices in electrical circuits.

CO4 - Use relevant diode in different electronic circuits.

CO5 - Use BJT and FET in various electronic circuits.

CO6 - Use various types of sensors and transducers.

Sr. No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5	CO6
1	Measure the parameters of simple electrical and identify presence of flux lines in magnetic circuit.(e.g. current, voltage, power, flux)	✓	-	-	-	-	-
2	Measure frequency, time period, rms value, peak value of sinusoidal AC waveform for resistive and inductive circuit using CRO.	✓	-	-	-	-	-
3	Phase difference of voltage and current in inductive circuit	✓	-	-	-	-	-
4	Measure the line voltage, phase voltage and phase current and line current in three phase star connected balanced load.	✓	-	-	-	-	-
5	Measure the line voltage, phase voltage and phase current and line current in three phase delta connected balanced load.	✓	-	-	-	-	-
6	Determination of the voltage and current ratio of single phase transformer.	-	✓	-	-	-	-
7	Operate DC shunt motor by connecting three point starter.	-	✓	-	-	-	-
8	Operate DC series motor by connecting two point starter.	-	✓	-	-	-	-
9	Reverse the direction of rotation of universal	-	✓	-	-	-	-

	motor						
10	Demonstrate the operation of stepper motor for various speed rotation.	-	✓	-	-	-	-
11	Use multimeter for measurement of voltage, current (AC, DC), resistance and continuity of the given electrical circuit.	-	-	✓	-	-	-
12	Connect fuse in electrical circuit and check its operation at normal and abnormal conditions.	-	-	✓	-	-	-
13	Connect MCB in electrical circuit and check its operation at normal and abnormal conditions.	-	-	✓	-	-	-
14	Connect ELCB in electrical circuit and check its operation at normal and abnormal conditions.	-	-	✓	-	-	-
15	Use of earth tester for measurement of earthing resistance of a installed earthing of laboratory.	-	-	✓	-	-	-
16	Connect the Zener diode in the circuit and test its operation in forward and reverse bias mode.	-	-	-	✓	-	-
17	Determine the voltage regulation by using Zener diode under variable input and output conditions.	-	-	-	✓	-	-
18	Check the output waveform of L, C and π filters on CRO of rectifier circuit.	-	-	-	✓	-	-
19	Make the input and output connections of UPS and measure the output voltage under online and offline mode.	-	-	-	✓	-	-
20	Make the input, output connections and check the operation of UPS under normal and overload condition.	-	-	-	✓	-	-
21	Test input /output characteristics of NPN transistor in CE configuration	-	-	-	-	✓	-
22	Test input /output characteristics of NPN transistor in CB configuration.	-	-	-	-	✓	-
23	Check the switch ON and switch OFF condition of LED by using transistor.	-	-	-	-	✓	-
24	Determine the Drain and Transfer characteristics of FET.	-	-	-	-	✓	-
25	Measure temperature of liquid using RTD (PT-	-	-	-	-	-	✓

	100) transducer.						
26	Measure temperature of liquid using thermocouple measurement.	-	-	-	-	-	✓
27	Check the motion of given object using photoelectric sensor.	-	-	-	-	-	✓
28	Measure the resistance of LDR in varying light intensity.	-	-	-	-	-	✓
29	Measure displacement using LVDT.	-	-	-	-	-	✓
30	Measurement of displacement using potentiometer.	-	-	-	-	-	✓

Content Page

List of Practical's and Progressive Assessment Sheet

9	Reverse the direction of rotation of universal motor	46					
10	Demonstrate the operation of stepper motor for various speed rotation.	51					
11	Use multimeter for measurement of voltage, current (AC, DC), resistance and continuity of the given electrical circuit.	56					
12	Connect fuse in electrical circuit and check its operation at normal and abnormal conditions.	65					
13	Connect MCB in electrical circuit and check its operation at normal and abnormal conditions.	70					
14	Connect ELCB in electrical circuit and check its operation at normal and abnormal conditions.	75					
15	Use of earth tester for measurement of earthing resistance of a installed earthing of laboratory.	80					
16	Connect the Zener diode in the circuit and test its operation in forward and reverse bias mode.	86					
17	Determine the voltage regulation by using Zener diode under variable input and output conditions.	94					
18	Check the output waveform of L, C and π filters on CRO of rectifier circuit.	102					

19	Make the input and output connections of UPS and measure the output voltage under online and offline mode.	109					
20	Make the input, output connections and check the operation of UPS under normal and overload condition.	116					
21	Test input /output characteristics of NPN transistor in CE configuration	122					
22	Test input /output characteristics of NPN transistor in CB configuration.	131					
23	Check the switch ON and switch OFF condition of LED by using transistor.	139					
24	Determine the Drain and Transfer characteristics of FET.	145					
25	Measure temperature of liquid using RTD (PT-100) transducer.	153					
26	Measure temperature of liquid using thermocouple measurement.	160					
27	Check the motion of given object using photoelectric sensor.	167					
28	Measure the resistance of LDR in varying light intensity.	173					
29	Measure displacement using LVDT.	180					

30	Measurement of displacement using potentiometer.	187					

Practical No.1 Measure the parameters of simple electrical and identify presence of flux lines in magnetic circuit. (E.g. current, voltage, power, flux)

I Practical Significance:

To measure the parameters of a simple electrical circuit and identify the presence of flux lines in a magnetic circuit, you can use various instruments and techniques.

II Industry /Employer Expected outcome:

Apply basic concept of electrical and electronics engineering in various application in relevant technical fields.

III Course level learning outcome:

Calculate and measure basic electrical quantities and parameters.

IV Laboratory Learning outcome:

LLO Use electrical meters for measurement of electrical parameters.

LLO Identify presence of magnetic flux lines

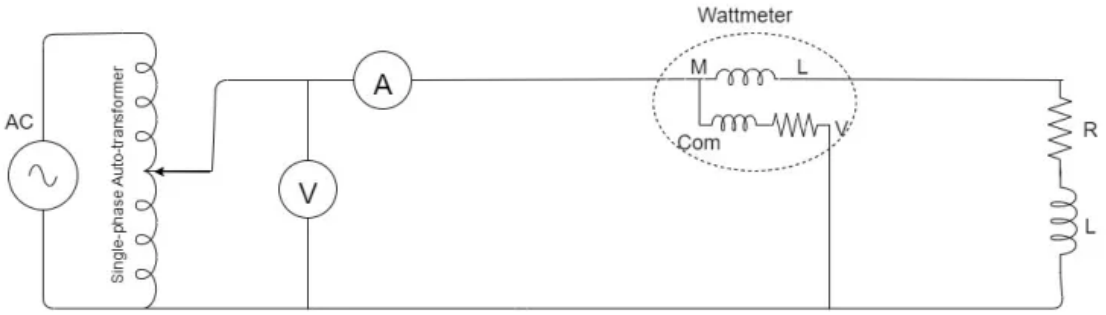
V Relevant Affective Domain related outcome:

Follow safety electrical rules for safe practices.

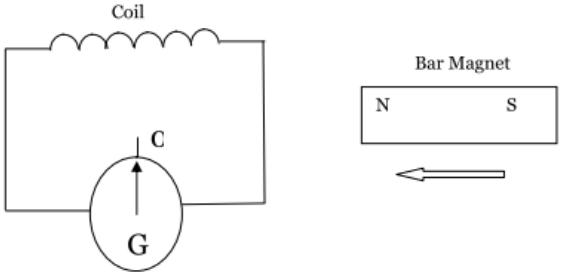
VI Minimum Theoretical Background:

- Voltage describes the "pressure" that pushes electricity. The amount of voltage is indicated by a unit known as the volt (V), and higher voltages cause more electricity to flow to an electronic device.
- Current is a flow of electrical charge carriers, usually electrons or electron-deficient atoms. The common symbol for current is the uppercase letter I. The standard unit is the ampere, symbolized by A.
- We can define power as the rate of doing work, it is the work done in unit time. The S.l. unit of power is Watt (W) which is joules per second (J/s). Sometimes the power of motor vehicles and other machines is given in terms of Horsepower (hp), which is approximately equal to 745.7 watts.
- Magnetic flux is a measurement of the total magnetic field which passes through a given area. It is a useful tool for helping describe the effects of the magnetic force on something occupying a given area.

VII Actual circuit diagram used in laboratory with equipment specifications:



Circuit for measurement of voltage, current and power



Circuit for identify presence of magnetic flux lines in magnetic circuit

VIII Resources Required:

S.NO.	Name of Resource	Suggested Board Specifications	Quantity
1	Autotransformer	Autotransformer 0-270V,4A	1 No.
2	Voltmeter	0-250-500V	1 No.
3	Ammeter	0-5-10A	1 No.
4	Rheostat	100ohm,5A	1 No.
5	Inductor	Suitable inductor	1 No.
5	Wattmeter	0-750-1500-3000W	1 No.
6	Bar magnet	Bar magnet of known polarity	1 No.
7	Galvanometer	Suitable range	1 No.
8	Inductive coil	Any suitable coil having large number of turns	1 No.

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hand.
3. Gradually increase the voltage of auto-transformer.

X Procedure:

A) Procedure Circuit for measurement of voltage, current and power

1. Connect the circuit as per circuit diagram.
2. Apply the voltage using autotransformer.
3. Measure the voltage, current and power of the circuit

B) Procedure Circuit for measurement of voltage, current and power

1. Connect two ends of the coil to the Galvanometer.
2. Take a bar magnet of known polarity.
3. Move the bar magnet in the coil as per the sequence given in observation table.
4. Observe the deflection of Galvanometer.

XI Resources used:

Sr. No.	Name of Resources	Suggested Broad Specification	Quantity
1			
2			
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XII Actual Procedure followed:

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XIII Observation table for measurement for voltage, current and power.

Sr. No.	Voltage(V)	Current(A)	Power(W)

Observation table for identifying magnetic flux.

S.N.	Movement of Bar Magnet	Movement of the Magnet	Deflection of Galvanometer connected across coil	
			Forward / Reverse	Less/ More
1	Towards the coil	Slow		
2	Towards the coil	Fast		
3	Away from the coil	Slow		
4	Away from the coil	Fast		

XIV Results:

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XV Interpretation of Results (Giving meaning to the results):

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XVI Conclusions (Actions to be taken based on the interpretations):

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XVII Practical Related Questions:

1. Define current.
2. Write the function of an ammeter.
3. Define voltage.
4. Write the function of voltmeter.
5. Define power.
6. Write the formula of power.
7. Define magnetic flux.
8. Define magnetic lines of force.
9. State Faraday's laws of electromagnetic induction.
10. Define flux density and write the symbol of the same.

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XVIII References/suggestions for further reading:

1. https://www.sciencedirect.com/topics/engineering/circuit-parameter
2. https://study.com/academy/lesson/operating-simple-circuits-parts-functions.html
3. https://uomustansiriyah.edu.iq/media/lectures/5/5_2018_03_18!08_37_55_PM.pdf
4. https://byjus.com/physics/circuit-diagram/

XIX Assessment Scheme:

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
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 (40%)		**10 Marks**
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%
	T**otal**	100 %

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

Practical No. 2: Measure frequency, Time period, Peak value, RMS value of sinusoidal AC waveform for resistive and inductive circuit using CRO.

I Practical significance:

An alternating ac waveform is one that varies in both magnitude and direction in more or less an even manner with respect to time. An AC function can mathematically represent either a power source or a single source with the shape of an AC waveform

II Industry/Employer Expected Outcome(s):

Use electrical equipment efficiently for different electronic engineering application.

Use single phase AC supply for Electrical and electronic equipments.

III Course Level Learning Outcome(s):

Calculate and measure basic electrical quantities and parameters.

IV Laboratory Learning Outcome(s):

LLO Interpret the AC waveform for resistive and inductive circuit displayed on CRO.

V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background:

Waveform: The shape of the curve obtained by plotting the instantaneous values of voltage or current as ordinate against time is called its waveform.

Time period (T): The time taken in seconds to complete one cycle of an alternating quantity is called its time period. It is generally represented by *T*. Unit of time period is seconds.

$$\boldsymbol{T = \frac{1}{f}}$$

Frequency (F): The number of cycles that occur in one second is called the frequency (*f*) of the alternating quantity.

$$\boldsymbol{F = \frac{1}{T}}$$

Amplitude. The maximum value (positive or negative) attained by an alternating quantity is called its amplitude or peak value. The amplitude of an alternating voltage or current is designated by ***Vm*** or ***Im*** respectively.

Average Value: The average value of a alternating quantity is equal to the average of all its instantaneous values over a period of time.

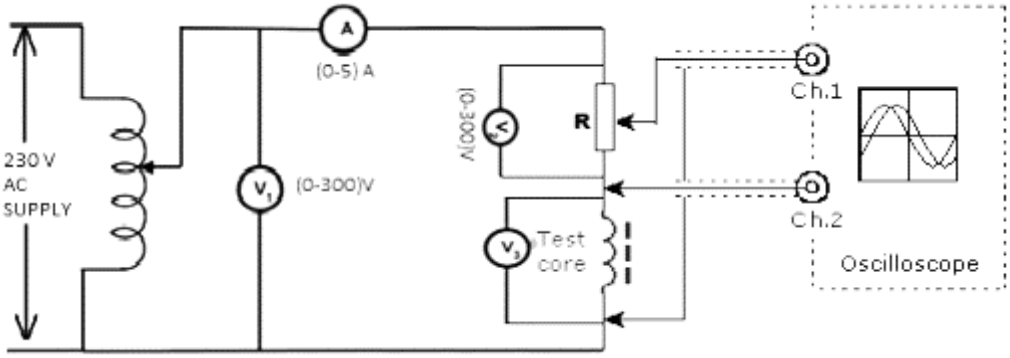
$$\boldsymbol{Vavg = 0.637 * Vmax}$$

Peak Value: It is the maximum value attained by an alternating quantity. The peak or maximum value of an alternating voltage or current is represented by ***Vm* or *Im*.**

R.M.S Value: The effective or R.M.S. value of an alternating current is that steady current (d.c.) which when flowing through a given resistance for a given time produces the same amount of heat as produced by the alternating current when flowing through the same resistance for the same time.

$$Vrms = 0.707 * Vmax$$

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
3	Voltmeter	Suitable Voltmeter	1
4	Ammeter	Suitable Ammeter	1
5	CRO	With 2 attenuator probes	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.
5. Do not give high voltage to CRO.

X Procedure:

1. Connect the circuit as per circuit diagram.
2. Connect the CRO for observing current and voltage waveform.
3. Repeat step 2 for different input voltages.

XI Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity

XII Actual Procedure Followed:

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XIII Observations:

1. Time period of AC waveform (T)= …….. division
2. Time per division=…….
3. Peak value of ac waveform= ……. Division
4. Volt per division= …….

XIV Calculations:

1. Time period of ac waveform (T)= ……..division X ……. Time per division = ……. Seconds
2. Peak value of ac waveform= …….. division X ……..... volt per division = …… volts
3. R.M.S. value of ac waveform = Peak value X 0.707= …… Volts
4. Average value of ac waveform = Peak value X 0.637=…… Volts

XV Results:

1. Time period : ……...seconds
2. Peak value: ……..volts
3. R.M.S. value: ……volts
4. Average value: ……..... volts

XVI Interpretation of results:

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XVII Conclusion and recommendation:

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XVIII Practical related questions (Provide space for answers):

Define waveform, instantaneous value, cycle, amplitude, time period, frequency, angular frequency, R.M.S. value, average value, peak value

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 3: Phase difference between voltage and current in inductive circuit

I Practical Significance:

Phase difference between voltage and current in resistive and inductive circuits plays an important role in electrical and electronic engineering. Because without these components such as relays, solenoids, inductors, chokes, coils, loudspeakers, motors, generators, transformers and electricity meters etc, would not work. Phase difference between voltage and current in a circuit depends on parameters of the circuit. Based on this, circuit has lagging, leading or unity power factor.

II Industry/ Employer Expected Outcomes(s):

Apply basic concept of electrical and electronic engineering in various applications in relevant technical fields.

III Course Level Learning Outcomes(s):

Calculate and measure basic electrical quantities and parameters.

IV Laboratory Learning Outcomes(s):

LLO Measure the phase difference between voltage and current in the AC circuit of the inductive circuit

V Relevant Affective Domain related outcome(s):

Follow safe practices when undertaking electrical works.

VI Minimum Theoretical Background:

The **phase difference** or phase shift as it is also called of a Sinusoidal Waveform is the angle Φ (Greek letter Phi), in degrees or radians that the waveform has shifted from a certain reference point along the horizontal zero axis. In other words, phase shift is the lateral difference between two or more waveforms along a common axis and sinusoidal waveforms of the same frequency can have a phase difference.

The phase difference, Φ of an alternating waveform can vary between 0 to its maximum time period, T of the waveform during one complete cycle and this can be anywhere along the horizontal axis between, Φ = 0 to 2π (radians) or Φ = 0 to 360^{o}depending upon the angular units used.

Then the equation for the instantaneous value of a sinusoidal voltage or current waveform for pure resistive circuit are

$I_r=I_m \sin\omega t$ and $V_r=V_m \sin\omega t$

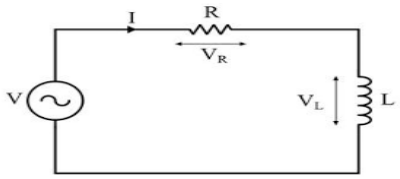
And for pure inductive circuit are

$I_L=I_m \sin\omega t$ and $V_L =V_m \sin(\omega t+90)$

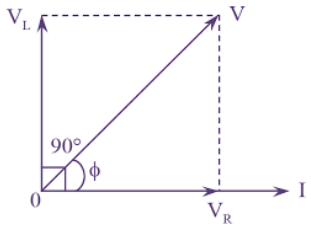
And for R-L (resistive and inductive) circuit is

$I=I_m \sin\omega t$ and $V =V_m \sin(\omega t+ \Phi)$,

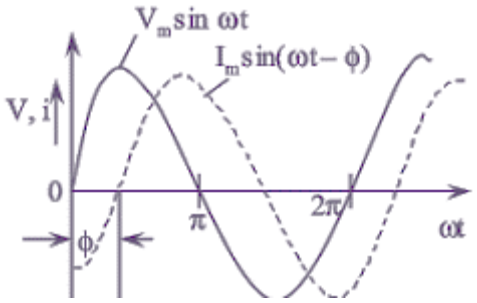
Where Φ represents phase angle.



R-L series circuit connection across A.C. supply

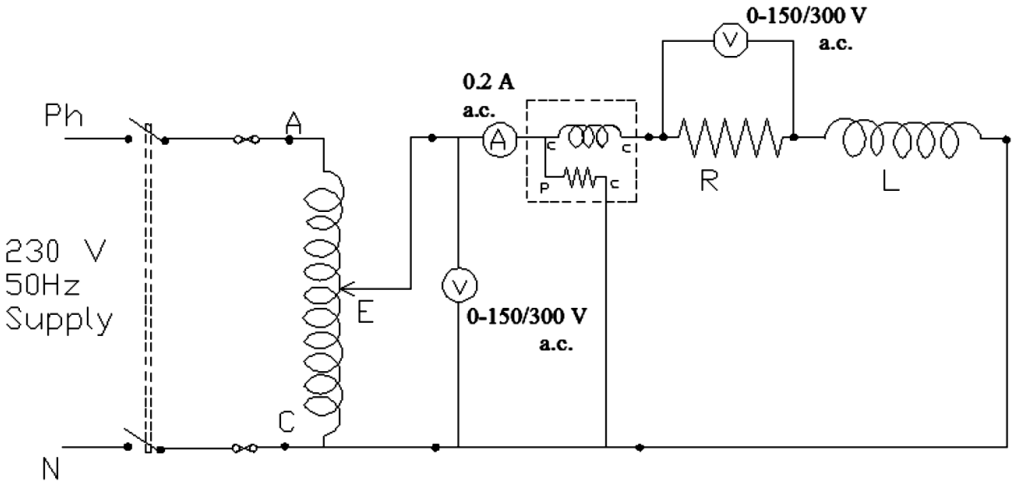


Phasor representation of Vr, V_L and V, (lagging Power factor V is leading over I by Φ)



Waveform representation of supply voltage V and circuit current I, phase difference is Φ, I is lagging behind V by an angle of Φ

VII Actual circuit diagram used in laboratory with equipment specifications:



VIII Resources required:

S. No.	Particulars	Specification	Quantity
1	Rheostat	Suitable rating	1
2	Inductor	Suitable rating	1
4	Voltmeter	Suitable rating	2
5	Ammeter	Suitable rating	1
6	Wattmeter	Suitable rating	1
7	Single phase autotransformer	Suitable rating	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect Ammeter in series.
4. Connect Voltmeter in parallel.

X Procedure:

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage across R and L, measure current and power
5. Repeat the procedure for different voltages.
6. Draw phasor diagram for above readings.

XI Resources used:

S. No.	Name of Resource	Broad Specifications	Quantity	Remarks (If any)

XII Actual procedure followed:

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XIII Observations and Calculations:

Sr. No.	Supply voltage V (volts)	Current I (amp)	Voltage across resistance VR volts	Voltage across choke coil VL volts	Power P (watts)

Calculations:

Sr. No.	Vr= I*R	Voltage across pure inductance $V_L=\sqrt{Vcoil^2 - Vr^2}$)	R=V_R/I	X_L=V_L/I	Z=V/I	Cos(Φ)= P/VI	Φ	Reactive power Q (VAR)	Apparent power S (VA)

XIV Results:

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XV Interpretation of results:

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XVI Conclusions and Recommendations (if any):

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XVII Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Give current, voltage relation in R, L and C element.
2. Draw phasor diagrams showing the relation of V_1, V_2 and V_3
3. Calculate the power factor of the circuit.
4. Obtain phase difference between supply voltage and current for your set-up.
5. Write the concept of lagging and leading power factor.
   (Space to write answers)

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XVIII References / Suggestions for Further Reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://youtu.be/4EgQBPcDMoU?si=IU65Y7v9CGdhipyT
4. https://www.electrical4u.com/rl-series-circuit/

XIX Assessment Scheme:

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
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 (40%)		**10 Marks**
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	100 %

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

Practical No. 4: Measure the live voltage, phase voltage and phase current and line current in three phase star connected balanced load.

I Practical Significance:

In practice, large power application like Transformer, Transmission line etc. use three phase systems. In a three phase circuit loads can be connected in balanced star and delta mode. Practical will help the students to acquire necessary skills.

II Industry/Employer Expected Outcome(s):

Three-phase power is commonly used in factories and manufacturing plants to power large equipment such as compressors, pumps, conveyors, and motors, often use three-phase power to run large fans and pumps It is necessary to formulate voltage and current relations for system parameters for testing , calculations and interpretations.

III Course Level Learning Outcome(s):

Calculate and measure basic electrical quantities and parameters.

IV Laboratory Learning Outcome(s):

LLO 1 Measure the live voltage, phase voltage, phase current and line current in three phase star connected balanced load.

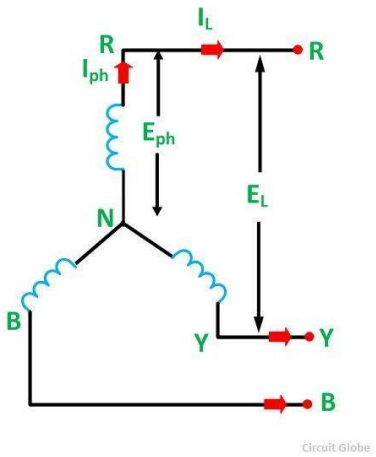
LLO 2 Determine phase voltage and line current in delta connected load.

V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required):

In the **Star Connection**, the similar ends (either start or finish) of the three windings are connected to a common point called star or neutral point. The three-line conductors run from the remaining three free terminals called **line conductors**.



In star connection line voltage is root 3 times of phase voltage.

Line voltage = $\sqrt{3}$ x Phase voltage

$$E_L = \sqrt{3}\, E_{ph}$$

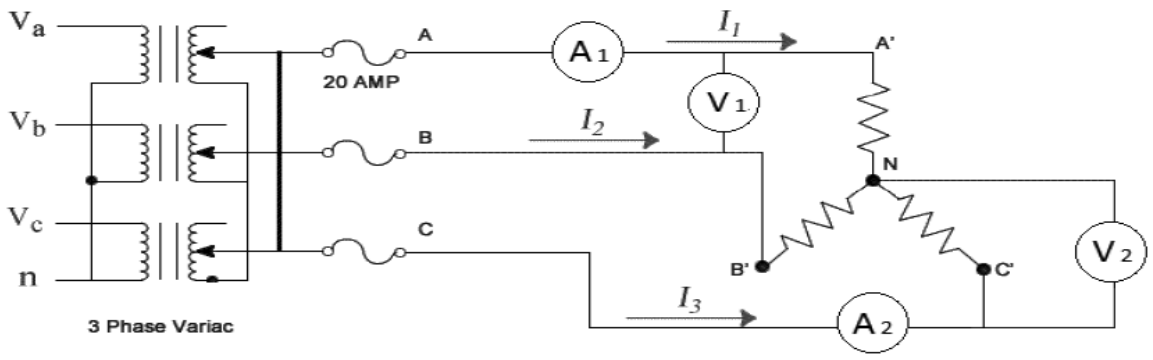
The same current flows through phase winding as well as in the line conductor as it is connected in series with the phase winding.

$$I_R = I_Y = I_B = I_L$$

Star connection is preferred for long distance power transmission because it is having the neutral point. In this we need to come to the concept of balanced and unbalanced current in power system. When equal current will flow through all the three phases, then it is called as balanced current.

Usually, Star Connection is used in both transmission and distribution networks (with either single phase supply or three – phase. Delta Connection is generally used in distribution networks. Since insulation required is less, Star Connection can be used for long distances.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Three Phase Variac	Suitable Three phase variac	1 No.
2	Three Phase load	Suitable range	1 No.
3	A.C. Ammeter	Suitable A.C. ammeter	2 No.
4	A.C. voltmeter	Suitable A.C. Voltmeter	2 No.

IX Precautions to be followed:

1. Avoid loose connections.
2. Don’t touch wire with wet hands.
1. Ensure the output voltage of the Autotransformer should be zero.

X Procedure:

1. Connect the circuit as shown in circuit diagram.
2. Confirm all the meters should be at zero position.
3. Set the rheostat at maximum position.
4. Set the autotransformer output voltage zero.
5. Switch ON the supply.
6. Record the reading of ammeters, voltmeters.
7. Take different readings at different input voltages.

XI Required Resources/apparatus/equipment with specification:

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

XII Actual Procedure Followed:

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XIII Observation and Calculation table:

Sr. No.	Line Voltage (volts)	Phase Voltage (Volts)	Line current (Amp)	Phase Current (Amp)	Ratio V_L/V_{ph}	Ratio I_L/I_{ph}

XIV Result(s):

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XV Interpretation of results:

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XVI Conclusion and recommendation:

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XVII Practical related questions (Provide space for answers):

1. Define balanced load.
2. State the application of star connection.
3. What will be the value of neutral current for three phase star connected balanced load?
4. State the methods to measure power in three phase circuit.

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme:

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 5: Measure the live voltage, phase voltage and phase current and line current in three phase delta connected balanced load.

I Practical Significance:

In practice, large power application like Transformer, Transmission line etc. use three phase systems. In a three phase circuit loads can be connected in balanced star and delta mode. Practical will help the students to acquire necessary skills.

II Industry/Employer Expected Outcome(s):

Three-phase power is commonly used in factories and manufacturing plants to power large equipment such as compressors, pumps, conveyors, and motors, often use three-phase power to run large fans and pumps It is necessary to formulate voltage and current relations for system parameters for testing, calculations and interpretations.

III Course Level Learning Outcome(s):

Calculate and measure basic electrical quantities and parameters.

IV Laboratory Learning Outcome(s):

LLO Find the phase voltage and line current relation in delta connected load.

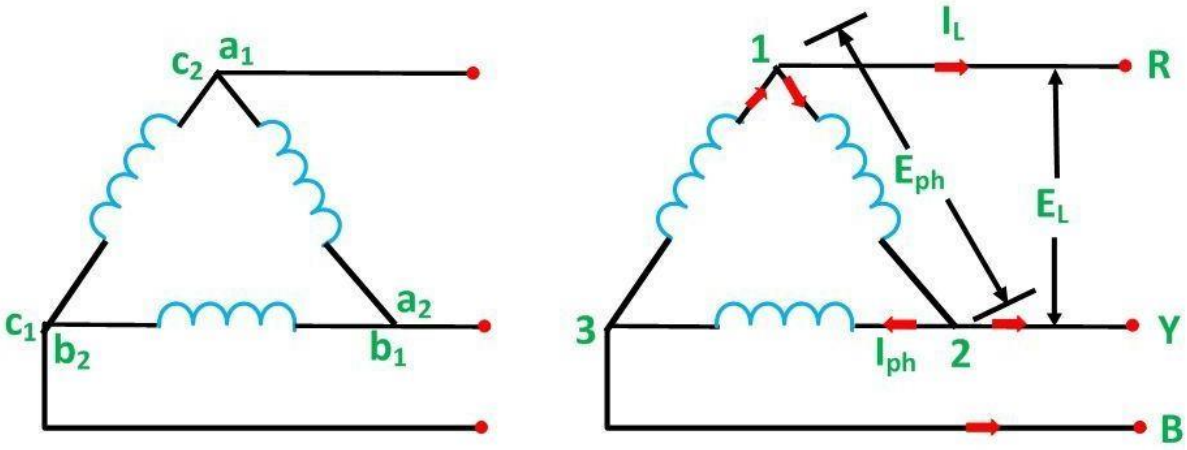
V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required):

The delta in a three-phase system is formed by connecting one end of the winding to the starting end of other winding and the connections are continued to form a closed loop. The star in the three-phase system is formed by connecting one end of all three impedances are connected together.

