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

ELECTRICAL AND ELECTRONIC MEASUREMENT

(313334)

Semester – III

(EE/EP)

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/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.

(Printed on July, 2024)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION, MUMBAI

Certificate

This is to certify that Mr. /Ms ……………………………………………………….........

Roll No. ……………………………., of Third Semester of Diploma in …..……………………………..…………………………………………… of Institute, ………………………………………………………………………………………

(Code : ……………………) has completed the term work satisfactorily in course **Electrical And Electronic Measurement (313334)** 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 Institution

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative '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 practicals to focus on the outcomes, rather than the traditional age-old practice of conducting practicals to 'verify the theory" (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the industry/employer expected outcome, course level learning outcome, laboratory learning outcome, 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.

The electrical diploma holder has to work in industry as technical person in middle level management. He has to work as production, maintenance, testing engineer in various industries like power generation, transmission, distribution, traction etc. and has to deal with different electrical measurement. While performing above task he has to measure different electrical and electronics parameters with testings, therefore he/she must require the skills for these measurements abroad idea of different meters and equipment.

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) to be achieved through this course learning

- **PO 1. Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, sciences and engineering fundamentals with electrical 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 analyse individual needs and engage in updating in the context of technological changes.

List of relevant expected psychomotor domain skills

This Lab manual intends to develop expected psychomotor domain skills of students. The skills mentioned below will be developed through the experiments performed in this Laboratory**.**

1. To use the vocabulary of electrical measurement system.
2. To identify various measuring instruments.
3. Ability to draw and sketch.
4. Ability to operate and handle the meters/instruments.

Practical Course Outcome matrix

Course level learning outcomes (COs)

CO1 - Apply the basics of measurement to the measuring instruments.
CO2 - Measure precisely electrical power and energy using appropriate meters.
CO3 - Use digital measuring instruments for different applications.
CO4 - Maintain required pressure for given application using pressure transducer.
CO5 - Use appropriate transducer for maintaining required flow, level and temperature in given application.

Sr. No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
1	*Identification of measuring instruments on the basis of symbols on dial, type, accuracy, class, position and scale.	✓	-	-	-	-
2	*Identification of the components of PMMC and PMMI instruments.	✓	-	-	-	-
3	Troubleshooting of PMMC and PMMI instruments.	✓	-	-	-	-
4	Calibration of the ammeter/voltmeter for measurement of electrical parameters.	✓	-	-	-	-
5	Extension of the range of voltmeter and ammeter using shunt and multiplier.	✓	-	-	-	-
6	*Extension of range of ammeter using current transformer (CT).	✓	-	-	-	-
7	*Extension of range of voltmeter using potential transformer (PT).	✓	-	-	-	-
8	*Measurement of power in a single-phase circuit using electro-dynamic watt-meter.	-	✓	-	-	-
9	Troubleshoot of electro-dynamic wattmeter for measurement.	-	✓	-	-	-
10	*One wattmeter method of measurement of active power in a three-phase balanced load.	-	✓	-	-	-
11	One wattmeter method of measurement of reactive power in a three-phase balanced load.	-	✓	-	-	-
12	*Two watt-meters method of measuring active power in a three-phase balanced load.	-	✓	-	-	-
13	*Calibration of single-phase energy meter by direct loading.	-	✓	-	-	-
14	Troubleshoot of single-phase energy meter.	-	✓	-	-	-
15	*Demonstration of smart energy meter.	-	✓	-	-	-

16	Measurement of low resistance using bridges.	-	-	✓	-	-
17	Measurement of medium and high resistance using bridges.	-	-	✓	-	-
18	*Measurement of supply voltage, frequency, peak value in single phase circuit using CRO/DSO.	-	-	✓	-	-
19	*Measurement of linear displacement using potentiometer.	-	-	-	✓	-
20	Measurement of angular displacement using potentiometer.	-	-	-	✓	-
21	Measurement of displacement using LVDT.	-	-	-	✓	-
22	Measurement of weights using strain gauge.	-	-	-	✓	-
23	*Measurement of pressure using bourdon tube pressure gauge.	-	-	-	✓	-
24	*Measurement of flow using orifice meter.	-	-	-	-	✓
25	Measurement of flow using venturi meter.	-	-	-	-	✓
26	Measurement of flow using rotameter.	-	-	-	-	✓
27	*Measurement of level using capacitance transducer.	-	-	-	-	✓
28	*Measurement of temperature using RTD.	-	-	-	-	✓
29	Measurement of temperature using Thermocouple.	-	-	-	-	✓

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 involve students in performance of each experiment.
3. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
4. Teachers should give opportunity to students for hands on experience after the demonstration.
5. Teacher is expected to share the skills and competencies to be developed in the students.
6. 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.
7. 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.
8. Student should well prepare while submitting write-up of exercise.
9. Attach/paste separate papers wherever necessary.

Content Page

List of Practical's and Progressive Assessment Sheet

Sr. No.	Title of the Practical	Page no.	Date of Performance	Date of Submission	Assessment Marks (25)	Dated sign. of Teacher	Remarks (If any)
1.	*Identification of measuring instruments on the basis of symbols on dial, type, accuracy, class, position and scale.	1					
2.	*Identification of the components of PMMC and PMMI instruments.	9					
3.	Troubleshooting of PMMC and PMMI instruments.	15					
4.	Calibration of the ammeter/voltmeter for measurement of electrical parameters.	21					
5.	Extension of the range of voltmeter and ammeter using shunt and multiplier.	30					
6.	*Extension of range of ammeter using current transformer (CT).	37					

7.	*Extension of range of voltmeter using potential transformer (PT).	43						
8.	*Measurement of power in a single-phase circuit using electro-dynamic watt-meter.	48						
9.	Troubleshoot of electro-dynamic wattmeter for measurement.	54						
10.	*One wattmeter method of measurement of active power in a three-phase balanced load.	61						
11.	One wattmeter method of measurement of reactive power in a three-phase balanced load.	67						
12.	*Two watt-meters method of measuring active power in a three-phase balanced load.	73						
13.	*Calibration of single-phase energy meter by direct loading.	80						
14.	Troubleshoot of single-phase energy meter.	87						

15.	*Demonstration of smart energy meter.	93					
16.	Measurement of low resistance using bridges.	99					
17.	Measurement of medium and high resistance using bridges.	105					
18.	*Measurement of supply voltage, frequency, peak value in single phase circuit using CRO/DSO.	112					
19.	*Measurement of linear displacement using potentiometer.	118					
20.	Measurement of angular displacement using potentiometer.	125					
21.	Measurement of displacement using LVDT.	132					
22.	Measurement of weights using strain gauge.	140					
23.	*Measurement of pressure using bourdon tube pressure gauge.	147					

24.	*Measurement of flow using orifice meter.	154					
25.	Measurement of flow using venturi meter.	162					
26.	Measurement of flow using rotameter.	170					
27.	*Measurement of level using capacitance transducer.	177					
28.	*Measurement of temperature using RTD.	184					
29.	Measurement of temperature using Thermocouple.	192					
Total							

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

Practical No. 1: Identification of measuring instruments on the basis of symbols on dial, type, accuracy class, position and scale.

I Practical Significance

Electrical Engineering diploma graduate are expected to identify various measuring instruments as per IS codes. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Identify measuring instruments on the basis of symbols on dial, type, accuracy, class, position and scale.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Maintain tools and measuring instruments.

VI Relevant Theoretical Background (With diagrams if required)

I.S. 2032-1969 has standardized certain symbols for different types of analog instruments used for electrical measurement purpose. These symbols are printed on the dial of the instruments. Information about meter can be obtained from these symbols.

Data on instrument dial

The data needed for use of the instrument is in the form of symbols.

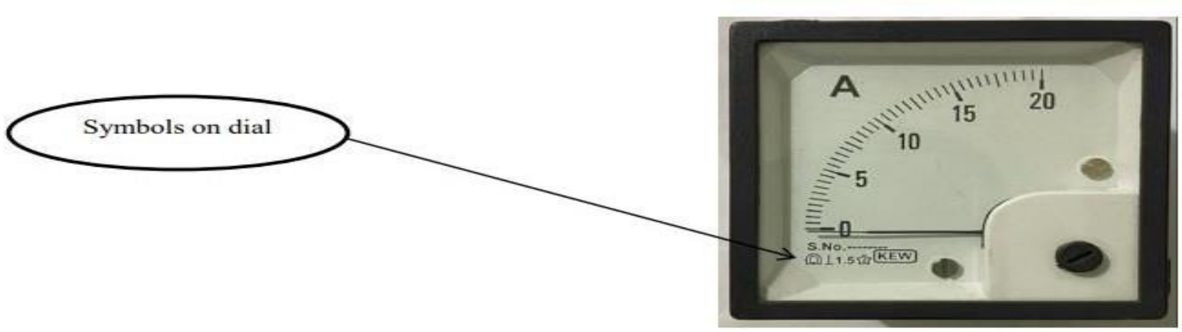

Fig:1.1 Dial of Analog Instrument

Terminal markings on Moving Coil (MC) instruments

Moving coil instruments are only used on DC supply. The positive (+) terminal is red in colour and negative (-) terminal is black in colour. This type of instrument must be connected in the circuit with correct polarity i.e. positive (+) terminal of instrument to positive of supply and negative (-) terminal of instrument to negative of supply.

Fig:1.2 Terminal markings on Moving Coil (MC) instruments

Terminal markings on Moving Iron (MI) instruments

Moving iron instruments are used on both DC and AC supply. Both the terminals are of same colour. The instruments can be connected in the circuit without identifying line and the neutral of the supply.

Terminal markings on multi-range instruments

In multi-range instruments common terminal is marked as positive (+) or common (red) and other terminals of different ranges are black in colour with measurement range value.

Accuracy class of instrument

Accuracy class refers to relative error. The classification of instruments is based on the measuring accuracy and is dependent on quality and application. Class 0.1, 0.2, 0.3 instruments are used for precision and laboratory measuring instruments, Class 0.5 for portable measuring devices and laboratory devices and class 1.0, 1.5, 2.5 for industrial and panel measuring devices

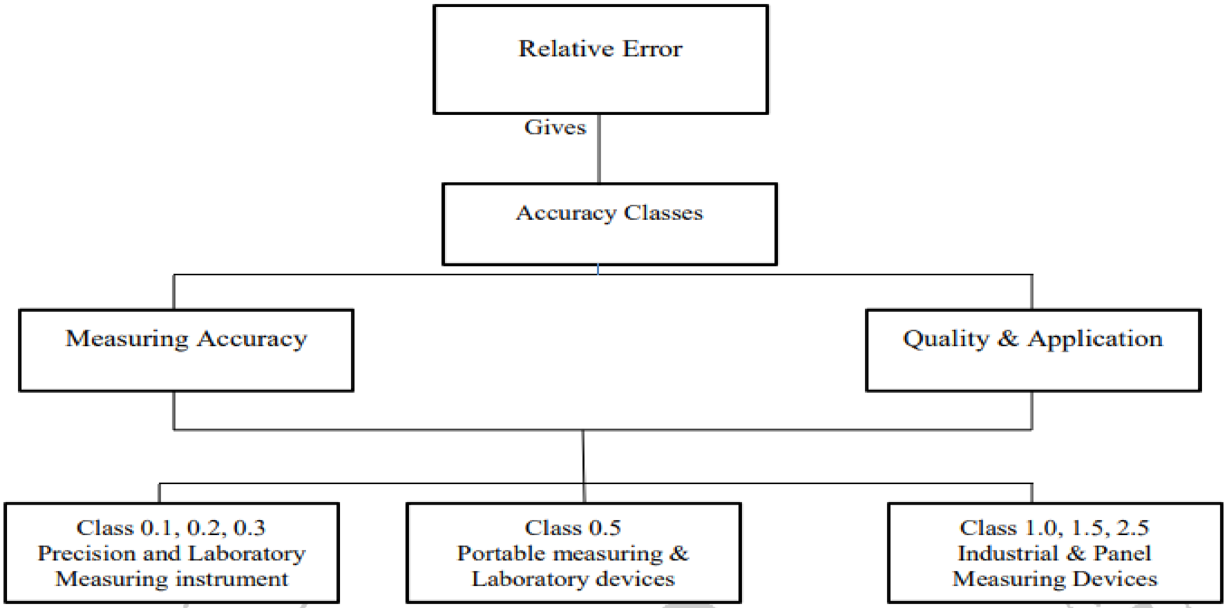

Fig:1.3 Block diagram of accuracy class of Instrument

Types of Scale:

The different types of scales and their applications are as follows-

1. Extended scales- Current measurement for short overload time.
2. Linear scales- MC instruments
3. Non-linear scales- MI instruments
4. Non-linear scales, coarse- Ohmmeter, megger.

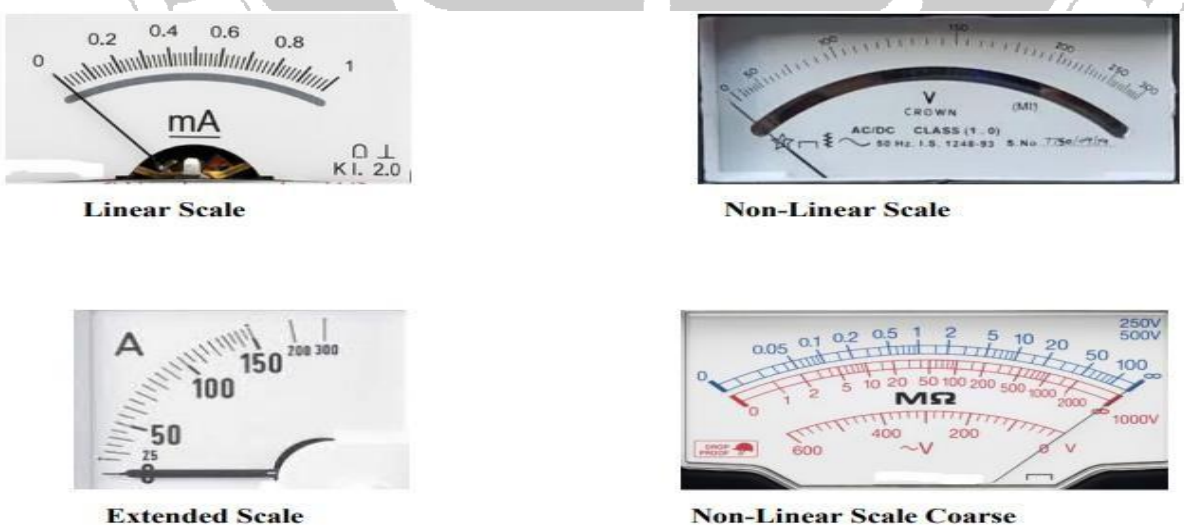

Fig: 1.4. Types of Scale

Parallax Error

Parallax error occurs when the scale of an instrument, pointer of an instrument and the observer's eye are not in correct alignment (in a line).

To minimize parallax error, instruments are provided with mirror scale and observer should read the scale in such a way that the pointer and its mirror image must coincide each other.

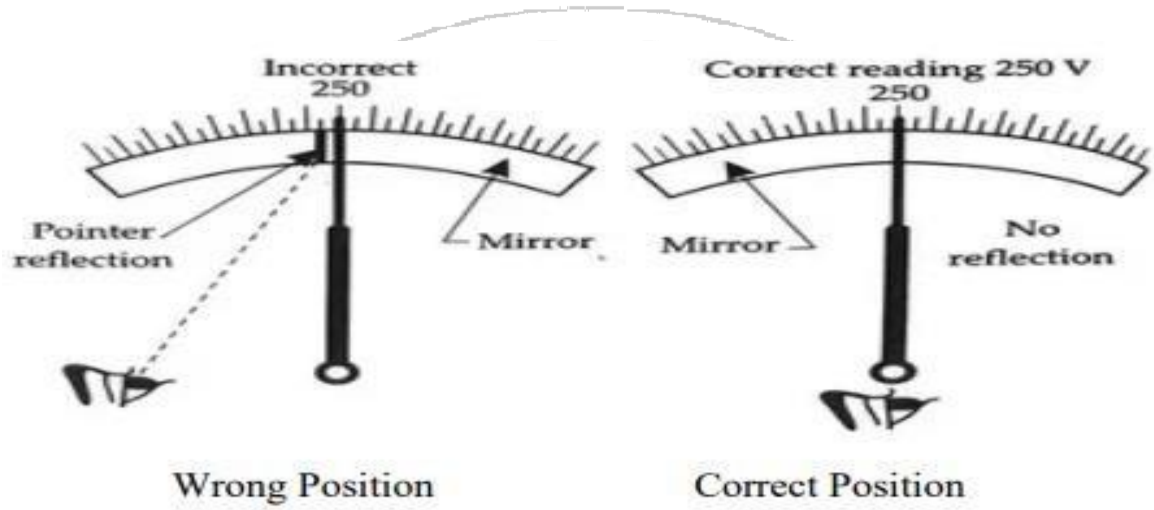

Fig: 1.4 Parallax Errors

VII Practical set-up / Circuit diagram / Work Situation

Select various instruments from laboratory.

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	Moving Coil meter Voltmeter	Standard range	1	
2	Moving Coil meter Ammeter	Standard range	1	
3	Moving iron meter Ammeter	Standard range	1	
4	Moving iron meter Voltmeter	Standard range	1	
5	Ammeter, extended scale	Standard range	1	
6	Ohm-meter	Standard range	1	

IX Precautions to be followed

1. Choose the correct range of meter. (e.g. for measuring single-phase supply voltage correct range is 0-300V
2. Identify the correct instrument for AC/DC measurement.
3. Use the instrument in the correct position as specified on dial.
4. Correct the zero error of the meter by adjusting zero adjustment screw.

X Procedure

1. Select an Ammeter of required range depending on the following:
- Rating as indicated on dial
- Type of supply
- Type of instrument
- Mounting method
- Meter symbols

2. Select Voltmeter, Wattmeter and follow the above procedure.

XI Observation table (use blank sheet)

Sr. No.	Specification of meter	Symbol	Meaning of symbol	Types of instrument	Mounting Method	Remarks

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. Which Class of instrument is generally used on panel board?
2. Name the instrument, which can be used on both AC and DC supply.
3. State the procedure for zero adjustment of pointer.
4. Draw the BIS symbol to identification of instruments for the following items.

Sr.No.	Items	BIS Symbols
1.	Direct and alternating current	
2.	Testing potential 500V	
3.	Vertical using position	
4.	Class 1.5 determined by the length of scale	
5.	Moving coil instrument	
6.	Galvanometer	
7.	Unit symbol for frequency	

(Space for answers)

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XVI 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 Publications
2. https://www.electrical4u.com/electrical-international-symbol/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi A. V. Bakshi K. A. Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune

XVII 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. 2: Identification of the components of PMMC and MI instruments

I Practical Significance

Electrical Engineering diploma graduate are expected to handle PMMC and MI instruments to measure basic parameters like voltage and current of field devices/equipments. In some situation it becomes necessary to identify the faulty components of the instruments. This practical will help you in acquiring necessary skills to identify the components of PMMC and MI instruments.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Identify the components of PMMC and MI instruments.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.

VI Relevant Theoretical Background (With diagrams if required)

P.M.M.C. instrument (construction):-

The instrument has a Deflecting system, a Controlling system and a Damping system. The Deflecting System consists of a permanent magnet made of Alnico, a core of soft iron and moving coil of enameled copper wire. The moving coil has a thin cross- section and about 50 - 100 turns. It is wound on a rectangular aluminum former. The former is pivoted on a spindle. The moving coil is free to rotate in the gap of permanent magnet and fixed core. Controlling system consists of springs, called control springs, made of phosphor bronze. (springs also act as the leads for the current).Damping torque is produced by the principle of eddy current. Eddy current damping system Generates eddy currents in the permanent magnet and damps the oscillations of indicating pointer by providing force in the opposite direction.

P.M.M.C. instrument (operation):-

A deflecting torque is produced proportional to current through the moving coil which moves in the field of permanent magnet. Control springs produce the controlling torque which is proportional to angle of deflection.

Eddy currents circulating in the aluminum former produce damping torque which is proportional to eddy emf induced in it.

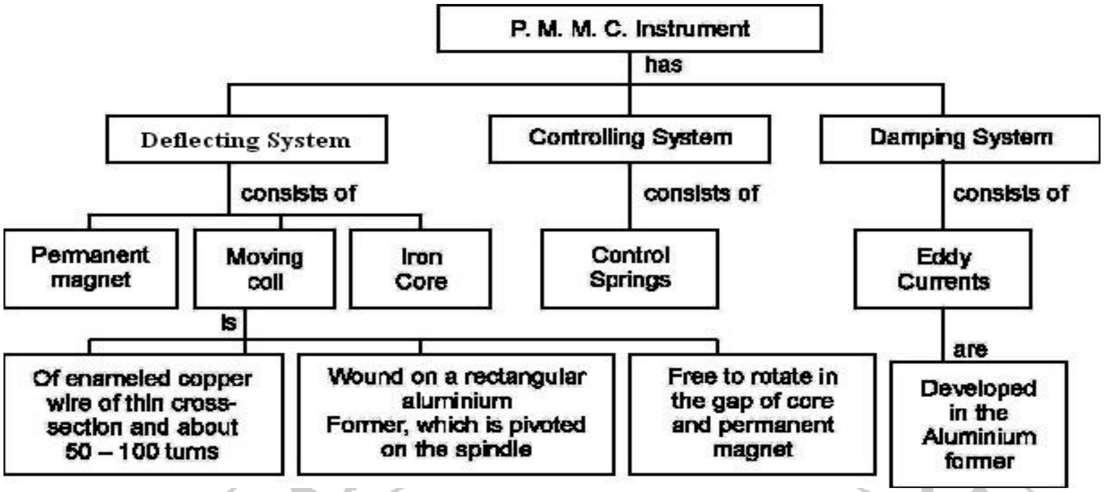

Fig:2.1 Structure of P.M.M.C. instrument

Repulsion type MI instrument (construction) :-

The instrument has Deflecting system, controlling system and Damping system. Deflecting system consists of a circular coil. A soft iron piece called fixed iron is attached to the coil from inside. Spindle is along the axis of coil. Another soft iron piece called as moving iron is attached to the spindle. Controlling system consists of springs, called control springs made of phosphor bronze. Damping system consists of air friction damping.

Repulsion type M. I. Instrument (operation):-

While coil carries current, the soft iron pieces get magnetized. Similar poles are formed on the nearer faces of soft iron pieces and they repel each other. Thus the deflecting torque is due to the repulsion and it is proportional to square of the current through the coil. Control spring provide the controlling torque which is proportional to angle of deflection. Air friction damping is provided to the instrument. So damping torque is proportional to movement of piston in air chamber.

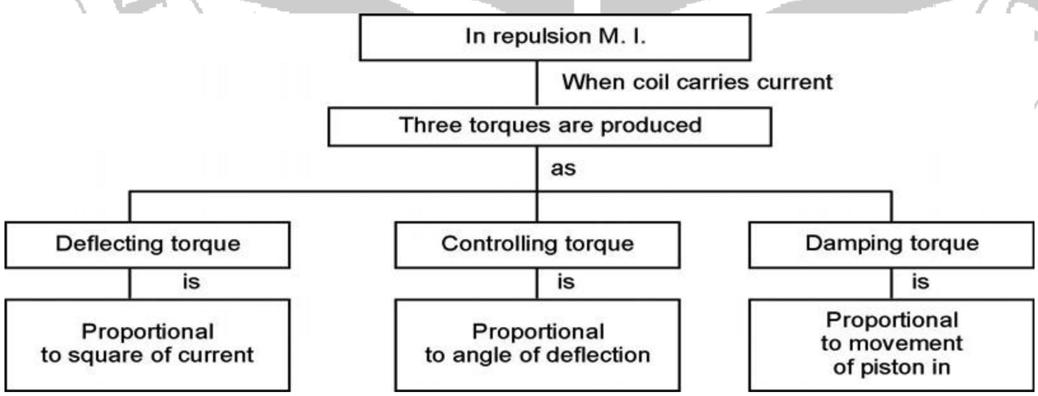

Fig: 2.2 Structure of Repulsion type M. I. Instrument

VII Practical set-up / Circuit diagram / Work Situation

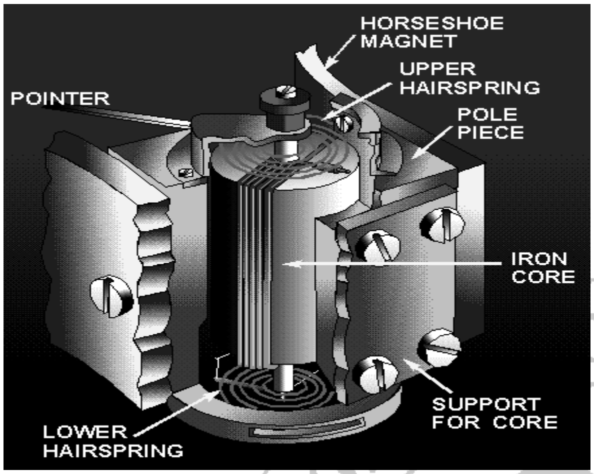

Fig:2.3.Internal structure of PMMC Instruments

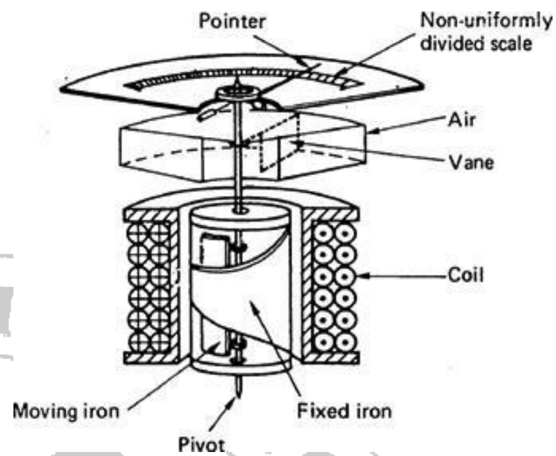

Fig:2.4 Internal strutcure of repulsion type MI instruments

VIII Required Resources/apparatus/equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	MI Instrument	Working model Voltmeter, Ammeter	1
2	PMMC Instruments	Working model Voltmeter, Ammeter	1
3	Screw Driver	Standard Size	1
4	Plier	Standard Size	1

IX Precautions to be followed

1. Use proper screw driver.
2. Don't exert more pressure while opening the screw.

X Procedure

Part A: - **Identification of PMMC instrument**

1. Observe the given working model of P.M.M.C. instrument.
2. Observe Deflecting, Controlling and Damping systems.
3. Write different parts with their function and material in given observation table. Draw sketch showing all parts of the instrument and label them. **(Note:-Use blank sheet to draw the sketch)**

Part B:- Identification of MI instruments

1. Observe the given working model of M. I. instrument.
2. Observe Deflecting, Controlling and Damping systems.
3. Write different parts with their function and material in given observation table. Draw sketch showing all parts of the instrument and label them. **(Note:- Use blank sheet to draw the sketch)**

XII Observation table (prepare table on blank sheet)

Sr. No.	Parts	Material	Function

XIII Result(s)

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XIV Interpretation of results

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XV Conclusion

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XVI **Practical related questions** (Note:- Teacher should provide various questions related to practical-sample given)

1. State the constructional difference between PMMC and MI instrument.
2. Observe the scale of PMMC and MI instruments and comment on it.
3. Why PMMC instrument is used for DC only?

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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 Publications
2. https://www.e1ectrica14u.com/electrical-measuring-instruments-types-accuracy-precision-resolution-speed/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi , A. V. Bakshi, K.A. Bakshi ISBN 9788l843l4380First 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. 3: Troubleshooting of PMMC and MI instruments.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to troubleshoot measuring instruments. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Identify the components of PMMC and PMMI instruments.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment

VI Relevant Theoretical Background

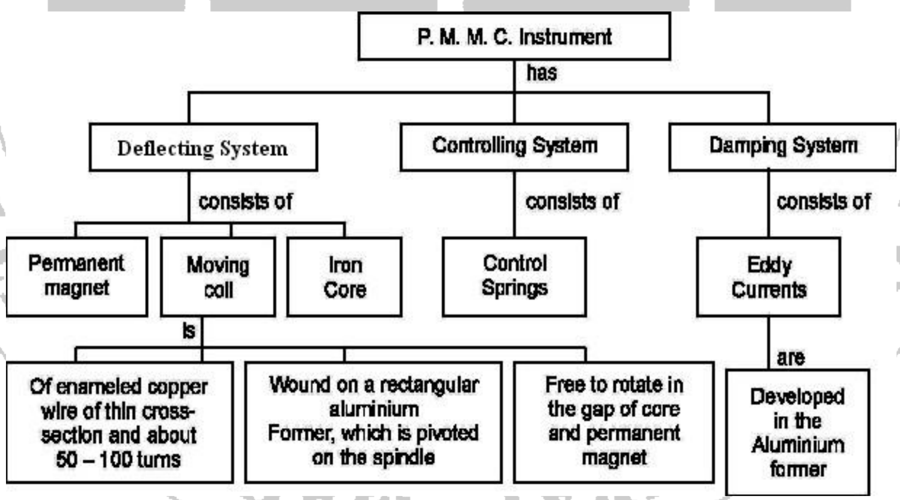

Fig:3.1. Structure of PMMC instruments

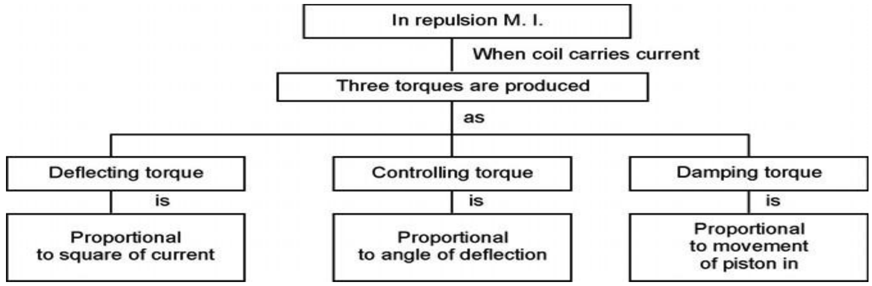

Fig: 3.2. Structure of MI (repulsion type instrument) instruments

VII Practical set-up / Circuit diagram / Work Situation

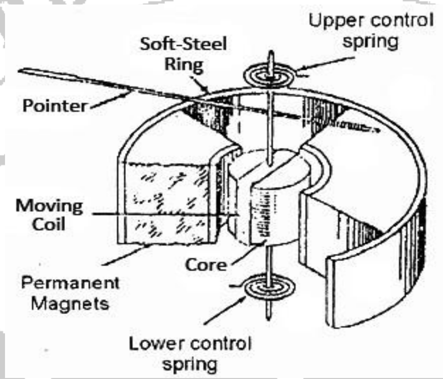

Fig: 3.3.Internal structure of PMMC instrument

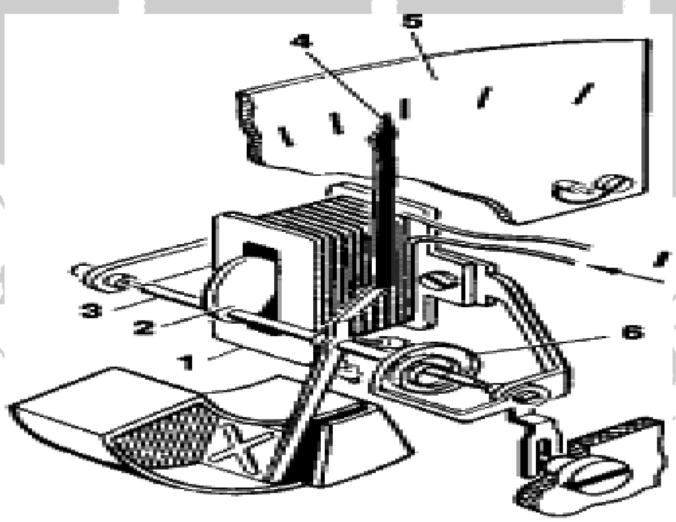

Fig: 3.4. Internal structure of MI instrument

1. Coil, 2. Core, 3. Shaft, 4. Pointer, 5. Scale, 6. Spring and 7.current

VIII Required Resources/apparatus/equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	MI Instrument	Working model Voltmeter, Ammeter	1
2	PMMC Instruments	Working model Voltmeter, Ammeter	1

IX Precautions to be followed

1. Select proper range of meters.
2. Be careful while selecting PMMC/MI meters.
3. Don't increase the voltage/current beyond meters capacity
4. Don't touch the live wire

X Problem Statement (to be provided by Teacher, sample given here)

1. PMMC meter doesn't show deflection.
2. Pointer of MI instrument oscillates for a long time before it comes to final steady state position.

XII Observations

Student should observe the faults, find the causes and provide the remedial action. Prepare troubleshooting chart.

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Trouble shooting chart for MI Instrument (use blank sheet)

Sr. No.	Fault	Cause	Remedial Action

Trouble shooting chart for PMMC Instrument (use blank sheet)

Sr. No.	Fault	Cause	Remedial Action

XIII Result(s)

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XIV Interpretation of results

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XV Conclusion

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XVI Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. State the reason for non-deflection of instrument pointer.
2. State the reason for oscillations of pointer for a longer period before it comes to final steady state position.
3. "PMMC instruments can be used for measurement of AC quantities". State true or false with justification.

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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 Publications
2. https://www.e1ectrica14u.com/electrical-measuring-instruments-types-accuracy-precision-resolution-speed/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi ,K. A. Bakshi ISBN 9788l843l4380 First 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. 4: Calibration of ammeter/voltmeter for measurement of electrical parameters

I Practical Significance

Accurate measurement of electrical quantities leads to accurate efficiency calculations. The economics of any machine or power system is decided by efficiency and ultimately the readings from meters. Hence it is of prime importance to read the electrical quantities. Hence to get accurate readings on the meters, they must be calibrated regularly.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Calibrate the ammeter /voltmeter for measurement.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

The calibration is the process of checking the accuracy of the result by comparing it with the standard value. In other words, calibration checks the correctness of the instrument by comparing it with the reference standard. It helps us in determining the error occur in the reading and adjust the voltages for getting the ideal readings.

VII Practical set-up / Circuit diagram / Work Situation

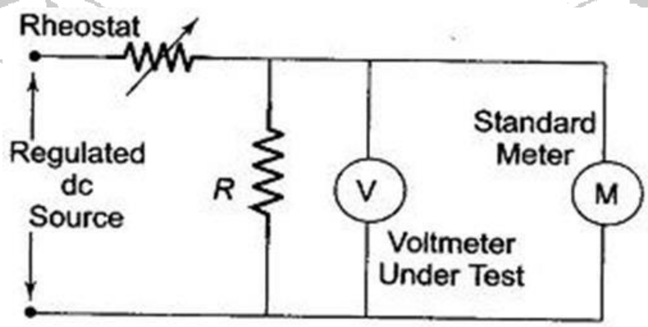

Fig:4.1. Calibration of voltmeter

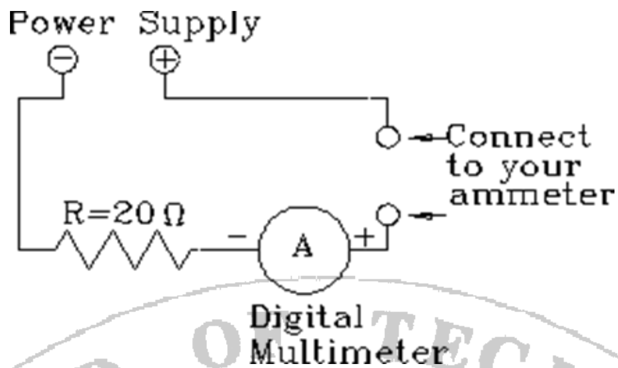

Fig: 4. 2 Calibration of Ammeter

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	Analog voltmeter	Range available in lab	1	
2	Standard Voltmeter	Properly calibrated with standard	1	
3	Analog Ammeter	Range available in lab	1	
4	Digital multimeter	Standard range	1	
5	DC Power Supply	0-30V,	1	
6	Rheostat/Resistance box	0-1k/0-10k/1M ohm	1	

IX Precautions to be followed

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

X Procedure

Part A: Calibration of voltmeter

1. Connect the circuit as shown in figure
2. Apply suitable voltage to the circuit using standard supply.
3. Vary the rheostat to set different voltages .
4. Measure voltages on both the voltmeters.
5. Repeat the procedure for different 3 voltages.
6. Plot the graph for voltage of standard meter vs. voltage of meter under test.

Part B: Calibration of Ammeter

1. Connect the circuit is as shown in figure 4.2.
2. Connect Ammeter under Test.
3. Measure Current through both the meters.
4. Change the R value, repeat the procedure to get more readings.
5. Tabulate the Reading
6. Repeat the Procedure for 3 different currents.
7. Plot the graph for current through standard ammeter vs. current through meter under test.

XI Observation

Part A: Calibration of voltmeter

- For V_1= 10V (Maximum range can be decided by Teacher depending on available voltmeter and DC supply.)
- Repeat the procedure for V_1= 5V; V_1= 3V (50% and 30% of maximum voltage)

V1=......................(Maximum Voltage)

Sr. No.	R value in ohm	Measured Voltage with Voltmeter under Test in Volt V_A	Measured Voltage with standard Voltmeter in Volt V_B	% Accuracy = $\frac{VA-VB}{VB}$ x 100

V1=.................(50% of maximum voltage)

Sr. No.	R value in ohm	Measured Voltage with Voltmeter under Test in Volt V_A	Measured Voltage with standard Voltmeter in Volt V_B	% Accuracy = $\frac{VA-VB}{VB}$ x 100

V1=..................(30 % of maximum voltage)

Sr. No.	R value in ohm	Measured Voltage with Voltmeter under Test in Volt V_A	Measured Voltage with standard Voltmeter in Volt V_B	% Accuracy = $\frac{VA-VB}{VB}$ x 100

Part B: Calibration of Ammeter

Sr. No.	R value in ohm	Current I_A of under test ammeter (Amp)	Current I_B of standard ammeter(Amp)	% Accuracy = $\frac{IA-IB}{IB}$ x 100

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical- sample given)

1. State the errors in analog voltmeter.
2. Stare full scale deflection of the given voltmeter.
3. State effect of resistance which is connected in parallel to the given analog meter.
4. State the percentage of accuracy of different ammeter in your laboratory.

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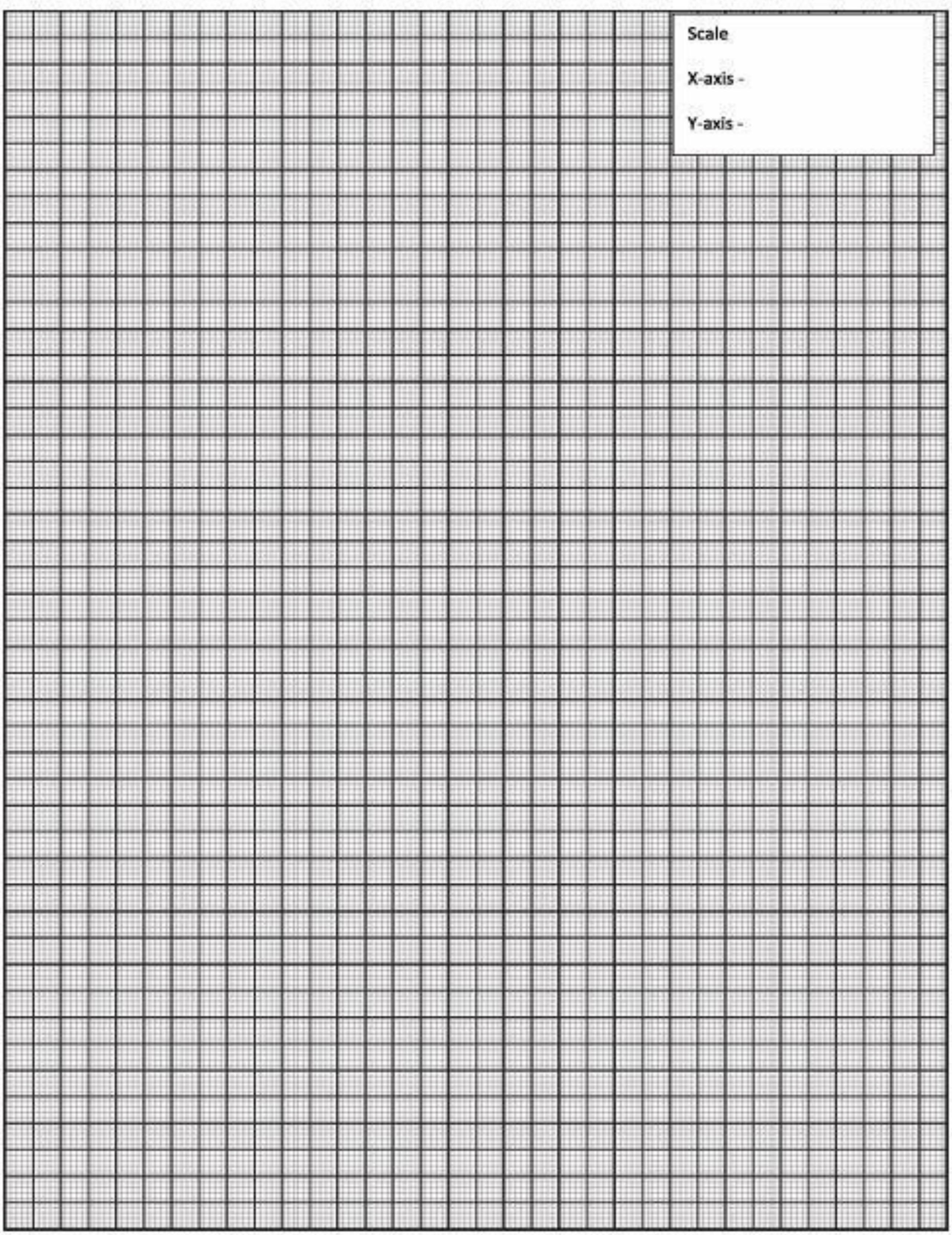
XVI References/Suggestions for further reading

1. https://www.electricalandcontrol.com/how-to-calibrate-an-ac-ammeter-an-ac-voltmeter/#AC_Ammeter_Calibration
2. Laboratory Manual for Introductory Electronics Experiments, Maheshwari L.K.,Anand M.M.S., New Age International Pvt ,New Delhi

XVII 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. 5: Extension of the range of voltmeter/ammeter using shunt and multiplier

I Practical Significance

Electrical Engineering diploma graduate are expected to measure high value of voltage and current. This higher value of current and voltage can be measured using low range meters by extending their range by using shunt & multiplier. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Extend the range of voltmeter and ammeter by using shunt and multiplier.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

The current capacity of D.C. ammeter depends upon the resistance of the coil of the particular instrument. So for Low range D.C. Ammeter, to measure a high value of D.C. current, its resistance should be reduced, which is done with the help of a device called 'Shunt'.

Shunt is a low resistance, necessarily lower than the instrument and it is connected in parallel with Ammeter i.e. instrument coil.

Thus a low range D.C. Ammeter with the help of 'Shunt' can measure high value D.C. current.

Shunt resistance

A low range D.C. Ammeter with resistance 'r' ohms and maximum safe working current (full deflection) 'I' amp, can measure the high current of 'I' amp with the help of 'Shunt' of resistance R_{sh} given by

$$R_{sh} = \frac{r}{(M-1)} \text{ ohms}$$

Where M= Multiplying Power of 'Shunt'=I/i

A Low range D.C. Ammeter with resistance ‘r’ohms and full-scale deflection ‘i’ amp	‘Shunt’ of resistance $R_{sh} = \frac{r}{(M-1)}$	Can measure ‘I’ amp where M=Multiplying Power of Shunt=I/i

Measurement of high value of D.C. Voltage

The current carrying capacity of D.C. voltmeter also depends upon the resistance of the coil of the particular instrument. So, for a low range D.C. voltmeter, to measure a high value of D.C. voltage, its resistance should be increased, which is done with the help of a device called ‘multiplier’.

‘Multiplier’ is a high resistance and it is connected in series with the instrument coil.

Thus a low range D.C. voltmeter with the help of ‘multiplier’ can measure high value of D.C. voltage.

Low range D.C. Voltmeter	With the help of ‘multiplier’ hich is high resistance in series	Measures high D.C. Voltage

Multiplier resistance

A low range D.C. voltmeter of resistance ‘r’ ohms and maximum safe working voltage (full scale deflection) ‘v’ volts, can measures the high voltage of ‘V’ volts with the help of ‘Multiplier’ of resistance R_{se} given by

R_{se} = r (M-1) ohms

Where M=Multiplying Power of ‘Multiplier’= V/v

A low range D.C. voltmeter with resistance ‘r’ ohms and full-scale deflection ‘v’	by a ‘Multiplier’ of resistance R_{se} = r (M-1)	Can measure ‘V’ volts where M= Multiplying Power of ‘Multiplier’= V/v

VII Practical set-up / Circuit diagram / Work Situation

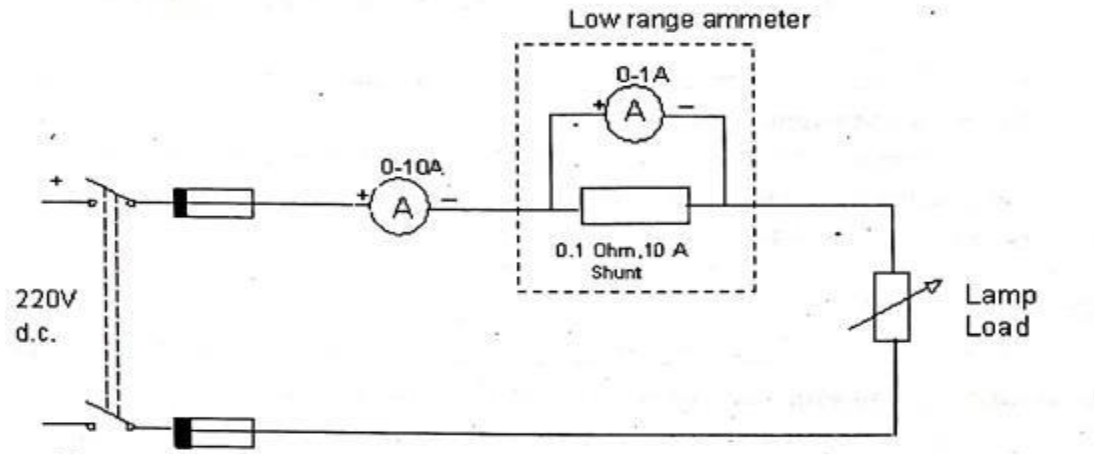

Fig: 5.1 Extension of the range of ammeter using shunt

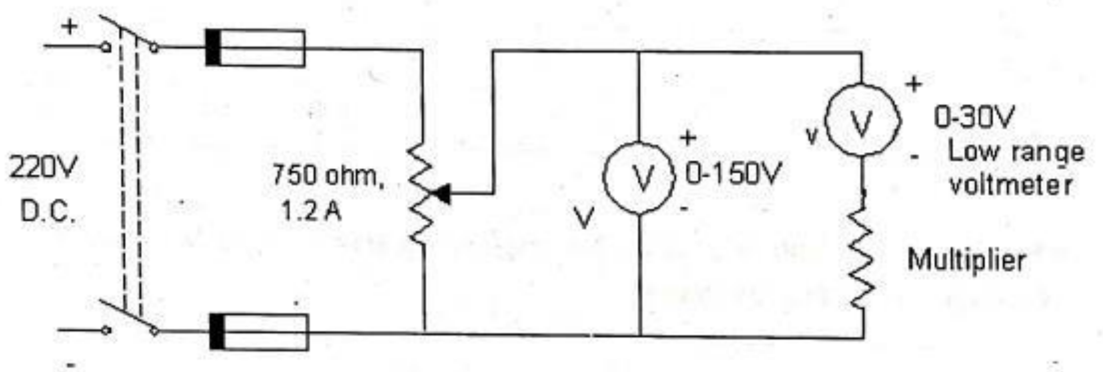

Fig: 5.2 Extension of the range of voltmeter using multiplier

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	DC Ammeter	Low range (0-1A) and Shunt	1	
2		(0-10A)	1	
3	DC Voltmeter	Low range (0-30V) and Multiplier	1	
4		(0-150V)	1	
5	Potential divider/Rheostat	750Ω ,1.2A	1	
6	Resistive Load/Lamp Bank	Upto 10Amp	1	

IX Precautions to be followed

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

X Procedure

Part A: Extension of the range of ammeter using shunt

1. Measure resistance of low range ammeter.
2. Calculate value of shunt resistance R_{sh} so that the low range ammeter can measure 10 amp.
3. Connect the low range ammeter and shunt in parallel with each other.
4. Connect the circuit as shown in circuit diagram.
5. Switch on the supply.
6. Increase current 'I' in steps to 2 ,4,6,8,10 amp and note down 'i'.
7. Find multiplying power of 'Shunt'.
8. Switch off the supply.

Part B: Extension of the range of voltmeter using multiplier

1. Measure resistance of low range voltmeter.
2. Calculate value of multiplier resistance R_{se} so that the low range voltmeter can measure 300V
3. Connect the low range voltmeter and multiplier in series with each other.
4. Connect the circuit as shown in circuit diagram of part B.
5. Keep potential divider to such position that minimum voltage is applied to the circuit initially.
6. Switch on the Supply.
7. Increase voltage 'V' in steps to 50,100,150,200,230 Volts and note down 'v'.
8. Find multiplying power of Multiplier.
9. Switch off the supply.

XI Observation and Calculation

Part A: Extension of the range of ammeter using shunt.

Sr. No.	Current 'I' Amp	Current 'i' Amp	$M=\frac{I}{i}$
1			
2			
3			
4			

Part B: Extension of the range of voltmeter using multiplier

Sr. No.	Voltage 'V' Volts	Voltage 'v' Volt	$M = \frac{V}{v}$
1			
2			
3			
4			

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. What is the meaning of 'High Value'?
2. What is meant by 'Range of an instrument'?
3. Why it is necessary to increase the range of a DC Ammeter and Voltmeter?
4. What is the advantage of using 'Shunt' and 'Multiplier'?
5. How the range of given Ammeter is extended to 75 Amp D.C?