In **Delta (Δ) or Mesh connection**, the finished terminal of one winding is connected to start terminal of the other phase and so on which gives a closed circuit. The three-line conductors are run from the three junctions of the mesh called **Line Conductors**.



To obtain the **delta connections**, a_2 is connected with b_1, b_2 is connected with c_1 and c_2 is connected with a_1 as shown in the above figure. The three conductors R, Y and B are running from the three junctions known as **Line Conductors**.

The current flowing through each phase is called **Phase Current (Iph)**, and the current flowing through each line conductor is called **Line Current (I_L).**

The voltage across each phase is called **Phase Voltage (E_{ph})**, and the voltage across two line conductors is called **Line Voltage (E_L).**

Relation between Phase Voltage and Line Voltage in Delta Connection

$$E_{RY} = E_{YB} = E_{BR} = E_L$$

In delta connection, line voltage is equal to phase voltage.

Relation between Phase Current and Line Current in Delta Connection

In delta connection line current is root three times of phase current.

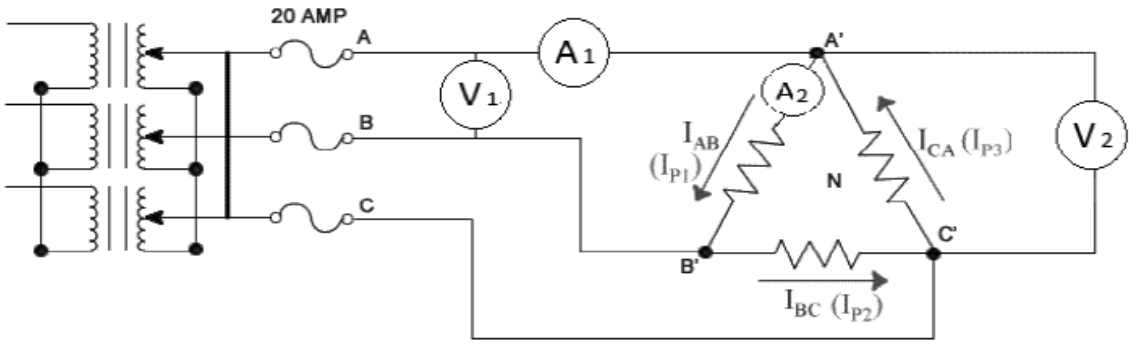
$$\text{Line Current} = \sqrt{3} \text{ x Phase Current}$$

$$I_L = \sqrt{3} I_{ph}$$

In a Delta Connection, the Line and Phase Voltages are same and hence, more insulation is required for individual phases. Usually, Star Connection is used in both transmission and distribution networks (with either single phase supply or three – phase. Delta Connection is generally used in distribution networks

Three Phase balanced network are used in the power industry for the reason of economy and performance. Three phase generators and motors run smoothly, with no torque pulsation, unlike single phase machine. In addition balanced three phase system may be operated as three or four wire systems, which much less copper needed for the power delivered as compared with three single phase systems.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Three Phase Variac	Suitable Three phase variac	1 No.
2	Three Phase load	Suitable range	1 No.
3	A.C. Ammeter	Suitable A.C. ammeter	2 No.
4	A.C. voltmeter	Suitable A.C. Voltmeter	2 No.

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hands.
3. Ensure the output voltage of the Autotransformer should be zero.

X Procedure:

1. Connect the circuit as shown in circuit diagram.
2. Confirm all the meters should be at zero position.
3. Set the rheostat at maximum position.
4. Set the autotransformer output voltage zero.
5. Switch ON the supply.
6. Record the reading of ammeters, voltmeters.
7. Take different readings at different input voltages.

XI Required Resources/apparatus/equipment with specification:

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

XII Actual Procedure Followed:

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XIII Observation and Calculation table:

Sr. No.	Line Voltage (volts)	Phase Voltage (volts)	Line current (amp)	Phase Current (amp)	Ratio V_L/V_{ph}	Ratio I_L/I_{ph}

XIV Result(s):

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XV Interpretation of results:

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XVI Conclusion and recommendation:

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XVII Practical related questions (Provide space for answers)

1. Define balanced load and unbalanced load.
2. State the application of Delta connection.
3. What are the advantage of three phase system over single phase system?
4. Compare Star and delta connection.

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 6: Determination of the voltage ratio and current ratio of single phase transformer.

I Practical Significance:

A single phase Transformer is used for changing voltage levels in electronic circuits. Mostly electronic devices/ circuits are energized with DC supply. To lower the voltage level of AC supply voltage transformer is used and this lowered AC voltage level further rectified to DC supply. Voltage ratio of a transformer decides increasing or decreasing voltage level.

II Industry/Employer Expected Outcome(s):

Determine voltage and current ratio of single phase transformer.

III Course Level Learning Outcome(s):

Use different electrical machines by making connections.

IV Laboratory Learning Outcome(s):

LLO Determine the transformation ratio.

V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background:

Voltage ratio: The voltage ratio of a transformer is equal to the ratio of primary voltage and secondary voltage

$$voltage\ ratio = \frac{Vp}{Vs}$$

Where

Vp = Primary voltage

Vs = secondary voltage

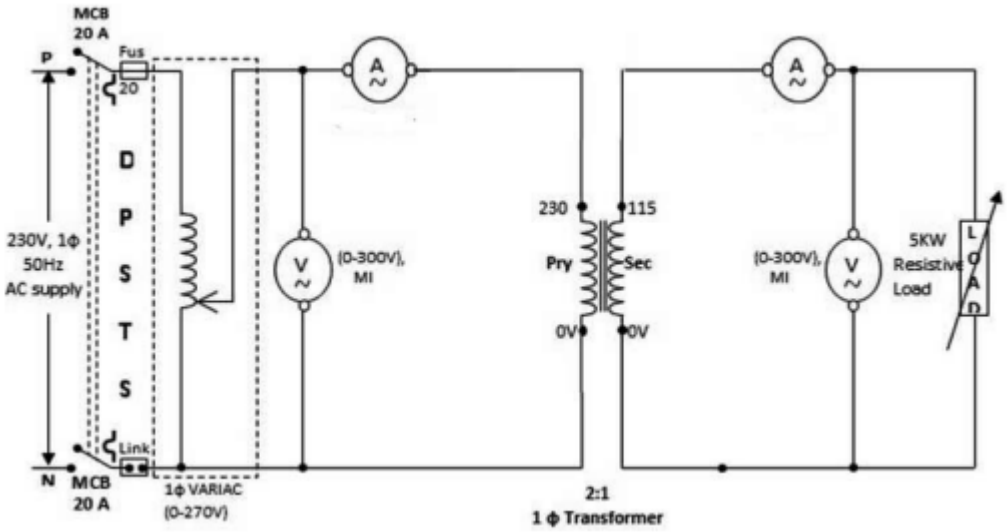
Current ratio: The current ratio of a transformer is equal to the ratio of primary current and secondary current

$$current\ ratio\ = \frac{Ip}{Is}$$

Where

Ip = primary current Is = secondary current

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Ammeter	0-10 A AC	2
2	Voltmeter	0-300 V AC	2
3	Single Phase Transformer	1 kVA 230/115 V single phase transformer	1
4	Resistive load	Single phase 230V, 15 A Resistive load	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.

X Procedure:

1. Connect the circuit as per circuit diagram.
2. Switch on power supply.
3. Note down reading of ammeter and voltmeter.
4. Calculate current and voltage ratio

XI Required Resources/apparatus/equipment with specification:

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

XII Actual procedure followed:

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XIII Observations and calculations:

Sr. No.	Primary Voltage (Vp)	Secondary Voltage (Vs)	Primary Current (Ip)	Secondary Current (Is)	Voltage Ratio = (Vp/Vs)	Current Ratio = (Ip/Is)
1						
2						
3						
4						

XIV Results:

Voltage Ratio is …… and current ratio is …… for given transformer

XV Interpretation of results:

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XVI Conclusion and recommendation:

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XVII Practical related questions (Provide space for answers):

1. Define transformer.
2. Define voltage ratio.
3. Define current ratio.
4. Define transformation ratio.
5. State EMF equation of single phase transformer.
6. Define step up and step down transformer.
7. Give applications of step up and step down transformer.

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 7: operate DC Shunt motor by connecting three point starter.

I Practical Significance:

DC shunt motor draws very high current during starting which may burn armature winding. Hence to protect DC shunt motor from damage due to heavy starting current, Three point starter is used to start DC shunt motor.

II Industry/Employer Expected Outcome(s):

Select and connect DC motor to DC supply using particular starter for different applications.

III Course Level Learning Outcome(s):

Use different electrical machines by making connections.

IV Laboratory Learning Outcome(s):

LLO DC shunt motor operation.

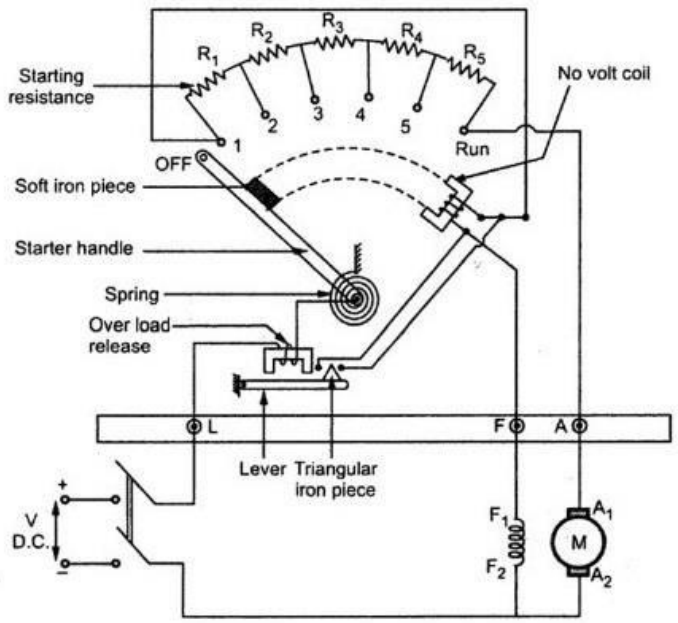
V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background:

3 point starter is a device whose main function is starting of DC shunt motor. The 3 point starter connects the resistance in series with the circuit which reduces the high starting current and hence protect DC Shunt motor from damage. For DC series motor 2 point starter is used.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC motor	3 HP 220V, DC	1
2	DC supply	220V DC 20 Amp	1
3	Three point starter	Suitable for 3 HP DC shunt motor	1
4	Tachometer	Suitable range around 0 to 5000 rpm	1

IX Precautions to be followed:

1. Connect the three point starter with DC shunt motor properly.

X Procedure:

1. Connect the circuit as shown in circuit diagram.
2. Switch on DC supply.
3. Move the handle of 3 point starter from Start to Run position gradually.
4. Observe the starting of DC shunt motor.
5. By using tachometer measure the speed of the DC shunt motor

XI Required Resources/apparatus/equipment with specification:

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

XII Actual Procedure followed:

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XIII Observations:

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XIV Results:

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XV Interpretation of results:

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XVI Conclusion and recommendation

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XVII Practical related questions (Provide space for answers)

1. State types of starters used for DC motors.
2. Starter is necessary for starting of DC motors.
3. Write the functions of different parts of three point starter.

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 8: Operate DC series motor by connecting two point starter.

I Practical Significance:

DC series motor draws very high current during starting which may burn armature winding. Hence to protect DC series motor from damage due to heavy starting current, Two point starter is used to start DC series motor.

II Industry/Employer Expected Outcome(s):

Select and connect DC motor to DC supply using particular starter for different applications.

III Course Level Learning Outcome(s):

Use different electrical machines by making connections.

IV Laboratory Learning Outcome(s):

LLO DC series motor operation.

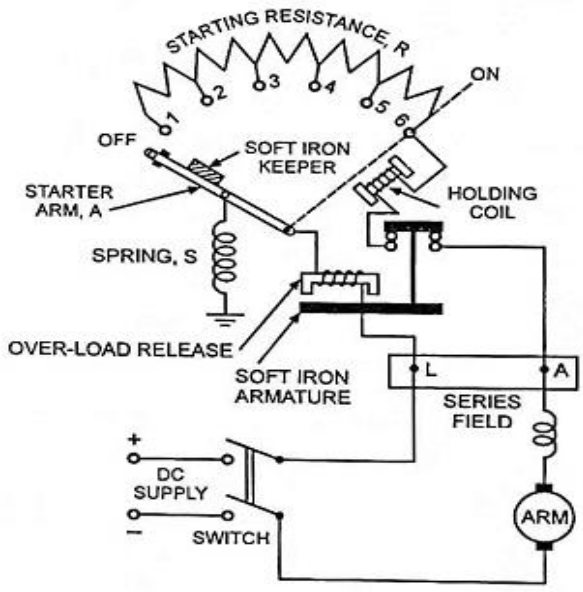
V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

2 point starter is a device whose main function is starting of DC series motor. The 2 point starter connects the resistance in series with the circuit which reduces the high starting current and hence protect DC Series motor from damage. For DC Shunt motor 3 point starter is used.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC series motor	3 HP 220V, DC	1
2	DC supply	220V DC 20 Amp	1
3	Two point starter	Suitable for 3 HP DC shunt motor	1

IX Precautions to be followed:

1. Connect the two point starter with DC shunt motor properly.
2. Do not start DC series motor without any load.

X Procedure:

1. Connect the circuit as shown in circuit diagram.
2. Switch on DC supply.
3. Move the handle of 3 point starter from Start to Run position gradually.
4. Observe the starting of DC shunt motor.
5. By using tachometer measure the speed of the DC shunt motor

XI Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity

X11 Actual Procedure followed:

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XIII Observations:

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XIV Results:

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XV Interpretation of results:

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XVI Conclusion and recommendation

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XVII Practical related questions (Provide space for answers)

1. State types of starters used for DC motors.
2. Starter is necessary for starting of DC motors.
3. Write the functions of different parts of three point starter.

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 9: Reverse the direction of rotation of universal motor.

I Practical Significance:

Reversal of rotation of Universal motor plays an important role in electrical and electronic engineering for different medical instrumentation applications.

II Industry/Employer Expected Outcome(s)

Use universal motor for different applications. Reverser the direction of rotation of universal motor.

III Course Level Learning Outcome(s)

Use different electrical machines by making connections.

IV Laboratory Learning Outcome(s)

LLO Speed reversal of universal motor.

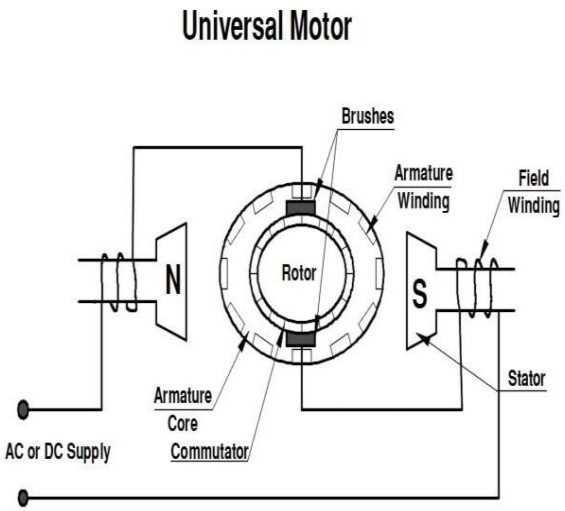
V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

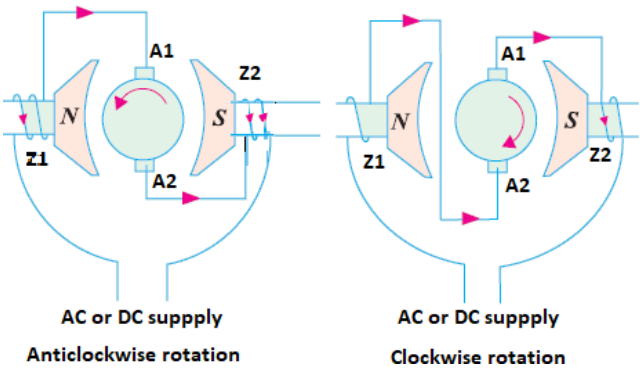
VI Relevant Theoretical Background

Universal motor can be operated on AC and DC supply. It consists of armature, armature winding, field winding, armature winding and field winding are connected in series with each other since this is basicallya series motor.

The direction of rotation of a universal motor can be changed by either: (i) Reversing the field connection with respect to those of armature; or (ii) By using two field windings wound on the core in opposite directions so that the one connected in series with armature gives clockwise rotation, while the other in series with the armature gives counterclockwise rotation.



VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Universal motor	Suitable rating	1
2	Supply AC or DC	Suitable supply	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.

X Procedure

1. Connect universal motor to AC/DC supply.
2. Mark the rotation of motor.
3. Change the armature winding terminal.
4. Mark the rotation of motor.

XI Required Resources/apparatus/equipment with specification:

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

XII Actual Procedure Followed:

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XIII Observations:

Sr. No.	Winding connection	Direction of rotation
1	Normal	
2	Reversed	

XIV Results:

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XV Interpretation of results:

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XVI Conclusion and recommendation

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XVII Practical related questions (Provide space for answers)

1. State working of universal motor.
2. State main parts of State different types of single phase induction motors.
3. Give applications of universal motor.

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XVIII References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 10: Demonstrate the operation of stepper motor for various speed rotation.

I Practical significance: Stepper motors convert electricity into rotation. Not only does a stepper motor convert electrical power into rotation, but it can be very accurately controlled in terms of how far it will rotate and how fast. Stepper motors are typically used for holding or positioning applications.

II Industry/Employer expected outcome:

Apply basic concept of electrical engineering in various application in relevant technical field. Identify different types of supply sources, equipment and machines.

III Course level learning outcome:

Use different electrical machines by making connection.

IV Laboratory Learning Outcome

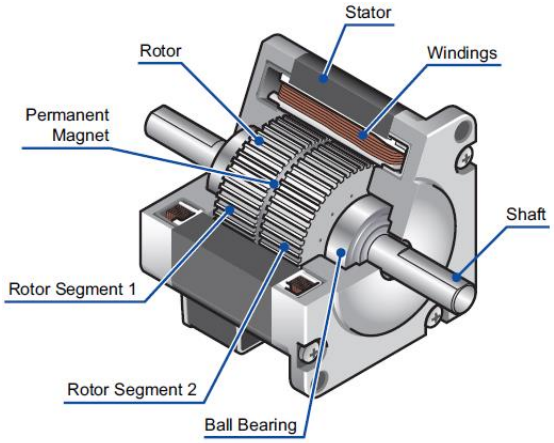
Demonstrate the stepper motor operation.

V Relevant Affective Domain related outcome

Follow safety electrical rules for practices.

VI Relevant Theoretical background

The construction of a stepper motor is fairly related to a DC motor. It includes a permanent magnet like Rotor which is in the middle & it will turn once force acts on it. This rotor is enclosed through a no. of the stator which is wound through a magnetic coil all over it. The stator is arranged near to rotor so that magnetic fields within the stators can control the movement of the rotor.



Stepper Motor

The stepper motor can be controlled by energizing every stator one by one. So the stator will magnetize & works like an electromagnetic pole which uses repulsive energy on the rotor to move forward. The stator's alternative magnetizing as well as demagnetizing will shift the rotor gradually &allows it to turn through great control.

The stepper motor working principle is Electro-Magnetism. It includes a rotor which is made with a permanent magnet whereas a stator is with electromagnets. Once the supply is provided to the winding

of the stator then the magnetic field will be developed within the stator. Now rotor in the motor will start to move with the rotating magnetic field of the stator. So this is the fundamental working principle of this motor.

Stepper Motor Construction

In this motor, there is a soft iron that is enclosed through the electromagnetic stators. The poles of the stator as well as the rotor don't depend on the kind of stepper. Once the stators of this motor are energized then the rotor will rotate to line up itself with the stator otherwise turns to have the least gap through the stator. In this way, the stators are activated in a series to revolve the stepper motor.

A stepper motor is a type of electromechanical device that converts electrical pulses into discrete mechanical movements. Unlike DC or AC motors that rotate continuously, a stepper motor moves in precise increments or steps, hence the name "step- per." A stepper motor, also known as step motor or stepping motor, is an electrical motor that rotates in a series of small angular steps, instead of continuously. Stepper motors are so named because each pulse of electricity turns the motor one step. The operation of a stepper motor for various speed rotation lies in understanding the capabilities and application of stepper motors in different scenarios. Commercially, stepper motors are used in floppy disk drives, flatbed scanners, computer printers, plotters, slot machines, image scanners, compact disc drives, intelligent lighting, camera lenses, CNC machines, and 3D printers. They are used in numeric control of machine tools. Used in tape drives, and electric watches. The stepper motor also uses in X-Y plotter and robotics. It has wide application in textile industries and integrated circuit fabrications.

A stepper motor is an electromechanical device it converts electrical power into mechanical power. Also, it is a brushless, synchronous electric motor that can divide a full rotation into an expansive number of steps. The motor's position can be controlled accurately without any feedback mechanism, as long as the motor is carefully sized to the application. Stepper motors are similar to switched reluctance motors. The stepper motor uses the theory of operation for magnets to make the motor shaft turn a precise distance when a pulse of electricity is provided. The stator has eight poles, and the rotor has six poles. The rotor will require 24 pulses of electricity to move the 24 steps to make one complete revolution. Another way to say this is that the rotor will move precisely 15° for each pulse of electricity that the motor receives. Stepper motors are typically used for holding or positioning applications. In areas like lasers and optics, they are used in precision positioning equipment such as linear actuators, linear stages, rotation stages, and more. They can also be used in Packaging Machinery.

VII Actual circuit diagram used in laboratory

Student should draw the relevant circuit diagram under the guidance of teacher

VIII Required resources/apparatus/equipment with specifications:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Stepper motor	Suitable range	1 No.
2	Stepper motor driver	Suitable range	1 No.
3	Stepper motor controller	Suitable range	1 No.
4	Power supply	Suitable range	1 No.
5	Connecting wires	Suitable wires	1 No.

IX Precautions to be followed

1. The motor constantly draws electrical currents
2. The motor will be overheated if you leave the power on for an extended period
3. Make sure to disconnect the power (Vcc) to the Darlington array I you are not debugging/testing it.

X. Procedures

Student should write the procedure under the guidance of teacher.

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XI Resources Used (Student should the required resources)

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

XII Actual Procedure followed

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XIII Observations

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XIV Results

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XV Interpretation of results

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XVI Conclusions and recommendation

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XVII Practical related questions.

1. How to change the rotation speed of a stepper motor?
2. How to reverse the rotation direction?
3. Enlist the applications of stepper motor.

XVIII References/Suggestions for further reading

1. https://www.monolithicpower.com/stepper-motors-basics-types-uses
2. https://www.orientalmotor.com/stepper-motors/technology/stepper-motor-basics.html
3. https://www.elprocus.com/stepper-motor-types-advantages-applications/
4. https://eepower.com/technical-articles/stepper-motors-part-1-an-overview/

XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
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 (40%)		**10 Marks**
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%
	T**otal**	100 %

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

Practical No. 11: Use of Multimeter for measurement of voltage, current (AC, DC), resistance and continuity of the given electrical circuit.

I Practical Significance:

Multimeter is used for measurement of voltage, current in AC and DC circuit. Also resistance and continuity of the given electrical circuit can be checked by using multimeter.

II Industry/Employer Expected Outcome(s):

In the industry, Electrical Engineering diploma graduate are expected to handle digital multimeter to measure basic parameters like voltage, current and resistance of the field devices. Therefore this practical will help you to acquire necessary skills**.**

III Course Level Learning Outcome(s):

Use different electrical machines by making connections.

IV Laboratory Learning Outcome(s):

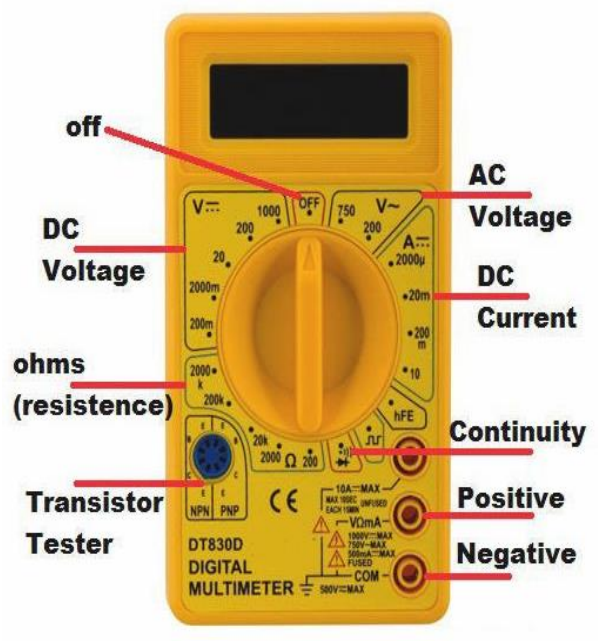
Use of Multimeter for measurement.

V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

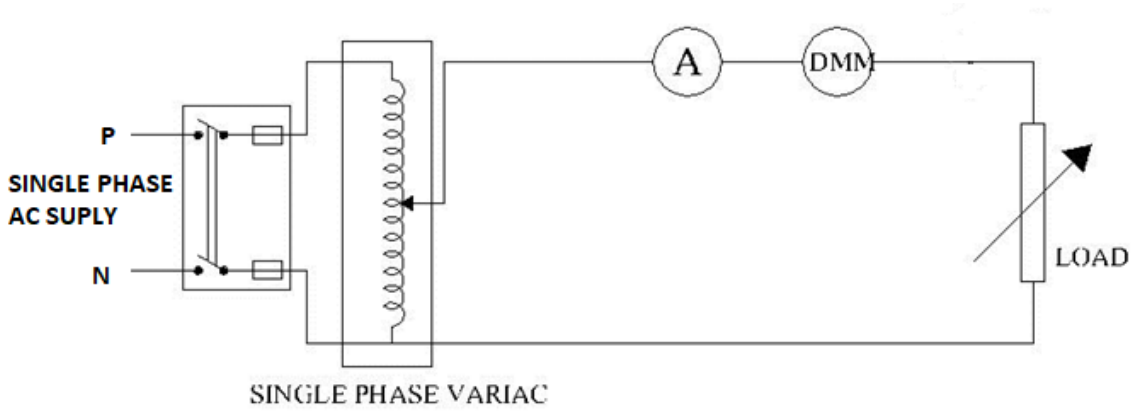
VI Relevant Theoretical Background:

Multimeter is a portable multi range instrument used for measurement of current voltage and resistance. Front panel of digital multimeter consists of Display panel, selector switch, common input connector.

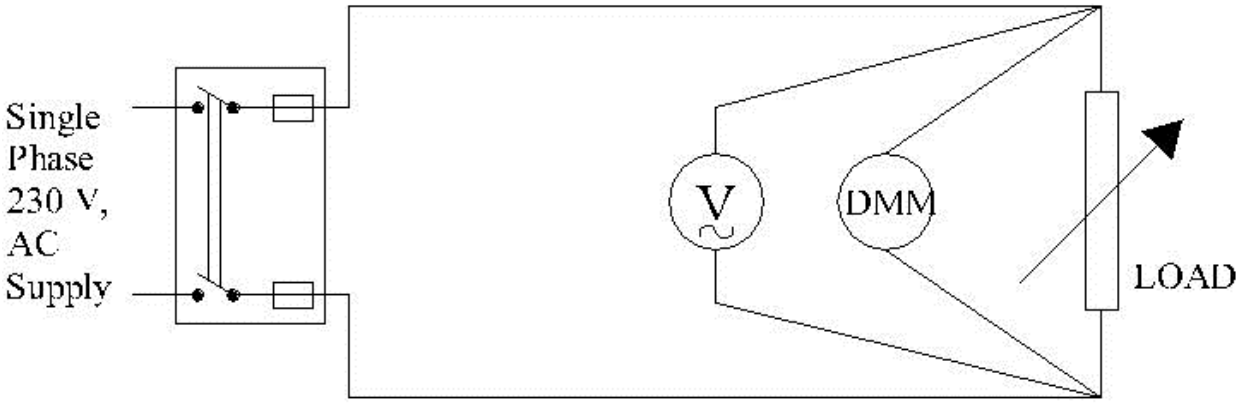


VII Circuit diagram:

a) AC Current Measurement



b) AC Voltage Measurement

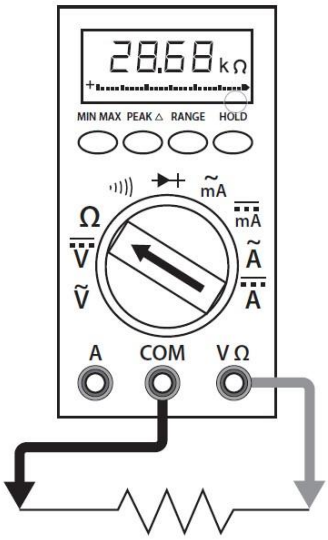


c) DC Current Measurement (Circuit diagram to be drawn by student under the guidance of teacher)

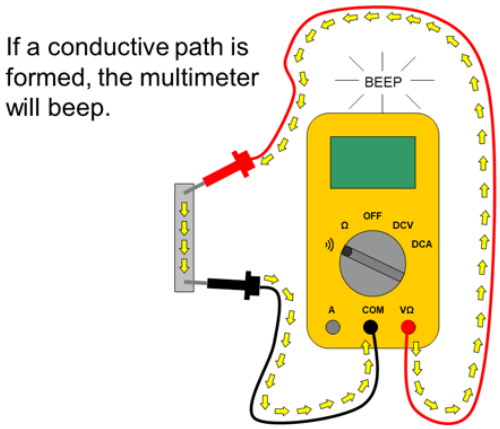
d) DC Voltage Measurement

(Circuit diagram to be drawn by student under the guidance of teacher)

e) Resistance Measurement



f) Continuity checking



VIII Required Resources:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single phase Variac/ Dimmerstat	(0-270V), 4A	1
2	Ammeter	Suitable range PMMC/MI	1
3	Voltmeter	Suitable range PMMC/MI	1
4	Digital Multimeter	Voltage:DC:600Volts;AC:600Volts, Current:DC:20amps;AC:20amps	1
5	Lamp Bank /Lamp Load	5KW	1
6	Rheostat	Suitable range	1
7	DC supply	Suitable voltage	

IX Precautions to be followed:

1. Select proper range of meters.
2. Be careful while selecting AC/DC meters.
3. Don't increase the current beyond meters capacity.
4. Use dimmerstat for voltage variation in AC.
5. Don't touch the live wires.
6. Set the DMM at correct AC /DC voltmeter, AC/DC ammeter mode by operating selector switch.