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XVI 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 Publications
2. https://www.electricaldeck.com/2021/04/extension-of-range-of-ammeter.html
3. Electrical Measurements and Measuring Instruments U. A. Bakshi ,A. V. Bakshi ,K.A. Bakshi ISBN 9788l843l4380First Edition — 2008 Technical Publications Pune.

XVII 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: Extension of the range of ammeter using Current Transformer (CT)

I Practical Significance:

Instrument transformers are the transformers, employed in conjunction with relevant instruments like ammeter, voltmeter, wattmeter and energymeter and they serve as an important part of the measuring devices.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Extend the range of ammeter by using CT, take the safety precaution while using CT.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

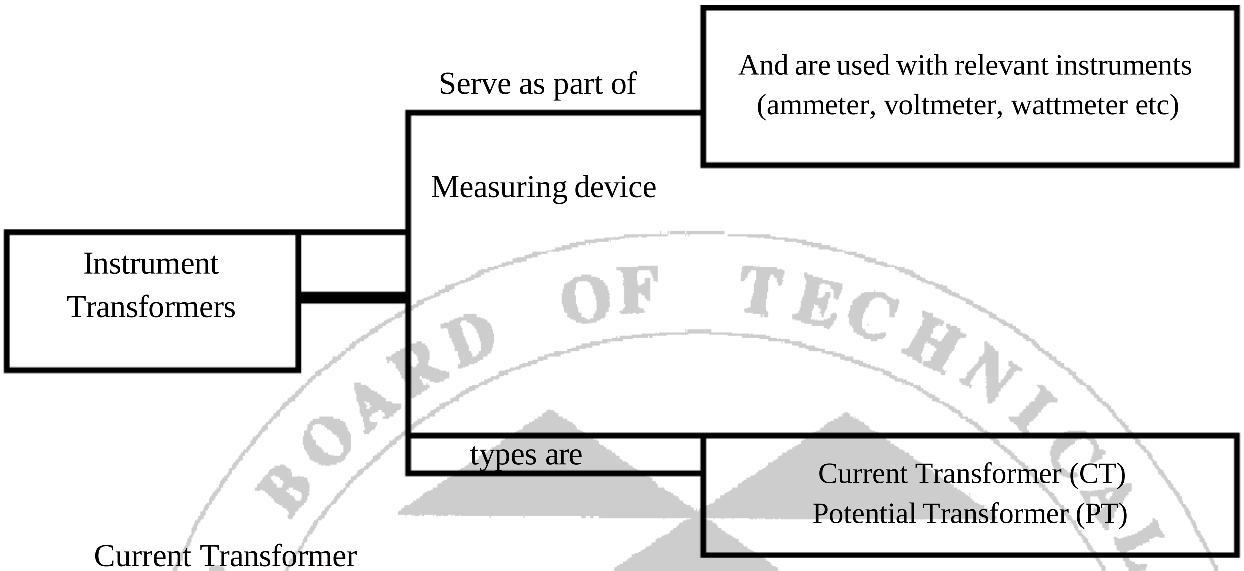
Instrument Transformers

These are the transformers employed in conjunction with relevant instrument (ammeter, voltmeter, wattmeter and energymeter) and they serve as an important part of the measuring devices.

These transformers are of two types: -

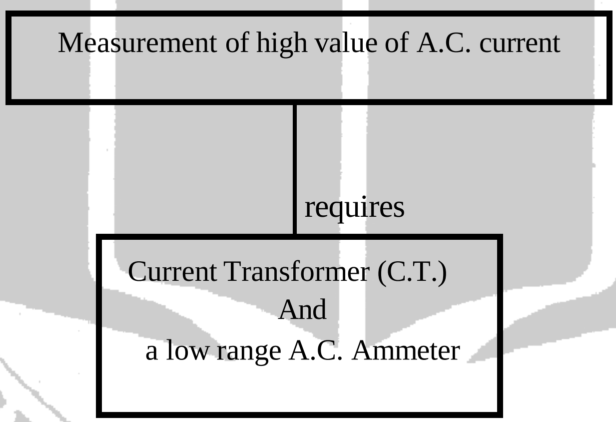
Current Transformer (C.T.) or Series Transformer and

Potential Transformer (P.T.) or Parallel Transformer



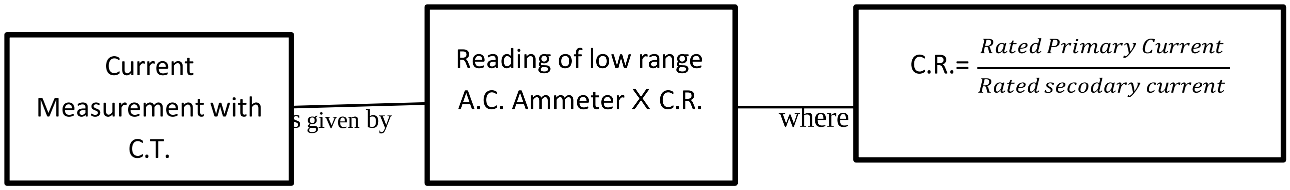
Current Transformer

Current Transformer is employed along with a low range A.C. ammeter so as to measure high value of A.C. current where ever and whenever the current of an A.C. circuit exceeds the safe working current of the measuring instrument (e.g. ammeter, voltmeter, wattmeter or energy meter).



The high value of current to be measured is equal to the reading of low range A.C. Ammeter multiplied by Current Ration (C.R.) of the C.T., where

$$\text{Current Ratio} = \frac{\text{Rated Primary current}}{\text{Rated Secondary Current}}$$



VII Practical set-up / Circuit diagram / Work Situation

a) Extend range of ammeter by using CT

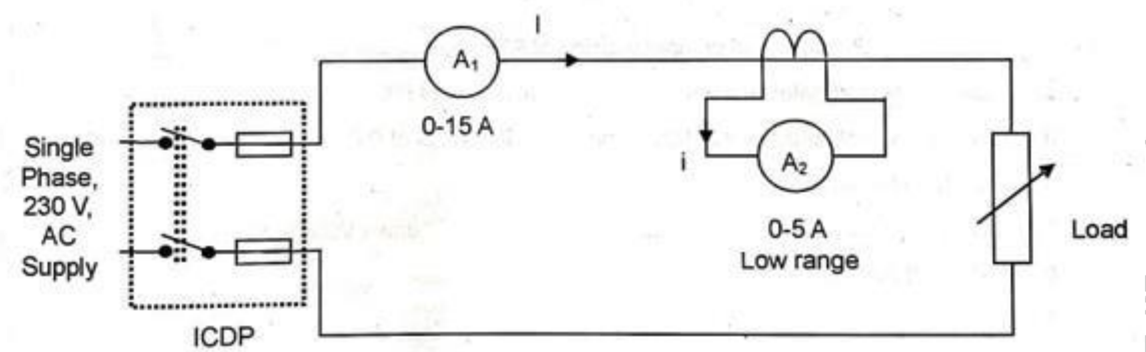


Fig: 6.1 Extend range of ammeter by using CT

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remark
1.	Current Transformer	15/5,25/5 or suitable range	1	
2.	Analog Ammeter	(0-5A),(0-15A) or suitable range	1	
3.	Lamp Load	15Amp	1	
4.	Single Phase Variac	1-Phase,1 kVA,(0-270V)	1	
5.	Digital Multimeter	Standard Range	1	

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 wire.
6. Secondary of CT should always be short circuited.

X Procedure

1. Make the connections as per Figure 6.1
2. Check and adjust zero setting of ammeter and voltmeter. (if any)
3. Keep the autotransformer at minimum position.
4. Put the electrical load in off condition.
5. Switch on the AC supply.
6. Gradually increase the output of autotransformer up to rated voltage.
7. Switch on the load switch/ switches in steps.
8. Note ammeter readings I_1 and I_2in observation table.
9. Repeat step 7 and 8 four times.
10. Switch off the load and gradually decrease the output of autotransformer to minimum.
11. Switch off the supply.

XI Observation table

$$\text{Current Ratio} = \frac{Rated\ Primary\ current}{Rated\ Secondary\ Current} =$$

Sr.No.	Current 'I_1' Amp	Current 'I_2' Amp	I_1/I_2	Actual Current = I_2 x C.R. (Amp)
1.				
2.				
3.				
4.				

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: - Teacher should provide various questions related to practical-sample given)

1. Current up to 250 amperes is to be measured with a low range ammeter. Suggest the method and range of the instruments required. Draw the circuit diagram.
2. “Secondary of CT should never be kept open circuited”. Justify the statement.
3. State the precaution while using Current Transformer.
4. What are the advantages and disadvantages of Current Transformers and Shunts?

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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 Publications
2. https://www.electricaldeck.com/2021/04/extension-of-range-of-ammeter.html
3. Electrical Measurements and Measuring Instruments U. A. Bakshi A. V. Bakshi K.A. Bakshi ISBN 9788l843l4380First 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. 7: Extension of the range of voltmeter using Potential Transformer (PT)

I Practical Significance

Electrical Engineering diploma graduate are expected to measure higher voltage, a potential transformer is an instrument transformer used in power system for accurate voltage measurement and protection purposes. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

Extend the range of voltmeter by using PT, take the safety precaution while using PT.

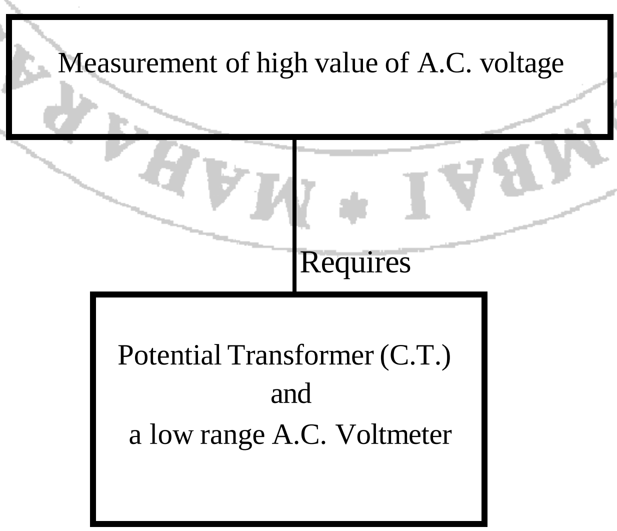
V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

Potential Transformer

Potential Transformer is employed along with a low range A.C. voltmeter so as to measure high value of A.C. voltage wherever and whenever the voltage of an A.C. circuit exceeds the safe working of the instrument.



High value of voltage to be measured is equal to the reading of low range A.C. Voltmeter multiplied by Voltage Ratio(V.R.) of the P.T. where

Voltage Ratio $= \frac{Rated\ Primary\ voltage}{Rated\ Secondary\ voltage}$

Voltage Measurement with P.T. → is given by → Reading of low range A.C. Voltmeter X V.R. → where → V.R.= $\frac{Rated\ Primary\ Voltage}{Rated\ secodary\ voltage}$

VII Practical set-up / Circuit diagram / Work Situation

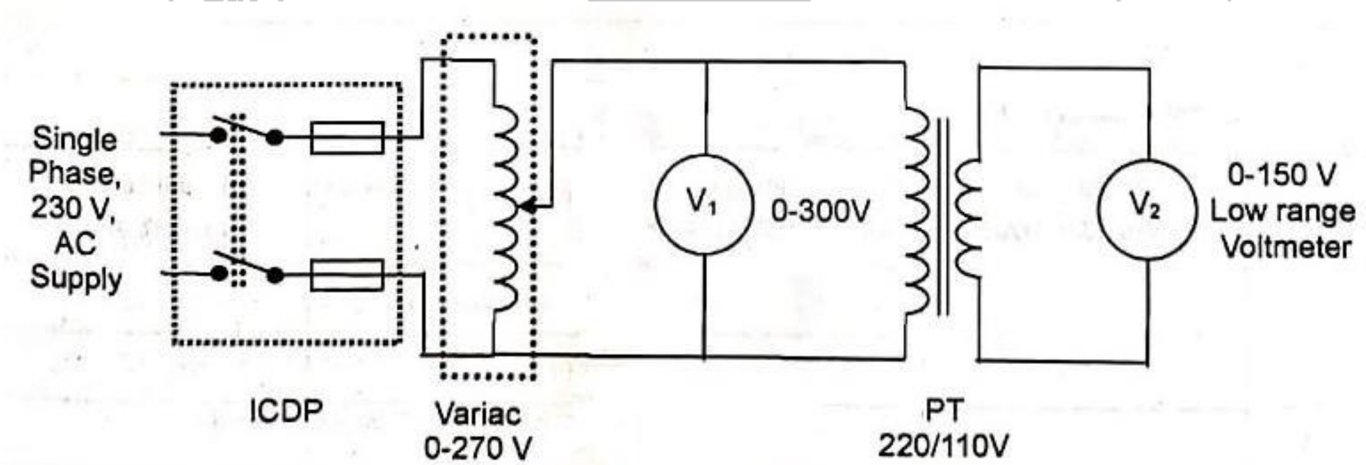


Fig:7.1 Extension of the range of voltmeter using Potential Transformer (PT)

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remark
1.	Potential Transformer	220/110 ,440/110 or suitable range	1	
2.	Analog Voltmeter	(0-150V),(0-300V)	1	
3.	Single Phase Variac	1-Phase,1 kVA,(0-270V)	1	
4.	Digital Multimeter	Standard Range	1	

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.

X Procedure

1. Make the connections as per Figure 7.1.
2. Check and adjust zero setting of voltmeter. (if any)
3. Keep the autotransformer at minimum position.
4. Switch on the AC supply.
5. Gradually increase the output of autotransformer in steps (eg-100V,150V,200V,230V)
6. Note voltmeter readings $V_1$and V_2 in observation table.
7. Switch off the supply.

XI Observation table

$$\text{Voltage Ratio} = \frac{Rated\ Primary\ voltage}{Rated\ Secondary\ voltage} =$$

Sr.No.	V_1 (Volts)	V_2 (Volts)	V_1/ V_2	Actual Voltage = V_2 x V.R. (Volts)
1.				
2.				
3.				
4.				

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. Voltages up to 11 kV are to be measured with low range voltmeter. Suggest the method and range of the instruments required. Draw the circuit diagram.
2. What are the advantages and disadvantages of Potential Transformers and Multipliers ?

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XVI 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 Publications
2. https://www.electricaldeck.com/2021/04/extension-of-voltmeter-range.html
3. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi , K.,A.Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune.

XVII 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: Measurement of power in a single-phase circuit using electro-dynamic watt-meter

I Practical Significance

Electrical Engineering diploma graduate are expected to handle measuring instruments to measure power of field devices. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Measure power in a single –phase circuit by electro-dynamics watt-meter and determining the multiplying factor of a wattmeter also changes the current range of wattmeter by making changes in the current.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

Dynamometer type wattmeter

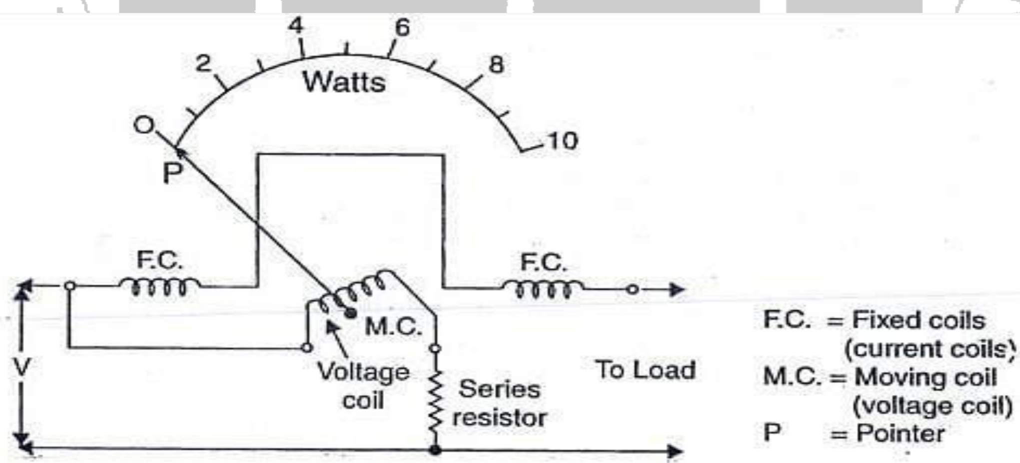


Fig: 8.1 Structure of Dynamometer type wattmeter

Reading of Wattmeter

Reading of wattmeter is given by multiplication of

1. Voltage across pressure coil(V)
2. Current through the current coil (I) and
3. Cosine of the angle between V & I.

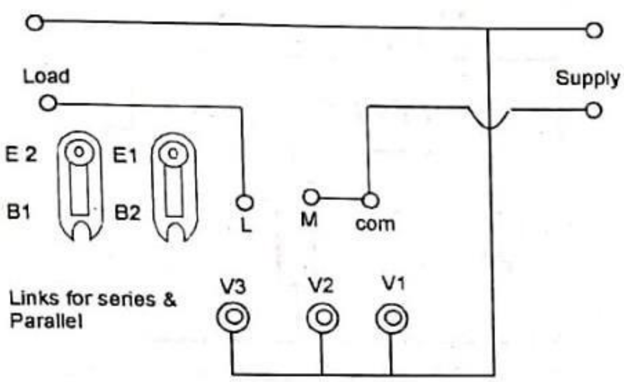
Extension of range of wattmeter

The current range of wattmeter can be extended by connecting the two parts of fixed coil in parallel. And by connecting them in series, lower range for current is obtained.

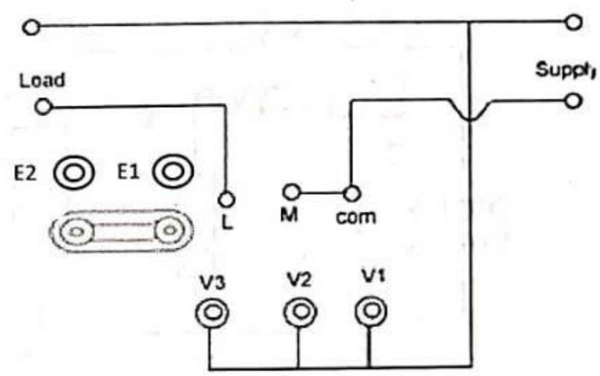
By providing series resistance of different values the voltage range of wattmeter can be extended.

For low current range i.e. (0-5A), join B_1 and B_2 together.

For high current range i.e. (0-10A), join B_1, E_2 and B_2, E_1 together.



Connection of Links for High Current Range



Connection of Links for Low Current Range

Multiplying Factor of wattmeter

As two different ranges of voltage and current are available for wattmeter to calculate actual power multiplying factor should be used.

The multiplying facto of wattmeter is given by the product range, current range and rated power factor of wattmeter, divided by the full scale deflection of wattmeter.

$$\text{Multiplying factor} = \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$$

VII Practical set-up / Circuit diagram / Work Situation

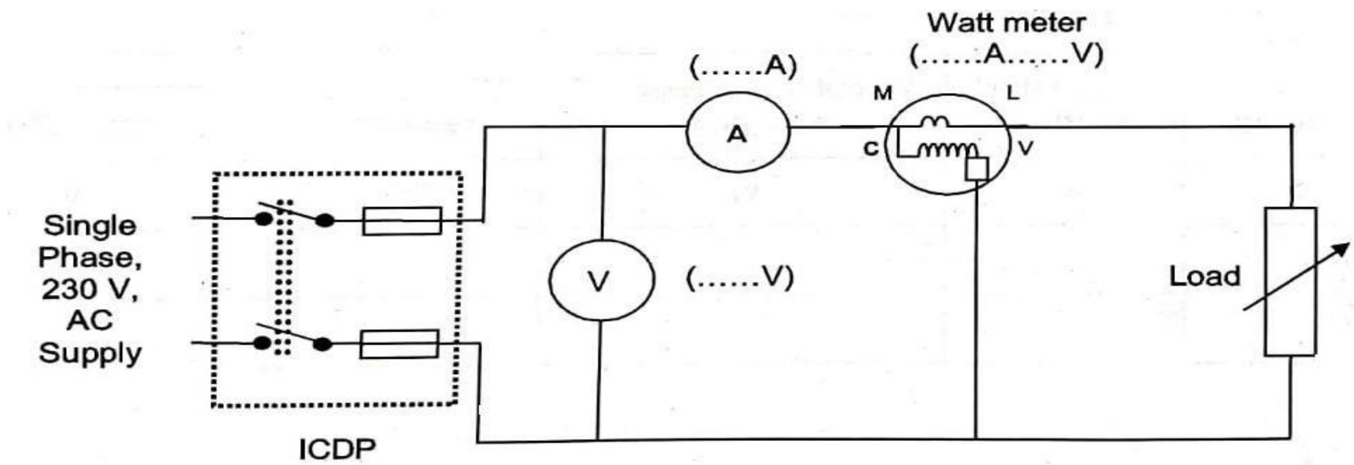


Fig: 8.2.Measurement of power in single phase circuit

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remark
1.	Single Phase Variac	1-Phase,1 kVA,(0-270V)	1	
2.	A.C. Voltmeter	(0-300V)	1	
3.	A.C. Ammeter	(0-10A)	1	
4.	Wattmeter	(600W,250V,5/10A)	1	
5.	Resistive /Lamp Load	15A	1	

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. Don’t touch the live wire.
5. Use autotransformer to vary for safety reason.

X Procedure

1. Calculate multiplying factor of wattmeter and record the same in observation table.
2. Make the connections as per the circuit diagram.
3. To avoid confusion first make a series connection i.e. supply line point to ammeter, ammeter to M point of wattmeter, L point of wattmeter to load and load to supply neutral. Then parallel

connections i.e. M point of wattmeter to C point of wattmeter. V point of wattmeter to supply neutral or load point and then voltmeter connection.

4. Check and adjust zero setting of wattmeter, ammeter and voltmeter. (if any)
5. Keep the autotransformer at minimum position.
6. Put the electrical load in off condition.
7. Switch on the supply.
8. Gradually increase the output of autotransformer up to rated voltage.
9. Switch on the load switch/ switches in steps.
10. Note voltmeter, ammeter & wattmeter readings in observation table.
11. Take another reading by increasing load.
12. Note voltmeter, ammeter & wattmeter readings in observation table.
13. Switch off the load and supply.
14. Calculate the power in the circuit using formula.

XI Observation and Calculation

Multiplying factor $= \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$

M.F = ……………………………………………………………………………

……………………………………………………………………………….

For Resistive Load cos ϕ =1

Sr.No.	Ammeter Reading	Voltmeter Reading	Calculated Power =Vx I x cos ϕ	Wattmeter reading	Actual measured power = Wx M.F
	I (Amp)	V(Volt)	(Watt)	(Watt)	(Watt)

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. In a circuit power is measured with a wattmeter with 15A, 400V, 1500 Watts F.S.D. The reading was 750Watts. What is the power consumed by load?
2. "Watt meters are not used for measuring power in D. C. circuits". State whether the given statement is true or false. Give reasons.
3. One wattmeter is rated for 10A, 20A, 150V, 300V and 600V.The full scale deflection is 1500W. Calculate M.F. for this combination.
4. Wattmeters are not used for measuring power in D.C. circuits, State true or false. Give reasons.

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XVI 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 Publications
2. https://www.eeeguide.com/power-measurement-in-single-phase-circuit-by-wattmeter/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi ,K. A., Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune.

XVII 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: Troubleshoot of electro-dynamic wattmeter for measurement

I Practical Significance

This practical is expected to develop the skills like, to use single phase wattmeter and troubleshoot wattmeter.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Apply the basics of measurement to the measuring instruments.

IV Laboratory Learning Outcome(s)

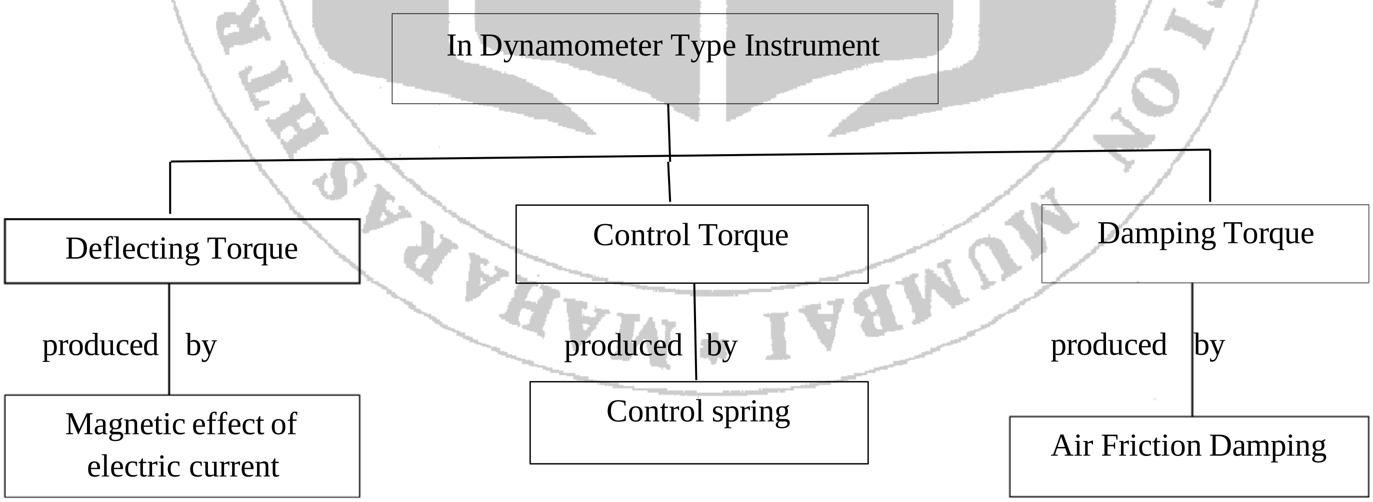
Carry out troubleshooting of electrodynamic wattmeter.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

In dynamometer type instrument deflecting torque is produced by magnetic effect of electric current. Control torque is provided by control springs. Damping torque is provided by Air Friction damping.



Dynamometer type wattmeter

In a dynamometer type wattmeter the fixed coil (current coil) is connected in series with the load. This coil is divided in to two parts and they are kept parallel to each other. The coil is thick in cross section and has lesser number of turns. The moving coil (pressure coil) is connected across the load. It is thin in cross-section and has hundreds of turns. It has a high non- inductive resistance in series with it.

Errors in watt meter due to connection

There are two alternate methods of connecting wattmeter in a circuit. The errors are introduced in the measurement owing to power loss in the current and pressure coil.

The two alternate methods of connecting wattmeter are as follows:

1. Connection of M and C

In this connection, the pressure coil is connected on the supply side therefore, the voltage applied to the pressure coil is the voltage across the load plus the voltage drop across the current coil. Thus the wattmeter measures the power loss in its current coil plus power consumed by the load.

This connection is used for low current and high voltage circuit.

2. Connection of L and C

In this connection, the current coil is on the supply side therefore, it carries the pressure coil current plus load current. Thus the wattmeter measures the power loss in its pressure plus the power consumed by the load.

This connection is used for high current and low voltage circuit

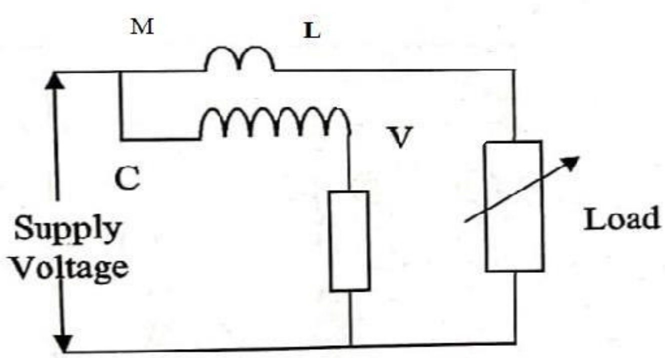


Fig: 9.1 Connection of M and C

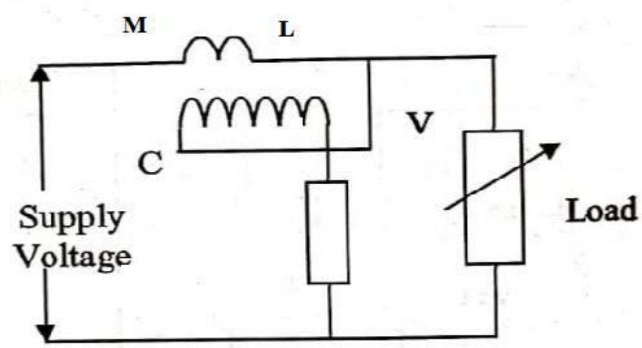


Fig:9.2 : Connection of L and C

Wattmeter Reading
=Power consumed by load +
Power loss in current coil

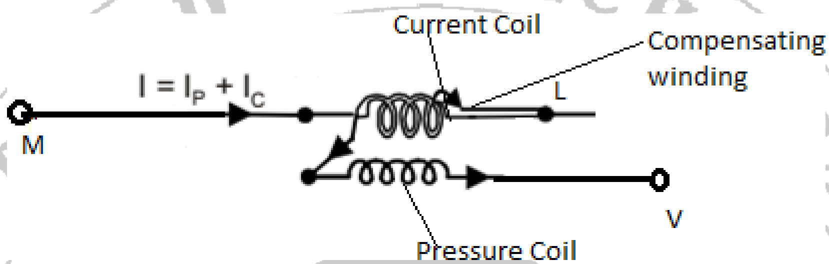
Wattmeter Reading
=Power consumed by load +
Power loss in pressure coil

Compensated Wattmeter

In low power factor wattmeter, compensated coil is used to compensate error caused by power loss in its pressure coil.

Compensating winding is a winding connected in series with pressure coil. It has same number of turns as that of current coil, but has small cross-section.

The compensating coil carries the pressure coil current and produces a field opposite to the current coil field due to the lad current and the pressure coil current through it.



VII Practical set-up / Circuit diagram / Work Situation

Fig:9.3. Front View of wattmeter

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	Wattmeter	Standard range	1	
2	Voltmeter	(0-300V)	1	
3	Ammeter	(0-5A)	1	
4	Single Phase Variac	1-Phase,1 kVA,(0-270V)	1	

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. Don't touch the live wire.

X **Problem Statement** (to be provided by Teacher, sample given here)

1. Wattmeter reads high.
2. Wattmeter reads low.

XI **Procedure** (Student should write the procedure) (use blank sheet)

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XII **Observation** (Prepare table on blank sheet for several faults)

Student should observe the troubles, find the causes and provide the remedial action

Sr. No.	Fault	Cause	Remedies

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: - Teacher should provide various questions related to practical-sample given)

1. If capacitance effect exceeds than inductance effect in pressure coil, what will happen?
2. Wattmeter has weak operating field state the reason.
3. Describe, how the errors caused by vibration of moving system are avoided?
4. Why does a dynamometer type instrument require a magnetic shield?

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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 Publications.
2. https://en.wikipedia.org/wiki/Wattmeter
3. Electrical Measurements and Measuring Instruments U. A. Bakshi ,A. V. Bakshi, K. A. Bakshi ISBN 9788l843l4380 First 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. 10: One wattmeter method of measurement of active power in a three-phase balanced load

I Practical Significance

Electrical diploma graduate is expected to handle measuring instruments to measure active power of 3-phase circuit using one wattmeter. Therefore, this practical will help you to acquire necessary skill.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Measure active power in three phase balanced load by using one wattmeter method. .

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

Measurement of power in 3 phase circuit

Power in 3 phase system may be measured by using

1. Three single phase wattmeter - This method is used for a star connected, 4 wire system, balanced or unbalanced load.
2. Two 1 phase wattmeter - This method is suitable for 3 phase, 3 wire system and widely used. It is applicable to both delta and star system, balanced or unbalanced load.
3. One single phase wattmeter - This method is applicable to balanced load only.
4. One 3 phase wattmeter - 3 phase wattmeter consists of two or three wattmeter elements mounted together in one case with moving coils mounted on the same spindle.

One wattmeter method for measurement of active power is for 3 phase balanced load only. The current coil of the wattmeter is connected in one of the lines and one end of pressure coil is connected to the same line. The readings are taken by connecting other terminal of pressure coil alternately to other 2 lines. The sum of the two readings gives active power.

VII Practical set-up / Circuit diagram / Work Situation

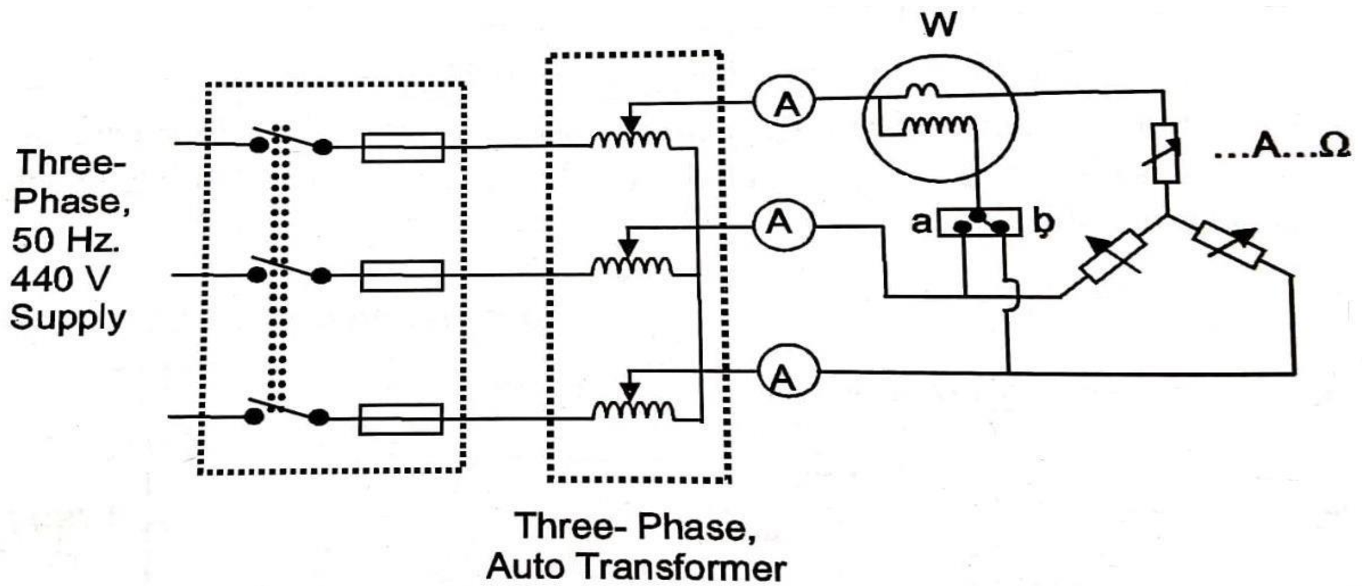

Fig 10:1.One wattmeter method of measurement of active power in a three-phase balanced load

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	3-phase Auto transformer (Dimmerstat)	Standard specification	1	
2	A.C. Ammeter	(0-5A)	3	
3	A.C. Voltmeter	(0-300V)	1	
4	Wattmeter	(600W,500V,5A)	1	
5	Three phase lamp Bank	Suitable range	1	
6	Two way Switch	5A,600V	1	

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. Don't touch the live wire.

X Procedure

1. Make the connections as per Figure:10.1.
2. Check and adjust zero indication of wattmeter and note the multiplying factor of wattmeter.
3. Switch on the supply.
4. Increase the output of dimmerstat up to rated voltage.
5. Adjust load for equal currents through all ammeters.(Balanced load).
6. Note voltmeter, ammeter & wattmeter reading W1 with switch at position 'a'.
7. Note wattmeter reading W2 with the switch at position 'b'.
8. Take two readings for different current for balanced load.
9. Switch off the load and then the supply.
10. Calculate total active power and power factor.

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

Multiplying factor $= \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$

M.F = ……………………………………………………………………………

……………………………………………………………………………

S. N.	Ammeter Reading	Voltmeter Reading	Watt-meter reading x M.F.		Total Active Power	tan ϕ	ϕ	Power factor
			W1	W2	P=W1 +W2			
	I(Amp)	V(Volt)	(Watt)	(Watt)	(Watt)	$\frac{\sqrt{3}(W1-W2)}{(W1+W2)}$	$\tan^{-1}\phi$	$\cos\phi$

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. State the condition of balanced star connected load.
2. In star connection when is the load said to be balanced?
3. Active power in 3 phase balanced load circuit with one wattmeter method is to be measured. Draw phasor diagram for the same.
4. Write the relation between kW, kVA & kVAr.

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XVI 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 Publications
2. https://www.electrical4u.com/measurement-of-three-phase-power/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi ,K. A. Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune

XVII 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. 11: One wattmeter method of measurement of reactive power in three-phase balanced load

I Practical Significance

Electrical diploma graduate is expected to handle measuring instruments to measure reactive power of 3-phase circuit using one wattmeter. Therefore, this practical will help you to acquire necessary skill.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Measure reactive power in three phase balanced load by using one wattmeter method. .

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

It is often convenient and even essential that reactive power be measured. For example in load monitoring, such a measurement gives the operator the information of the nature of load. Also the reactive power serves as a check on power factor measurements, since ratio of reactive and active power is $\tan \Phi = Q/P$ Where Q & P are the reactive and active power respectively.

One wattmeter method for measurement of reactive power is for 3 phase balanced load only. The current coil of the wattmeter is connected in one of the lines. The pressure coil is connected across two lines. The reactive power is $\sqrt{3}$ times the wattmeter reading.

VII Practical set-up / Circuit diagram / Work Situation

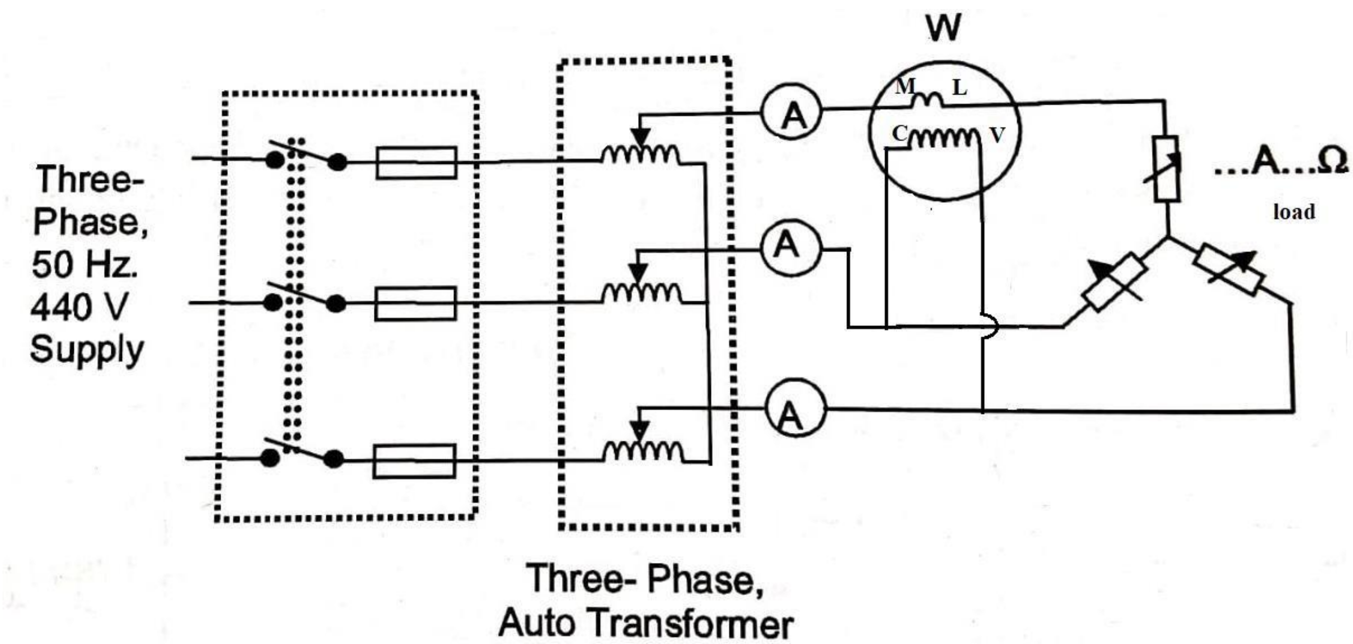

Fig: 11.1. One wattmeter method of measurement of reactive power in three-phase balanced load

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	3-phase Auto transformer (Dimmerstat)	Standard specification	1	
2	A.C. Ammeter	(0-5A)	3	
3	A.C. Voltmeter	(0-300V)	1	
4	Wattmeter	(600W,500V,5A)	1	
5	Inductive Bank	5A,250V	1	

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. Don't touch the live wire.

X Procedure

1. Make the connections as per circuit diagram.
2. Check and adjust zero indication of wattmeter and note the multiplying factor of wattmeter.
3. Switch on the supply.
4. Increase the output of dimmerstat up to rated voltage.
5. Adjust load for equal currents through all ammeters. (Balanced load).
6. Note voltmeter, ammeter & wattmeter reading W.
7. Take two readings for different current for balanced load.
8. Switch off the load and then the supply.
9. Calculate total active power and power factor.

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

Multiplying factor $= \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$

M.F = ……………………………………………………………………………

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Sr.No	Voltage V (Volts)	Current I (Amp)	Power W (Watt)	Total Reactive Power , Q= √3 W (VAR)
1				
2				
3				
4				

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical- sample given)

1. Why is it essential to measure reactive power?
2. List four electrical equipment, which consume reactive power.
3. A single phase wattmeter is used for measurement of reactive power in 3 phase balanced load. If the total reactive power is 173 kVAr. Calculate the reading of wattmeter.
4. Suggest suitable method to measure power consumed by a three phase inductor motor used for pumping the water.

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XVI 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 Publications
2. https://www.electrical4u.com/measurement-of-three-phase-power/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi ,K. A. Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune

XVII 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: Two wattmeter method of measuring active power in three-phase balanced load

I Practical Significance:

Electrical diploma graduate is expected to handle measuring instruments to measure power of 3-phase circuit using two wattmeters. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Measure active power in three phase balanced load by using two wattmeter method.

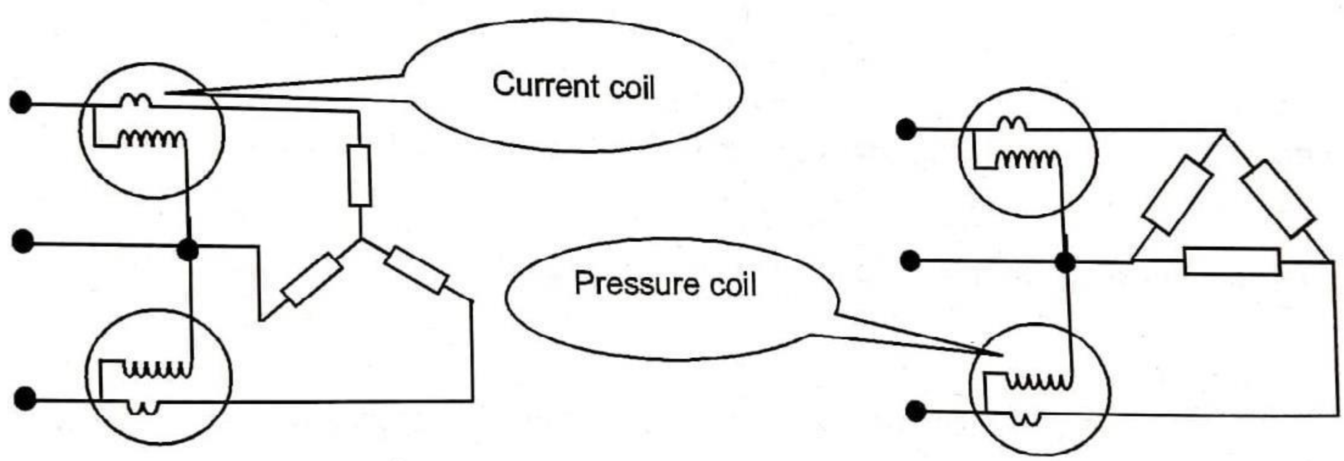
V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

Watt-meter connection for measurement of active power in three-phase load using two wattmeter

For measurement of active power in three phase balanced load, using two wattmeter, the current coils of wattmeter are connected between any two lines and pressure coil is connected between third line and its own current coil and other terminal is connected to third line as shoen in the circuit diadram. This is irrespective of star or delta connection of the load.



Total active Power using two wattmeter

The power consumed by the load in three phase circuit is given by the algebraic sum of two wattmeter readings irrespective of the load is balanced or unbalanced.

Effect of power factor on reading of wattmeter

1) For unity power factor

$\cos\phi$ =1 and ϕ =0

Total Power,W=W1 + W2 =3 VI $\cos\phi$ = 3VI

At unity power factor, the readings of two wattmeters are equal; each wattmeter reads half of the total power.

2) For 0.5 power factor

$\cos\phi$ = 0.5 and ϕ = 60^0

Total power, W =W1+W2=3 Vl $\cos\phi$ =3Vl x 0.5=3/2 VI

3) For zero power factor

$\cos\phi$ = 0 and ϕ = 90^0

Total power, W =W1+W2=3 Vl $\cos\phi$ =3 V1 x 0 =0

At zero power factor, the readings of two wattmeters are equal; but having opposite sign.

VII Practical set-up / Circuit diagram / Work Situation

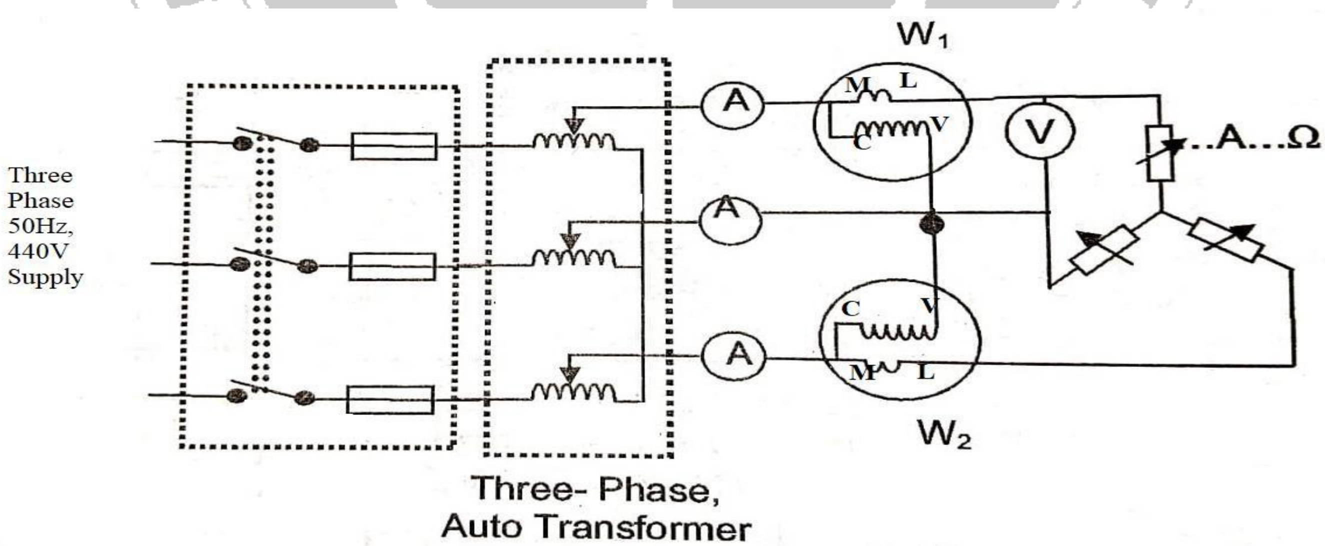


Fig:12:1. Two wattmeter method of measuring active power in three-phase balanced load

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	3-phase Auto transformer (Dimmerstat)	Standard specification	1	
2	A.C. Ammeter	(0-5A)	3	
3	A.C. Voltmeter	(0-300V)	1	
4	Wattmeter	(600W,500V,5A)	2	
5	Three phase resistive load/lamp bank	Suitable specification	1	
6	Three phase inductive load	Suitable specification	1	
7	Digital multimeter	Standard range	1	

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. Don't touch the live wire.

X Procedure

1. Make the connections as per circuit diagram.
2. Check and adjust zero indication of wattmeter and note the multiplying factor of wattmeter.
3. Switch on the supply.
4. Increase the output of dimmerstat up to rated voltage.
5. Adjust load for equal currents through all ammeters. (Balanced load).
6. Note voltmeter, ammeter & wattmeter reading W.
7. Take two readings for different current for balanced load.
8. Switch off the load and then the supply.
9. Calculate total active power and power factor.

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

Multiplying Factor for wattmeter (W1)

$$\text{Multiplying factor} = \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$$

M.F = ……………………………………………………………………………

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Multiplying Factor for wattmeter (W2)

$$\text{Multiplying factor} = \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$$

M.F = ……………………………………………………………………………

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S.N.	**Type of load**	**Ammeter reading**	**Voltmeter reading**	**Watt-meter Reading x M.F**	**Watt-meter Reading x M.F**	**Total Active power**
		I (Amp)	**V (Volt)**	**W1 (Watt)**	**W1 (Watt)**	**W=W1+W2**
1	Pure Resistive					
2	Resistive +Inductive (i.e. inductive Load)					

Calculation:

Sr. No	Types of Load	tan ϕ	ϕ	Power factor
		$\frac{\sqrt{3}(W1 - W2)}{(W1 + W2)}$	$\tan^{-1}\phi$	$\cos\phi$
1	Pure Resistive			
2	Resistive +Inductive (i.e. inductive Load)			

XII Result(s)

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XIII Interpretation of result

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. State the advantages of two wattmeter method of measuring power in three phase circuit.
2. When does the wattmeter read negative in two wattmeter method of measuring power?
3. In three-phase balanced circuit, while measuring a power using two wattmeter, one wattmeter reads 2000 watts and other wattmeter reads 1500 watts respectively, Calculate the total active power and power factor of the load when i) both wattmeter readings are positive and ii) 1500 watt reading is obtained after reversing the pressure coil connection.
4. State what happen if pressure coil of one of the wattmeter is disconnected from the circuit.

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XVI 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 Publications
2. https://www.electrical4u.com/measurement-of-three-phase-power/
3. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi ,K. A. Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune
4.

XVII 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. 13: Calibration of single phase energy meter by direct loading

I Practical Significance

Electrical Engineering diploma graduate are expected to find errors if any in single phase energy meter by calibration. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Calibrate single phase energy meter by direct loading.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

The energy meter may become inaccurate during its vigorous use due to various reasons.