X Procedure:

A) AC Current Measurement

1) Connect a circuit as shown in fig for measurement of AC current.
2) Switch ON the supply.
3) Keep dimmerstat at minimum position.
4) Increase the output voltage of dimmerstat up to the rated value.
5) Switch on the load bank switches gradually in steps.
6) Record the current in the observation table after measuring with DMM reading
7) Record the ammeter reading.
8) Increase the load on by switching on one more switch of the load bank.
9) Repeat steps 6-9 for more readings**.**

B) AC voltage measurement

1) Connect a circuit as shown in fig for measurement of AC Voltage.
2) Switch ON the supply.
3) Keep dimmerstat at minimum position.
4) Increase the output voltage of dimmerstat up to the rated value.
5) Switch on the load bank switches gradually in steps.
6) Record the voltmeter reading.

7) Set the DMM at correct AC voltmeter mode by operating selector switch, record DMM voltage reading.
8) Increase the load on by switching on one more switch of the load bank.
9) Repeat steps 6-9 for more readings.

C) DC Current Measurement

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D) DC Voltage Measurement

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E) Resistance Measurement

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F) Continuity checking

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XI Required Resources

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1			
2			
3			
4			
5			
6			
7			
8			

XII Observation table:

a) AC Current Measurement

Sr. No.	Ammeter Reading	DMM Reading
1		
2		
3		

b) AC Voltage Measurement

Sr. No.	Voltmeter Reading	DMM Reading
1		
2		
3		

c) DC Current Measurement

Sr. No.	Ammeter Reading	DMM Reading
1		
2		
3		

d) DC Voltage Measurement

Sr. No.	Voltmeter Reading	DMM Reading
1		
2		
3		
4		

e) Resistance Measurement

Sr. No	Resistance measured by DMM
1	
2	
3	

f) Checking continuity

Sr. No	If circuit is continued alarm beeps	If circuit is open alarm doesn't beeps
1		
2		

XIII Result(s):

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XIV Interpretation of results:

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XV Conclusion and recommendation:

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XVI Practical related questions:

(Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.)

1. List the minimum and maximum range of current that can be read with multimeter given to you.
2. State the procedure for continuity test using multi-meter.
3. State the applications of multimeter.

[Space for answers]

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XVII References/Suggestions for further reading:

1. Experiments in Basic Electrical Engineering S.K.Bhattacharya K.M.Rastogi ISBN:978-81-224-1041-6 New Age International Publication
2. https://en.wikipedia.org/wiki/current_clamp
3. Electrical Measurement and Measuring Instruments U.A.Bakshi A.V.Bakshl K.A.Bakashi ISBN 9788184314380First Edition -2008Technical Publications Pune

XVIII Suggested Assessment Scheme:

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No. 12: Connect the fuse in electrical circuit and check its operation at normal and abnormal conditions.

I Practical Significance:

An electrical fuse is a safety device that operates to provide protection against the overflow of current in an electrical circuit. An important component of an electrical fuse is a metal wire or strip that melts when excess current flows through it. It helps to protect the device by stopping or interrupting the current.

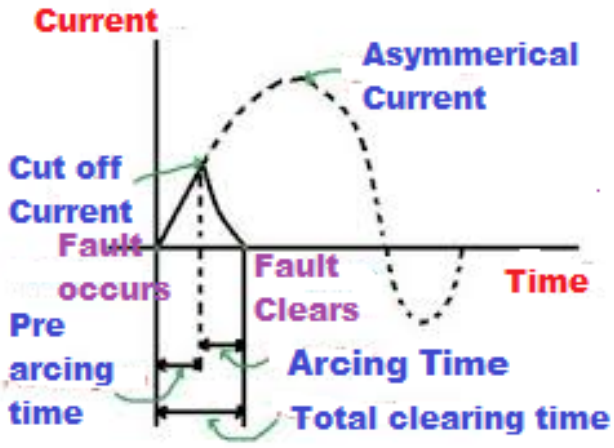
II Industry/ Employer Expected Outcomes(s):
Select the relevant fuse for different requirements.

III Course Level Learning Outcomes(s):
Use electrical safety devices in electrical circuit.

IV Laboratory Learning Outcomes(s):
Connection of fuses in electrical circuit.

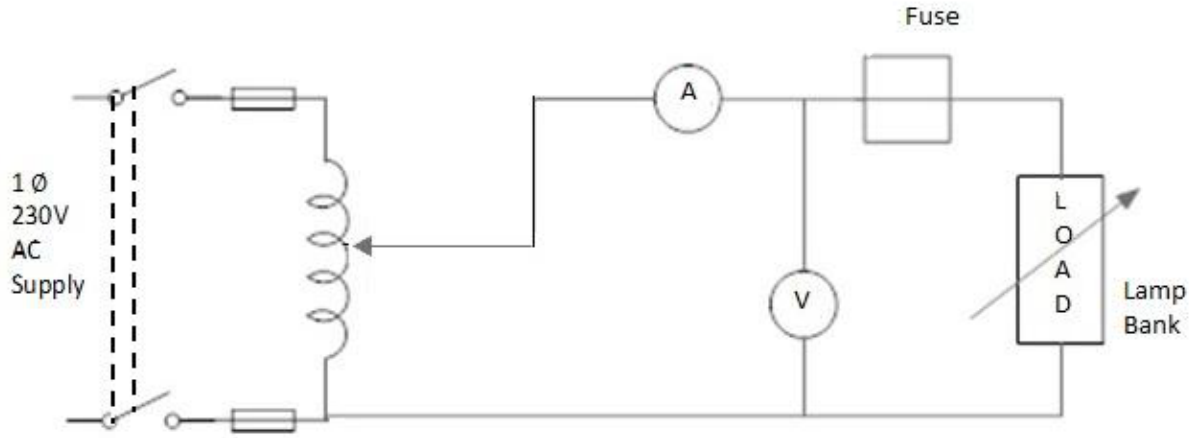
V Relevant Affective Domain related outcome(s):
Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background:
Fuses are basic safety devices widely deployed in electrical circuits for excess current or overcurrent protection. If a stronger than expected current surges through the fuse, it will blow and break the circuit, minimising heat damage and reducing the risk of electrocution or fire. It consists of a small link of soft metal, which melts when excessive current passes through it. The fuse wires are usually bare wires and made of lead and tin. Lead alloy is used for small current and tinned copper wire is used for large current. Upto 3 amperes load, lead fuse wires are used, upto 15 amperes alloy of lead and tin is used and above 15 amperes, tinned copper wires are used. If a short circuit occurs anywhere in the wiring system, excessive current flows through the wires and fuse and if fuse operates properly, it will melt, cutting of the current before any harm can be done to the connected equipment or circuit.



Cut off Characteistics of Fuse

VII Actual circuit diagram used in laboratory with equipment specification:



VIII Required Resources /apparatus/equipment with specifications:

Sr. No.	Particulars	Specification	Quantity
1	Fuse	Range – 0 to 6 A	01
2	Voltmeter	Range 0-300V	01
3	Auto-transformer (Dimmer)	Single phase, 0-270V, 50 Hz , 6A	01
4	Ammeter	0-10A	01
5	Resistive Load / Lamp Load (Bank)	Range 10-20 A	01

IX Precautions to be followed:

1. There should not be any loose connection.
2. Ensure the proper rating of fuse is selected for the given circuit.
3. Ensure that supply is OFF while replacing the fuse.
4. Follow electrical safety rules,

X Procedure:

1. There should not be any loose connection.
2. Switch on the supply and adjust the rated load current.
3. Gradually increase the load current in steps of 10% of rated and note down the time of operation for each current above rated till fuse blows.
4. Plot the graph between current and time of operation.

XI Resources Used (Students should write the required resources):

S.No.	Name of resources	Broad Specifications	Quantity
1			
2			
3			
4			

XII Actual Procedure followed:

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XIII Observation table:

Sr. No.	Voltmeter reading in volts	Current through fuse element in Amps.	Time of operation in seconds
1			
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6			
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XIV Results:

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XV Interpretation of Results:

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XVI Conclusions and recommendation:

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XVII Practical Related Questions: (Use separate sheet for answer)

1. State the function of fuse.
2. State the limitations of fuse.

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XVIII References/suggestions for further reading :

1. https://www.youtube.com/watch?v=W770Z1yvXs8
2. https://www.vedantu.com/physics/working-principle-of-an-electrical-fuse
3. https://byjus.com/question-answer/what-are-the-characteristics-of-fuse-wire/
4. https://electrical-engineering-portal.com/fuse-characteristics-protection-circuits
5. https://testbook.com/physics/electrical-fuse

XIX Assessment Scheme:

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	2
4	Working in team	10 %
Product related (40%)		**10 Marks**
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%
	T**otal**	100 %

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

Practical No. 13: Connect MCB in electrical circuit and check its operation at normal and abnormal conditions.

I Practical Significance:
MCB is the most important component of power distribution system. It provides safety, proper operation of the system and ease in smooth operation of the installation. Therefore, it is essential to know the working of this component.

II Industry/ Employer Expected Outcomes(s):
Select proper rating of MCB for different electrical applications.

III Course Level Learning Outcomes(s):
Use electrical safety devices in electrical circuit.

IV Laboratory Learning Outcomes(s):
Connection of MCB in electrical circuit.

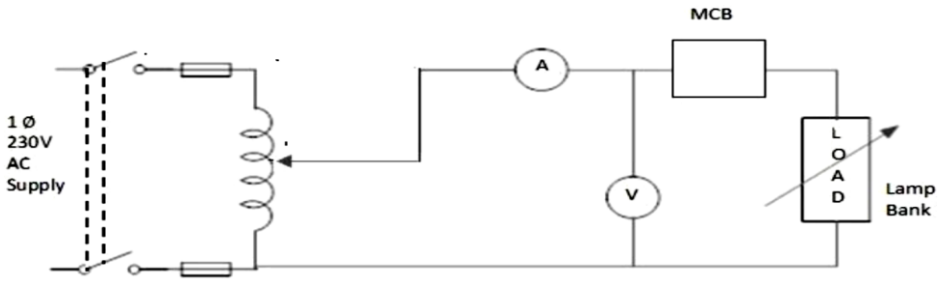
V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background:
MCB switches "OFF" the electrical circuit during overload and short circuits. MCBs have current ratings ranging from A to 100 A & as their name implies, they have a compact size. There are three main types of MCBs, classified according to the current range at which they trip instantly.

- Type B- Trips at 3 To 5 times rated current, suitable for resistive or slightly inductive loads.
- Type C- Trips at 5 to 10 times rated current, suitable for moderate inductive loads.
- Type D- Trips at 10 to 20 times rated current, suitable for loads with a high inductive components.

VII Actual circuit diagram used in laboratory with equipment specification:



VIII Required Resources /apparatus/equipment with specifications:

Sr. No.	Particulars	Specification	Quantity
1.	Single pole MCB	0.5/1 A , Type B, 6 KA, 240 V	01
2.	Auto-transformer (Dimmer)	Single phase, 0-270V, 50 Hz , 6A	01
3.	A.C. Ammeter	Range 0-10A	01
4.	A.C. voltmeter	Range 0- 300 V	
5.	Resistive Load / Lamp Load (Bank)	Suitable size	01

IX Precautions to be followed:

1. While testing MCB proper ratings of fuses should be used in ICDP.
2. Ensure the proper rating of MCB is selected for the given circuit.
3. Follow electrical safety rules.

X Procedure:

1. Connect the circuit as per the circuit diagram shown.
2. Switch on the supply.
3. Apply the rated voltage to the MCB.
4. Increase the load up to 3 times current rating of MCB.
5. Record the tripping time of MCB and ammeter reading in the observation table.
6. Increase the load up to 4 to 5 times of current rating of MCB.
7. Record the tripping time of MCB and ammeter reading in the observation table.

XI Resources Used (Students should write the required resources):

Sr. No.	Name of resources	Broad Specifications	Quantity
1			
2			
3			
4			
5			

XII Actual Procedure followed:

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XIII Observation table:

Sr. No.	Current through circuit	Tripping time of MCB
1		
2		
3		
4		
5		

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions and recommendation:

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XVII Practical Related Questions: (Use separate sheet for answer)

1. State the applications of MCB.
2. MCB selection needs to be done carefully; explain.
3. State the specification of MCB.

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XVIII References/suggestions for further reading:

1. https://byjus.com/physics/miniature-circuit-breaker
2. https://www.electronicsforu.com/technology-trends/learn-electronics/miniature-circuit-board-mcb
3. https://www.electrical4u.com/miniature-circuit-breaker-or-mcb/

XIX Assessment Scheme:

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance indicators		Weightage
Process related (60%)		**15 Marks**
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 (40%)		**10 Marks**
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%
	T**otal**	100 %

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

Practical No. 14: Connect ELCB in electrical circuit breaker and check its operation at normal and abnormal conditions.

I Practical Significance:
ELCB is a life -saving device which is designed to prevent human life from electric shocks. Connection of switchgears plays important role in engineering. Correct connection is necessary for operating equipment safely. This device provides the safety in an electrical installation. Therefore, it is essential to know the working of this component.

II Industry/ Employer Expected Outcomes(s):
Select proper rating of MCB for different electrical applications.

III Course Level Learning Outcomes(s):
Use electrical safety devices in electrical circuit.

IV Laboratory Learning Outcomes(s):
Connection of ELCB in electrical circuit.

V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

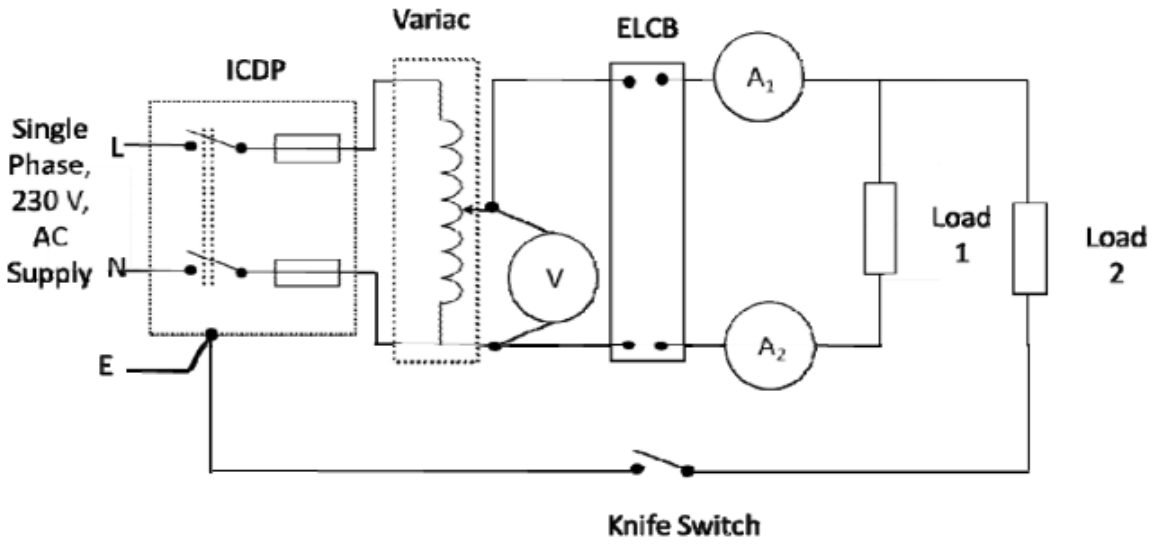
VI Relevant Theoretical Background:
An Earth-leakage circuit breaker (ELCB) is a safety device used in electrical installations with high Earth impedance to prevent injury to humans and animals due to electric shock. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected.

It monitors the leakage current that flows out of the circuit through any unintended path. The ELCB disconnects the power when earth leakage is detected. It helps detect current leaks and insulation failures in the electrical circuits that would cause electrical shocks to anyone coming into contact with the circuit.

There are two types of ELCB: voltage operated and current operated. Current operated ELCBs are widely used. The current operated ELCBs are also called as RCCB (Residual current circuit breaker. Basically, it works on the principle of Kirchhoff's Current Law (KCL) i.e. incoming current is equal to outgoing current. Residual current is the difference between line current and neutral current.

At the event of earth leakage, current find the earth path, hence imbalance occurs between line current and neutral current. The coil in toroidal transformer senses residual current which connected to relay.

VII Actual circuit diagram used in laboratory with equipment specification:



VIII Required Resources /apparatus/equipment with specifications:

Sr. No.	Particulars	Specification	Quantity
1	Earth leakage circuit breaker (ELCB)	Single phase ,2 Pole-40Amp-120/240V AC,50Hz	01
2	Digital Multi meter	$3\frac{1}{2}$ Digit display	01
3	Auto-transformer (Dimmer)	Single phase, 0-270V, 50 Hz , 6A	01
4	Ammeter	0-5A, 0-10A	02
5	Resistive Load / Lamp Load (Bank)	Suitable size	01
6	Knife Switch	Single Pole Single Throw	01

IX Precautions to be followed:

1. While testing ELCB proper ratings of fuses should be used in ICDP.
2. Ensure the proper rating of ELCB is selected for the given circuit.
3. Precautions should be taken while operating knife switch.

X Procedure:

1. Connect the ELCB as per the circuit diagram.
2. Record the observation in ammeters.
3. If Knife switch is not available, then remove neutral wire of load and touch to Earth terminal of ICDP

XI Resources Used (Students should write the required resources):

S.No.	Name of resources	Broad Specifications	Quantity
1			
2			
3			
4			
5			

XII Actual Procedure followed

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XIII Observation table:

Before operating knife switch

Sr. No.	Current through live wire	Current through neutral wire
1		
2		
3		
4		
5		

After operating knife switch

Sr. No.	Current through live wire	Current through neutral wire
1		
2		
3		
4		

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions and recommendation:

………
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XVII Practical Related Questions: (Use separate sheet for answer)

1. What is ELCB also known as?
2. State the working principle of ELCB?
3. State how the ELCB differ from MCB.
4. Is ELCB trip in the event of short circuit in an electric circuit?
5. Name the device used for earth leakage and over current protection.

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XVIII References/suggestions for further reading:

1. https://www.electricaltechnology.org/2021/09/elcb-earth-leakage-circuit-breaker.html
2. https://engineering.electrical-equipment.org/electrical-distribution/earth-leakage-circuit-breaker-elcb.html
3. https://www.etechnog.com/2021/12/what-is-elcb-full-form-function-diagram.html
4. https://www.homemade-circuits.com/make-simple-earth-leakage-circuit/
5. https://electrical-engineering-portal.com/working-principle-of-earth-leakage-circuit-breaker-elcb-and-residual-current-device-rcd

XIX Assessment Scheme:

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No.15 Use of earth tester for measurement of earthing resistance of a installed earthing of laboratory.

I Practical Significance:

Earthing System or Grounding System is an electrical network work as a safety measure to protect human life as well as equipment. The main objective of the Earth testing is to measure the value of earth resistance and compare and maintain it with recommended value of earth system resistance.

II Industry/ Employer Expected Outcomes(s):

Use earth tester for measurement of earthing resistance.

III Course Level Learning Outcomes(s):

Use Electrical safety devices in electrical circuit.

IV Laboratory Learning Outcomes(s):

Measurement of earth resistance.

V Relevant Affective Domain related outcome(s):

Follow safety electrical rules for safe practices.

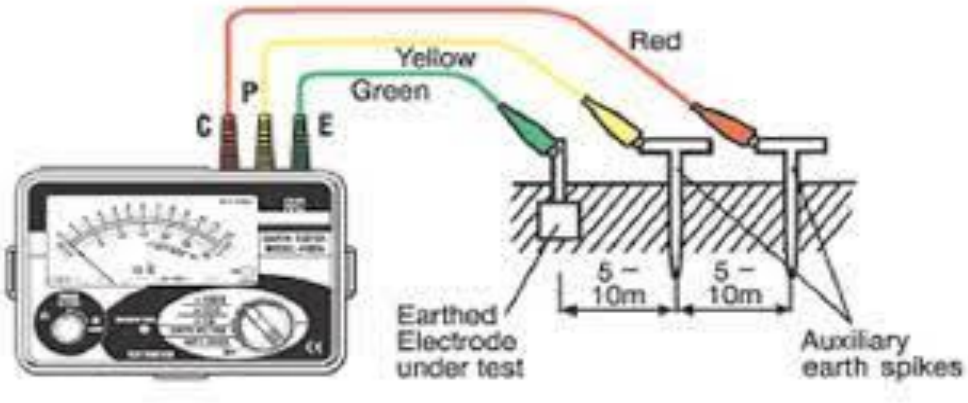
VI Minimum Theoretical Background:

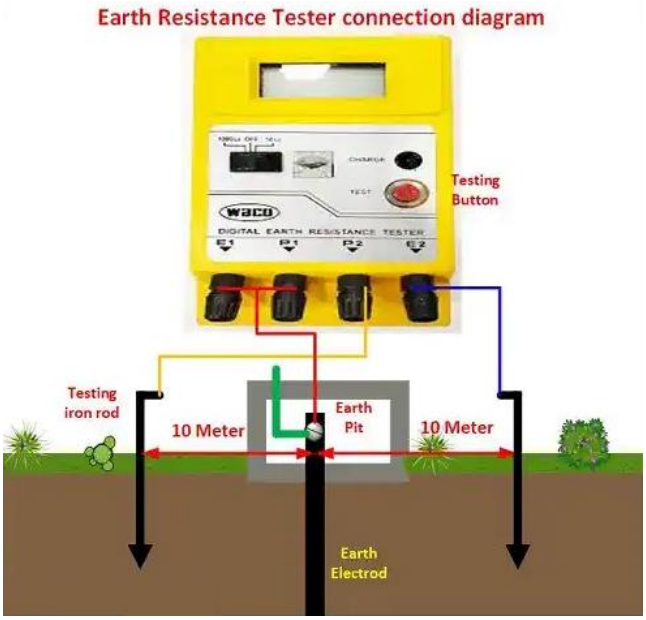
The instrument used for measuring the resistance of the earth is known as earth tester. All the equipment of the power system is connected to the earth through the earth electrode. The earth protects the equipment and personnel from the fault current. The resistance of the earth is very low. The fault current through the earth electrode passes to the earth. Thus, protect system from damage. As per Indian standard as well as international standard (IEEE and IEC), earthing resistance should not be more than following recommended value for various installations:

1. Household-5 Ohm
2. Power station-0.5 Ohm
3. Major substations- 1 Ohm
4. Minor substation-2 Ohm

Earth tester is a special type of megger used for measurement of earth resistance having additional constructional features of rotating current reverser and rectifier. It has four terminals namely P1, P2 and C1, C2. Two terminals PI and C1 are shorted to form a common point to be connected to the earth electrode. P1, P2. The other two terminals P2 and C2 are connected to auxiliary electrodes P and C respectively.

VII Actual circuit diagram used in laboratory with equipment specifications:





VIII Resources required:

S.No.	Name of Resources	Suggested broad Specification	Quantity
1	Earth Tester with connecting cables	Analog or digital type	1 Set
2	Hammer ball peen	1Kg	1 No.
3	Combination plier	200mm	1 No.
4	Screw driver	300mm	1 No.
5	Earth electrode (for test)	-	1 No.

IX Precautions to be followed:

1. Read carefully the instructions of the manufacturer.
2. All connection should be tight.
3. Select the proper range of tester.
4. Handle rotation should be as per instruction given on instruments.

X Procedure:

1. Connect the earth tester and connecting cables.
2. Drive the current electrode at a distance of 30 meters from the main electrode.
3. Drive the potential electrode midway between the main and current electrodes.
4. Short the terminal C1 and P1, of the earth tester (if four terminals) and connect the terminals to the main electrode.
5. Connect the terminal P2 and C2 of the earth tester to the potential electrode and current electrodes respectively.
6. Rotate the earth tester at its rated speed.
7. Measure the resistance of the earth electrode directly in the tester and enter the value in observation table.
8. Repeat the measurement by shifting the auxiliary electrode position as state in Nos. 2 to 4 of observation table.
9. Calculate average value of earth resistance.
10. If the value is found more than 5 Ohm, pour water in funnel of earth electrode a measure the earth resistance.

XI Resources Used (Student should the required resources):

Sr. No.	**Name of resources**	**Broad Specification**	**Quantity**
1			
2			
3			
4			

XII Actual Procedure followed:

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XIII Observations and Calculations:

S.N.	Position of electrode	Earth resistance	Average Earth resistance
1	Current electrode 30m, Potential electrode 15m(from the main electrode)		
2	Current electrode 40m, Potential electrode 20m(from the main electrode)		
3	Current electrode 36m, Potential electrode 18m(from the main electrode)		
4	Current electrode 24m,Potential electrode 12m (from the main electrode)		

XIV Results:

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XV Interpretation of results (Giving meaning to the results):

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XVI Conclusions and Recommendations:

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XVII Practical Related Questions:

1. State the methods of reducing resistance of the earth electrode.
2. What will happen, if two earth electrodes are joined together?
3. What will be the effect of change in the speed of rotation of earth tester?
4. State the causes of higher value of earth resistance.
5. State the operating principle of earth tester.

[Space for answers]

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XVIII References / Suggestions for Further Reading:

1. https://electrical-engineering-portal.com/download-center/books-and-guides/power-substations/earth-resistance-testing
2. https://youtu.be/6RJnsa83xTA?si=No2XrxTpbOJnU3HL
3. https://www.electricaldeck.com/2021/06/earth-tester-or-earth-resistance-tester-construction-and-working.html

XIX Assessment Scheme:

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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

Practical No.16 : Connect the Zener diode in the circuit and test its operation in forward and reverse bias mode.

I Practical Significance:

Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits. The student will be able to plot the forward and reverse characteristics of the Zener diode and measure the Zener voltage

II Industry/Employer Expected Outcome(s):

Electrical and Electronic industries use different types of DC power supplies with different voltage and current ratings. Zener diode works as a voltage regulator in DC power supply. The Employee should be able to test Zener diode for its ratings.

III Course Level Learning Outcome(s):

Use relevant diode in different Electronic circuits.

IV Laboratory Learning Outcome(s):

LLO Check the forward and reverse VI characteristics of Zener diode.

V Relevant Affective Domain related outcome(s):

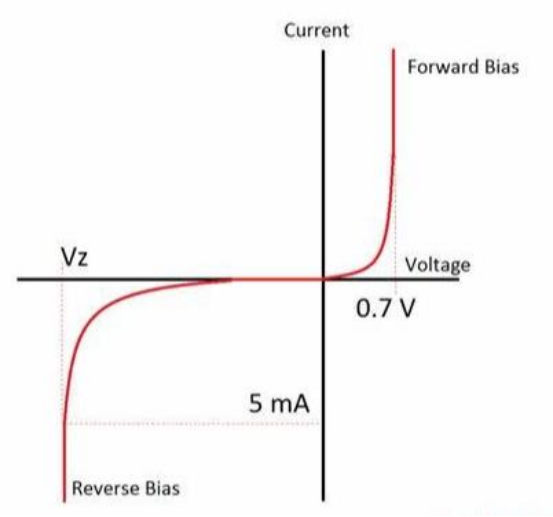
1. Handle components and equipment carefully.
2. Follow the safety precautions.

VI Relevant Theoretical Background (With diagrams if required):

Zener diode is formed by combining highly doped P and N semiconductor materials. It works on the principle of Zener breakdown and is normally operated in reverse breakdown region. In reverse breakdown region, high current flow through the diode leading to high power dissipation.