It is necessary to calibrate the meter to determine and remove the errors so that same meter can be used for correct measurement of energy.

An electricity meter, electric meter, electrical meter, or energy meter is a device that measures the amount of electric energy consumed by a consumer.

Electronic meters display the energy used on an LCD or LED display and some can also transmit readings to remote places. In addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc. They can also support time-of-day billing, for example, recording the amount of energy used during on-peak and off-peak hours.

Pulse Rate of Electronic Energy Meter (EEM)

The pulse rate of EEM is calculated by counting the blinking of LED. Usual pulse rates of EEMs are 800 to 3600 pulses or impulses/ kWh. For most EEMs the pulse rate is 3200. It means that if 1000 Watt of power is consumed for 1 Hour the LED will blink 3200 times.

Fig: 13.1.Front View of Electronic Energymeter

VII Practical set-up / Circuit diagram / Work Situation

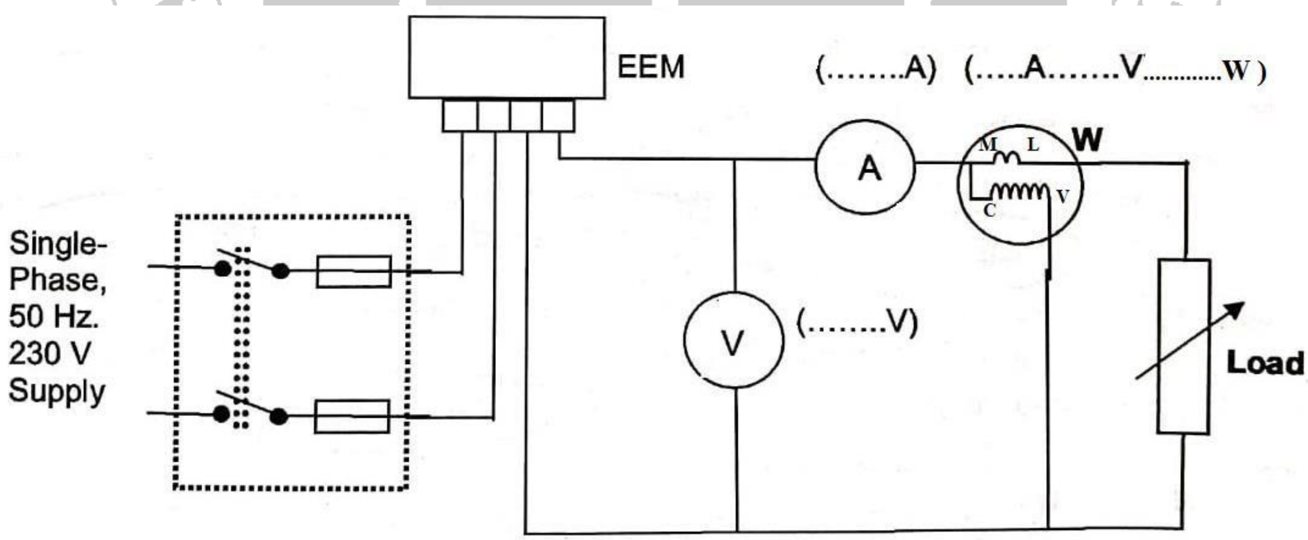

Fig:13.2.Calibration of EEM

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remark
1.	Single Phase Variac	1-Phase,1 kVA,(0-270V)	1	
2.	Single phase electronic energymeter	Single phase , Two wire,240V,50Hz,Class-I , 3200 imp/kWh	1	
3.	A.C. Voltmeter	(0-300V)	1	
4.	A.C. Ammeter	(0-10A)	1	
5.	Wattmeter	(600W,250V,5/10A)	1	
6.	Resistive /Lamp Load	15A	1	

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. Don't touch the live wire.
5. Use auto-transformer for safety reason.

X Procedure

1. Make the connections as per Figure13.2.
2. Check and adjust zero indication of wattmeter and note the multiplying factor of wattmeter.
3. Initially keep dimmerstat at minimum position.
4. Keep all the switches of load bank at off position.
5. Switch on the supply.
6. Increase the output voltage of the dimmerstat gradually to rated voltage.
7. Switch on the switches of load bank step by step (say up to 500/1000 watts).
8. Count the pulses and time required using stop watch.
9. Record the reading in observation table.
10. Note voltmeter, ammeter & wattmeter reading.
11. Take another two readings for different load. (Say 1000 watts, 1500 Watts)
12. Switch off the supply.
13. Calculate % error of EEM.

XI Observation table (use blank sheet provided if space not sufficient)

Multiplying factor $= \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$

M.F = ………………………………………………………………………………

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Sr. No.	Ammeter Reading	Voltmeter Reading	Wattmeter Reading x MF	Number of pulses	Time in second
	I(Amp)	V(Volt)	W(Watt)	P	t

Sample Calculation:

Number of pulses per kWh of EEM = --------------------------------

(As mentioned on front panel of Electronics Energy Meter)

Sr.No.	Energy recorded by EEM(Er) kWh	Calculated Energy (Ea) kWh	% Error	Mean % Error
	$\frac{Number\ of\ pulses}{Number\ of\ pulses\ per\ kWh}$	$\frac{(W * t)}{(3600 * 1000)}$	$(Er - Ea)/Ea)$*100	

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. A single phase electronics energy meter has a constant of 3200 pulses/kwh. A test was carried out with a resistive load for one minute, during which meter gives 60 pulses. The voltage and current was 220 Volts and 5 ampere respectively. Calculate the percentage error.
2. State the meaning of positive percentage error and negative percentage error of an energy meter.

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XVI 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 Publications
2. https://www.electrical4u.com/construction-of-ac-energy-meter/
3. https://en.wikipedia.org/wiki/E1ectricity_meter
4. Electrical Measurements and Measuring Instruments U. A. Bakshi A. V. BakshiK. A. Bakshi ISBN 97881843 l4380First Edition — 2008Technical Publications Pune

XVII 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. 14: Troubleshoot of single-phase energy meter

I Practical Significance

Electrical Engineering diploma graduate are expected to troubleshoot the energy meter. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Carry out troubleshooting of single phase energy meter.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

The conventional mechanical energy meter is based on the phenomenon of “Magnetic Induction”. It has a rotating Aluminium disc. Based on the flow of current, the disc rotates which makes rotation of other wheels. This will be converted into corresponding measurements in the display section. Since many mechanical parts are involved, mechanical defects and breakdown are common. More over chances of manipulation and current theft will be higher.

Electronic Energy Meter is based on Digital Micro Technology (DMT) and uses no moving parts. So the EEM is known as “Static Energy Meter”. In EEM the accurate functioning is controlled by a specially designed IC called ASIC (Application Specified Integrated Circuit).

The basic building blocks of a digital energy meter are: Voltage sensor circuit, current sensor circuit, zero crossing detector circuit, analog to digital converter circuit, microprocessor circuit and a digital display.

In voltage sensing circuit the supply voltage is first stepped down using a transformer and then rectified using full wave bridge circuit to remove ripples. This is further attenuated using potentiometer and amplified to suit the requirement of microprocessor. It is then converted to digitized form using analog to digital converter.

In the current sensing circuit a current transformer is used to step down the sensed current. Suitable resistor is used to convert the current to its voltage equivalent. This gives the simulated voltage equivalent of current. It is then converted to digitized form using analog to digital converter.

Power factor angle can be measured by measuring the angle between V and I and finding the cosine of the angle. This is done by Zero crossing detector circuit.

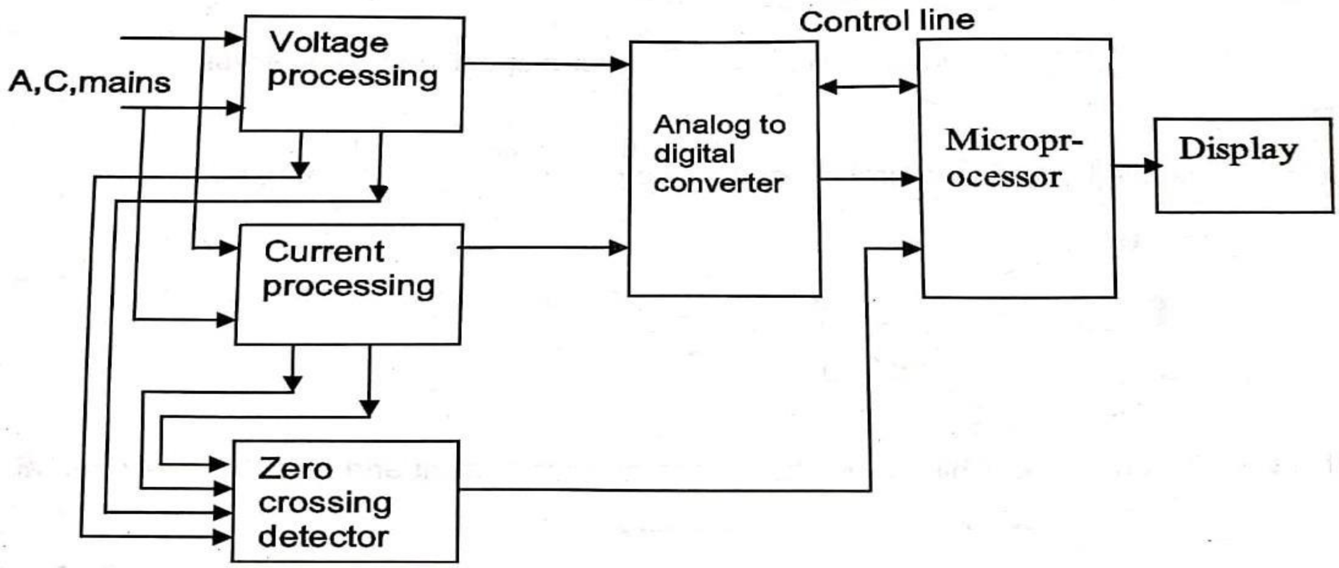

Fig.14.1 Block Diagram of Electronic Energy Meter

Pulse rate of Electronics Energy Meter (EEM)

The pulse rate of EEM is calculated by counting the blinking of LED. Usual pulse rates of EEMs are 800 to 3600 pulses or impulses/ kWh. For most EEMs the pulse rate is 3200. It means that if 1000 Watt of power is consumed for 1 Hour the LED will blink 3200 times.

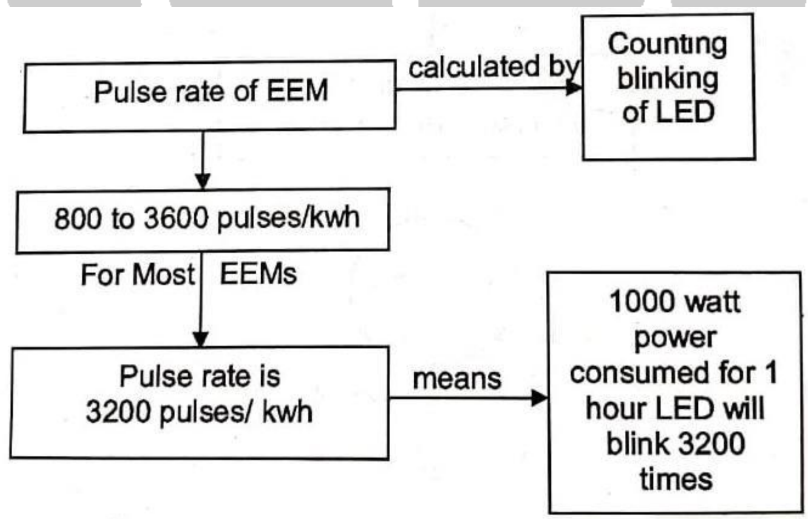

Fig.14.2 Pulse rate of Electronic Energy Meter

VII Practical set-up / Circuit diagram / Work Situation

Fig.No.14.3 Front view of Electronic Energy Meter

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remark
1.	Single phase electronic energymeter	Single phase , Two wire,240V,50Hz,Class-I , 3200/kWh	1	
2.	Resistive /Lamp Load	15Amp	1	

IX Precautions to be followed

- Don't touch the live wire.

X Problem statement (to be provided by Teacher, sample given here)

1. Supply LED on meter front panel not blows.
2. Meter runs slow i.e. number of pulses counts are less.

XI Procedure (Student should write procedure and use blank sheet)

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XII Observation table (use blank sheet to prepare troubleshooting table)

(Identify problems or issues by combination of visual inspection, testing with specialized equipment or tool, and analyzing usage data and Suggest remedial action)

Sr. No.	Fault	Cause	Remedial action

XIII Result

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XIV Interpretation of Result

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XV Conclusion and recommendation

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XVI Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. State the reason for electricity bills getting inflated after replacement of old Electromechanical meters by new electronic meters by the utilities.
2. Give the reason for earth LED of energy meter glows.

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XV 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 Publications
2. https://www.electrical4u.com/construction-of-ac-energy-meter/
3. https://en.wikipedia.org/wiki/E1ectricity_meter
4. Electrical Measurements and Measuring Instruments U. A. Bakshi A. V. Bakshi K. A. Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune

XVI 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. 15: Demonstration of smart energy meter

I Practical Significance

Use of smart energymetyer has become need of an hour. It provides detailed information of consumption in order to reduce electricity bills and also increase knowledge about the status of the electricity grid. Electrical Engineering diploma graduate are expected to handle smart energymeter efficiently. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Measure precisely electrical power and energy using appropriate meters.

IV Laboratory Learning Outcome(s)

Demonstrate the working of smart energy meter.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

Single Phase Smart Electricity Meter,is a modern device used to measure and record the consumption of electrical energy in a single phase electrical system. It is a type of advanced metering infrastructure (AMI) technology that enables utilities to remotely monitor and manage electricity usage. This innovative device is equipped with advanced features such as two-way communication capabilities, real-time data monitoring, and remote electricity meter reading.

Fig:15.1 Front view of Smart Energymeter

VII Practical set-up / Circuit diagram / Work Situation

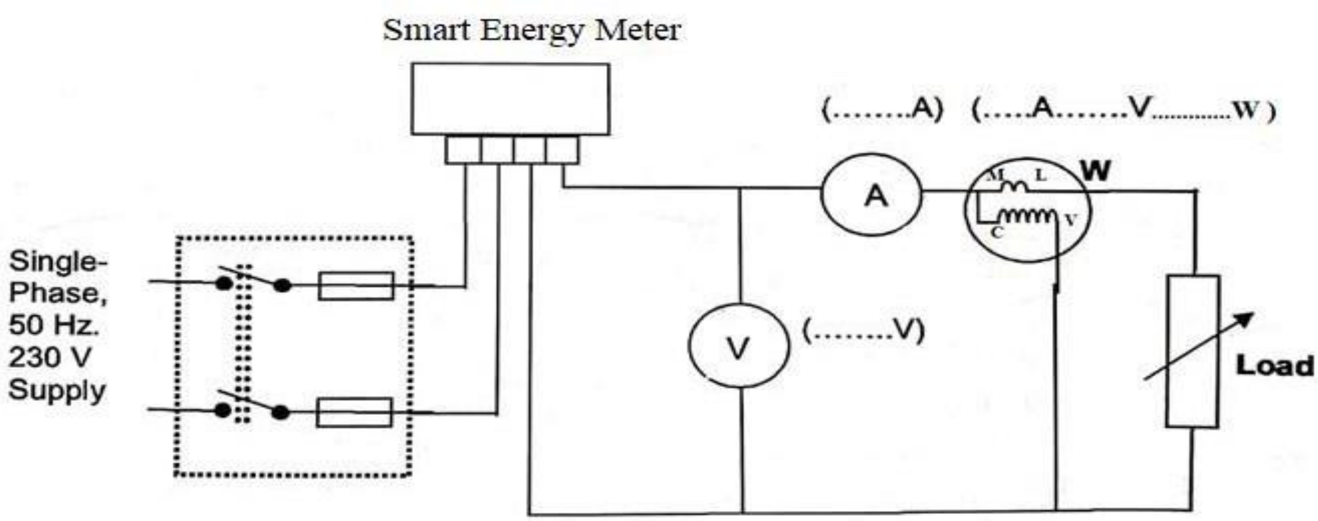

Fig 15.2 Circuit diagram for Demonstration of Smart Energymeter

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remark
1.	Single Phase Variac	1-Phase,1 kVA,(0-270V)	1	
2.	Smart Energymeter	Single phase , Two wire,240V,50Hz,Class-I ,	1	
3.	A.C. Voltmeter	(0-300V)	1	
4.	A.C. Ammeter	(0-10A)	1	
5.	Wattmeter	(600W,250V,5/10A)	1	
6.	Resistive /Lamp Load	15A	1	

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. Don't touch the live wire.
5. Use auto-transformer for safety reason.

X Procedure

1. Make the connections as per Figure 15.2.
2. Check and adjust zero indication of wattmeter and note the multiplying factor of wattmeter.
3. Initially keep dimmerstat at minimum position.
4. Keep all the switches of load bank at off position.
5. Switch on the supply.
6. Increase the output voltage of the dimmerstat gradually to rated voltage.
7. Switch on the switches of load bank step by step (say up to 500/1000 watts).
8. Keep the load ON for time t.
9. Record the readings voltmeter,ammeter and wattmeter in observation table.
10. Read Smart Enegymeter and note down in observation table.
11. Take another two readings for different load by changing the time t (Say 1000 watts, 1500 Watts).
12. Switch off the supply.
13. Compare the measured value parameters and smart energymeter parameter.

XI Observation table (use blank sheet provided if space not sufficient)

Multiplying factor $= \frac{Voltage\ range\ X\ Current\ Range\ X\ Rated\ Power\ Factor}{Full\ Scale\ Deflection}$

M.F = ……………………………………………………………………………

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Sr. No.	**Measured values using Analog meters**				**Calculated Energy (E) kWh**	**Using Smart Energymeter**			
	Voltage V (Volt)	**Current I (Amp)**	**Wattmeter Reading x MF Power P (Watt)**	**Time(t) Seconds**	$\frac{(W*t)}{(3600*1000)}$	**Voltage V (Volt)**	**Current I (Amp)**	**Power P (Watt)**	**Measured energy (E) kWh**

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. Compare Electronic Energymeter with Smart Energymeter.
2. Write advantages and disadvantages of smart energymeter.

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XVI References/Suggestions for further reading

1. https://en.wikipedia.org/wiki/Smart_meter
2. https://www.cdac.in/index.aspx?id=product_details&productId=SmartEnergyMeter
3. https://www.sciencedirect.com/science/article/abs/pii/S0045790620306273

XVII 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. 16: Measurement of low resistance using bridge

I Practical Significance

Electrical Engineering diploma graduate to measure low resistance using Kelvin double bridge. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot Electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Use digital measuring instruments for different applications.

IV Laboratory Learning Outcome(s)

Measure low resistance by using bridges.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background (With diagrams if required)

Low resistance measure the with Wheatstone bridge includes the contact resistance and lead resistance.

Use of Kelvin's Bridge eliminates the errors due to contact resistance and lead resistance. It also improves sensitivity.

On the Kelvin's Bridge terminals are provided to connect current input, galvanometer and unknown resistance. A knob is provided for adjustment of the ratio of "P/Q". For balancing the bridge a variable standard resistance is used, which consists of a tapped resistance for coarse adjustment and slide wire resistance for fine adjustment.

While measuring low resistance with Kelvin's Bridge the ratio "P/Q" is adjusted first. Then adjust the coarse adjustment of standard resistance to get minimum deflection and finally adjust the slide wire for null point.

When null point is obtained, the value of unknown resistance is given by multiplication of "P/Q" and value of standard resistance which is the addition of tapped resistance and slide wire resistance.

Standard low resistance is constructed with four terminals. One pair of terminals is marked C. C called current terminals. The other pair is marked as P, P and is called as pressure terminals.

The use of pressure terminals for measuring voltage across low resistance with four terminals eliminates error due to contact resistance and lead resistance.

Fig :16.1 Front view of Kelvin Double Bridge

VII Practical set-up / Circuit diagram / Work Situation:

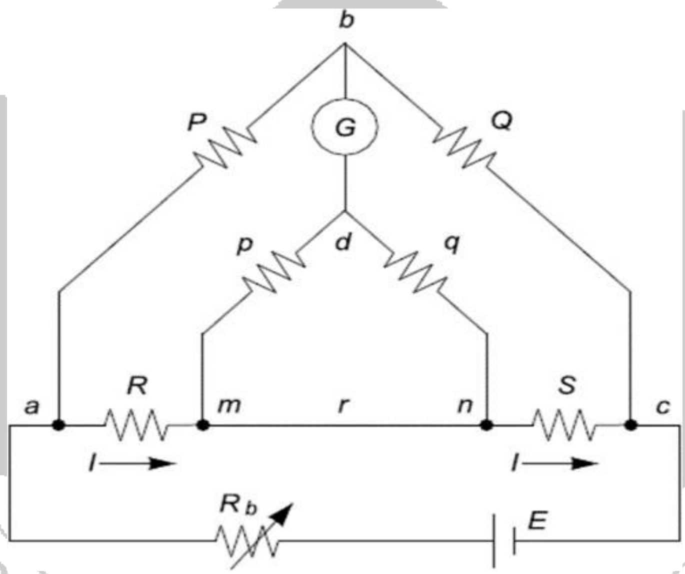

Fig :16.2 Kelvin Double Bridge

VIII Required Resources/apparatus/equipment

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks
1	Kelvin's Double Bridge	Kit	1	
2	Battery regulated DC supply.	0-110V	1	
3	Galvanometer	0-100mA	1	
4	Unkown low resistance- Transformer winding/Ammeter resistance	Various low values resistance	1	

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. Don't touch the live wire.
5. There should not be any loose connections.
6. Use only low voltage supply to give rated current to kelvin's Bridge.

X Procedure

1. Connect the circuit as per Figure 16.2
2. Connect the apparatus at the terminals indicated on Kelvin's Bridge.
3. Select the proper range multiplier *"P/Q"*
4. Connect a rheostat in series with a battery or a low voltage supply to input terminals of the bridge.
5. Press the key of galvanometer. Vary the knob of main dial as per deflection of galvanometer for coarse adjustment. Use slide wire for fine adjustment. Take the reading when galvanometer shows null deflection.
6. Calculate the value of unknown resistance using given formula.
7. Switch off the supply.
8. Using reversing switch on bridge, reverse the direction of current.
9. Switch on the supply.
10. Repeat above procedure.
11. Calculate value of resistance in each case and find the mean from above two readings.
12. Replace the given low resistance by another resistance and repeat the same procedure.

XI Observation table

Sr. No.	P	Q	S	Calculated $R=\frac{P}{Q}$

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. How can the effect of thermoelectric emf be eliminated?
2. Kelvins Bridge is more suitable for measurement of low resistance. Give reason.
3. State the advantage of using four terminal resistances.
4. Why this bridge is called “double bridge”?

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XVI 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 Publications
2. https://www.electrical4u.com/?s=kelvin+double+bridge
3. https://en.wikipedia.org/wiki/Kelvin_bridge
4. Electrical Measurements and Measuring Instruments U. A. Bakshi, A. V. Bakshi, K. A. Bakshi ISBN 9788l843l4380First Edition — 2008Technical Publications Pune

XVII 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. 17: Measurement of medium and high resistance using bridges.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to handle Bridges to measure medium and high resistances. A Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. Therefore, this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Use Bridges to measure the unknown resistance.

IV Laboratory Learning Outcome(s)

Measure medium and high resistance by using bridges.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

Wheatstone Bridge is an instrument designed to measure unknown resistance in electrical circuits. It calculates the unknown resistance by balancing the two legs of the bridge circuit where one leg contains both known resistors and the other leg contains one known (variable) and one unknown resistor.

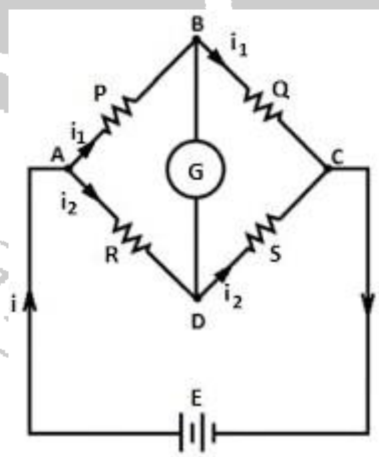

Fig. 17.1 Wheatstone Bridge

Construction of Wheatstone Bridge requires four resistors P, Q, R, and S that are placed in the form of four sides AB, BC, AD, and DC of a quadrilateral ABCD. A cell E is connected between the A and C ends of this quadrilateral, and a sensitive galvanometer G is placed between the B and D ends.

Wheatstone Bridge works on the principle of null deflection i.e., there is no current flowing through the galvanometer, and its needle shows no deflection, hence the name null deflection. In the unbalanced state of the Wheatstone bridge i.e., when the potential across the galvanometer is different, the galvanometer shows the deflection, and as the bridge becomes balanced by changing the variable resistor, the potential difference across the galvanometer becomes zero i.e., the equilibrium state of Wheatstone bridge.

VII Actual Circuit diagram used in laboratory with equipment Specifications

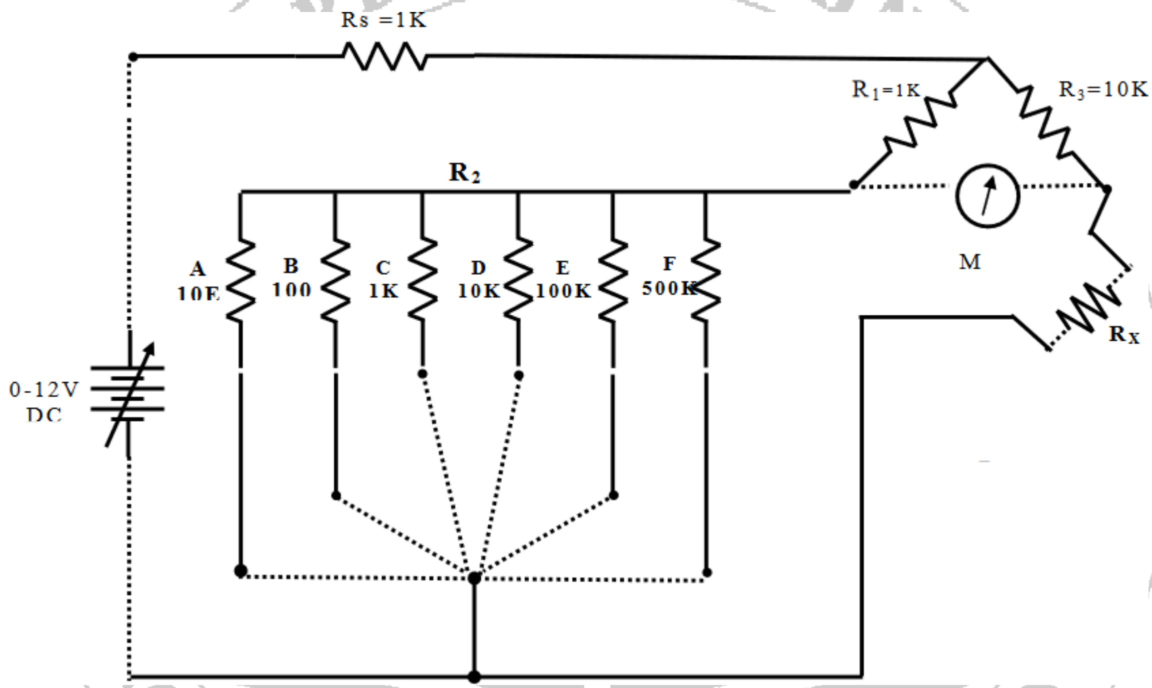

Fig. 17.2 Actual circuit diagram of Wheatstone Bridge

VIII Required Resources/apparatus/equipment with specification

Sr. No	Name of Resources	Suggested Broad specifications	Quantity	Remark
1	Wheatstone Bridge	Kit	1 No.	
2	Copper wire coils of various sizes	1 sq.mm, 1.5 sq.mm, 2.5 sq. mm	1 coil each	

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. Take the trainer kit. Measure resistors A, B, C, D, E, F, R_1 and the variable pot R_3.
2. Note down the values of each resistors.
3. Connect the kit to main 230V supply and switch it on. Measure the DC supply voltage.
4. Select the unknown resistor and measure its resistance R_x and note it down.
5. Connect the resistor to the terminal R_x and connect the power supply in to the circuit.
6. Connect the galvanometer to M of the bridge with the help of jumper.
7. Connect the S_1 terminal to any resistor A, B, C, D, E, F and adjust pot R_3 to get null reading on the galvanometer.
8. Once the null reading is found, remove all the jumpers and measure the value of R_3. Put value of R_3 in the formula given below and calculate R_x.
9. $R_x=R_2*R_3/R_1$ (R_2= A or B or C .... or F)
10. Match the value of practical R_x and with value of R_x measured using multimeter.
11. Take 4-5 reading to find unknown resistance R_x with different resistors.

XI Observation Table

Sr. No.	Resistance R_1 (ohm)	Resistance R_2 (ohm)	Resistance R_3 (ohm)	Unknown Resistance $R_x=R_2*R_3/R_1$ (ohm)
1				
2				
3				
4				
5				

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. State the applications of Wheatstone Bridge.
2. When Wheatstone Bridge is said to be balanced?

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney-Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book: H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 18: Measurement of supply voltage, frequency, peak value in single- phase circuit using CRO/DSO.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to handle cathode ray oscilloscope (CRO) to measure basic parameters like voltage, frequency, and time period of supply systems. Therefore, this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Use measuring instruments.

IV Laboratory Learning Outcome(s)

Measure of supply voltage, frequency, peak value in single-phase circuit by using CRO/DSO.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

CRO is an instrument used to measure electric parameter such as voltage, frequency, time period of given waveform like sinusoidal, triangular, square. CRO is also used to test various active and passive electrical components such as resistor, capacitor, and inductor.

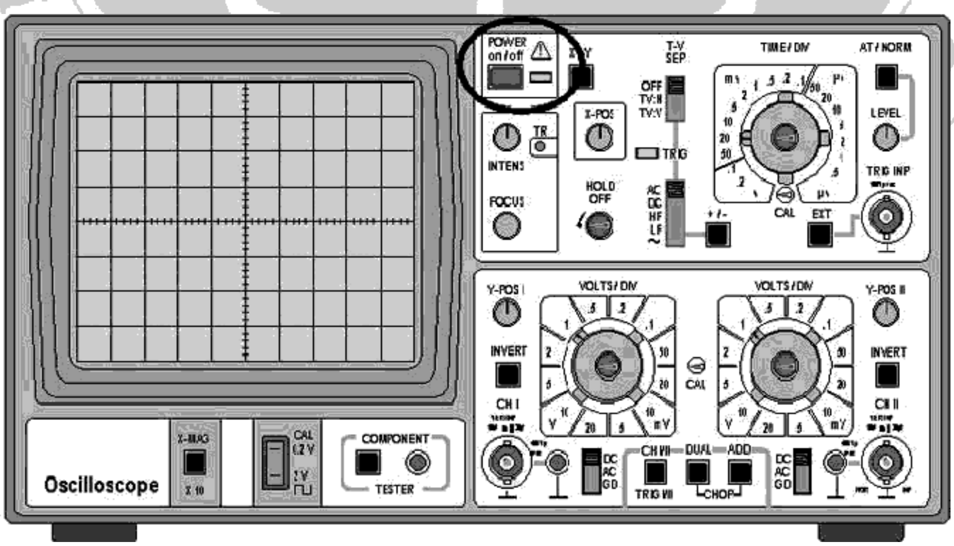

Fig. 18.1 CRO Front Panel

VII Actual Circuit diagram used in laboratory with equipment Specifications

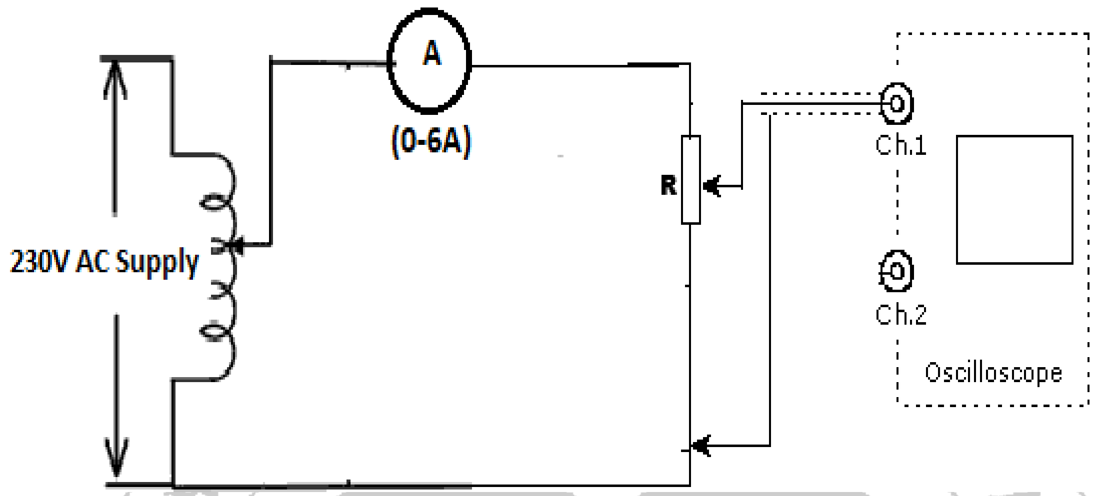

Fig.18.2 Connection Diagram to measure supply frequency by CRO

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Name of Resource	Specification	Quantity	Remark
1	Rheostat	Suitable Rheostat (0-220ohm, 5A)	01	
2	CRO	20/30/100MHz Frequency with attenuator probes	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 the circuit as per Fig. 18.2.
2. Connect the CRO for observing voltage waveform of supply across the resistance.
3. The horizontal sweep is turned ON and the display appearing on the screen is adjusted by varying different control knobs provided on the front panel of CRO, till the signal is suitably displayed.
4. After obtaining the display of good deflection, count the number of horizontal divisions for a complete cycle to get the time period (T) of supply voltage.
5. Calculate the frequency of supply by using equation: f=1/T Hz

XI Observation Table

Sr. No.	Number of Division in complete cycle (m)	Time per Division (n)	Time Period T = m* n (seconds)	Frequency f= 1/T (Hz)
1.				
2.				

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. State the test condition indicated if vertical line is observed on CRO.
2. State the need of proper earthing of CRO.
3. “Trace of the spot on the screen looks like a continuous line”. Give reason.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney-Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book: H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 19: Measurement of linear displacement using potentiometer.

I Practical Significance

Potentiometers are rarely used to directly control significant amounts of power (more than a watt or so). Instead they are used to adjust the level of analog signals (for example volume controls on audio equipment), and as control inputs for electronic circuits. User-actuated potentiometers are widely used as user controls, and may control a very wide variety of equipment functions. Potentiometers are widely used in consumer electronics. This practical help you to measure the linear displacement using potentiometer.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Select the relevant transducers for measuring various parameters.

IV Laboratory Learning Outcome(s)

Measure linear displacement by using potentiometer.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Linear Potentiometer: The 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. Potentiometers are found in many electrical and electronic applications and in many different forms, sizes and power ratings. For instance, in a relatively high power applications 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 Actual Circuit diagram used in laboratory with equipment Specifications:

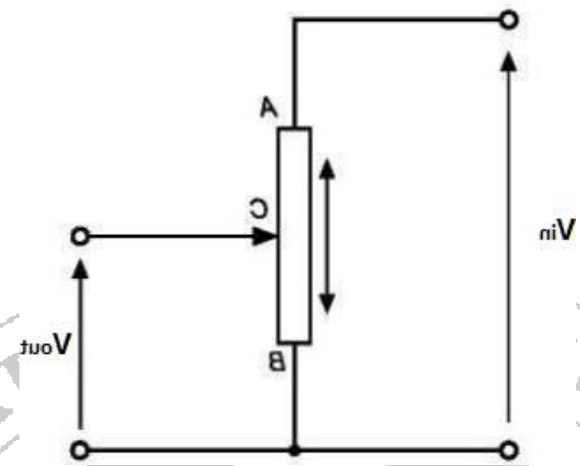

Fig. 19.1 Linear Potentiometer experimental setup

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,

$$\boldsymbol{Vout = Vin * \frac{CB}{AB}}$$

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 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 as given by the above potentiometer equation.

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Particulars	Specification	Quantity	Remark
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. Identify the component of given setup.
2. Connect potentiometer setup as in Fig. 19.1.
3. Switch on the power supply
4. Manually displace the wiper of potentiometer by 50 cm.
5. Record the output resistance using DMM.
6. Record the output voltage V_{out} using DMM in observation table.
7. Repeat the steps 4 to 6 for 5 times with an interval of 50 cm displacement.
8. Plot the graph of displacement Vs output voltage.

XI Observation Table

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

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

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. State the output voltage obtained at 200 cm.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book: H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 20: Measurement of angular displacement using potentiometer.

I Practical Significance

In the industry environment Electrical Engineering/Industrial Electronics diploma graduate are expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. The angular displacement is one of important physical quantity has to measure in various application. Therefore, this practical will help to measure angular displacement using potentiometer.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Select the relevant transducers for measuring various parameters.

IV Laboratory Learning Outcome(s)

Measure the angular displacement by using potentiometer.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Angular Potentiometer

The most commonly used of all the "Position Sensors", is the potentiometer because it is an inexpensive and easy to use position sensor. It has a wiper contact linked to a mechanical shaft that can be either angular (rotational) in its movement, and which causes the resistance value between the wiper/slider and the two end connections to change giving an electrical signal output that has a proportional relationship between the actual wiper position on the resistive track and its resistance value. In other words, resistance is proportional to position.

Potentiometers come in a wide range of designs and sizes such as the commonly available round rotational type. When used as a position sensor the moveable object is connected directly to the rotational shaft of the potentiometer. A DC reference voltage is applied across the two outer fixed connections forming the resistive element. The output voltage signal is taken from the wiper terminal of the sliding contact as shown below.

This configuration produces a potential or voltage divider type circuit output which is proportional to the shaft position. Then for example, if you apply a voltage of say 10v across the resistive element of the potentiometer the maximum output voltage would be equal to the supply voltage at 10 volts, with the minimum output voltage equal to 0 volts. Then the potentiometer wiper will vary the output signal from 0 to 10 volts, with 5 volts indicating that the wiper or slider is at its half-way or centre position. The output signal (V_{out}) from the potentiometer is taken from the centre wiper connection as it moves along the resistive track, and is proportional to the angular position of the shaft.

VII Actual Circuit diagram used in laboratory with equipment Specifications

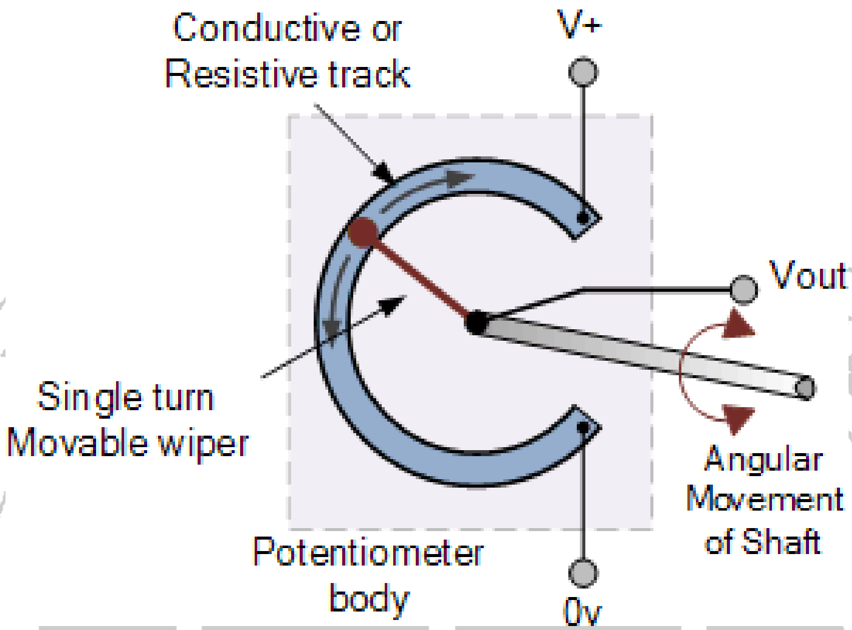

Fig. 20.1 Angular Potentiometer experimental setup

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Angular potentiometer	Displacement range 0-300^0, single turn	01	
2	Power supply	DC regulated power supply 0-30 V 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. Identify the component of given setup.
2. Connect potentiometer setup as in Fig 20.1.
3. Switch on the power supply

4. Manually displace the wiper of potentiometer by 30^0 displacements.
5. Record the output resistance using DMM.
6. Record the output voltage V_{out} using DMM in observation table.
7. Repeat the steps 4 to 6 for 5 times with an interval of 30^0 displacement.
8. Plot the graph of displacement Vs output voltage.

XI Observation Table:

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

XII Results

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV **Practical related questions (**Note:- Teacher should provide various questions related to practical-sample given)

1. State the output voltage when the wiper is at 0^0
2. State the maximum angular range of potentiometer.
3. State the input voltage applied to potentiometer
4. State the output voltage obtained at 300^0

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book: H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co.Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 21: Measurement of displacement using LVDT.

I Practical Significance

LVDT is passive transducer based 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 you to measure displacement using LVDT.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Select the relevant transducers for measuring various parameters.

IV Laboratory Learning Outcome(s)

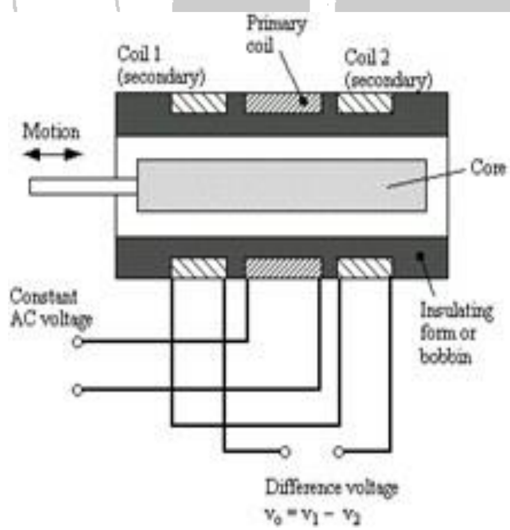
Measure displacement by using LVDT.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

LVDT "Linear Variable Differential Transformer" is most widely used inductive transducer to translate linear motion into electrical signals.



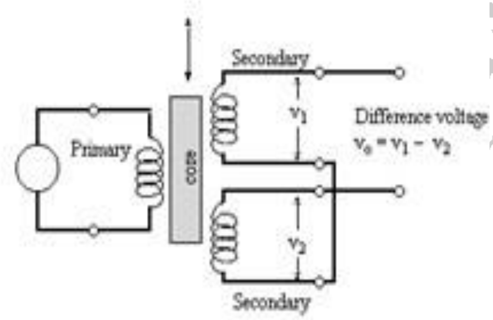


Fig.21.1 Linear Variable differential Transformer (LVDT)

Construction of LVDT: LVDT consists of a cylindrical former where it is surrounded by one primary winding in centre of the former and the two secondary windings connected in series opposition. The number of turns in both the secondary winding are equal, but are series opposite to each other.

Working of LVDT (Linear Variable Differential Transformer): The Linear Variable Differential Transformer works on the principle of electromagnetic induction. When we give supply to the primary winding of the LVDT, a current start flowing through the primary winding. Due to magnetic property of current, the magnetic lines of force starts flowing around the primary coil, thus a magnetic field is set up around the primary winding. As in general transformers, due to magnetic effect of primary winding, an e.m.f. is also set up in secondary winding when the magnetic lines of force of primary winding cuts (come across contact) the iron rod and secondary winding. This e.m.f. causes a current to flow in secondary winding and this whole process is known as mutual inductance.

Case 1 (When the rod is placed in Centre i.e. Area of contact of iron rod is same with both secondary coils):

When the iron rod is placed in centre of both secondary coils then the area of contact of iron rod between two secondary windings is equal, then the equal amount of e.m.f. is developed in the both coils.

Case 2(When the Rod is moved towards the right to the coil S2): When the rod is moves to the right side towards the secondary coil 2 then the area of contact of rod is larger with secondary coil S2 as compared to coil S1. Therefore, more amount of magnetic field cuts the coil S2 and thus more e.m.f. will be induced in the secondary coil S2.

Case 3(When Iron Rod is moved towards the left, to coil S1): When the iron rod is moved towards the coil S1 that is to left side then the contact area of secondary coil S1 will be larger than coil S2. Thus more e.m.f. will be induced in secondary coil S2.

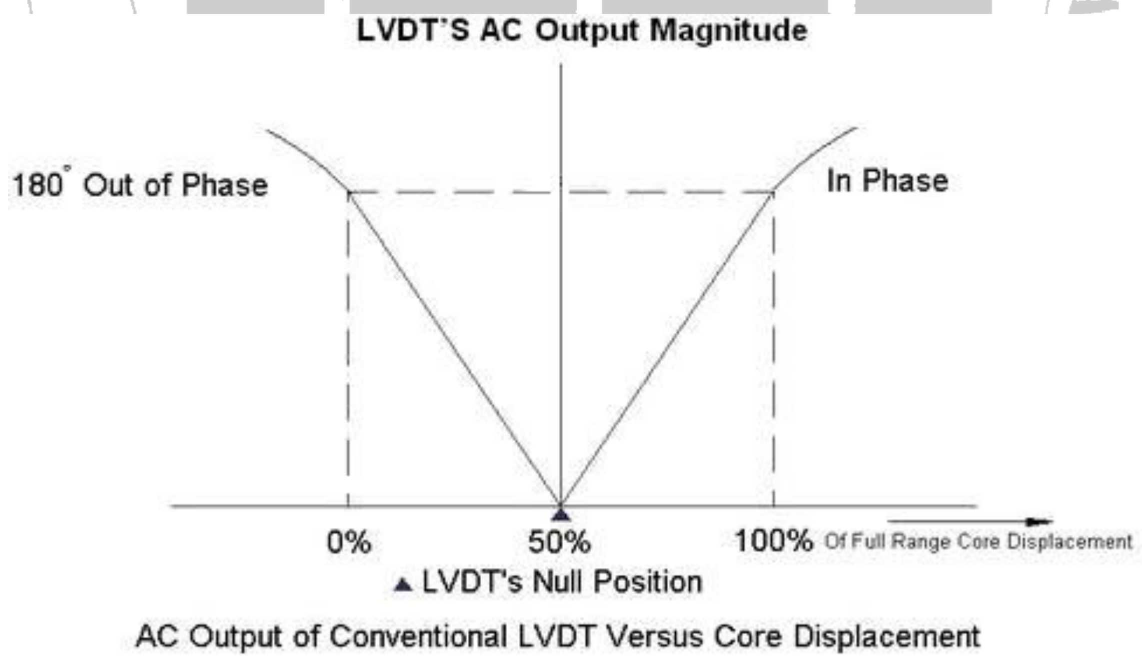
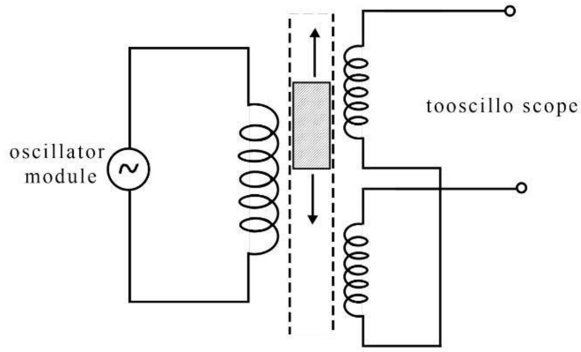


Fig. 21.2 Characteristics of LVDT

VII Actual Circuit diagram used in laboratory with equipment Specifications



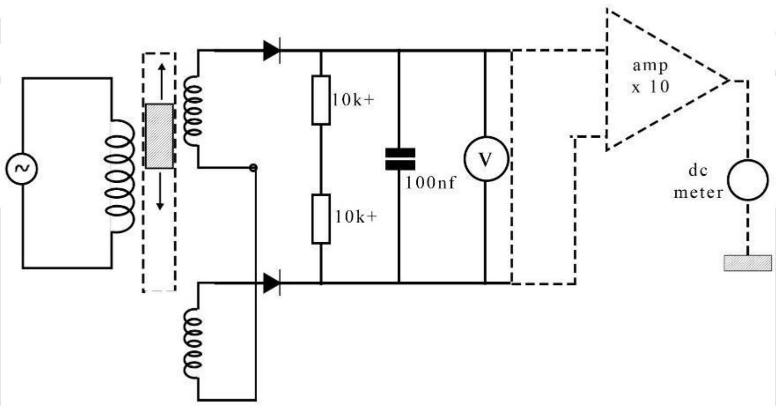


Fig.21.3 LVDT experimental setup

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Particulars	Specification	Quantity	Remark
1	**LVDT trainer kit-**	Displacement range +/- 20 mm. Accuracy of +/- 2% Primary Excitation 4 KHZ and 1 Volt, RMS Output : Digital display of +/- 20mm	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 LVDT setup as in diagram.
3. Switch on the power supply.
4. Manually displace the core of LVDT by 1mm.
5. Record the digital display indication w.r.t displacement.
6. Record the output voltage V1 using DMM in observation table.
7. Cross check output voltage V1 using C.R.O.
8. Repeat the steps 4 to 7 for 5 times with an interval of 1mm placement on both side of centre position of core.
9. Plot the graph of displacement Vs output voltage.

XI Observation Table

Sr. No.	Displacement	Indication on digital display	Output voltage
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

XII Results

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. State the output voltage when the core is at centre position
2. State the maximum linear range of LVDT.
3. State the input voltage is applied to primary winding of LVDT.
4. State the output voltage is obtained at secondary winding of LVDT.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 22: Measurement of weights using strain gauge

I Practical Significance

A Strain Gauge is passive transducer which resistance change as per applied pressure. The strain gauge is used as Load Cell in weighing machine. In this practical student will able measure the pressure (weight) applied on strain gauge.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Select the relevant transducers for measuring various parameters.

IV Laboratory Learning Outcome(s)

Measure weights by using strain gauge.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Strain gauge is a resistive transducer whose resistance changes when subjected to stress (due to change in length, area and resistivity).When gauge is subjected to positive stress its length increases while its area cross section decreases since resistance of conductor is directly proportional to length and inversely proportional to area of cross section, resistance to gauge increases this change in resistance is measured by wheat stone bridge.