The Zener breakdown occurs when the electric field across the junction produced due to the reverse voltage is sufficiently high, this breaks covalent bonds. Thus a large numbers of carriers are generated which causes a more current to flow. This mechanism is called as Zener breakdown. After Zener breakdown the reverse current increases sharply but voltage across Zener diode remains constant. Zener resistance of a Zener diode is a ratio of reverse Zener voltage to the reverse Zener current.

Figure 1: Symbol of Zener diode



V-I Characteristics of Zener diode

VII Actual Circuit diagram used in laboratory with equipment Specifications:

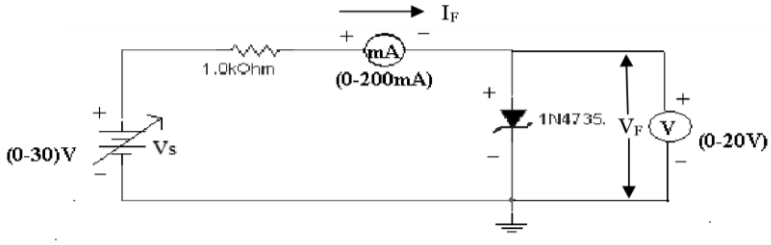


Figure 2: Zener diode in forward bias

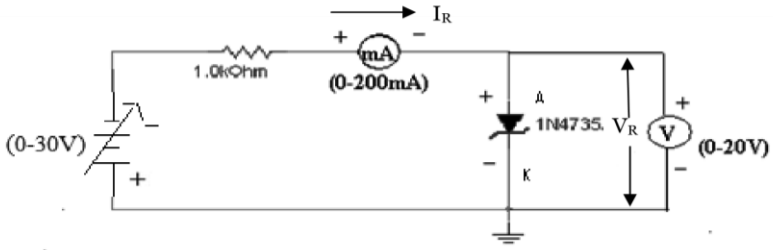


Figure 3: Zener diode in reverse bias

VIII Required Resources/apparatus/equipment with specification:

S.No.	Instrument /Components	Specification	Quantity
1	Digital Multimeter	Digital Multimeter	2
2	DC Regulated power supply	Variable DC power supply 0-30V,2A,SC protection, display for voltage and current.	1
3	Voltmeter	0-20V	1
4	Ammeter	(0-200ma,0-200μA)	1
5	Bread board	5.5CM X 17CM	1
6	Zener Diode	IN4735 (or any other equivalent diode)	1
7	Resistor	1KΩ(0.5watts /0.25 watta)	1
8	Connecting wires	Single strand Teflon coating(0.6mm diameter)	As per requirement

IX Precautions to be followed:

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the experiment do not exceed the input voltage of the Zener diode beyond the rated voltage of diode. This may lead to damaging of the diode.
3. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.

X Procedure:

1. Connect the circuit as shown in figure 2.
2. Switch ON the power supply.
3. Record the forward voltage and forward current in the observation table nol.
4. Increase the input voltage in step of 0.1 V
5. Record the forward voltage and forward current in the observation table nol.
6. Repeat steps 4 to 5 till 1 V is reached.
7. Plot the graph for the forward bias characteristics of Zener diode by taking forward voltage on X- axis and forward current on Y-axis.
8. Connect the circuit as shown in figure 3.
9. Vary input voltage gradually in steps of 1V up to 12V.
10. Record the corresponding readings of reverse voltage and reverse current in the observation table no2.
11. Plot the graph for the reverse bias characteristics of Zener diode by taking V_R on X- axis and I_R on Y-axis.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			

XII Actual procedure followed:

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XIII Observations and Calculations:

Table 1: Measurement of V_F and I_F

SR.NO	V_F(volt)	I_F(mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		

Table 2: Measurement of V_R and I_R

SR.NO	V_R(volt)	I_R(mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		

Calculations: $R_F=\Delta V_F/\Delta I_F$ **ohm**

$R_Z=\Delta V_R/\Delta I_R$ **ohm**

XIV Results:

1. Zener breakdown voltage =……V.
2. Zener resistance = …….Ω

XV Interpretation of Results:

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……

XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. What is the value of Zener voltage for given zener diode?

2. What is the maximum value of reverse current for given zener diode?

3. What is the effect on voltage across zener diode and current flowing through it, when reverse voltage across it is more than breakdown voltage?

4. What portion of zener diode characteristics is most useful for voltage regulation applications?

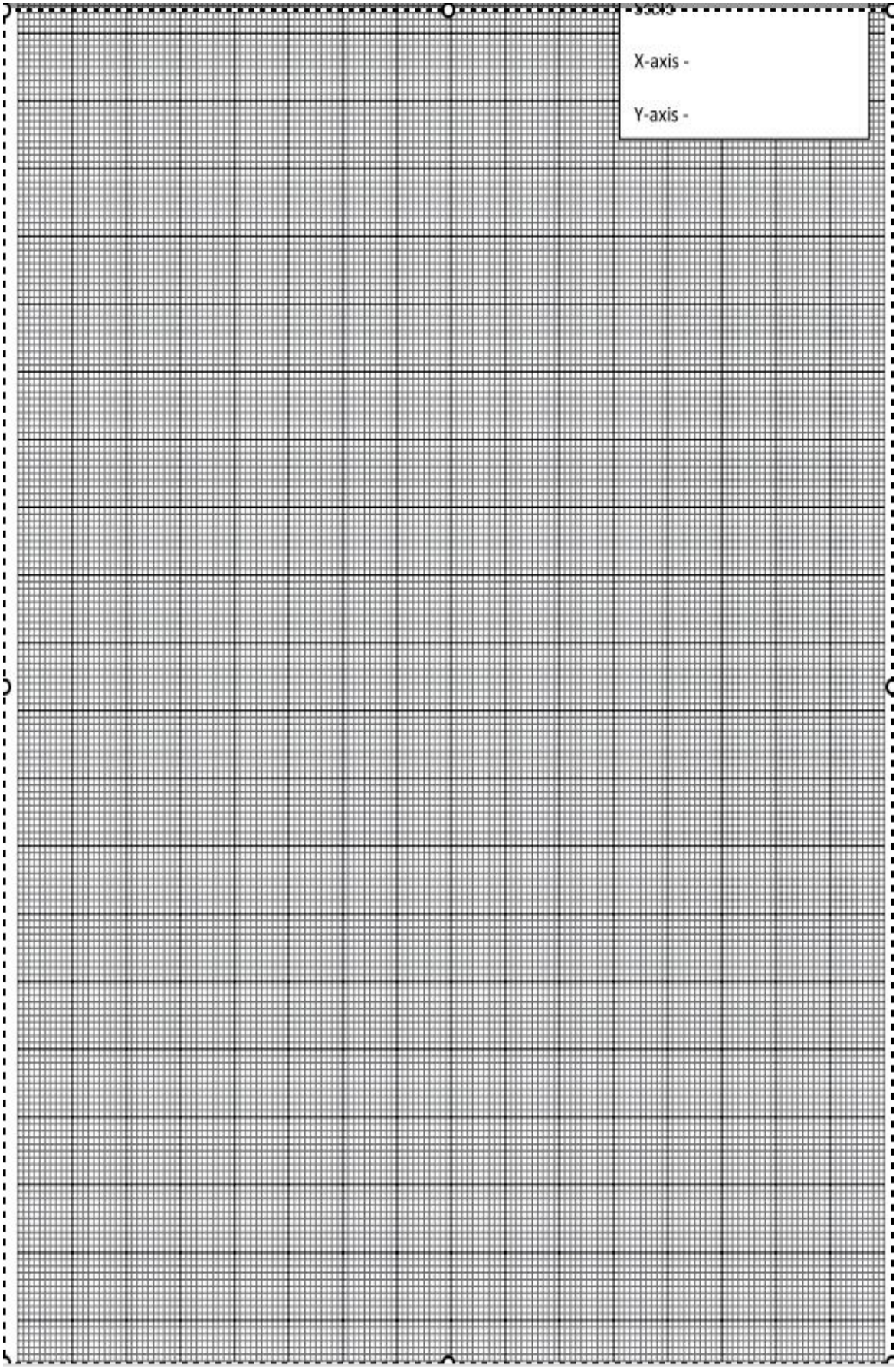
[Space for Answers]

XVIII References/ suggestions for further reading ; includes websites:
https://www.youtube.com/watch?v=itzPT3UbC1I

XIX Marking Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.17: Determine the voltage regulation by using zener diode under variable input and output conditions.

I Practical Significance:

It is required to provide regulated power supply to various circuits and Integrated Circuits. Zener diodes have a primary application as a voltage regulator. Various electronic equipment's and circuits require regulated power supply which can be provided by Zener voltage regulator. Student should be able to test zener as a voltage regulator for variable input and variable load.

II Industry/Employer Expected Outcome(s):

Electrical and Electronic industries use different types of DC power supplies with different voltage and current ratings. Zener diode works as a voltage regulator in DC power supply. Depending on the input voltage and required output voltage zener diode should be selected.

III Course Level Learning Outcome(s):

Use relevant diode in different Electronic circuits.

IV Laboratory Learning Outcome(s):

Find the voltage regulation of zener diode.

V Relevant Affective Domain related outcome(s):

1. Carefully handling of components and circuits.
2. Visually aesthetic connections.

VI Relevant Theoretical Background (With diagrams if required):

Zener diode is designed to operate in the breakdown region. It is possible to construct Zener diode with required breakdown voltage in reverse bias condition. After breakdown, Zener diode acts as a constant voltage source i.e. if the applied reverse voltage exceeds the Zener voltage; it keeps the voltage across the device constant. Since it acts as a constant voltage regulator i.e. it keeps the output voltage constant irrespective of changes in load current or changes in input voltage.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

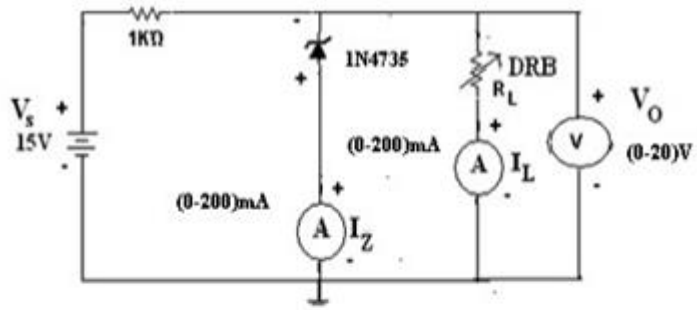


Figure 1: Load Regulation

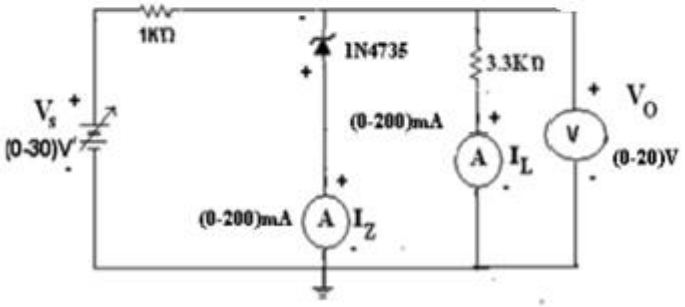


Figure 2: Line Regulation

VIII Required Resources/apparatus/equipment with specification:

S. No.	Instrument /Components	Specification	Quantity
1	Digital Multimeter	3 ½ digit display	1
2	DC Regulated power supply	Variable DC power supply 0-30V,2A, display for voltage and current.	1
3	Zener Diode	IN4735 (or any other equivalent diode)	1
4	DC Ammeter	0-200mA	02
5	Potentiometer	10KΩ	01
6	Resistor	1KΩ(0.5watts /0.25 watts)	1
7	Connecting wires	Single strand Teflon coating(0.6mm diameter)	As per requirement

IX Precautions to be followed:

1. Do not switch ON the power supply unless the circuit connection are checked as per the circuit diagram.
2. See the data sheet to know the reverse breakdown voltage of the given diode before Starting the experiment.
3. Connect Voltmeters/Ammeters in correct polarities as shown in the circuit diagram
4. Switch OFF the power supply after taking readings.

X Procedure:

1. Connect the circuit as per the circuit diagram.
2. Switch ON the power supply.

Load Regulation (Keep the Input voltage at 5V-10V)

1. By changing the Load Resistance $R_{L,}$ measure the corresponding output (Voltmeter) voltage.

2. Measure the current in the two ammeters to measure zener current Iz and Load current I_L

Line Regulation

Keep the Load resistance R_L constant. Vary the input supply Vs & note down the corresponding output voltage.

Graph

Plot the graph of Load current I_L (X-axis) Versus Load voltage Vo (Y-axis). Plot a graph between Input voltage Vs (X-axis) Versus Output Voltage Vo (Y-axis)

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

a. Load Regulation

Input Voltage V_S = ———-

Table: 1

Sr. No	I_Z(mA)	I_L(mA)	V_O(V)

Calculation: No Load Voltage V_{NL}- Output voltage across $R_L$when Load current is minimum. Full load Voltage V_{FL}- Output voltage across $R_L$when Load current is maximum.

b. Line Regulation

Ie: 2

Sr. No	V_S(V)	I_Z (mA)	I_L (mA)	V_O(V)

Calculations:

i. Load Regulation=$\frac{V_{NL}-V_{FL}}{V_{FL}}$ x 100 (From Table: 1)

ii. Line Regulation=$\frac{\Delta V_0}{\Delta V_S}$x 100 (From Table: 2)

XIV Results:

1. Zener breakdown voltage =…….
2. Forward resistance of zener diode = ……Ω

XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Give the value of input voltage when Zener current starts increasing?

2. For what value of Load resistance the Load current is Minimum?

3. For what value of Load resistance the Load current is Maximum?

4. Define zener breakdown?

[Space for Answers]

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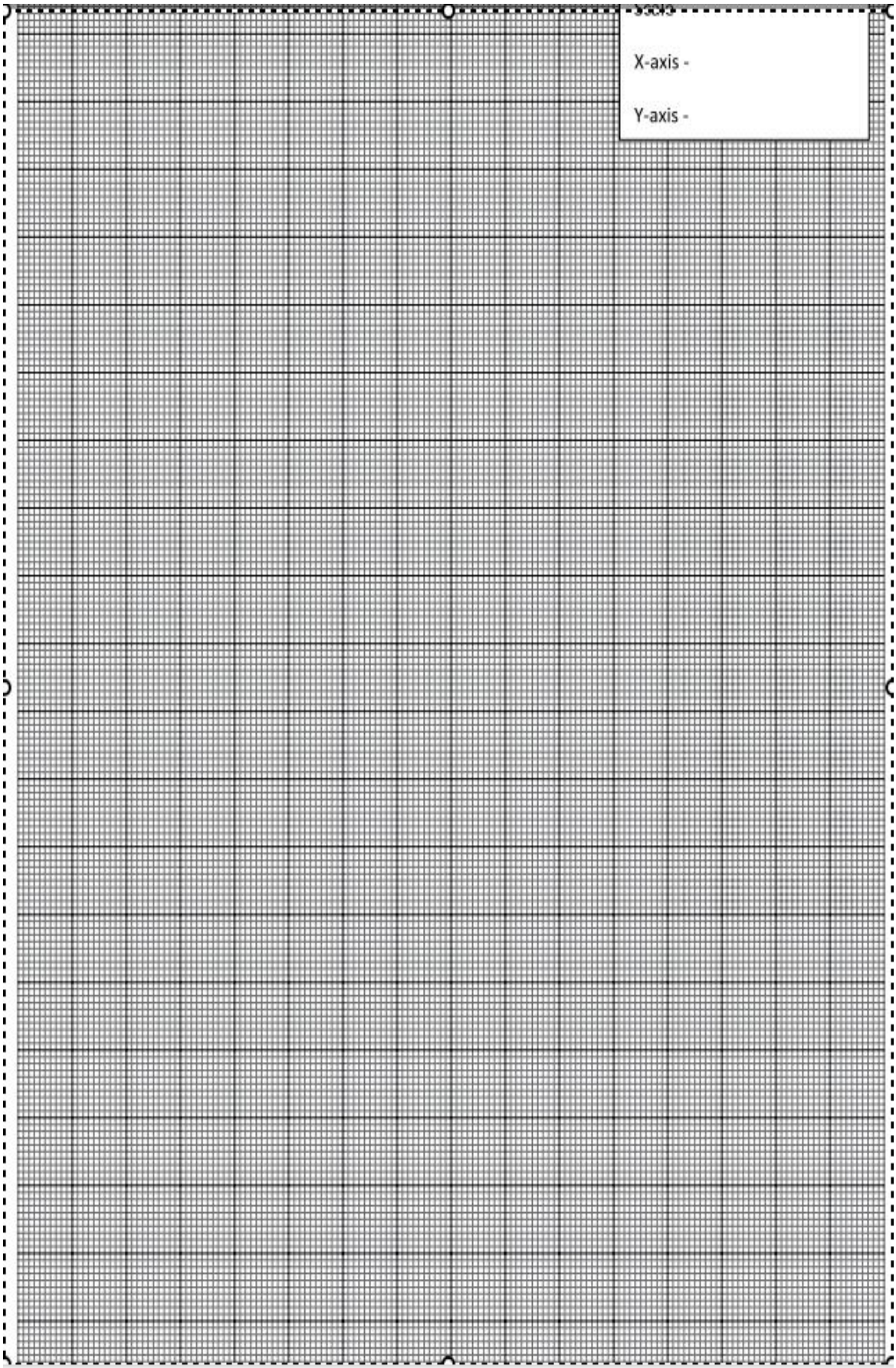
XVIII References/ suggestions for further reading ; includes websites:
https://www.youtube.com/watch?v=itzPT3UbC1I

S.No.	Title of Book/Website	Author	Publication
1	Applied Electronics	R.S.Sedha	S.Chand and Co.,New Delhi 2008,ISBN 978-8121927833
2	Principles of Electronics	V.K.Mehta	S.Chand and Co.,Ram Nagar,New Delhi-110055,11th Edition,2014,ISBN 978-812-192405

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.18: Check the output waveform of L, C and π filters on CRO of rectifier circuit.

I Practical Significance:

The device which converts the pulsating DC into pure DC is called filter. Voltage regulator keeps the terminal voltage of the D.C. power supply constant, even if the A.C. input to the transformer varies or the load varies. The electronic passive elements like capacitor and inductors are used to perform this function. In this experiment the student will be able to test the performance of L, C, LC and CLC filters.

II Industry/Employer Expected Outcome(s):

Filters play active role in different D.C. power supplies used in industries. Depending upon the application different types of filters or their combination can be selected and tested.

III Course Level Learning Outcome(s):

Use relevant diode in different Electronic circuits.

IV Laboratory Learning Outcome(s):

Filter the ripples by using L, C and π filter.

V Relevant Affective Domain related outcome(s):

1. Handle the components with care
2. Make aesthetically clean connections
3. Work in team
4. Follow ethical practices

VI Relevant Theoretical Background (With diagrams if required):

A rectifier is a circuit that converts the AC signal into pulsating DC. This pulsating DC is converted into pure DC by using filters circuits. A filter circuit consists of passive components like inductors, capacitors or their combination. For example, an inductor allows AC On the other hand, capacitor allows flowing AC through it, but blocks DC. Therefore capacitor filter is always connected in parallel with the load. Whereas inductor filter is connected in series with the load. Combination of L and C i.e. LC or CLC filters are also widely used for getting better filtered output.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

(a) Sample

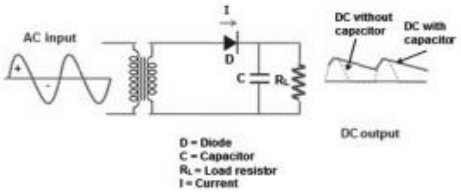


Figure1: Half wave rectifier with capacitor filter

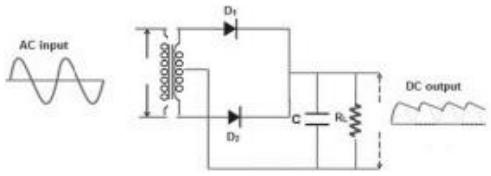


Figure 2: Full Wave rectifier with capacitor filter

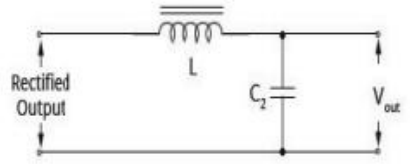


Figure 3: L-C Filter

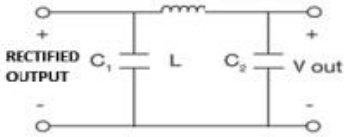


Figure4: C-L-C Filter

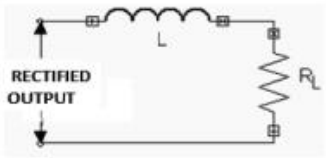


Figure 5: L Filter

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Instrument /Components	Specification	Quantity
1	Digital Multimeter	3 ½ digit display Digital Multimeter	1
2	Transformer(centre tapped)	6-0-6 V AC,500 mA	1
3	Diode	Silicon Diode IN4007	2
4	Resistor	1KΩ	1
5	Capacitor, Inductor	2.2πF,720mH	1
6	C.R.O.	0-20 MHz (Dual trace)	1
7	Connecting wires	Single strand	As per requirement
8	Any other		

IX Precautions to be followed:

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the experiment do not exceed the input voltage of the diode beyond the rated voltage of diode. This may lead to damage of the diode.
3. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.

X Procedure:

Part I

1. Connect the Electronic circuit for half wave rectifier on bread board as shown in Figure 1.
2. Connect the primary side of the transformer to AC mains and the secondary side to rectifier input
3. Before switching on power supply, check the connection.
4. Switch ON the power supply and set CRO in DC mode adjust level accurately.
5. Observe the Waveforms across load resistance R_1 for capacitor filter.
6. Connect the inductor as shown in Figure 5 and observe the waveform across load resistor

Part II

1. Connect the Electronic circuit for Full wave rectifier on bread board as shown in Figure 2.
2. Connect the primary side of the transformer to AC mains and the secondary side to rectifier input.
3. Before switching on power supply, check the connection.
4. Switch ON the power supply and set CRO in DC mode adjust level accurately.
5. Observe the Waveforms across load resistance R_1 for capacitor filter.
6. Connect the inductor as shown in Figure 5 and observe the waveform across load resistor
7. Compare waveforms observed for half wave rectifier and full wave rectifier

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

S.No.	Rectified output (V_m)	V_{dc} (V) measured without filter on CRO	V_{dc} (V) measured without filter on DMM	V_{dc} (V) measured with filter on CRO	V_{dc} (V) measured with filter on DMM
1					

Calculations:

$V_{dc}=V_m/\pi$

XIV Results:

V_{dc} calculated = …….V

XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. State the effect on output voltage if we replace the capacitor filter with pi filter.
2. Compare output wave form of LC filter and CLC filter for half wave rectifier as well as full wave rectifier
3. Draw the circuit diagram of bridge rectifier with pi filter.

[Space for Answers]

XVIII References/ suggestions for further reading ; includes websites:

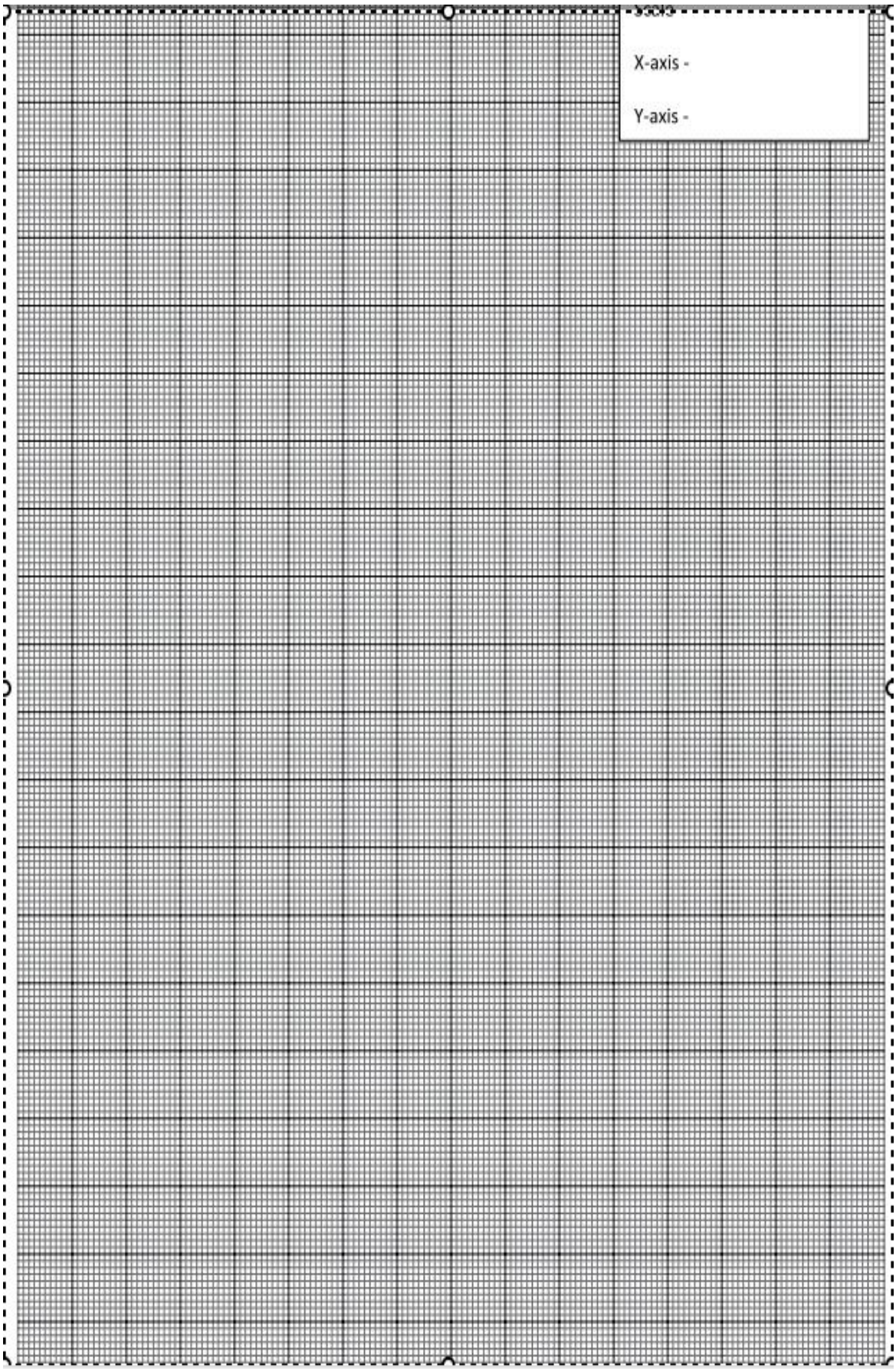
1. http://nptel.ac.in/courses/117103063/4
2. http://eecs.oregonstate.edu/education/docs/datasheets/XC-600178.pdf

S. No.	Title of Book / Website	Author	Publication
1	Applied Electronics	R.S.Sedha	S. Chand and Co., New Delhi 2008,ISBN 978-8121927833
2	Principles of Electronics	V.K.Mehta.	S. Chand and Co., Ram Nagar,New Delhi-110055,11th Edition,2014.ISBN 978-812-192405

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.19: Make the input and output connections of UPS and measure the output voltage under online and offline mode

I Practical Significance:

Uninterruptible Power Supplies (UPS) have important role in various applications where a reliable and continuous power supply is required.

II Industry/Employer Expected Outcome(s):

In industrial, domestic, commercial applications, continuous AC mains supply is needed. The employee is expected to select UPS of suitable ratings and test it under online and offline mode.

III Course Level Learning Outcome(s):

Use relevant diode in different Electronic circuits.

IV Laboratory Learning Outcome(s):

Check the operation of UPS under online and offline mode.

V Relevant Affective Domain related outcome(s):

1. Handle the equipments and components carefully.
2. Follow safety precautions.

VI Relevant Theoretical Background (With diagrams if required):

The purpose of a UPS is to provide emergency power (usually by a lead/acid battery) to a load when it senses that the input power source has failed. They are different from emergency power systems or standby generators because they provide near-instantaneous protection from power interruption by using a battery (which can be a super capacitor or flywheel). The battery itself usually has a short runtime (about 5-20 minutes), but it should be enough to either save all that precious data/progress that you have made, gracefully shut everything down, or fix the problem that caused the outage. A UPS can be used to protect hardware like data centers, computers, and other electrical equipment where an unexpected surge/sag can cause serious problems like data loss, business disruption, and even injuries or fatalities.

Types of Uninterruptible Power Supplies

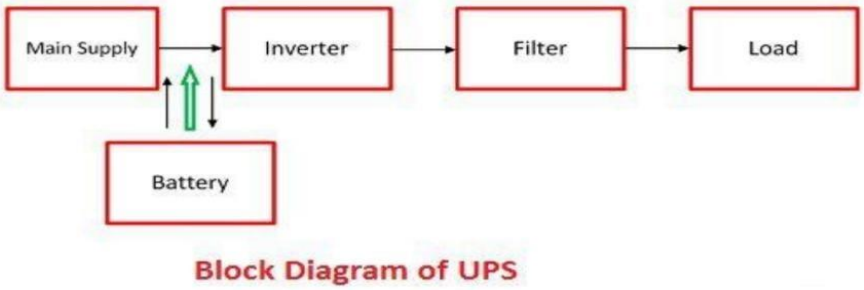
There are three types of uninterruptible power supplies: static, dynamic (rotary), and hybrid. Static uses power electronic converters, dynamic uses electromagnetic engines (generators and motor), and hybrid uses a combination of both static and dynamic.

1. Offline/Standby Uninterruptible Power Supply

The offline/standby UPS is the most basic out of the three. It provides light surge protection and battery back-up. During normal operations, it gets its power from its main power source (generally an AC outlet). Once it senses that the main power source goes beyond acceptable limits or fails, it switches to the "offline/standby" battery where it will then go to the DC/AC inverter power source and battery as such, there will be a small transfer time between the main

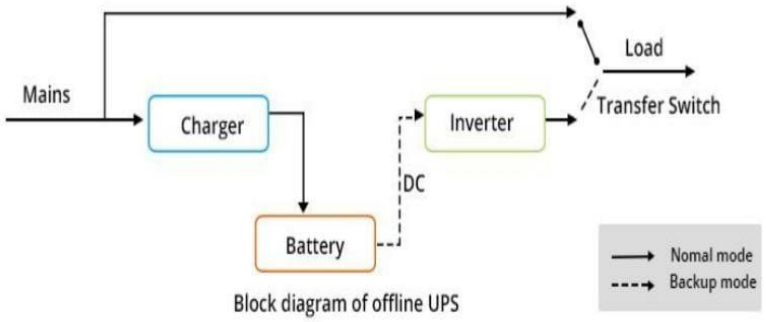
2. Online/Double Conversion Uninterruptible Power Supply

The online/double conversion UPS differs from the offline/standby as the DC/AC inverter is always connected on. This means there will be no transfer time between the main power source and battery, providing greater protection against spikes, sags, electrical noise, and complete power failure.

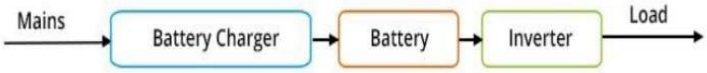


Block Diagram of UPS

VII Actual Circuit diagram used in laboratory with equipment Specifications:



Block diagram of offline UPS



Block diagram of online UPS

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1.	UPS	Input voltage- 230V AC ±15% single phase Output Voltage- 230V ±1% single phase Power capacity- 1kVA Frequency- 50 Hz ±0.5Hz	1
2.	Digital Multimeter	DMM:3 ½ digit display	1

VIX Precautions to be followed:

1. Do not install UPS in an outdoor area that is open to direct sunlight, moisture, thunderstorms or other drastic climatic conditions.
2. Only a skilled technician should do battery replacement.
3. Do not open the UPS cover unnecessarily.
4. If at all, you have to open the cover for checking any fault, it should be done only after switching the UPS off and disconnecting it from the mains.

X Procedure:

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.

Mains 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.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
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XII Actual procedure followed:

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XIII Observations and Calculations:

Sr.No.	Operating conditions	Input Voltage	Output Voltage
1.	Online Mode		
2.	Offline Mode		

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. What is mean by UPS?
2. List types of UPS.
3. List applications of UPS.
4. State the need of UPS.

[Space for Answers]

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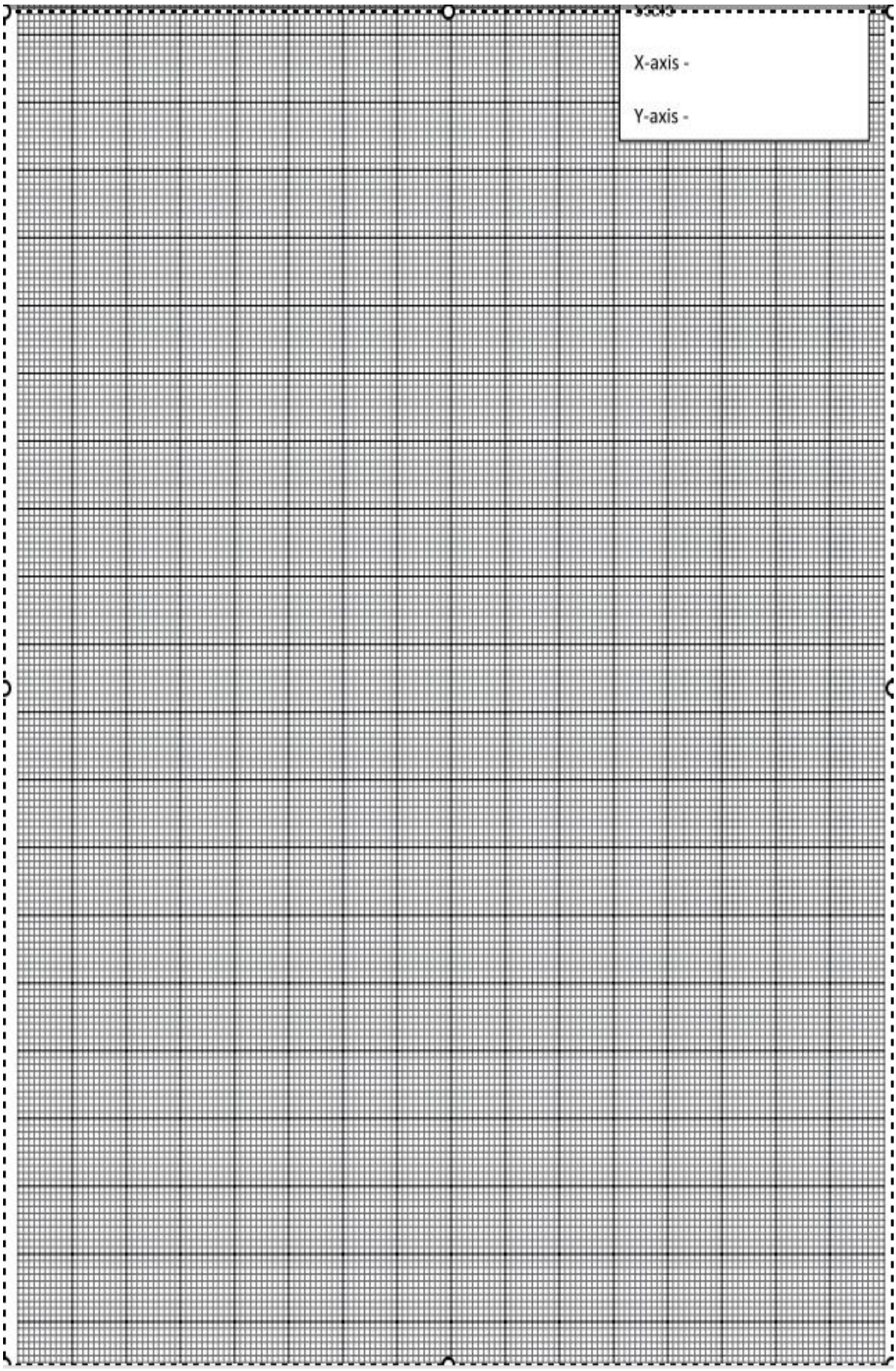
XVIII References/ suggestions for further reading ; includes websites:

1. UPS Working Principle and Types - Offline and Online UPS Systems
2. Microsoft Word - MpBe002c_Energieeffizienz von USV-Anlagen_Schlussbericht.doc

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.20: Make the input and output connections and check the operation of UPS under normal and overload condition

I Practical Significance:

Uninterruptible Power Supplies (UPS) have vital role in various applications where a reliable and continuous power supply is essential.

II Industry/Employer Expected Outcome(s):

In industrial, domestic and commercial applications continuous AC mains supply is needed. This can be provided by UPS. The employee is expected to select UPS of suitable ratings and test it under normal and overload conditions.

III Course Level Learning Outcome(s):

Use relevant diode in different Electronic circuits.

IV Laboratory Learning Outcome(s):

Check the abnormal and normal operation of UPS.

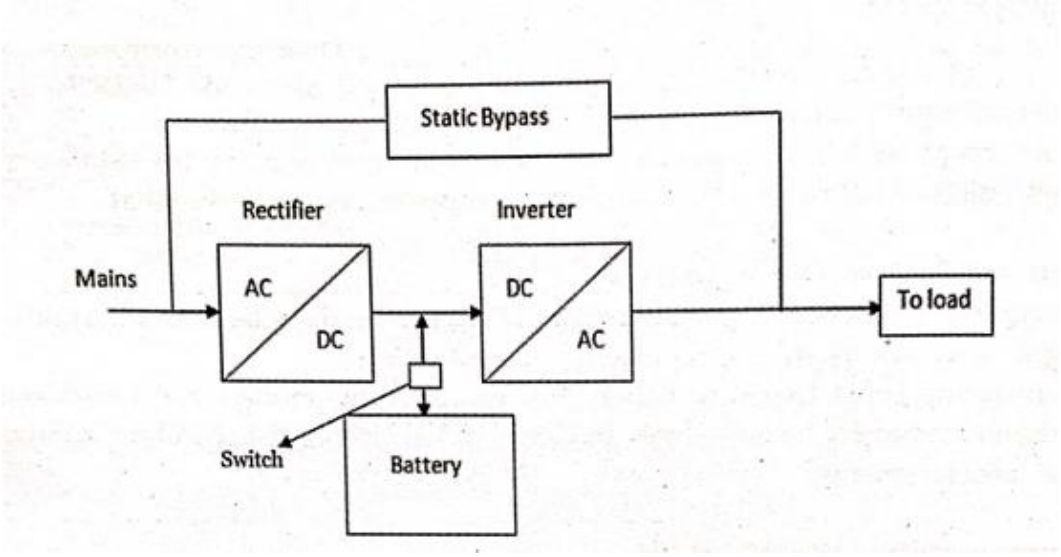
V Relevant Affective Domain related outcome(s):

1. Handle the equipment's and components carefully.
2. Follow safety precautions.

VI Relevant Theoretical Background (With diagrams if required):

In normal operation, a double-conversion UPS continually processes power twice. If the AC input supply falls out of predefined limits, however, the input rectifier shuts off and the output inverter begins drawing power from the battery instead. If you overload your UPS, it will either shut down or the load will be transferred to by- pass until the condition is reversed. When this happens, all of the devices connected to it will lose power.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1.	UPS	Input voltage- 230V AC ±15% single phase Output Voltage- 230V ±1% single phase Power capacity- 1kVA Frequency- 50 Hz ±0.5Hz	1
2.	Digital Multimeter	DMM:3 ½ digit display	1

IX Precautions to be followed:

1. Do not install UPS in an outdoor area that is open to direct sunlight, moisture, thunderstorms or other drastic climatic conditions.

2. Only a skilled technician should do battery replacement.

3. Do not open the UPS cover unnecessarily.

4. If at all, you have to open the cover for checking any fault, it should be done only after switching the UPS off and disconnecting it from the mains.

X Procedure:

a. When the load is OFF

1. Measure output voltage of UPS with the help of multimeter.
2. Measure Backup time with the help of stop watch.

b. When the load is overload

1. Measure output voltage of UPS with the help of multimeter.
2. Measure Backup time with the help of stop watch.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
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XII Actual procedure followed:

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XIII Observations and Calculations:

When the load is OFF

1. Output voltage of UPS …….. Volts
2. Backup time =. .....min.

When the load is overload:

1. Output voltage of UPS ..... Volts
2. Backup time. ...min.

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Write the technical specifications of the given UPS.
2. Write the type of battery used in UPS.
3. State the backup time of the UPS used.
4. List applications of UPS.

[Space for Answers]

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XVIII References/ suggestions for further reading ; includes websites:

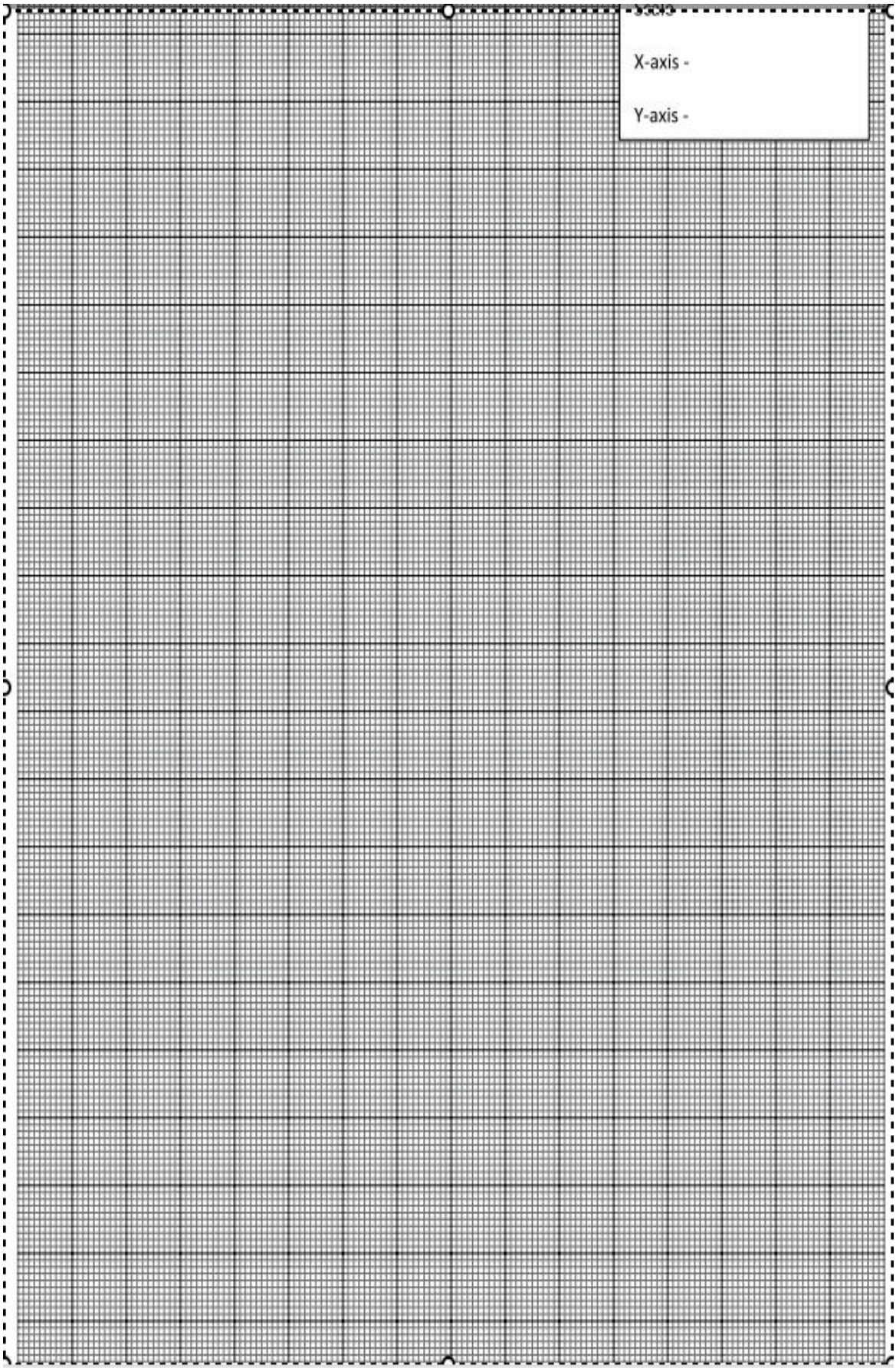
1. UPS Working Principle and Types - Offline and Online UPS Systems

2. Microsoft Word - MpBe002c_Energieeffizienz von USV-Anlagen_Schlussbericht.doc

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.21: Test input/output characteristics of NPN transistor in CE Configuration.

I Practical Significance:

A BJT is commonly used as an amplifier. Common Emitter (CE) mode is the universal mode of operation for a BJT. All types of amplifications can be performed using CE mode with suitable biasing. Common-emitter amplifiers are also used in radio frequency circuits..

II Industry/Employer Expected Outcome(s):

Amplifier circuits are used in all electronic equipment used in industries. Employee should be able select suitable type of transistor and configuration for given application.

III Course Level Learning Outcome(s):

Use BJT and FET in various Electronic circuits.

IV Laboratory Learning Outcome(s):

Check the operation of NPN Transistor under CE Configuration.

V Relevant Affective Domain related outcome(s):

1. Handle components and equipment carefully.
2. Work in team.

VI Relevant Theoretical Background (With diagrams if required):

BJT is called as Bipolar Junction transistor. It has 3 terminals namely emitter, base and collector. It is called bipolar device because current through it is due to free elctrons and holes. A transistor can be in any of the three configurations namely common base, common emitter and common collector.

The relation between of α,β and γ of CB, CE & CC are

$\alpha = \beta / 1+\beta$

$\beta = \alpha/1-\alpha$

$\gamma = 1+\beta = 1/1-\alpha$

In CE configuration base will be the input node and collector will be output node. Emitter is common to both input and output and hence the name common emitter configuration. A transistor in CE configuration is used widely as an amplifier

Symbol:

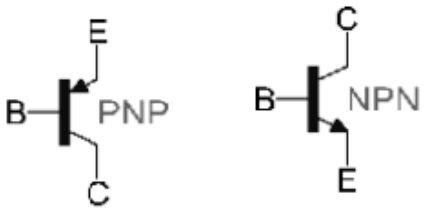


Figure 1: Symbol of BJT

Input Characteristics:

This curve gives the relationship between input current (I_B) and input voltage (V_{BE}) for constant output voltage (V_{CE}) By varying V_{BE} for constant V_{CE} it may be noted that below knee voltage current is very small. Beyond knee voltage, the base current (I_B) increases with increase in V_{BE} for constant V_{CE}

Input characteristics may be used to determine the value of common emitter transistor a.c. input resistance r_i. It is the ratio of change in base to emitter voltage (ΔV_{BE}) to resulting change in base current (I_B) at a constant collector to emitter voltage (V_{CE}).

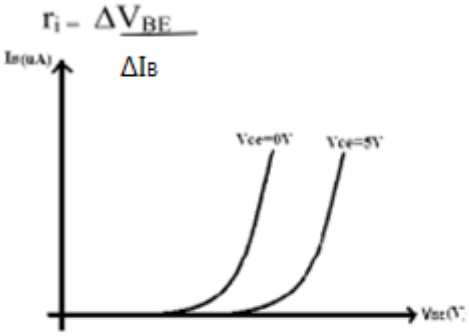


Figure 2: Input Characteristics of BJT in CE mode

Output Characteristic:

This curve gives the relationship between output current (I_C) and output voltage (V_{CE}) for constant base current (I_B).

The output characteristics are divided into three regions:

Cut off region: Transistor act as off switch.

Saturation region: Transistor act as on switch.

Active region: Transistor act as amplifier.

Output Characteristic may be used to determine the value of common emitter transistor a.c. output resistance r_o it is the ratio of change in collector to emitter voltage (ΔV_{CE}) to resulting change in collector current (ΔI_C) at a constant base current (I_B)

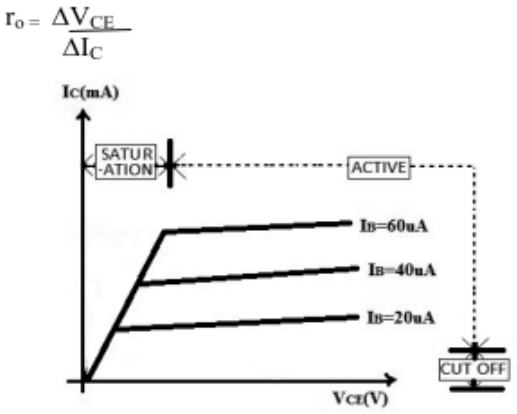


Figure 3: Output Characteristics of BJT in CE mode

VII Actual Circuit diagram used in laboratory with equipment Specification:

(a) Sample

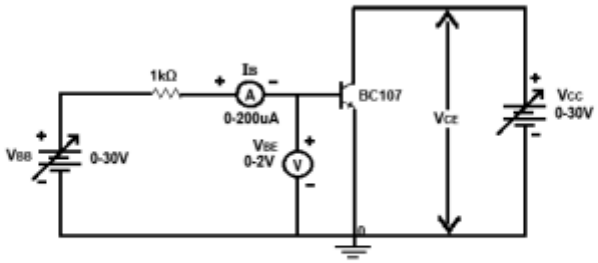


Figure: 3 Circuit diagram for Input Characteristics

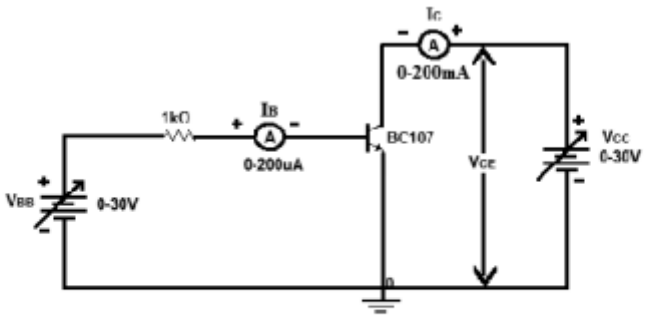


Figure 4: Circuit diagram for Output Characteristics

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Name of Resource	Suggested Specification	Quantity
1	DC power supply	0-30 V	2 no.
2	DC Voltmeter	(0-2V),(0-20V)	1 no.
3	DC Ammeter	(0-50milliamps),(0-500µA)	1 no.
4	Transistor	BC107	1 no.
5	Resistor	1KΩ	1 no.
6	Any other		

IX Precautions to be followed:

1. Care should be taken while handling terminals of components.
2. Select proper range and mode of ammeter and voltmeter.
3. Connect wires tightly while building circuit.
4. Show the connections to concerned teacher and then switch ON the power supply.

X Procedure:

Part I Input characteristics:

1. Connect the electrical circuit as shown in Figure 3.
2. Select suitable range of milli-ammeter, voltmeter and power supply.
3. Switch on the power supply and adjust the voltage V_{CE}=2V by varying Vcc
4. Vary the input voltage V_{BE} in steps of 0.1V and measure the current I_B for each Step.
5. Repeat the steps 3 and 4 for V_{CE} values of 5V and 10V.
6. Tabulate the readings

Part II Output characteristics:

1. Connect ammeter and adjust base current I_B.
2. Select suitable range of milli-ammeter, voltmeter and power supply.
3. Switch on the power supply and apply a constant current I_B=20 µA.
4. Vary V_{CE} from 0 to 10V is steps of 0.5 volts. Measure corresponding collective current I_C for each step.
5. Repeat steps 9 and 10 for various values of I_B=30 µA and 40 µA
6. Tabulate the readings

Graph

Plot a graph of V_{BE} (V) (X-axis) versus I_B(µA) (Y-axis) for different V_{CE} voltages.

Plot a graph of V_{CE} (V) (X-axis) versus I_C (mA) (Y-axis) for different I_B (µA) currents.

Calculate dynamic input resistance using the formula given below

$$r_i = \left.\frac{\Delta V_{BE}}{\Delta I_B}\right|_{V_{CE}} = \text{----------}$$

Calculate dynamic output resistance using the formula given below.

$$r_o = \left.\frac{\Delta V_{CE}}{\Delta I_C}\right|_{I_C} = \text{----------}$$

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
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XII Actual procedure followed:

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XIII Observations and Calculations:

Table 1: Input characteristics

S.No.	V_{CE}=……V		V_{CE}=……V		V_{CE}=……V	
	V_{BE} (V)	I_B(µA)	V_{BE} (V)	I_B(µA)	V_{BE} (V)	I_B(µA)
1						
2						
3						
4						
5						
6						

Table 2: Output characteristics

S.No.	I_B=…….. µA		I_B=…… µA		I_B=……. µA	
	V_{CE} (V)	I_C(mA)	V_{CE} (V)	I_C(mA)	V_{CE} (V)	I_C(mA)
1						
2						
3						
4						
5						
6						

Calculations:

$$r_i = \frac{\Delta V_{BE}}{\Delta I_B}$$

$$r_o = \frac{\Delta V_{CE}}{\Delta I_C}$$

$$\beta = \frac{I_C}{I_B}$$

XIV Results:

1. Input resistance =……. Ω
2. Output resistance =……. Ω
3. Current amplification factor β = ……

XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Write the steps to identify emitter, base and collector terminals of given transistor.
2. State the range of ammeter and voltmeter selected
3. The BJT has I_B-10 µA, I_{CO}=1 µA what is collector current I_C? (Take value of β obtained from the graph)?

[Space for Answers]

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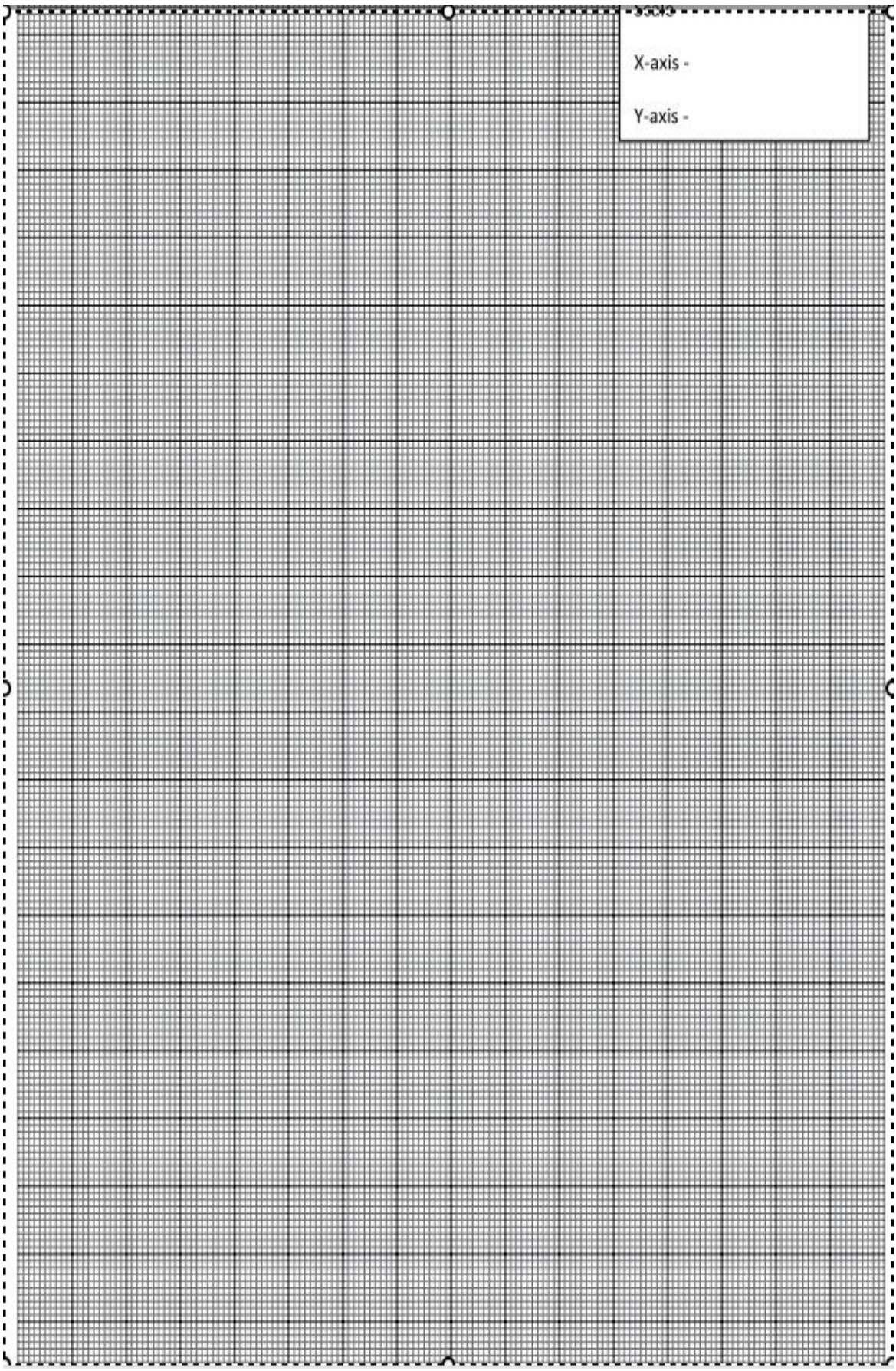
XVIII References/ suggestions for further reading ; includes websites:

S. No.	Title of Book / Website	Author	Publication
1	Applied Electronics	R.S.Sedha	S. Chand and Co., New Delhi 2008,ISBN 978-8121927833
2	Principles of Electronics	V.K.Mehta.	S. Chand and Co., Ram Nagar ,New Delhi-110055,11th Edition,2014.ISBN 978812192405
3	Web References		a. https://www.electrical4u.com/transistor-characteristics/ b. http://nptel.ac.in/courses/117107095/10

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.22: Test input/output characteristics of NPN Transistor in CB Configuration.

I Practical Significance:

A BJT Transistor is a semiconductor device used as an amplifier or switch electronic signals & electrical power. In this Practical students will plot the characteristics of NPN transistor in input output mode. CB configuration is commonly used for amplifiers that require low input impedance such as microphones.

II Industry/Employer Expected Outcome(s):

Amplifier circuits are necessary in all electronic equipment used in industries. Employee should be able to select suitable type of transistor and configuration for given application.

III Course Level Learning Outcome(s):

Use BJT and FET in various electronic circuits.

IV Laboratory Learning Outcome(s):

Check the operation of NPN Transistor under CB configuration.