Gauge factor: Sensitivity or gauge factor is defined as ratio of unit change in resistance to unit change in length.

$$G.F = \frac{DR/R}{DL/L}$$

Types of strain gauges

- **Unbonded**

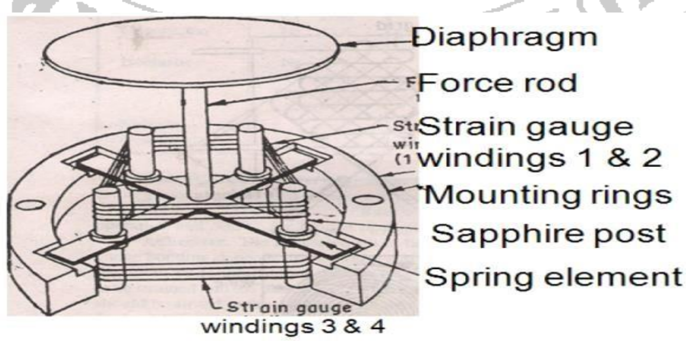

Fig. 22.1 Unbonded Strain Gauge

- **Bonded**

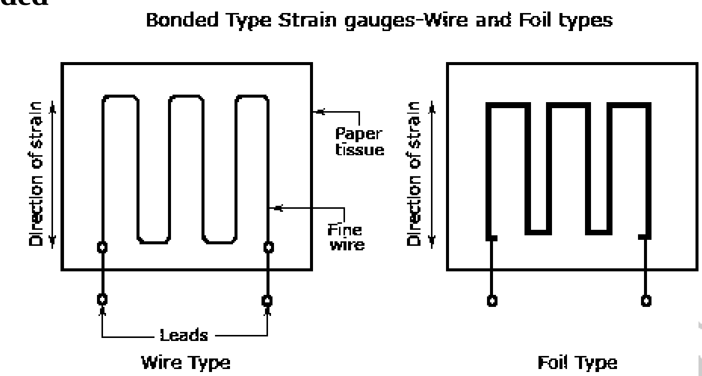

Fig. 22.2 Bonded type Strain Gauge

VII Actual Circuit diagram used in laboratory with equipment Specifications:

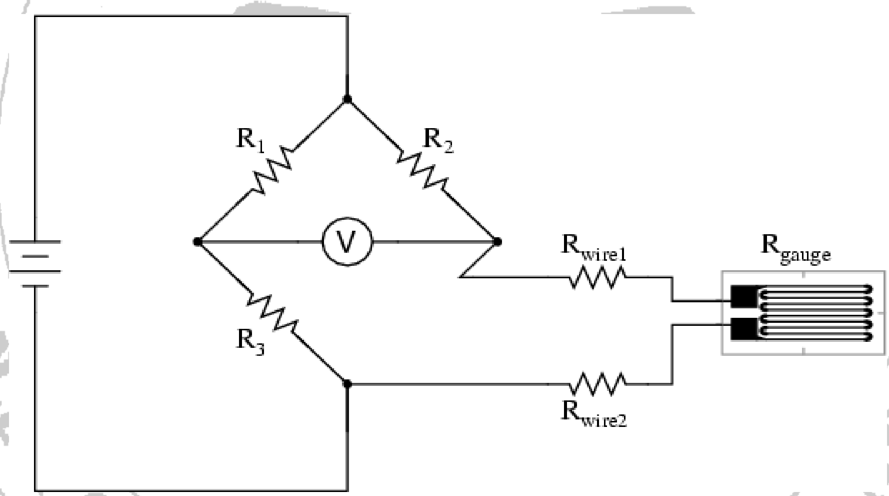

Fig. 22.3 Strain Gauge experimental setup

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Strain gauge trainer kit	Strain gages of 350 ohms, Accuracy: +/- 1% Power Supply 230 Vac, maximum of 5-kg load, Digital indication	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 stain gauge setup as in diagram.
3. Switch on the power supply.
4. Provide weight of 1kg on strain gauge platform.
5. Increase the weights in steps of 1kg.
6. Record the output on digital display.
7. Record the output voltage V_1 using DMM in observation table.
8. Repeat the steps 5 to 6 for 5 times with an interval.
9. Plot the graph of weights Vs output voltage.

XI Observation Table:

Sr. No.	Weights (kg)	Indication on Digital display	Output voltage (V_1)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

XII Results:

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. State the output voltage when no weight is applied on the platform.
2. State the maximum range of strain gauge.
3. State the type of strain gauge used in practical.
4. State the type of material used in strain gauge in practical setup.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 23: Measurement of pressure using bourdon tube pressure gauge.

I Practical Significance

In the industry environment Electrical Engineering/Industrial Electronics diploma graduate are expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. The pressure measurement can be done directly or indirectly. The bourdon tube is one of the transducers is used to measure pressure Therefore this practical will help you to measure the pressure using bourdon tube.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Select the relevant transducers for measuring various parameters.

IV Laboratory Learning Outcome(s)

Measure pressure by using Bourdon tube pressure gauge.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

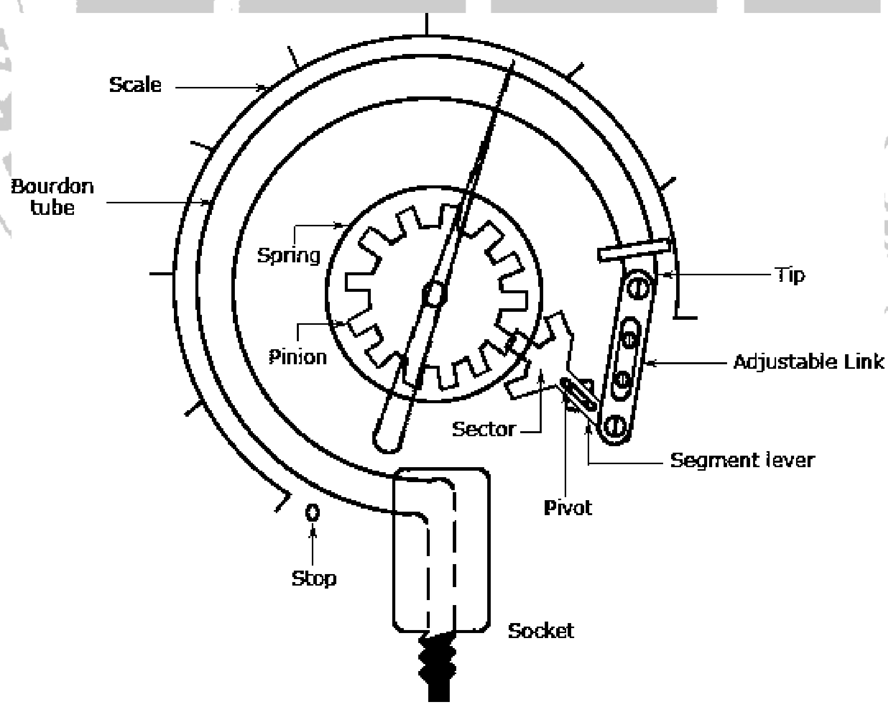

Fig. 23.1 Bourdon Tube Pressure Gauge

Bourdon Tube is known for its very high range of differential pressure measurement in the range of almost 100,000 psi (700 MPa). It is an elastic type pressure transducer. A C type bourdon tube consist of long thin wall cylinder of non- circular cross section, sealed at one end and made up of material such as phosphorous bronze, steel, beryllium copper, and attach by light line mechanism which operates the pointer. The other end of the tube is fixed and is open for application of pressure which is to be measured. The tube is soldered to a socket at the base through which pressure connection is to be made.

Working:

As the fluid pressure enters the bourdon tube, it tries to be reformed and because of a free tip available, this action causes the tip to travel in free space and the tube unwinds. The simultaneous actions of bending and tension due to the internal pressure make a non-linear movement of the free tip. This travel is suitable guided and amplified for the measurement of the internal pressure. But the main requirement of the device is that whenever the same pressure is applied, the movement of the tip should be the same and on withdrawal of the pressure the tip should return to the initial point.

VII Actual Circuit diagram used in laboratory with equipment Specifications

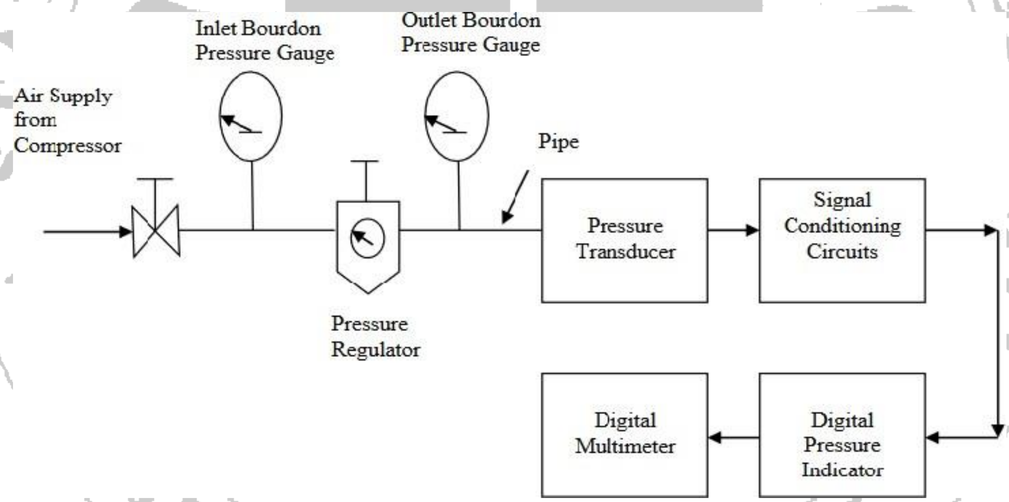

Fig. 23.2 Pressure Measurement Setup

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Particulars	Specification	Quantity	Remark
1	Bourdon tube pressure gauge	Input pressure range 0 – 50 psi. Accuracy of +/- 2%. Dial gauge indication in the range 0 to 50 psi and Digital display.	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 pressure measurement setup as in diagram.
3. Switch on the power supply
4. Provide pressure of 5 psi with compressor.
5. Increase the pressure in steps of 5 psi
6. Record the output pressure on dial gauge
7. Record the output pressure on digital display
8. Repeat the steps 4 to 7 for 5 times.

XI Observation Table

Sr. No.	Pressure on dial gauge (psi)	Pressure Indication on Digital Display (psi)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. State the output pressure when no pressure is applied from compressor.
2. State the maximum range of pressure measurement.
3. State the type of bourdon tube used in practical.
4. State the type of material used in bourdon tube.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 24: Measurement of flow using orifice meter.

I Practical Significance

Flow measurement is one of important process in industry. Orifice meter have been in use for fluid flow measurement. It is essentially a cylindrical tube that contains a plate with a thin hole in the middle of it. The thin hole essentially forces the fluid to flow faster through the hole in order to maintain flow rate. Therefore, this practical will help you to measure flow using the Orifice plate.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Maintain the different types of flow transducers.

IV Laboratory Learning Outcome(s)

Measure flow by using orifice meter.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Orifice plate is the simplest and cheapest form of primary elements and used more frequently than all others types. An orifice plate is inserted in the line and the differential pressure across it is measured. There are different types of orifice plates used as per applications.

- **Concentric Orifice plate**: It is most widely used. It is usually made up of material such as stainless steel, nickel, Monel, phosphor bronze etc. to withstand corrosive effects of the fluid. Its thickness varies from1/8” to ½” depending upon pipeline size and flow velocity. It has circular hole in the middle and is installed in the pipe line with the hole concentric to pipe line.
- **Eccentric Orifice Plate:** Is orifice which bore position is offset from centre line of the pipe. It is used in service if there is secondary fluid phase (gas contains liquid or liquid contains gas) in which the application of vent hole or drain hole on the concentric orifice plate may adversely affect the accuracy in case the vent or drain hole size requires large area to cater the secondary phase. Eccentric Orifice Plate is also used in service where severe entrainment may occur such as in dirty gas or liquid, which in this case the solid or slurries could plug the vent or drain hole.
- **Segmental Orifice plate**: It has a hole that is not circular but rather a segment of a concentric circle. It is used to measure the flow of light slurries and fluids with high concentration of solids. It eliminates the hold back foreign matter and provides more complete drainage than the eccentric orifice plates. It is more expensive and has slightly greater uncertainty.

- **Quadrant Orifice plate:** The upstream side of the bore is shaped like a flow nozzle while the downstream side acts as a sharp edge orifice plate. They are recommended for measurement of viscous fluids which have pipe Reynolds numbers bellow 10000.

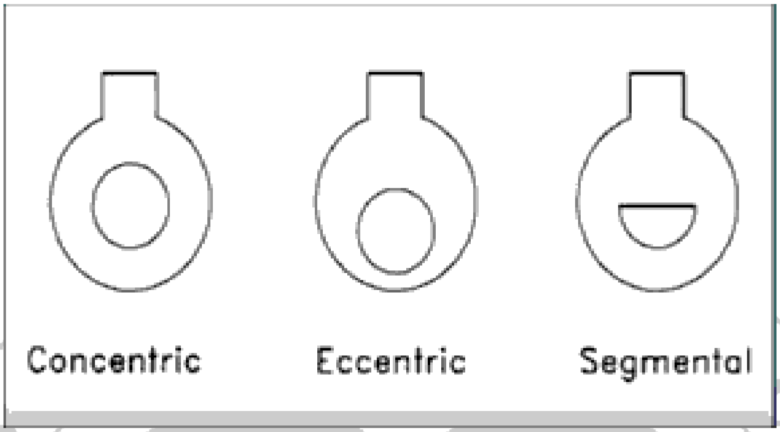

Fig. 24.1 Orifice Plates

VII Actual Circuit diagram used in laboratory with equipment Specifications

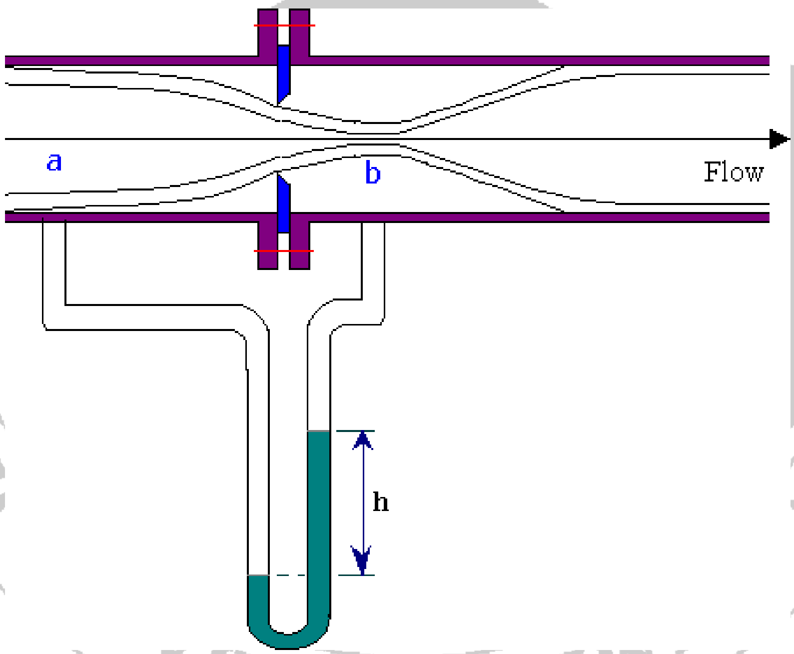

Fig. 24.2 Flow rate measurement using orifice meter

Flow rate calculation equation

$$V = K\sqrt{\frac{2gh}{p}}$$

$$Q = KA\sqrt{\frac{2gh}{p}}$$

$$\boldsymbol{W = K\sqrt{\frac{2gh}{p}}}$$

Where,
V=velocity of flowing fluid
Q= volume flow rate
W= mass flow rate
A= cross section area of pipe through which fluid is flowing
h = differential head (pressure) across the restriction element
g= acceleration due to gravity
p= density of the flowing liquid

$$K = \sqrt{\frac{C}{1-\beta^4}} = a\ constant$$

Where C= discharge coefficient
β =diameter ratio

$$\beta = \frac{d(diameter\ of\ restriction\ element)}{D(\ inside\ diameter\ of\ pipe)}$$

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Particulars	Specification	Quantity	Remark
1	Orifice meter measurement setup	1’’line size, concentric type, MOC-SS, U tube manometer 400 mm height, Range 0-1000LPH	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 Orifice meter measurement setup as in diagram.
3. Fill the sump tank with water.
4. Switch on the power supply.
5. Start the pump and ensure flow rate through pipe line

6. Measure differential pressure across the orifice using U tube manometer.
7. Calculate flow rate for obtained differential pressure.
8. Change valve position for increasing flow rate in pipe line.
9. Record the differential pressure, flow rate in observation table.
10. Repeat the steps 6 to 9 for 5 to 6 readings.
11. Plot the graph of differential pressure vs. flow rate.

XI Observation Table

Sr. No.	Flow rate on indicator	Calculated flow rate
1		
2		
3		
4		
5		
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7		
8		
9		
10		

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. Name the device used for differential pressure measurement.
2. State the maximum range of flow rate measurement.
3. State the type of orifice plate used in practical.
4. State the type of material used in orifice plate in practical setup.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 25: Measurement of flow by using venturi meter.

I Practical Significance

In the industry environment Electrical Engineering/Industrial Electronics diploma graduate are expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. The flow measurement is one of the important processes in industry. Different transducers are used in industry for flow measurement venturi tube one of it. Therefore, this practical will help you to measure the flow using venturi tube.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Maintain the different types of flow transducers.

IV Laboratory Learning Outcome(s)

Measure flow by using venturi meter.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

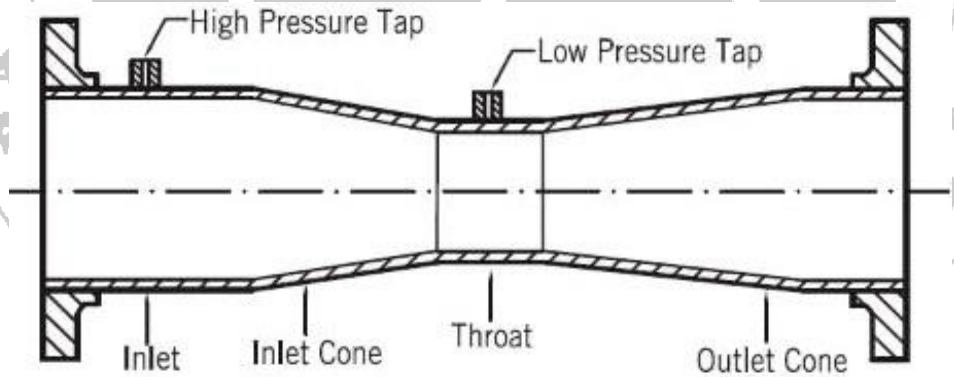

Fig. 25.1 Venturi Tube

Venturi Tubes: It is used where permanent pressure loss is of prime importance and good pressure recovery and maximum accuracy is desired in the measurement of high viscous fluids. It can handle slurry and dirty liquids that build up around other primary elements if the pressure taps are protected from plugging. They are usually made up of material such as cast iron and steel. They are available in the sizes from 100mm to 800mm. They are built in several form such as

1. Long form
2. Short form where venture outlet cone is shortened

3. Eccentric form
4. Rectangular form

A Venturimeter is a device used for measuring the rate of flow of a fluid flowing through a pipe.The main parts of a venturimeter are:

- A short converging part: It is that portion of the venturi where the fluid gets converges.
- Throat: It is the portion that lies in between the converging and diverging part of the venturi. The cross section of the throat is much less than the cross section of the converging and diverging parts. As the fluid enters in the throat, its velocity increases and pressure decreases.
- Diverging part: It is the portion of the venturimeter (venturi) where the fluid gets diverges.

Working

The venturimeter is used to measure the rate of flow of a fluid flowing through the pipes.

- As the water enters at the inlet section i.e. in the converging part it converges and reaches to the throat.
- The throat has the uniform cross section area and least cross section area in the venturimeter. As the water enters in the throat its velocity gets increases and due to increase in the velocity the pressure drops to the minimum.
- Now there is a pressure difference of the fluid at the two sections. At the section 1(i.e. at the inlet) the pressure of the fluid is maximum and the velocity is minimum. And at the section 2 (at the throat) the velocity of the fluid is maximum and the pressure is minimum.
- The pressure difference at the two section can be seen in the manometer attached at both the section.
- This pressure difference is used to calculate the rate flow of a fluid flowing through a pipe.

VII Actual Circuit diagram used in laboratory with equipment Specifications

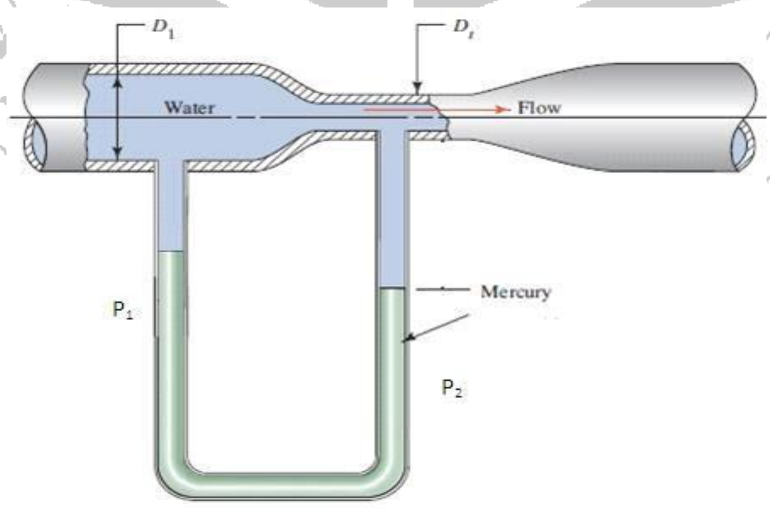

Fig 25.2 Flow measurement using Venturimeter

Flow rate Calculation Equation

$$V = K\sqrt{\frac{2gh}{p}}$$

$$Q = KA\sqrt{\frac{2gh}{p}}$$

$$W = K\sqrt{\frac{2gh}{p}}$$

Where,
V=velocity of flowing fluid
Q= volume flow rate
W= mass flow rate
A= cross section area of pipe through which fluid is flowing
h = differential head (pressure) across the restriction element
g= acceleration due to gravity
p= density of the flowing liquid

$$K = \sqrt{\frac{C}{1-\beta^4}} = a\ constant$$

Where C= discharge coefficient
β =diameter ratio

$$\beta = \frac{d(diameter\ of\ restriction\ element)}{D(\ inside\ diameter\ of\ pipe)}$$

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Particulars	Specification	Quantity	Remark
1	Venturi flow measurement setup	1’’line size, MOC-SS, U tube manometer 400 mm height, Range 0-1000LPH,	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 Venturi meter measurement setup as in diagram.
3. Fill the sump tank with water.
4. Switch on the power supply.
5. Start the pump and ensure flow rate through pipe line
6. Measure differential pressure across the venturi using U tube manometer.
7. Calculate flow rate for obtained differential pressure.
8. Change valve position for increasing flow rate in pipe line.
9. Record the differential pressure, flow rate in observation table.
10. Repeat the steps 6 to 9 for 5 to 6 readings.
11. Plot the graph of differential pressure Vs flow rate.

XI Observation Table

Sr. No.	Flow rate on indicator	Calculated flow rate
1		
2		
3		
4		
5		
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7		
8		
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10		

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. Name the device used for differential pressure measurement.
2. State the maximum range of flow rate measurement.
3. State the type of Venturi used in practical.
4. State the type of material used in Venturi in practical setup.