V Relevant Affective Domain related outcome(s):

1. Handle components and equipment carefully.
2. Work in team

VI Relevant Theoretical Background (With diagrams if required):

Input characteristics for CB configuration:

The curve given in figure 1 gives the relationship between input current (I_E) and input voltage (V_{EB}) for constant output voltage (V_{CB}). By varying V_{EB} for constant V_{CB} it may be noted that below knee voltage current is very small. Beyond knee voltage, the Emitter current (I_E) increases with small increase in emitter to base voltage V_{EB} for constant V_{CB}. As the collector to Base voltage is increased above 1V, the curve shifts upwards. Input characteristics used to determine the value of common base transistor AC input resistance r_i. It is the ratio of change in emitter to base voltage (ΔV_{EB}) to resulting change in emitter current (I_E) at a constant collector to base voltage (V_{CB}).

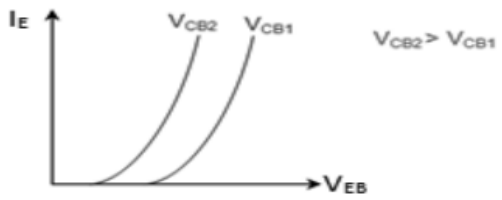


Figure 1: Input Characteristics for CB

Output Characteristics for CB configuration:

This curve gives the relationship between output current (I_C) and output voltage (V_{CB}) for a constant emitter current (I_E).

The output characteristics are divided into three regions:

Cut off region: Transistor act as OFF switch

Saturation Region: Transistor act as ON switch

Active Region: Transistor acts as amplifier.

Output characteristics may be used to determine the value of common base transistor Output resistance r_o. It is the ratio of change in collector to base voltage (ΔV_{CB}) to resulting change in Collector current (ΔI_C) at a constant emitter current (I_E).

$$R_i = \frac{\Delta V_I}{\Delta I_E} \quad r_i =$$

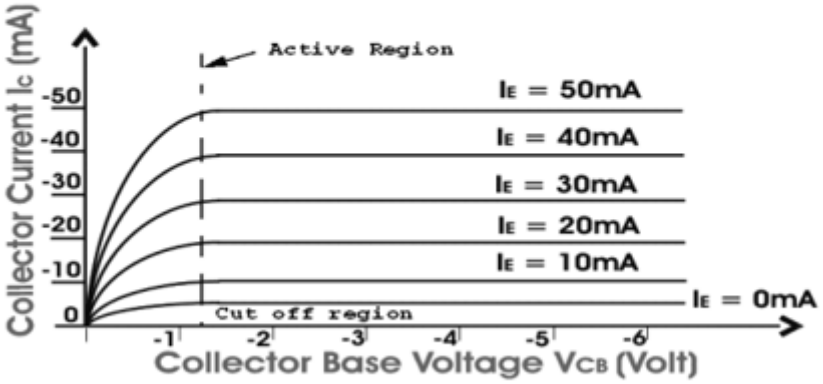


Figure 2: Output Characteristics for CB

VII Actual Circuit diagram used in laboratory with equipment Specifications:

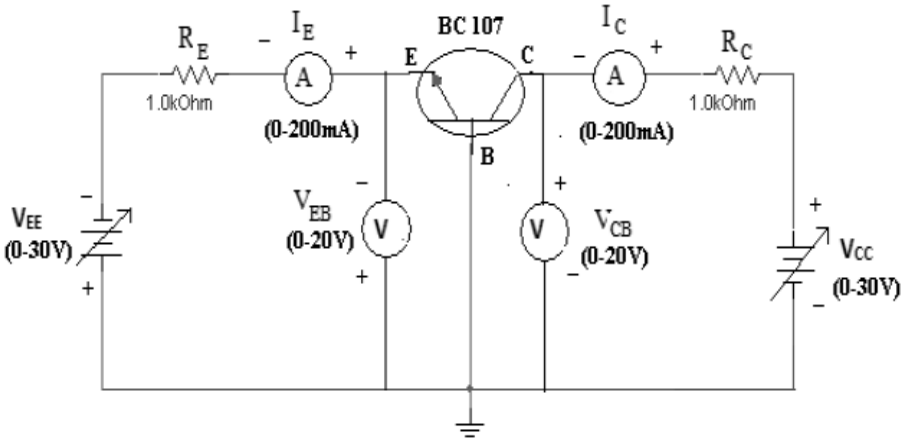


Figure 3. Circuit diagram of BJT in CB mode

VIII Required Resources/apparatus/equipment with specification:

S.No.	Instrument /Components	Specification	Quantity
1	Digital Multimeter	Digital Multimeter	2
2	DC Regulated power supply	Variable DC power supply 0-30V,2A,SC protection, display for voltage and current.	1
3	Voltmeter	0-20V,0-2V	1
4	Ammeter	(0-200ma,0-200µA)	1
5	Bread board	5.5CM X 17CM	1
6	Transistor	BC107(or any other equivalent)	1
7	Resistor	1KΩ(0.5watts /0.25 watt)	1
8	Connecting wires	Single strand Teflon coating(0.6mm diameter)	As per requirement

IX Precautions to be followed:

1. Care should be taken while handling terminals of components.
2. Select proper range of ammeter and voltmeter.
3. Connect wires tightly while building circuit..

X Procedure:

Part I Input characteristics:

1. Connect the circuit as shown in figure 3.
2. Keep output voltage V_{CB}= 0V by varying V_{CC}.
3. Vary V_{EB} in step of 0.1V from 0 to 1 V and note down the corresponding emitter current I_E 4. Repeat above procedure (step 3) for V_{CB}= 4V.

Part II Output characteristics:

1. Connect the circuit as shown in figure 3.
2. Keep input current I_E= 0mA by varying V_{EE}.
3. Vary V_{CB} in step of 1V from 1 to 10 V and note down the corresponding collector current Ic.
4. Repeat above procedure (step 3) for I_E-=10m

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
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XII Actual procedure followed:

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XIII Observations and Calculations:

Table 1: Input Characteristics

S. No.	V_{CB}=0V		V_{CB} =4V	
	V_{EB} (V)	I_E(mA)	V_{EB} (V)	I_E(mA)
1				
2				
3				
4				
5				
6				

Table 2: Output Characteristics

S. No.	I_E(mA)=0		I_E(mA)=10	
	V_{CB} (Volts)	**I_C (mA)**	**V_{CB} (Volts)**	**I_C (mA)**
1				
2				
3				
4				
5				
6				

Calculation:

1. Input resistance r_i:

$$r_i = \frac{\Delta V_{EB}}{\Delta I_E}$$

2. Output resistance r_o:

$$r_o = \frac{\Delta V_{CB}}{\Delta I_C}$$

3. Current amplification factor α:

$$\alpha = \frac{I_C}{I_E}$$

XIV Results:

1. Input resistance r_i: = Ω

2. Output resistance r_o: = Ω

4. Current amplification factor α:

XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Define α and β.
2. Compare CB & CE configuration.
3. Explain why CE configuration is preferred for amplification.

[Space for Answers]

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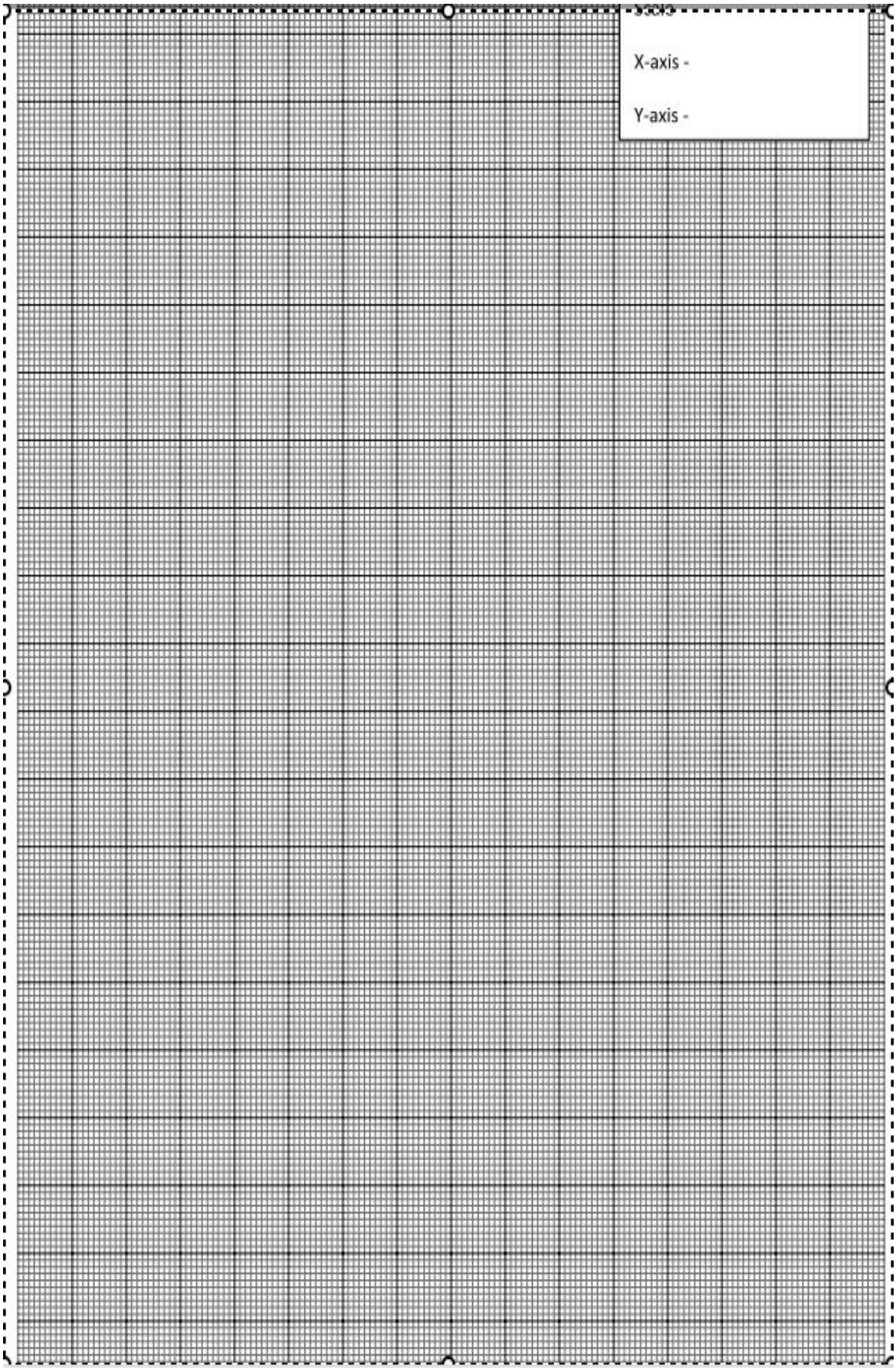
XVIII References/ suggestions for further reading ; includes websites:

1. https://www.electrical4u.com/transistor-characteristics/
2. http://nptel.ac.in/courses/117107095/11

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.23: Check the switch ON and switch OFF condition of LED by using transistor.

I Practical Significance:

The purpose of the Practical is to design and analyse the operation of transistor as a switch. Also, to test a suitable driver circuit and multi vibrators circuits for a given application using transistor.

II Industry/Employer Expected Outcome(s):

Many industrial application uses high frequency switching technique in electronic instruments. Employee should select and test different types of transistors as a high frequency switch.

III Course Level Learning Outcome(s):

Use BJT and FET in various electronic circuits.

IV Laboratory Learning Outcome(s):

Check operation of transistor for ON and OFF condition.

V Relevant Affective Domain related outcome(s):

1. Handle components and equipment carefully.
2. Work in team

VI Relevant Theoretical Background (With diagrams if required):

A transistor can function as a single-pole single-throw switch controlled by an electronic signal driving the base terminal. When the control signal on the base terminal turns the transistor off, it acts like an open switch. When the control signal on the base terminal turns the transistor on, it acts like a closed switch. When transistor is used for switching, it is in one of two states on or off . In the off state, the base bias current is zero and the transistor is in cut off region. In the on state, the base bias current is set large enough to drive the transistor into saturation region.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

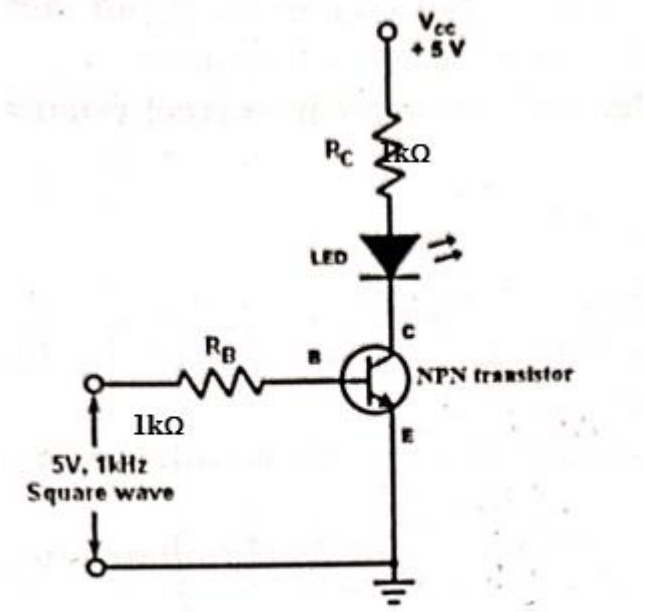


Figure 1: Transistor as a switch

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Instrument /Components	Specification	Quantity
1	CRO	30MHz	1
2	Function Generator	3MHz	1
3	Dual regulated power supply	0-30V	1
4	Digital Multimeter	Digital Multimeter: 3 ½ digit display.	1
5	Transister	BC107 or any other equivalent	1
6	Resister	1KΩ(0.5watts/0.25watts)	2
7	LED	3mm,Red/Green	1
8	Bread board	5.5CM X 17CM	1
9	Connecting wires	Single strand Teflon coating(0.6mm diameter)	As per requirement

IX Precautions to be followed:

1. Do not switch ON power supply unless you have checked the circuit connections as per circuit diagram.
2. While doing Practical do not exceed the input voltage of the transistor beyond its rated voltage. This may lead to damaging of transistor.
3. Connection voltmeter and ammeter in correct polarities as shown in the circuit diagram.

X Procedure:

1. Connect the circuit as shown in Figure wave to the base.
2. Apply 5V, 1 kHz square wave to the base.
3. Apply +5V dc voltage to collector.
4. Observe the input and output waveforms simultaneously using oscilloscope.
5. Apply OV square wave to the base.
6. Observe the input and output waveforms simultaneously using oscilloscope.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
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XII Actual procedure followed:

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XIII Observations and Calculations:

Sr. No.	Region	Input Voltage	Output Voltage	Switch ON\OFF
1.	Cut-off	0V		
2.	Saturation	5V		

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Compare the theoretical and practical values of parameters in cut off and saturation mode.
2. List applications of transistor as a switch.
3. State the operating regions in which a transistor acts as a switch.

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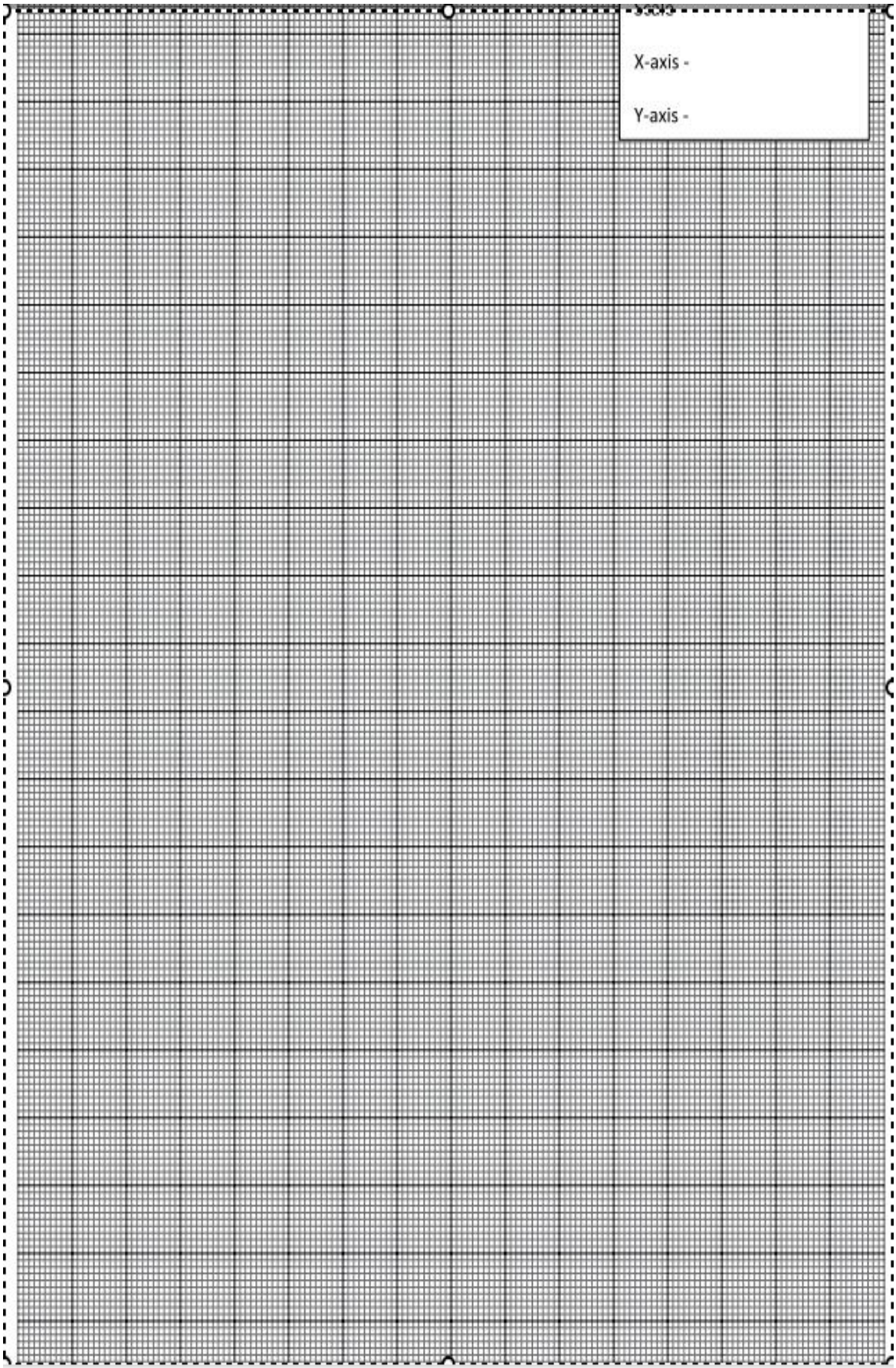
XVIII References/ suggestions for further reading ; includes websites:

1. https://www.electrical4u.com/transistor-characteristics/
2. http://nptel.ac.in/courses/117107095/11

XIX Suggested Assessment Scheme:

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.24: Determine the drain and transfer characteristics of FET.

I Practical Significance:

The field-effect transistor (FET) is a transistor that uses an electric field at the gate to control the electrical behaviour of the FET. JFETs are known as unipolar transistors since they involve single-carrier-type operation. Field effect transistors have a very high input impedance at low frequencies. In this Practical students will plot Drain and Gate Transfer characteristics of JFET. FET are used in high frequency applications.

II Industry/Employer Expected Outcome(s):

FET switch and FET amplifier are employed in high frequency circuits in electronic industries. The employee should be able to select suitable type of transistor and configuration for given applications.

III Course Level Learning Outcome(s):

Use BJT & FET in various electronic circuits.

IV Laboratory Learning Outcome(s):

Use FET (BFW10) to plot drain and transfer characteristics.

V Relevant Affective Domain related outcome(s):

1. Handle equipment and component carefully.

VI Relevant Theoretical Background (With diagrams if required):

Junction Field Effect Transistors are a type of FETs (high input impedance devices) which have three terminals namely Source (S), Gate (G) and Drain (D). These devices are also called voltage controlled devices as the voltage applied at the gate terminal determines the amount of current flowing in-between the drain and the source terminals.

N-channel JFET

N-channel JFET has its major portion made of n-type semiconductor. The mutually- opposite two faces of this bulk material form the source and the drain terminals. There are two relatively-small p-regions embedded into this substrate which are internally joined together to form the gate terminal. Thus, here, the source and the drain terminals are of n-type while the gate is of p-type.

P-channel JFET

P-channel JFET has its major portion made of p-type semiconductor. The mutually- opposite two faces of this bulk material form the source and the drain terminals. There are two relatively-small-regions embedded into this substrate which are internally joined together to form the gate terminal. Thus, here, the source and the drain terminals are of p-type while the gate is of n-type.

Drain Characteristics:

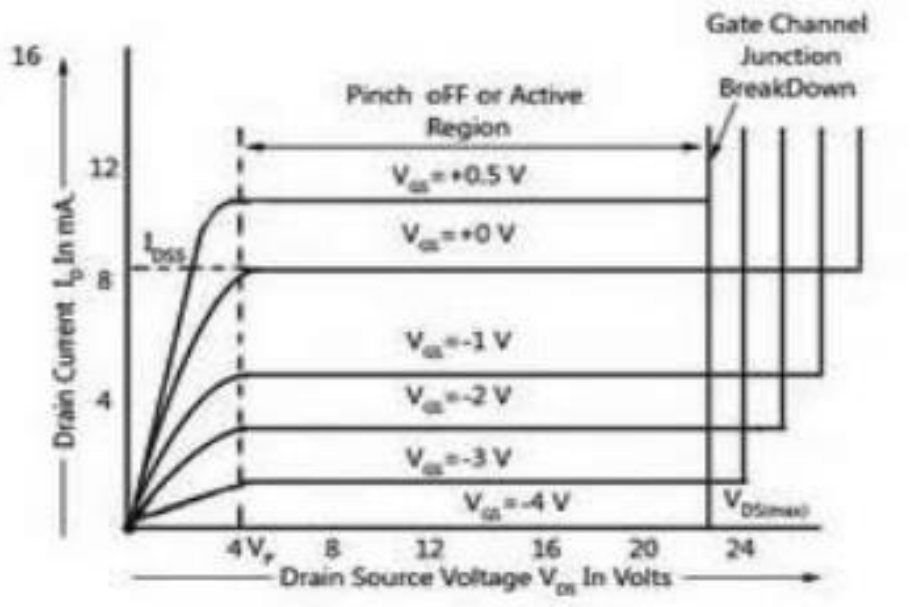
The curve is divided into following regions:

Ohmic Region: In this region drain current increases linearly with the increase in drain to source voltage, obeying ohm's law.

In this region drain current increases at the inverse square law rate with the increase in drain to source voltage. It is because of fact that with increase in drain to source voltage, drain current increases. This in turn increases reverse bias voltage across gate to source junction. As a result width of depletion region increases reducing effective width of channel.

Pinch off Region: This is also called saturation region.in this region drain current remains almost constant and at its maximum value.

Breakdown Region: In this region drain current increases rapidly as the drain to source voltage is increased. It happens because of breakdown of gate to source junction due to avalanche effect.



Gate/Transfer Characteristics;

It gives relationship between drain current (l_D) and gate to source voltage for a constant value of drain to source voltage(V_{DS}).

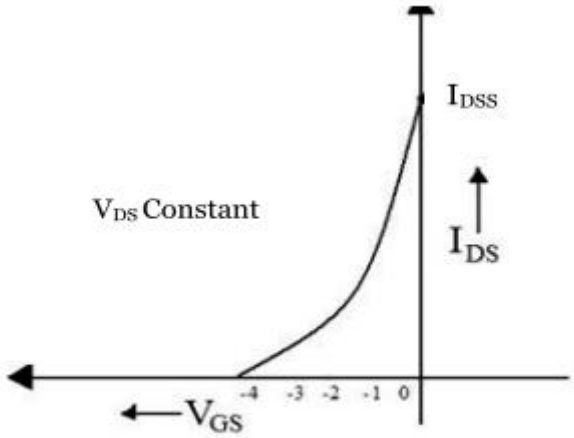
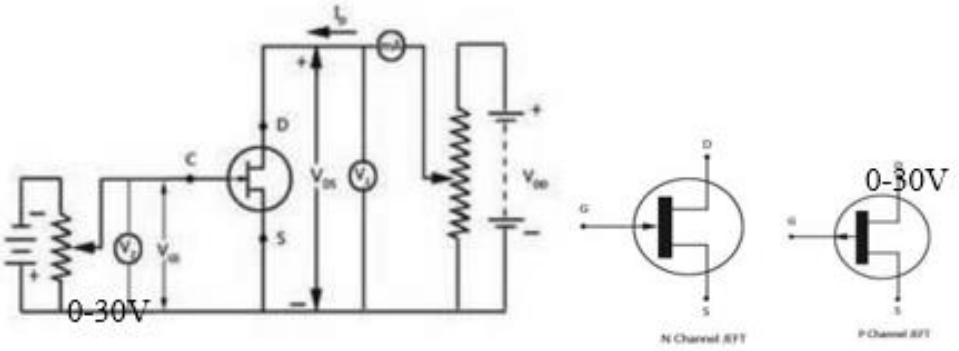


Figure 2: Transfer Characteristics

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S.No.	Instrument /Components	Specification	Quantity
1	power supply	0-30V 1 Amp	2 No.
2	Voltmeter	0-20V	1
3	Ammeter	(0-50ma,0-500µA)	1
4	Bread board	5.5CM X 17CM	1
5	JFET	BFW10,BFW15 or equivalent JFET	1
6	Connecting wires	Single strand Teflon coating(0.6mm diameter)	As per requirement

IX Precautions to be followed:

1. Care should be taken while handling terminals of components.
2. Select proper range & mode of ammeter and voltmeter.
3. Connect wires tightly while building circuit.
4. Show the connections to concerned teacher and then switch ON the power supply.

X Procedure:

Part I Drain characteristics:

1. Connect the electrical circuit as shown in fig 3.
2. Fix gate to source voltage (V_{GS}) at OV.
3. Increase drain to source power supply and note down drain to source voltage (V_{DS}) and drain current (I_D).
4. Increase gate to source dc power supply so that voltmeter connected to gate and source terminal show 1V.
5. Now repeat above procedure and note down drain to source voltage and drain current by increasing drain power supply.
6. Take readings for 3 to 4 gate voltage values and tabulate it.
7. Plot a graph of V_{DS} verses I_D for various values of V_{GS}.

Part II Transfer characteristics:

1. Connect the electrical circuit as shown in fig 3.
2. Set drain to source voltage to 1V, vary gate to source voltage in steps and note down corresponding drain current (I_D)
3. Repeat the procedure for different set values of drain voltage and keep the record of gate to source voltage and drain current.
4. Plot a graph of gate to source voltage verses drain current for different set values of drain to source voltage.
5. A graph will be in second quadrant as gate to source voltage is negative.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
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2			
3			
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XII Actual procedure followed:

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XIII Observations and Calculations:

Table 1: Drain Characteristics

S. No.	V_{GS}=……V		V_{GS}=……V		V_{GS}=……V	
	V_{DS} (V)	I_D(mA)	V_{DS} (V)	I_D(mA)	V_{DS} (V)	I_D(mA)
1						
2						
3						
4						
5						
6						

Table 2: Transfer Characteristics

S. No.	V_{DS} =0V		V_{DS} =……V		V_{DS} =……V	
	V_{GS} (V)	I_D(mA)	V_{GS} (V)	I_D(mA)	V_{GS} (V)	I_D(mA)
1						
2						
3						
4						

Calculations:

Drain dynamic Resistance:

$$rd = \frac{\Delta V_{DS}}{\Delta I_D}$$

Mutual Conductance:

$$gm = \frac{\Delta ID}{\Delta VGS}$$

Amplification Factor:

$$\mu = \frac{\Delta V_{DS}}{\Delta V_{GS}}$$

XIV Results:

1. Drain dynamic resistance (r_D) =……..
2. Mutual conductance (gm) =……
3. Amplification factor (μ) =…….

XV Interpretation of Results:

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……
……

XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Write the Part number and manufacturer of given JFET.
2. State the advantages of FET over BJT.
3. List the applications of JFET.

[Space for Answers]

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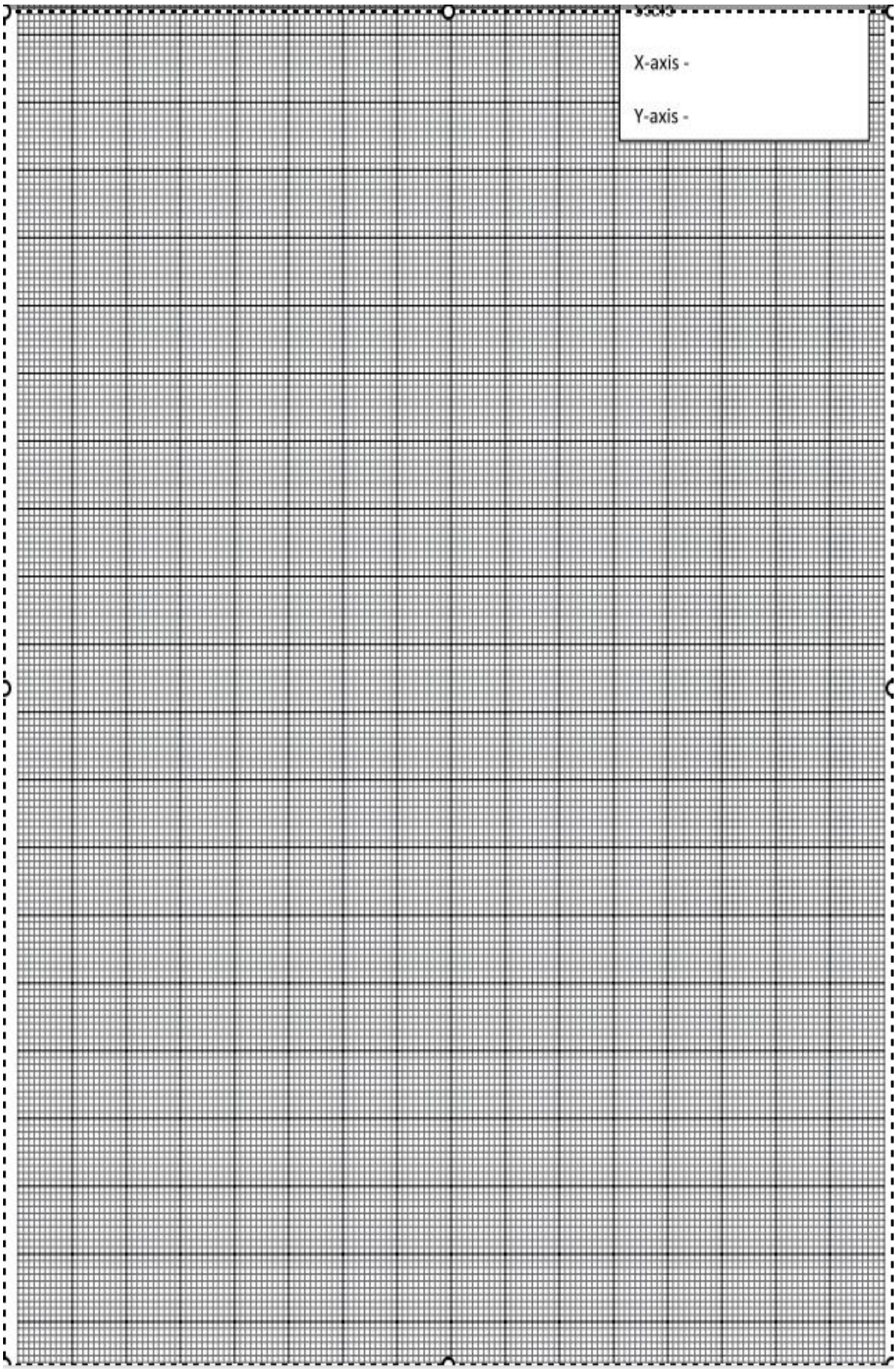
XVIII References/ suggestions for further reading ; includes websites:

1. http://www.electronics-tutorials.ws/transistor/tran_5.html
2. http://www.circuitstoday.com/characteristics-of-jfets
3. www.nptel.ac.in/courses/117107095/lecturers/lecture_36/lecture36_page1.htm

XIX Suggested Assessment Scheme:

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.25: Measure temperature of liquid using RTD (PT-100) transducer

I Practical Significance:

RTD (Resistance Temperature Detector) is most linear passive temperature transducer. PT-100 is most common low cost RTD. It is made up of platinum and it have 100 Ohm resistance at zero degree temperature. Since RTD have higher accuracy and repeatability, they are slowly replacing thermocouple in industrial application below 600° C. This practical will help you to measure temperature using RTD for given liquid.

II Industry/Employer Expected Outcome(s):

In the industry environment industrial electronics expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. It is necessary to measure temperature of different ranges in various industries. Employee should able to select, test and use appropriate temperature sensor.

III Course Level Learning Outcome(s):

Use various types of sensors and transducers.

IV Laboratory Learning Outcome(s):

Use of RTD (PT-100) for measurement of temperature.

V Relevant Affective Domain related outcome(s):

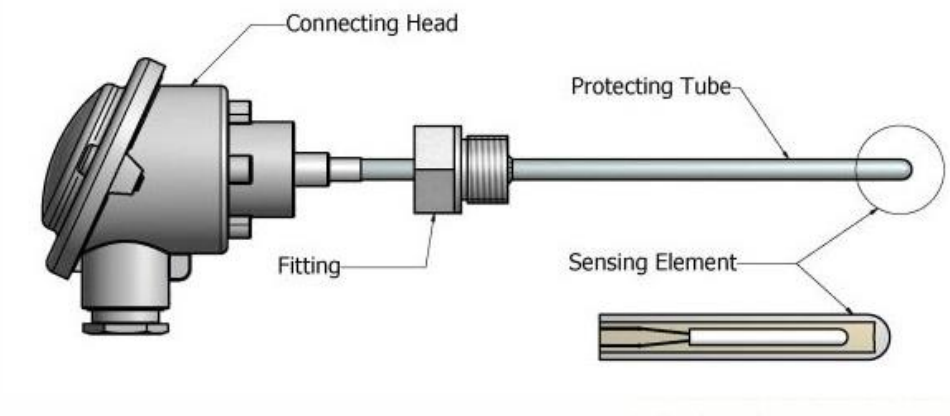
1. Follow safe practices.

2. Demonstrate working as a leader/a team member.

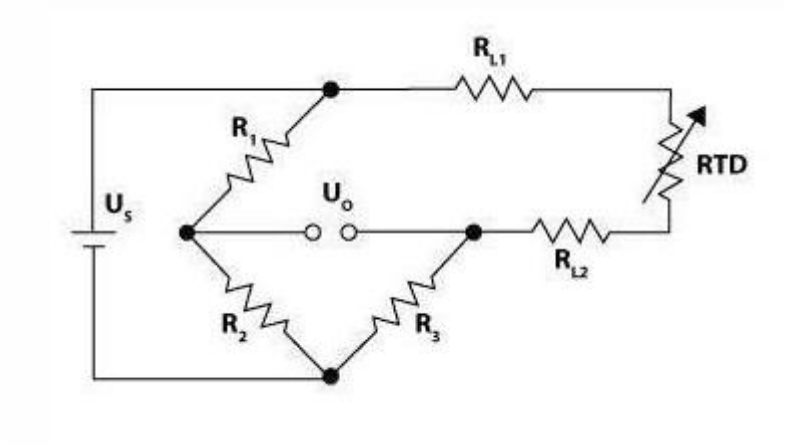
3. Maintain tools and equipment.

VI Relevant Theoretical Background (With diagrams if required):

Resistance Temperature Detector (RTD): The resistance of certain metals changes with temperature change. With the increase of temperature electrical resistance of certain metal increase in direct proportion to the rise of temperature. RTD is a sensor to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. RTD wire is made of pure materials of platinum, Nickel or copper. The material has accurate resistance/temperature relationship which is to provide an indication of temperature.



VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Board Specifications	Quantity
1	RTD setup	Any setup with standard RTD	1No.
2	DC power supply	0-30V,0-2A	1No.
3	MULTIMETER	Digital	1No.

IX Precautions to be followed:

1. Ensure proper earthing to the equipment.
2. Ensure that the Power Supply switch is in off condition initially.
3. Ensure proper settings of range of analog meter before use

X Procedure:

1. Connect RTD in bridge circuit as shown in setup.
2. Place mercury thermometer in given liquid.
3. Place RTD's metal part in the same liquid.
4. Measure resistance of RTD and output voltage for each 10° rise in temperature keeping heater on.
5. Repeat the procedure for 10 times.
6. Plot the Graph.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

SR. NO.	Temperature in Degree	Output Voltage	Resistance in ohm

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. List standard type of RTD available in market.
2. State method of measurement of resistance of RTD.
3. State Practical reason to cover RTD with metal case.
4. State the Meaning of PT-100.
5. State resistance of RTD at Room temperature

[Space for Answers]

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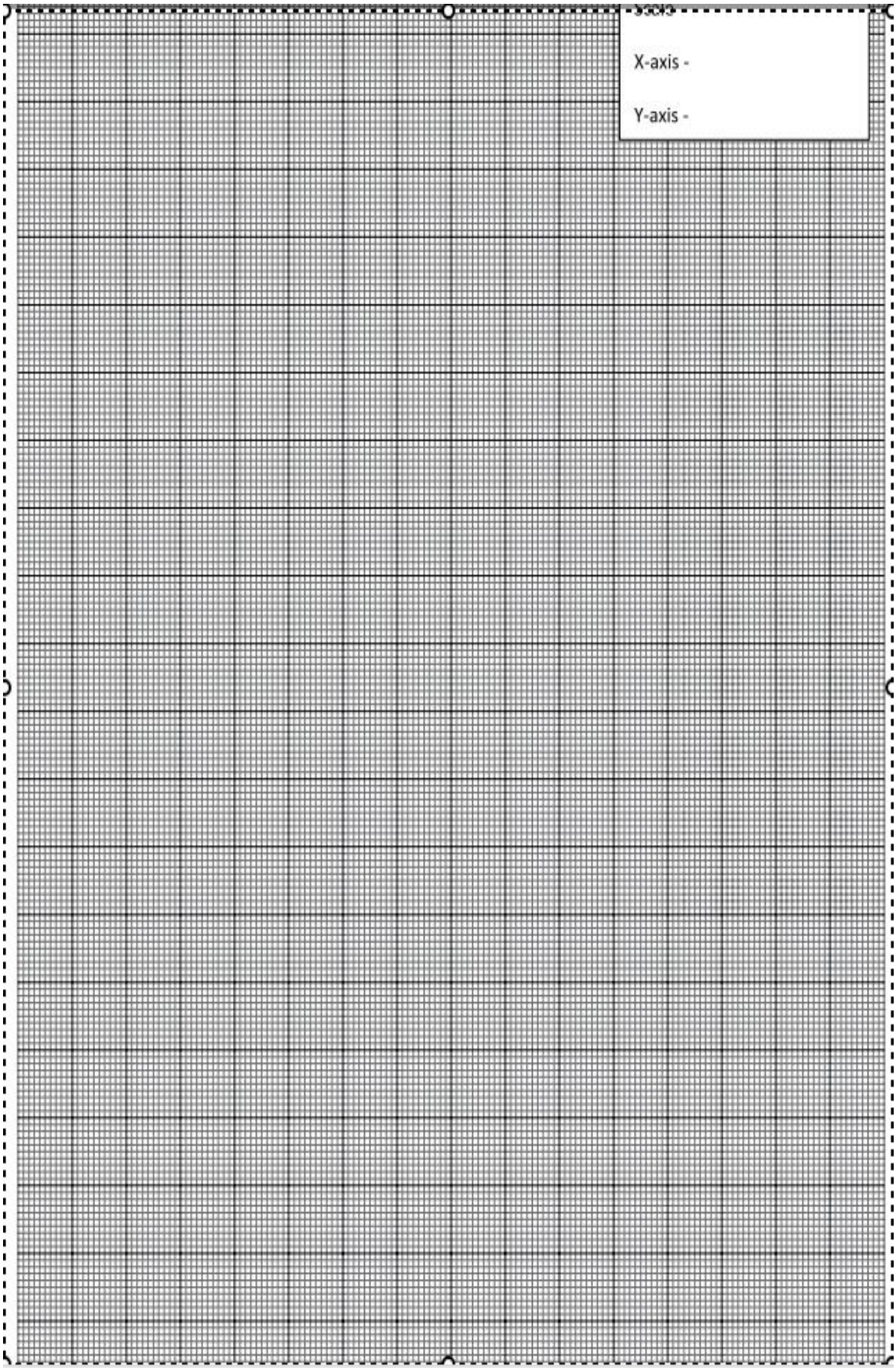
XVIII References/ suggestions for further reading ; includes websites:

1. Laboratory Manual for Introductory Electronics Practicals, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi: ISBN: 9780852265543
2. APPLICATION NOTES-PRACTICAL TEMPERATURE MEASUREMENTS from OMEGA
3. https://youtube/WmIgusHZyPc?t=42

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.26: Measure temperature of liquid using thermocouple.

I Practical Significance:

Thermocouple is the active temperature transducer based on Seebeck and Peltier effect. Since it is active transducer, designing of signal conditioner is easy. This is mostly used to measure the temperature above 300° C. This practical will help students to use thermocouple for measuring the temperature of the given liquid.

II Industry/Employer Expected Outcome(s):

In the industry environment it is expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. It is necessary to measure the high value temperature in various industries. Employee should able to select, test and use appropriate thermocouple.

III Course Level Learning Outcome(s):

Use various types of sensors and transducers.

IV Laboratory Learning Outcome(s):

Use active transducer (thermocouple) for measurement of temperature.

V Relevant Affective Domain related outcome(s):

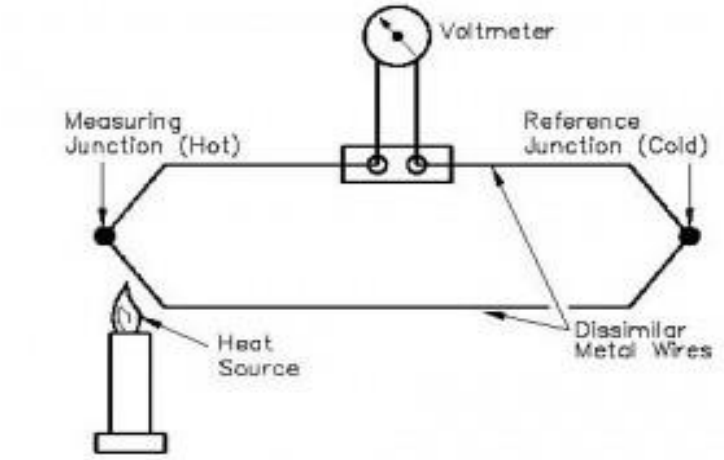
1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.

VI Relevant Theoretical Background (With diagrams if required):

A thermocouple is a device made by two different metals joined to form two junctions. The two wires are called thermo elements or legs of the thermocouple. One end of thermocouple is called as measuring end and the other end of the thermocouple is called reference end, The measuring end is immersed in the environment whose temperature T2 is to be measured, which can be for instance the temperature of a furnace at about 500°C, while the reference end is held at a different temperature T1, e.g. at ambient temperature.

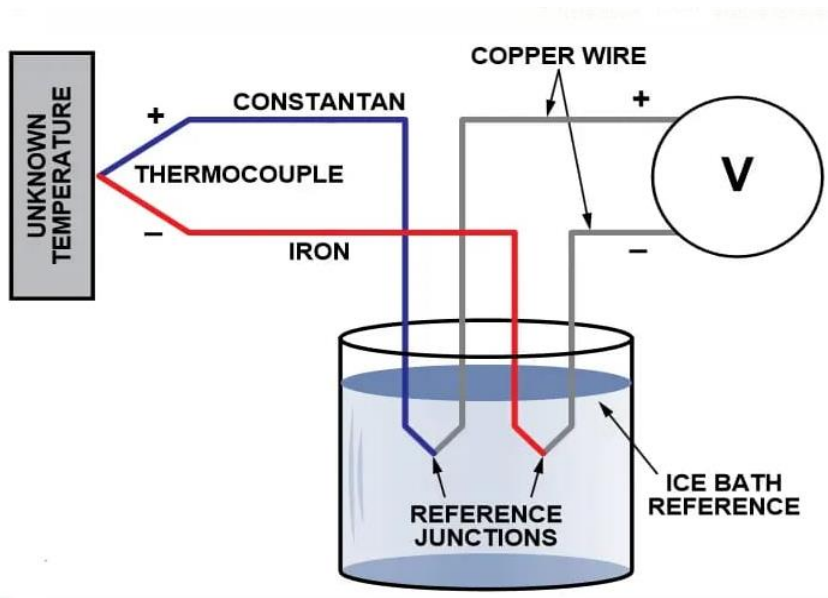
Thermocouples will cause an electric current to flow in the attached circuit when subjected to changes in temperature. The amount of current that will be produced is dependent on the temperature difference between the measurement and reference junction, the characteristics of the two metals used and the characteristics of the attached circuit.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



When a temperature difference exits between measuring junction and reference junction, and e.m.f. is produced which causes current in the circuit. e.m.f. produced can be measured by voltmeter.

I. Practical setup:



VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity
1	Thermocouple	Thermocouple K type: Temp range 0-200^{0}c	01
2	Temp bath	2KW,230V AC	01
3	Digital temperature indication	0^{0}c to 200^{0}c ,accuracy of +/- 1%	01
4	Digital Multimeter	0-200mV	01
5	Mercury Thermometer	0 to 300^{0}c	01
6	Compensating cable	2 wire,0.5mm^2	01

IX Precautions to be followed:

1. Ensure that proper connections are made as per the setup.
2. Ensure proper setting of devices used
3. Ensure the power switch is in off condition initially.

X Procedure:

1. Identify the component of given setup diagram.
2. Connect set up for temperature measurement with thermocouple.
3. Place the thermocouple, thermometer, immersion heater in temperature bath.
4. Record the room temp. with mercury thermometer
5. Record the output voltage with multimeter for room temperature.
6. Switch on the power supply of heater.
7. Note down the temperature for every 10 degree temperature rise.
8. Record the temperature using mercury thermometer.
9. Record the output voltage using multimeter.
10. Repeat the steps 7 to 9 for 10 readings.
11. Plot the temperature Vs voltage graph

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/ Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

SR. NO.	Temperature ºC	Voltage (mv)

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. State the output voltage when two terminals are short of thermocouple.
2. State the practical reason to cover thermocouple with metal case.
3. State the output voltage at room temperature.
4. State the different types of thermocouple.

[Space for Answers]

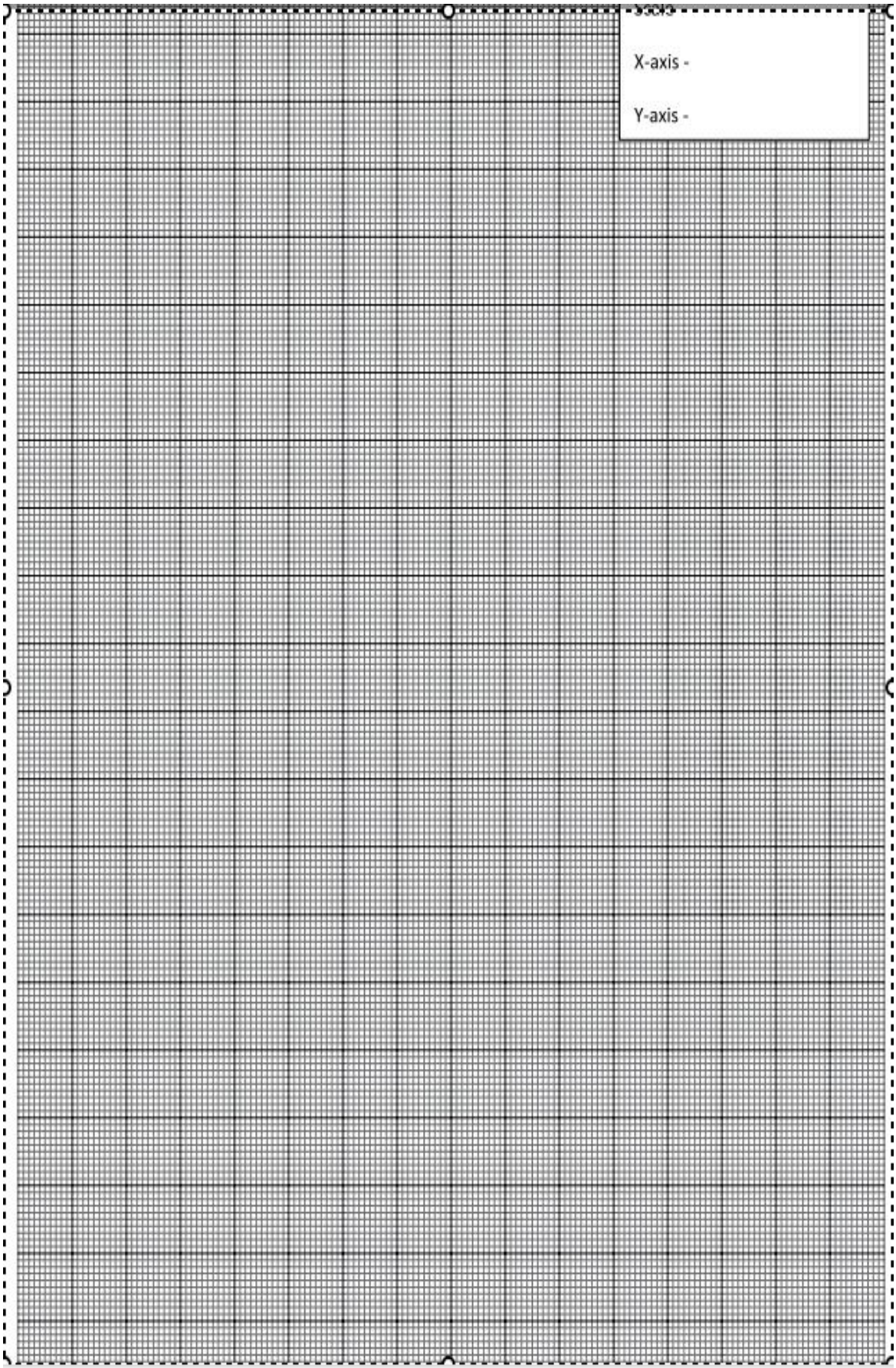
XVIII References/ suggestions for further reading ; includes websites:

1. Laboratory Manual for Introductory Electronics Practicals, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi: ISBN: 9780852265543
2. APPLICATION NOTES-PRACTICAL TEMPERATURE MEASUREMENTS from OMEGA
3. https://youtube/WmIgusHZyPc?t=42

XIX Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.27: Check the motion of given object using photoelectric sensor.

I Practical Significance:

A Photoelectric Sensor consists primarily of an Emitter for emitting light and a Receiver for receiving light. When emitted light is interrupted or reflected by the object, it changes the amount of light that arrives at the Receiver. The Receiver detects this change and converts it to an electrical output signal.

II Industry/Employer Expected Outcome(s):

Many industries which manufacture communication instruments uses optical fibre, light sensitive components .such as optical switches, optical relays, and optical isolators. Employee should be able to select, test and use proper photo sensing devices as per the application.

III Course Level Learning Outcome(s):

Use various types of sensors and transducers.

IV Laboratory Learning Outcome(s):

Use of photoelectric sensor to sense motion.

V Relevant Affective Domain related outcome(s):

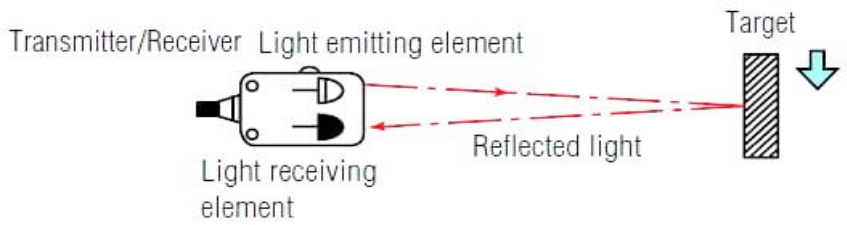
1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.

VI Relevant Theoretical Background (With diagrams if required):

A photoelectric sensor emits a light beam (visible or infrared) from its light-emitting element. A reflective-type photoelectric sensor is used from the target. A thru beam type sensor to detect the light beam sensor is used to measure the change in amount of light caused by the target crossing the optical axis. A beam of light is emitted from the light emitting element and is received by the light receiving element.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

I. Practical setup



VIII Required Resources/apparatus/equipment with specification:

Sr. No	Name of Resource	Suggested Board Specification	Quantity
1.	Photoelectric Sensor setup	Thru-beam mode sensors	1
2.	Target/Moving object	any	1

IX Precautions to be followed:

1. Make sure that the power supply is off while wiring.
2. Verify that the supply voltage variation is within the rating
3. If power is supplied from a commercial switching regulator, ensure that the frame ground (F.G.) terminal of the power supply is connected to an actual ground.
4. Avoid dust, dirt, and steam.
5. .Take care that the sensor does not come in direct contact with water, oil, grease or organic solvents, such as, thinner, etc

X Procedure:

1. Make the proper arrangement of Emitter for emitting light and a Receiver for receiving light.
2. Choose suitable size of moving target.
3. Place the target within the range of photoelectric sensor and note down the electrical Output.
4. Note the electrical output with and without interruption (reflection) of light.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

Sr. No	Position of target	Electrical output of sensor
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XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. State different photo emitter devices.
2. State different photo detector devices.
3. Define opto-coupler.
4. Draw symbol of LED, Photo diode, LDR' Photo transistor.

[Space for Answers]

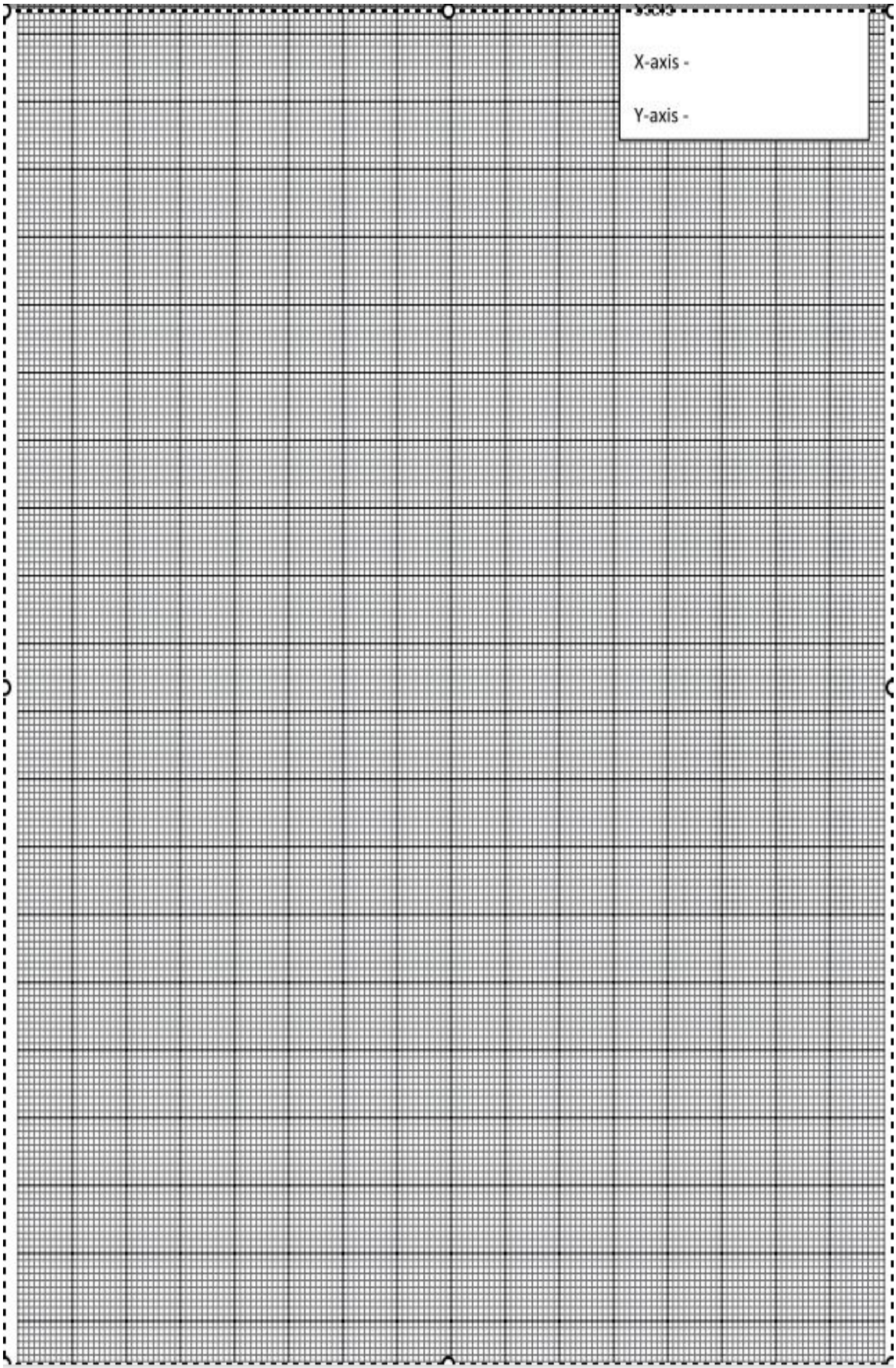
XVIII References/ suggestions for further reading ; includes websites:

1. Laboratory Manual for Introductory Electronics Practicals, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi: ISBN: 9780852265543
2. APPLICATION NOTES-PRACTICAL TEMPERATURE MEASUREMENTS from OMEGA
3. https://www.automation.com/en-us/articles/2014-1/fundamentals-of-photoelectric- sensors

XIX Suggested Assessment Scheme

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.28: Measure the resistance of LDR in varying light intensity.

I Practical Significance:

LDR (Light Dependent Resistor) sensor modules are used where there is a need to sense the presence and absence of light is necessary. These resistors are used as light sensors and the applications of LDR mainly include alarm clocks, automatic street light control, light intensity meters and burglar alarm circuits.

II Industry/Employer Expected Outcome(s):

Many industries which manufacture security systems. LUX meter, object counting instruments uses LDR as photo sensitive transducer. Employee should be able to select, test and use proper photo sensing devices as per the application.

III Course Level Learning Outcome(s):

Use various types of sensors and transducers.