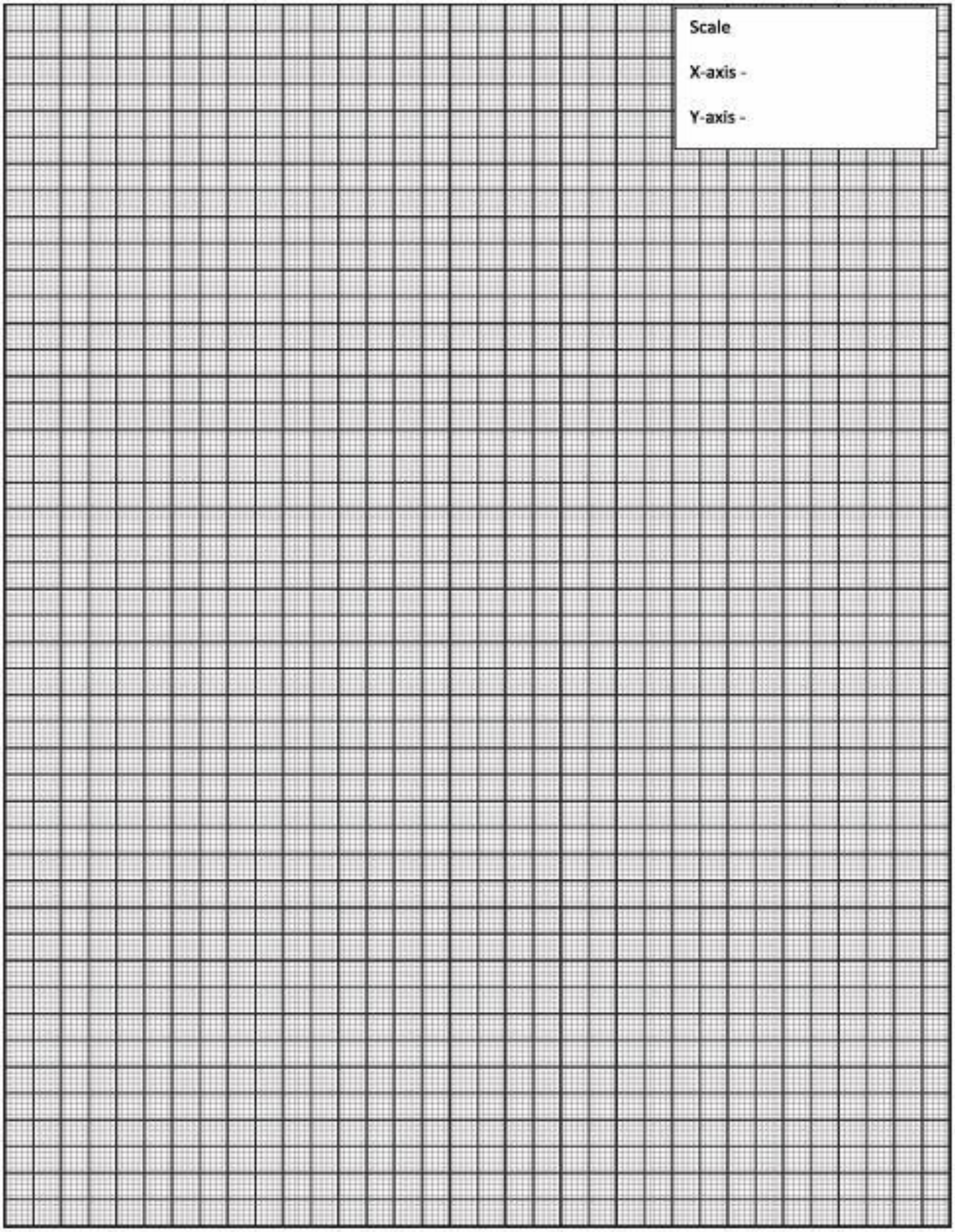
XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	


Scale
X-axis -
Y-axis -

Practical No. 26: Measurement of flow using Rotameter.

I Practical Significance

Rotameter is one of important instrument used by industry. The Rotameter have been in use for fluid flow measurement. It belongs to a class of variable area flow meters. This variable area principle consists of three basic elements: A uniformly tapered flow tube, a float, and a measurement scale. Therefore, this practical will help you to measure the flow using Rotameter

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Maintain the different types of flow transducers

IV Laboratory Learning Outcome(s)

Measure flow by using rotameter.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Rotameter: It is a variable area flow meter used for flow measurement. It consists of vertical tapered tube with a float which is free to move up and down within the tube. The free area between float and inside wall of the tube forms an annular orifice. The tube is mounted vertically with the small end at the bottom. The fluid to be measured enters the tube from the bottom and passes upwards around the float and exit at the top.

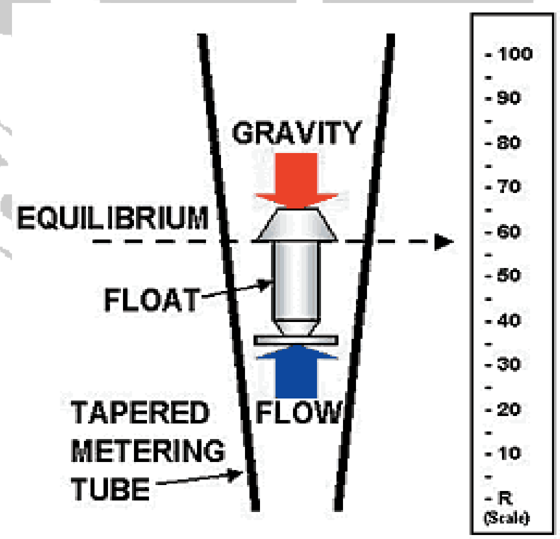


Fig. 26.1 Rotameter

Operating Principle

Its operating principle is based on a float of given density's establishing an equilibrium position where, with a given flow rate, the upward force of the flowing fluid equals the downward force of gravity.

Rotameters are the most widely used type of variable-area (VA) flow meter. In these devices, the falling and rising action of a float in a tapered tube provides a measure of flow rate as shown in Figure. Rotameter are known as gravity-type flow meters because they are based on the opposition between the downward force of gravity and the upward force of the flowing fluid. When the flow is constant, the float stays in one position that can be related to the volumetric flow rate. That position is indicated on a graduated scale. It can be used to measure the flow rates of most liquids, gases, and steam. The materials of construction include stainless steel, glass, metal, and plastic.

The tapered tube's gradually increasing diameter provides a related increase in the annular area around the float, and is designed in accordance with the basic equation for volumetric flow rate:

$$Q = kA\sqrt{gh}$$

where:

- Q = volumetric flow rate, e.g., gallons per minute
- k = a constant
- A = annular area between the float and the tube wall
- g = force of gravity
- h = pressure drop (head) across the float

With h being constant in a VA meter, we have A as a direct function of flow rate Q.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

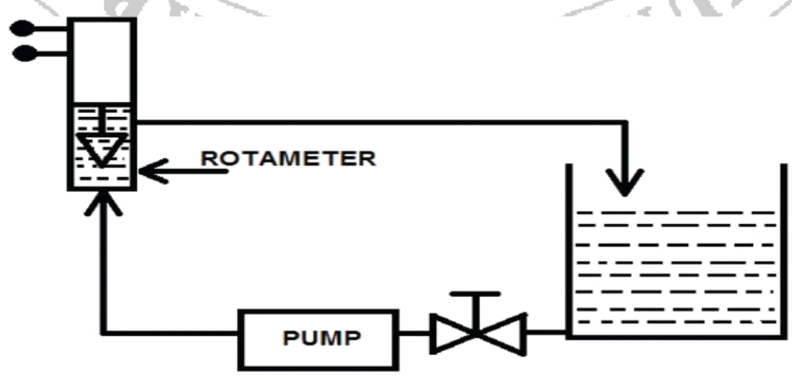


Fig.26.2 Flow measurement using rotameter

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Rotameter flow measurement setup	Range 0-1000 LPH, Glass tube body, Bob Material-SS, connection 1'', Mounting inlet bottom top outlet.	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 Rotameter measurement setup as in diagram.
3. Fill the sump tank with water.
4. Switch on the power supply.
5. Start the pump and ensure flow rate through pipe line
6. Measure flow rate indication on the Rotameter.
7. Change valve position for increasing flow rate in pipe line.
8. Record flow rate in observation table.
9. Repeat the steps 6 to 8 for 5 to 6 readings.

XI Observation Table

Sr. No.	Flow rate on indicator	Calculated flow rate
1		
2		
3		
4		
5		
6		
7		
8		
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XII Results:

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. State mounting position of Rotameter device used for flow measurement.
2. State the maximum range of flow rate measurement.
3. State the type of flow measurement used in practical.
4. State the type of material used in Rotameter in practical setup.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 27: Measurement of level using capacitance transducer.

I Practical Significance

In the industry environment Electrical Engineering/Industrial Electronics diploma graduate are expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. Level measurement is one of the important processes in industry. Level can be measure using different transducer, Capacitance transducer is one of them. Therefore, this practical will help you to measure the level using capacitance transducer.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Maintain the different types of level transducers.

IV Laboratory Learning Outcome(s)

Measure level by using Capacitance Transducer.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Capacitance level sensors are used for wide variety of solids, aqueous and organic liquids and slurries. The sensors can be designed to sense material with dielectric constants as low as 1.1 (coke and fly ash) and as high as 88 (water) or more. Sludges and slurries such as dehydrated cake and sewage slurry (dielectric constant approx. 50) and liquid chemicals such as quicklime (dielectric constant approx. 90) can also be sensed. Dual probe capacitance level sensors can also be used to sense the interface between two immiscible liquids with substantially different dielectric constants.

Working Principle: The principle of capacitive level measurement is based on change of capacitance. An insulated electrode acts as one plate of capacitor and the tank wall (or reference electrode in a non-metallic vessel) acts as the other plate. The capacitance depends on the fluid level. An empty tank has a lower capacitance while a filled tank has a higher capacitance. A simple capacitor consists of two electrode plate separated by a small thickness of an insulator such as solid, liquid, gas, or vacuum.

This insulator is also called as dielectric. Value of C depends on dielectric used, area of the plate and also distance between the plates.

$$C = E\left(\frac{KA}{d}\right)$$

Where:
C = capacitance in Pico farads (pF)
E = a constant known as the absolute permittivity of free space
K = relative dielectric constant of the insulating material
A = effective area of the conductors
d = distance between the conductors
This change in capacitance can be measured using AC bridge.

VII Actual Circuit diagram used in laboratory with equipment Specifications

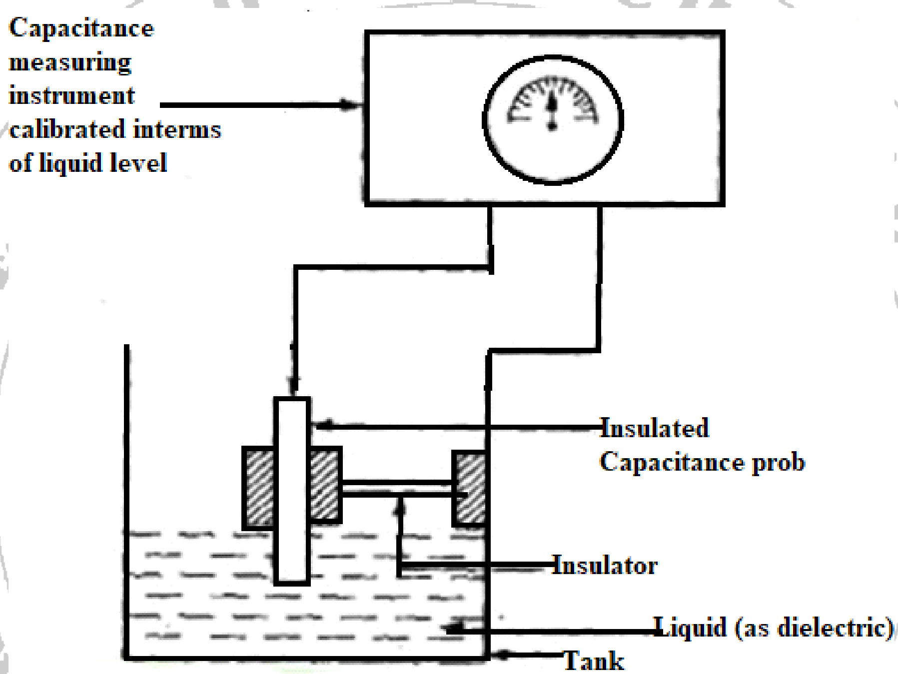

Fig. 27.1 Level Measurement using Capacitance Transducer

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Particulars	Specification	Quantity	Remark
1	Capacitance level measurement	Input range 0-500 mm, power supply 230 V ac , 2 wire capacitance type, top mounted, Digital display indication of 0 – 500mm.	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 set up diagram.
2. Connect level measurement setup as in diagram.
3. Switch on the power supply.
4. Measure the output when the tank is empty
5. Fill the tank in the range of 20% of maximum range.
6. Note down the level of the tank in mm. with the help of scale.
7. Record input and output for level measurement in observation table.
8. Repeat the steps 5 to 7 for 5 readings.

XI Observation Table

Sr. No.	Level on scale	Level on indicator
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. State the output of level in terms of capacitance when tank is empty and filled.
2. State the maximum range of level measurement.
3. State the type of capacitance level measurement used in practical.
4. State the type of material used in capacitance level measurement in practical setup.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 28: Measurement of temperature using RTD

I Practical Significance

In the industry environment Electrical Engineering/Industrial Electronics diploma graduate are expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. 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 0o temperature. This practical will help you to use to measure the temperature using RTD for given liquid.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Maintain the different types of temperature transducers.

IV Laboratory Learning Outcome(s)

Measure temperature by using RTD.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background

Resistance Temperature Detector (RTD): The resistance of certain metals changes with a temperature change. With the increase of temperature electrical resistance of certain metal increase in direct proportion to the rise of temperature.

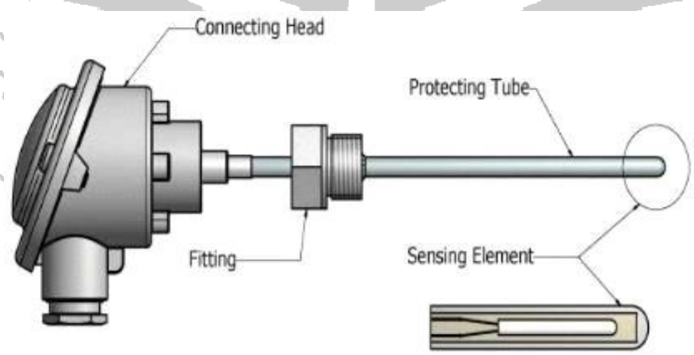

Fig. 28.1 Resistance Temperature Detector

In RTD devices; Copper, Nickel and Platinum are widely used metals. These three metals are having different resistance variations with respective to the temperature variations. That is called resistance-temperature characteristics. Platinum has the temperature range of 650^{o}c, and then the

Copper and Nickel have 120^{o}c and 300^{o}c respectively. The figure shows the resistance-temperature characteristics curve of the three different metals. For Platinum, its resistance changes by approximately 0.4 ohms per degree Celsius of temperature.

The construction is typically such that the wire is wound on a form (in a coil) on notched mica cross frame to achieve small size, improving the thermal conductivity to decrease the response time and a high rate of heat transfer is obtained. In the industrial RTD's, the coil is protected by a stainless steel sheath or a protective tube.

In RTD, the change in resistance value is very small with respect to the temperature. So, the RTD value is measured by using a bridge circuit. By supplying the constant electric current to the bridge circuit and measuring the resulting voltage drop across the resistor, the RTD resistance can be calculated. Thereby, the temperature can be also determined. This temperature is determined by converting the RTD resistance value using a calibration expression.

Rt'= Ro[1+ £t (t — to)]

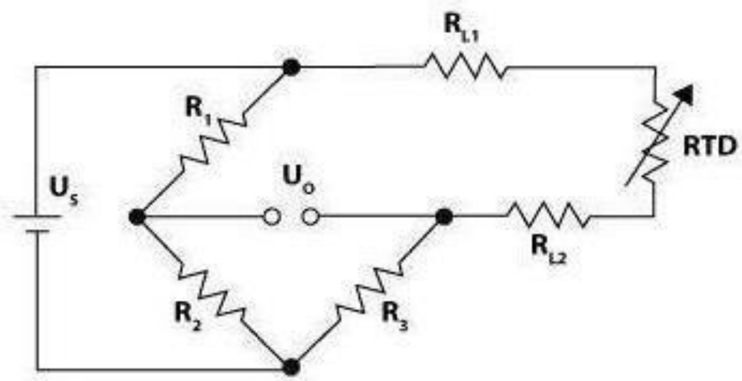

Fig. 28.2 RTD resistance Measurement using Bridge circuit

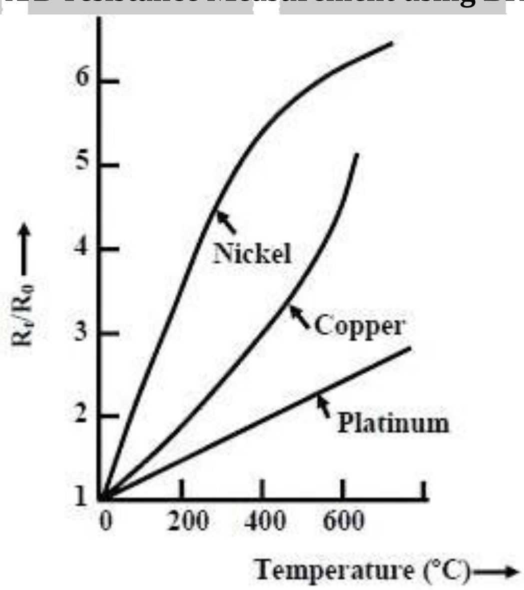

Fig. 28.3 RTD characteristic

VII Actual Circuit diagram used in laboratory with equipment Specifications:

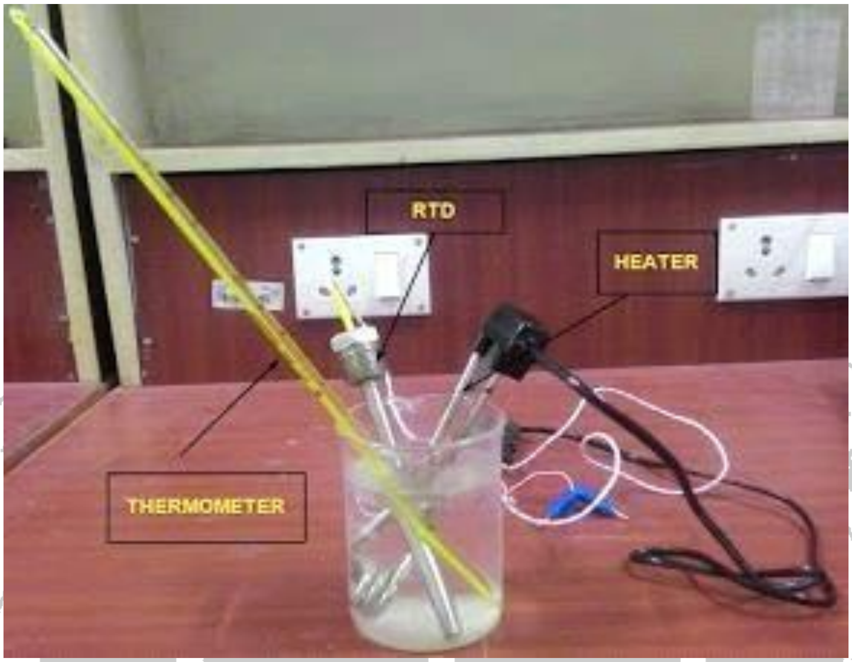

Fig. 28.4 Temperature measurement using RTD

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	RTD	Pt100	01	
2	Temp Bath	2 KW, 230V AC	01	
3	Digital Temperature indication	0^0C to 200^0C, accuracy of +/- 1%	01	
4	Mercury Thermometer	0 to 300^0C	01	
5	Digital Multimeter	0-200Ω	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 RTD.
3. Place the RTD, thermometer, immersion heater in temperature bath.
4. Record the room temp. with mercury thermometer
5. Record the output resistance with multimeter for room temperature.
6. Switch on the power supply of heater.
7. Note down the temperature for every 5 degree temperature rise.
8. Record the temperature using mercury thermometer.
9. Record the output resistance using multimeter.
10. Complete the observation table.
11. Repeat the steps 7 to 10 for 10 readings.
12. Plot the temperature Vs resistance graph.

XI Observation Table:

Sr. No.	Temperature (^{0}C)	Resistance (Ω)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d) …………

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Note:- Teacher should provide various questions related to practical- sample given)

1. State the output resistance when two terminals are short of RTD.
2. State the output when the element become open of RTD.
3. State the output resistance at room temperature.
4. State the different materials used for RTD
5. State the meaning of pt100.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -

Practical No. 29: Measurement of temperature using Thermocouple.

I Practical Significance

In the industry environment Electrical Engineering/Industrial Electronics diploma graduate are expected to handle various transducers for measurement of process parameters such as temperature, pressure, level, flow, displacement etc. Thermocouple is most useful active temperature transducer. It work based on See beck and Peltier effect. Since it is active transducer designing of signal conditioner is easy. This is mostly used to measure the temperature above $300^{o}C$. This practical will help you to use to measure temperature using thermocouple for given liquid.

II Industry/Employer Expected Outcome(s)

Troubleshoot electrical and electronics measuring instruments used for laboratory and industrial measurements.

III Course Level Learning Outcome(s)

Maintain the different types of temperature transducers.

IV Laboratory Learning Outcome(s)

Measure temperature by using thermocouple.

V Relevant Affective Domain related outcome(s)

1. Follow safety electrical rules for safe practices.
2. Maintain cleanliness of transducer setup.

VI Relevant Theoretical Background (With diagrams if required):

Thermocouple: A thermocouple is a device made by two different wires joined at one end, called junction end or measuring end. The two wires are called thermo elements or legs of the thermocouple: the two thermo elements are distinguished as positive and negative ones. The other end of the thermocouple is called reference end The junction end is immersed in the environment whose temperature T2 has 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.

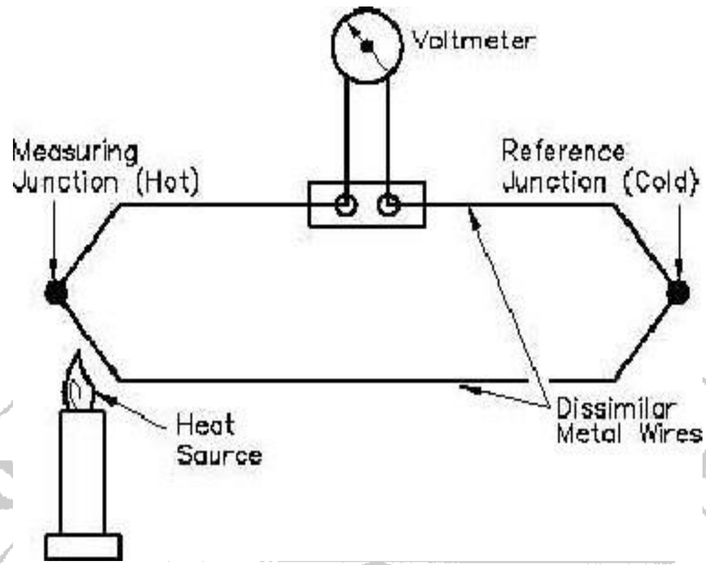

Fig. 29.1 Temperature measurement using Thermocouple

Heating the measuring junction as shown in above figure, Simple Thermocouple Circuit junction on the thermocouple produces a voltage which is greater than the voltage across the reference junction. The difference between the two voltages is proportional to the Difference in temperature and can be measured on the voltmeter (in millivolts).

VII Actual Circuit diagram used in laboratory with equipment Specifications

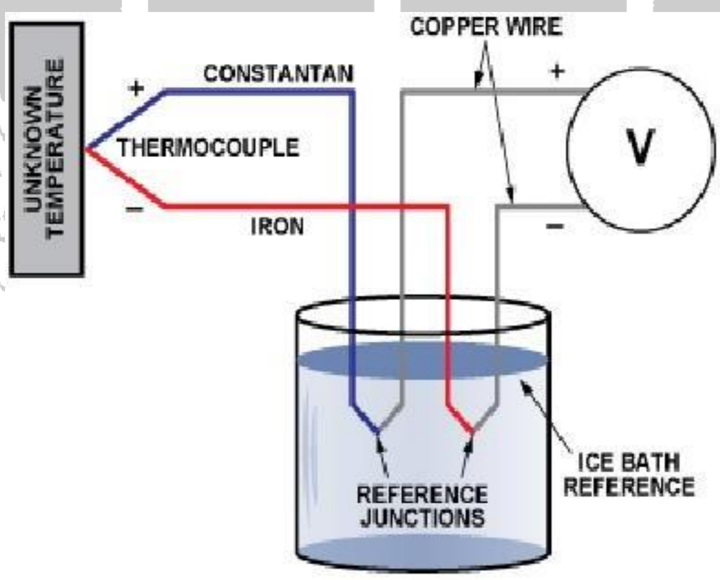

Fig. 29.2 Temperature Measurement Setup

VIII Required Resources/apparatus/equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Thermocouple	Thermocouple K Type: Temp range 0-2000C	1
2	Temp Bath	2 KW, 230V AC	1
3	Digital Temperature indication	00C to 2000C, accuracy of +/- 1%	1
4	Digital Multimeter	0-200mV	1
5	Mercury Thermometer	0-3000°C	1
6	Compensating cable	2 wire, $0.5mm^2$	1

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. Complete the observation table.
11. Repeat the steps 7 to 10 for 10 readings.
12. Plot the temperature V_s voltage graph.

XI Observation table

Sr. No.	Temperature(°C)	Voltage (mV)
1		
2		
3		

XII Result(s)

- Name of identified transducer a) …………
- Names of identified parts a) ………… b) ………… c) ………… d)………

XIII Interpretation of results

………
………
………

XIV Conclusion and recommendation

………
………
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XV Practical related questions (Note:-Teacher should provide various questions related to practical- sample given)

1. State the output voltage when two terminals are short of thermocouple.
2. State the output when one of the elements becomes open.
3. State the output voltage at room temperature.
4. State the different types of thermocouple.

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XVI References/Suggestions for further reading

1. Book: A.K.Sawhney -Electrical and Electronics Measurement and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2014; ISBN:9780000279744
2. Book:H.S.Kalsi- Electronic Instrumentation and Measurement, Tata Mc-Graw Hill Publication Co. Ltd, New Delhi 2019; ISBN:9353162513
3. www.electrical4u.com
4. www.electricaltechnology.org

XVII 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)**	

Scale

X-axis -

Y-axis -