IV Laboratory Learning Outcome(s):

Use passive transducer to measure resistance.

V Relevant Affective Domain related outcome(s):

1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.

VI Relevant Theoretical Background (With diagrams if required):

Light dependent resistors or in other words photo resistors are very useful especially in light/dark sensor circuits. They can also be referred to as photoconductors. Normally the resistance of an LDR is very high, but when they are illuminated with light resistance drops dramatically. A LDRs can have a variety of resistances and functions. For example, it can be used to turn on a light when the LDR is in darkness or to turn off a light when the LDR is in light. It can also work the other way around so when the LDR is in light it turns on the circuit and when it's in darkness the resistance increase and disrupts the circuit.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

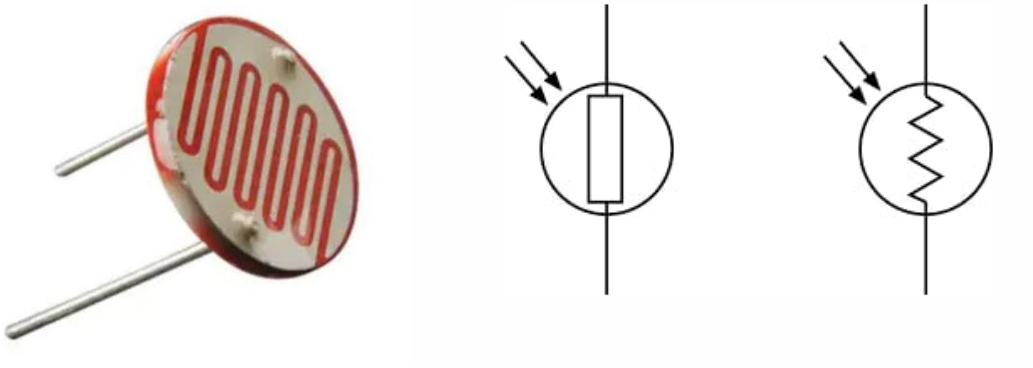


Figure 1: Symbol

I. Practical setup

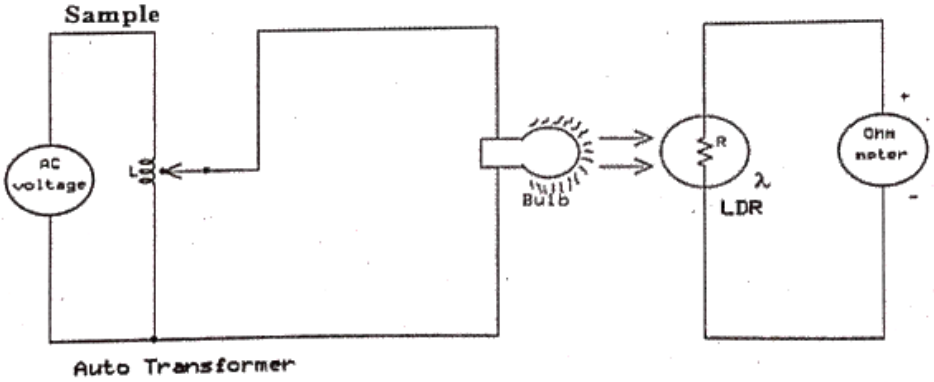


Figure 2 :- To measure the Resistance variation with light

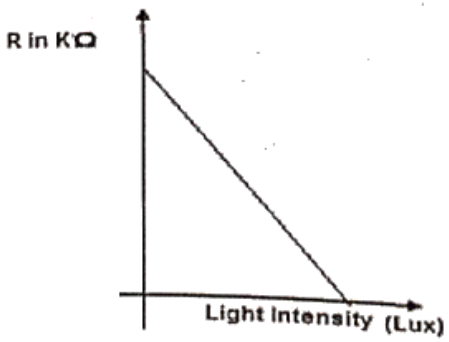


Figure 3.Ideal Characteristics of LDR

VIII Required Resources/apparatus/equipment with specification:

S. No.	Instrument/Components	Specification	Quantity
1	Digital Multimeter	Digital Multimeter: 3 ½ digit display	1
2	Bulb	60w or 100w or any other watt	1
3	LDR		1
4	Connecting wires	Single stand Teflon coating(0.6mm diameter)	As per requirement

IX Precautions to be followed:

1. Do not switch ON power supply unless you have checked the circuit connections as per the circuit diagram.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.

X Procedure:

1. Connect the circuit as shown in figure 2
2. Connect the ohm-meter section of DMM to LDR as shown in figure 2.
3. Keep the LDR in front of bulb in such way that maximum light falls on LDR.
4. Initially adjust the output voltage of dimmerstat to zero volt.
5. Measure the resistance of LDR.
6. Now increase the dimmerstat voltage in steps of 30 V.
7. Repeat steps 5 and 6 till the output voltage of dimmerstat reaches up to 230 volt.
8. Plot the graph light intensity (bulb voltage) verses resistance of LDR.
9. Take light intensity (bulb voltage) on X-axis and LDR resistance on Y-axis.
10. Plot the graph.

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

Measure resistance (R) in dark condition=……..k Ω

Sr. No.	Bulb voltage/light intensity(V/Lux)	Resistance R(Ω)
1		
2		
3		
4		
5		
6		

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. Which materials are used to fabricate LDR?
2. List four applications of LDR.
3. Whether the LDR is passive or active component?
4. Draw the symbol of LDR.
5. What is dark current related to LDR?
6. At what intensity of light, résistance of LDR is minimum? What is its value?

[Space for Answers]

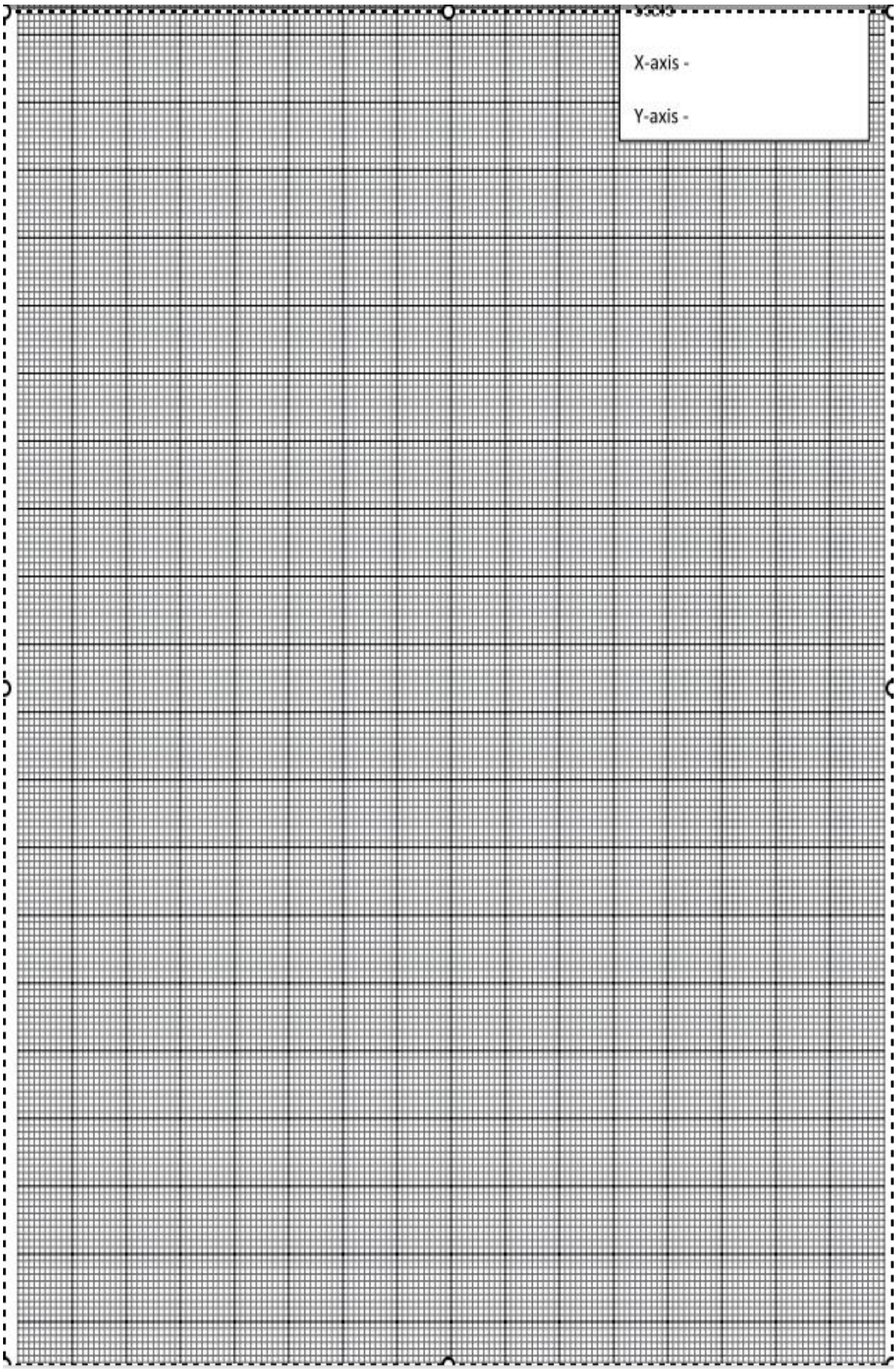
XVIII References/ suggestions for further reading ; includes websites:

1. Laboratory Manual for Introductory Electronics Practicals, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi: ISBN: 9780852265543
2. APPLICATION NOTES-PRACTICAL TEMPERATURE MEASUREMENTS from OMEGA
3. https://youtube/WmIgusHZyPc?t=42

XIX Suggested Assessment Scheme:

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
Y-axis -

Practical No.29: Measure displacement using LVDT.

I Practical Significance:

LVDT is passive transducer works on mutual inductance principle. It is used to Measure linear displacement. It is used as secondary transducer for measurement Pressure using bourdon tube. This practical help to measure displacement using LVDT.

II Industry/Employer Expected Outcome(s):

In the industry environment it is necessary to measure the displacement precisely and accurately. This is achieved by using LVDT as a displacement transducer. Employee should able to use LVDT according to its specification.

III Course Level Learning Outcome(s):

Use various types of sensors and transducers.

IV Laboratory Learning Outcome(s):

Use passive transducer to measure displacement.

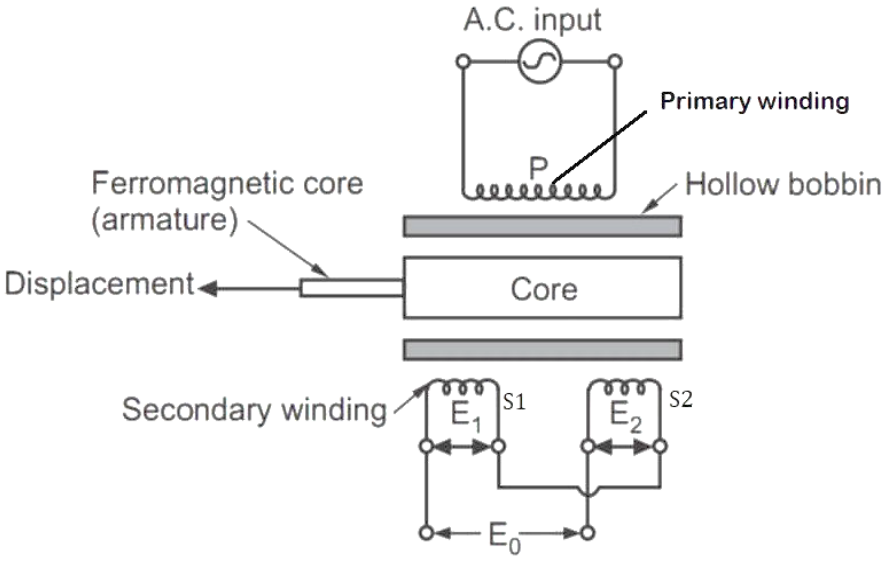
V Relevant Affective Domain related outcome(s):

1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.

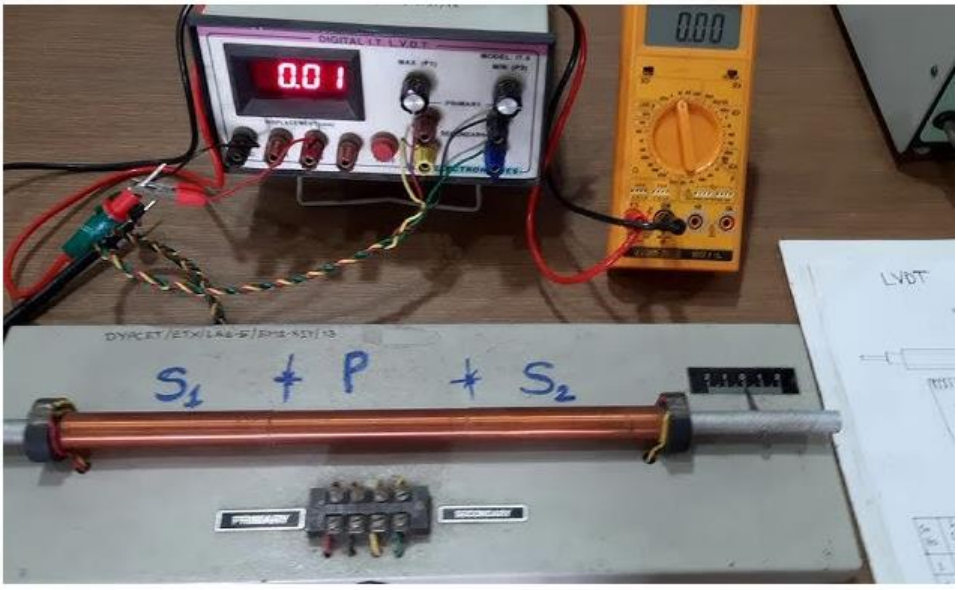
VI Relevant Theoretical Background (With diagrams if required):

LVDT is passive inductive transducer. It consists of single primary winding and two secondary windings wound on hollow cylindrical former. Primary is connected to an AC source. Secondary winding has an equal number of turns and is identically placed on either side of primary winding.

Principle of LVDT is based on mutual inductance. It converts linear motion into electrical voltage. It is a displacement sensor in which variation of inductance is the function of displacement. The displacement to be measured is applied to an arm attached to the soft iron core**.**



VII Practical setup:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Board Specification	Quantity
1	LVDT set up	0-100K,linear	2 No.
2	Function Generator	0-20Mhz,0-20Vp-p	1 No.
3	MULTIMETER	Digital	1 No.

IX Precautions to be followed:

1. Ensure proper earthing to the equipment.
2. Ensure the power switch is in 'off' condition initially.
3. Ensure proper settings of range of analog meter before use**.**

X Procedure:

1. Connect the LVDT in given set up.
2. Connect Voltmeter at secondary with LVDT in differential mode.
3. Move core to observe 0 volt on voltmeter.
4. Mark 0 reading on scale.
5. Move core left side by 0.5 cm.
6. Measure the voltage.
7. Repeat steps 5th and 6th for 5 to 10 readings.
8. Move core right side by 0.5 cm.
9. Measure the Voltage.
10. Repeat steps 8th and 9th for 5 to 10 readings.
11. Plot the graph by considering left movement positive and right movement negative.

XI Required Resources/apparatus/equipment with specifications:

S. No	**Instruments/Components**	**Suggested broad specification**	**Quantity**
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

Sr. No	Displacement Positive Direction	Output Voltage	Displacement Negative Direction	Output Voltage
1	Null Position		Null Position	
2				
3				
4				
5				
6				
7				
8				

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. State Application of LVDT other than displacement.
2. State the reason of shifting of null position of LVDT.
3. State the method of setting the null position.
4. Write the voltage at primary of LVDT
5. State whether LVDT characteristics is linear or nonlinear.

[Space for Answers]

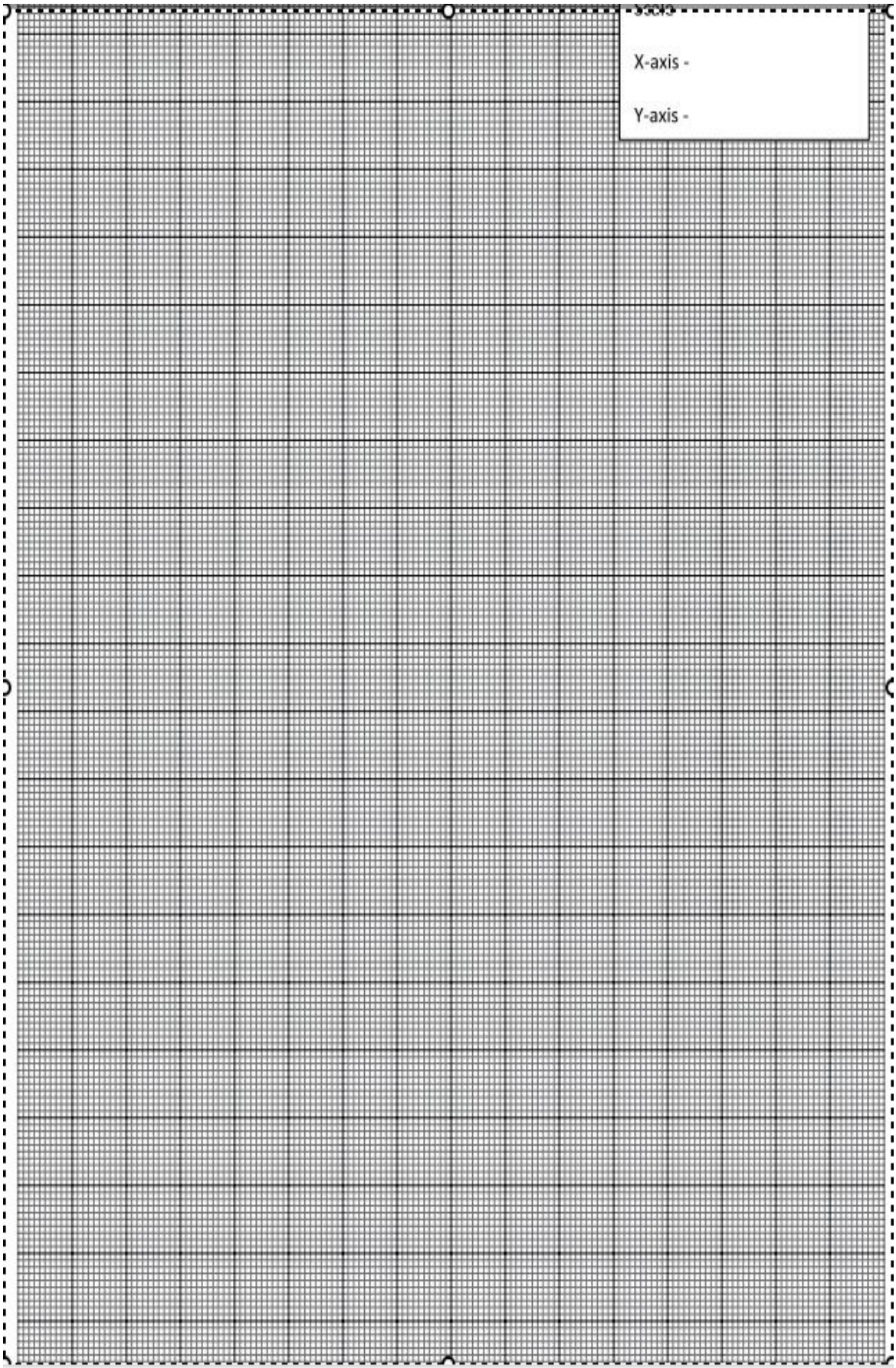
XVIII References/ suggestions for further reading ; includes websites:

1. Laboratory Manual for Introductory Electronics Practicals, Maheshwari, L.K.; Anand, M.M.S., New Age International Pvt. Ltd. New Delhi: ISBN: 9780852265543
2. APPLICATION NOTES-PRACTICAL TEMPERATURE MEASUREMENTS from OMEGA
3. https://youtube/WmIgusHZyPc?t=42

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	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Practical No.30: Measurement of displacement using potentiometer.

I Practical Significance:

Potentiometers are used to adjust the level of analog signals (for example volume controls of audio equipment) and to control inputs for electronic circuits. Potentiometer control a wide variety of equipment functions. Potentiometers are widely use in consumer electronics. This practical help to measure the linear displacement using potentiometer.

II Industry/Employer Expected Outcome(s):

In the industry environment it is necessary to measure the linear displacement precisely and accurately. This is achieved by using linear potentiometer as a displacement transducer. Employee should able to select and use potentiometer according to its specification and application.

III Course Level Learning Outcome(s):

Use various types of sensors and transducers.

IV Laboratory Learning Outcome(s):

Use passive transducer to measure displacement.

V Relevant Affective Domain related outcome(s):

1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.

VI Relevant Theoretical Background (With diagrams if required):

Potentiometer is a variable resistor which converts displacement into electrical signal. It is passive transducer. Potentiometer is an electrical device comprising a resistor with a sliding third contact, often termed a wiper, which allows the voltage to be varied depending upon where the slider is positioned along the length of the resistor. Potentiometer are found in many electrical and electronic applications and in many different forms, sizes and power ratings. For instance, in a relatively high power application a wire wound potentiometer may be used to provide a variable D.C. (or A.C.) power supply delivering many amperes at some voltage less than the supply voltage. In an electronic system a low power rated carbon track potentiometer may be used to preset the voltage on a circuit board to achieve the desired level of response. Manual adjustment of the wiper along the length of the fixed resistance produces a variable voltage at the wiper. The magnitude of this output voltage is directly proportional to its relative position along the length of the resistor. If the potentiometer wiper is appropriately connected to a moving system then any movement in that system will cause the wiper to move and so change the output voltage. This signal provides a direct measurement of position or change in position.

VII Practical setup:

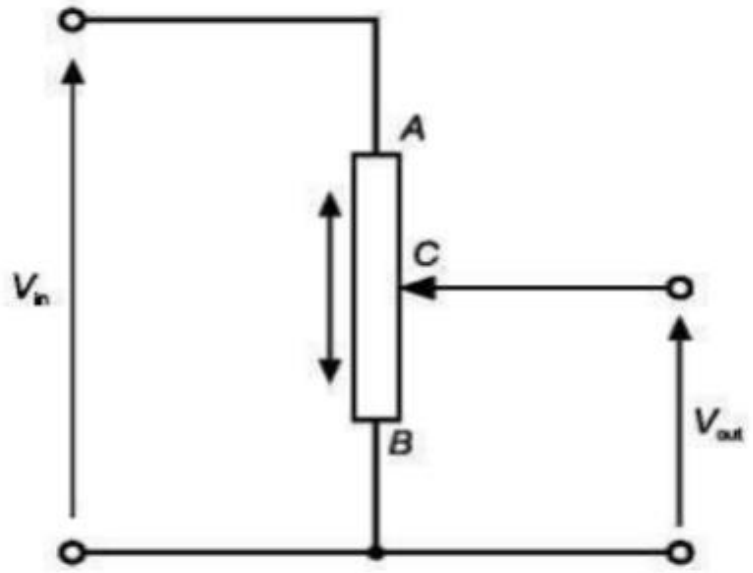

Figure: Linear Potentiometer experimental setup

The output voltage is governed by the position of the wiper (C) which may lie anywhere between the two ends, A and B, of the resistance. For the general case the output voltage is given by the expression,

$$V_{out} = V_{in} \frac{CB}{AB}$$

Where: CB is the linear distance from B to C;

AB is the maximum linear distance from B to A.

Hence when the potentiometer wiper is in position B the output voltage will be zero and when in position A the output voltage will be maximum (the full supply voltage Vin). In any intermediate position the voltage at the wiper will be some value between 0 and Vin.

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity
1	**Linear potentiometer**	Displacement range 0-400cm	01
2	**Power supply**	DC regulated power supply 0-30V DC	01
3	**DMM**	0-200V DC	01

IX Precautions to be followed:

1. Ensure that proper connections are made as per the setup.
2. Ensure proper setting of devices used.
3. Ensure the power switch is in off condition initially.

X Procedure:

1. Connect potentiometer setup as in diagram.
2. Switch on the power supply
3. Manually displace the wiper of potentiometer by 1cm
4. Record the output resistance using DMM.
5. Record the output voltage V_{out} using DMM in observation table.
6. Repeat the steps 3 to 5 for 10 times with an interval of 1cm displacement.
7. Plot the graph of displacement Vs output voltage

XI Required Resources/apparatus/equipment with specifications:

S. No	Instruments/Components	Suggested broad specification	Quantity
1			
2			
3			
4			

XII Actual procedure followed:

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XIII Observations and Calculations:

Sr. No.	Displacement (cm)	Output Voltage (Volt)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

XIV Results:

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XV Interpretation of Results:

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XVI Conclusions & Recommendations:

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XVII Practical Related Questions:

1. State the output voltage when the wiper is at 0 cm.
2. State the maximum linear range of potentiometer.
3. State the input voltage applied to potentiometer.
4. List applications of potentiometer.

[Space for Answers]

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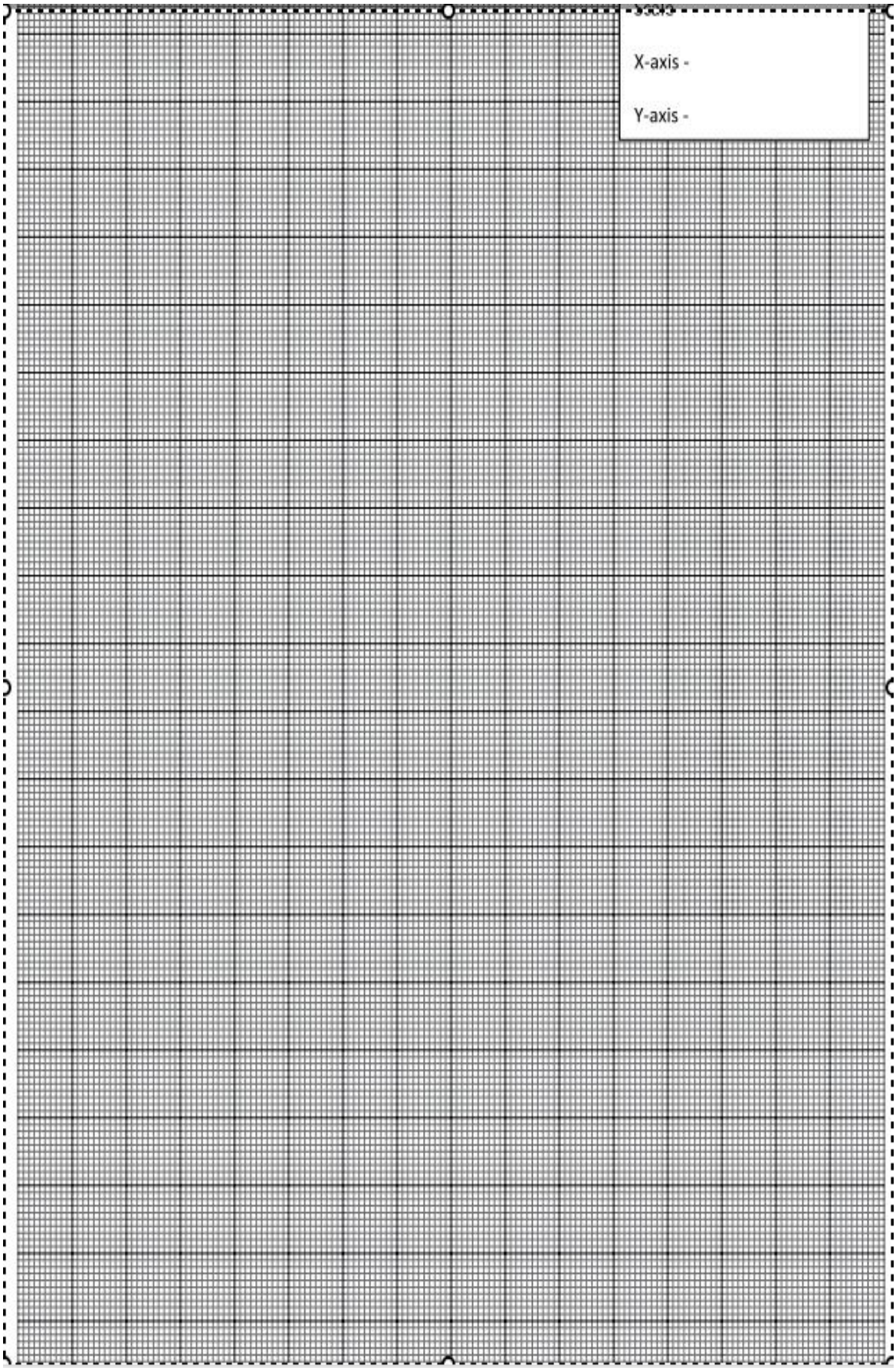
XVIII References/ suggestions for further reading ; includes websites:

Sr.	Title of Book	Author	Publication
1	Electrical and Electronic Measurements and Instrumentation	Sawhney, A.K.	DhanpatRai and Sons, N. Delhi 201; ISBN:9788177001006
2	Industrial Instrumentation and Control	Singh, S.K.	McGraw Hill Publishing; N. Delhi 2010; ISBN:9780070678200

XIX Suggested Assessment Scheme:

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated 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 %**

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


X-axis -
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