INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LABORATORY								
VI Semester: EEE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AEEC33	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: There are no prerequisites to take this course								

I. COURSE OVERVIEW:
The objective of this laboratory course is to learn about the electrical measurement methods, operational principles with suitable software and hardware. The lab emphasizes on the practical skills to design and realize the use of instruments for different electrical applications.

II. COURSES OBJECTIVES:
The students will try to learn

1. The characteristics of sensors, signal conditioning circuits and display devices.
2. The different waveforms using Lab VIEW software to measure various parameters.
3. The use of transducers in electrical and nonelectrical measurements.
4. The virtual instruments in measurement of analysis of electrical parameters.

III. COURSE OUTCOMES:
At the end of the course students should be able to:

CO1	Make use of transducers like thermocouple, thermistor and resistance temperature detector for measuring temperature.
CO2	Choose appropriate transducers for the measurement of strain, pressure, position and level
CO3	Examine the errors in measuring instrument by calibrating voltmeter, ammeter, LPF wattmeter, single phase energy meter, dynamometer power factor meter.
CO4	Develop Lab view programs for displaying electrical waveforms and Lissajous patterns.
CO5	Build simulation models in digital environment for the measurement of passive parameters like inductance, capacitance and resistance.
CO6	Analyze the quantities like turns ratio, reactive power, errors associated with current transformer for reducing the errors in measuring instruments.

IV. COURSE CONTENT:

EXERCISES FOR ELECTRICAL MEASUREMENTS & INSTRUMENTATION LABORATORY

Getting Started Exercises

Introduction

The significance of the Electrical Measurements & Instrumentation Lab is renowned in the various fields of engineering applications. The main objectives of this lab are to expose the students to different types of electrical measuring instruments and make the students understand how to use these instruments for measuring an unknown quantity. In this lab we also calibrate & test different types of electrical measuring instruments. It also uses lab view software to analyze various experiments. Lab VIEW is a graphical programming environment that provides unique productivity accelerators for test system development, such as an intuitive approach to programming, connectivity to any instrument, and fully integrated user interfaces.

1. Temperature and Speed sensing.

1.1. Measure the temperature of a thermo-couple using a signal conditioning device.

A thermocouple produces a temperature-dependent voltage as a result of the seebeck effect, and this voltage can be interpreted to measure temperature. Thermocouples transfer heat with the help of thermoelectricity into electrical energy.

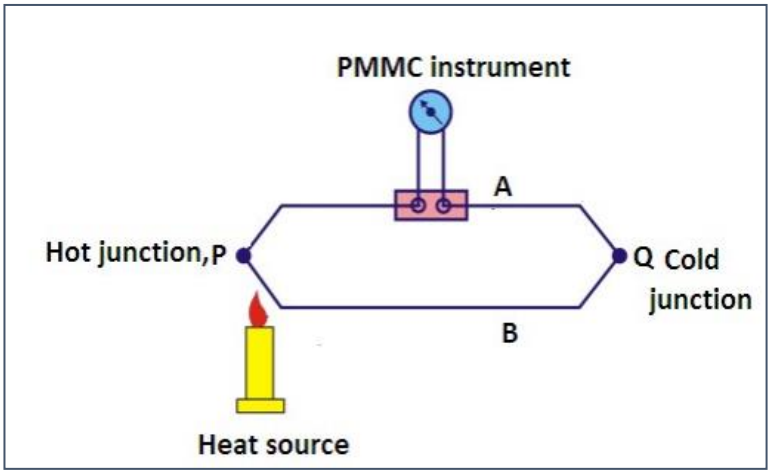

Fig. 1. Thermo-Couple with Signal Conditioning

Try

1. Measure the temperature using thermostats and resistance temperature detector with signal conditioning.
2. Record the temperatures at various atmospheric conditions.
3. Measure the temperature using J, K, or T-type thermocouple with a high degree of accuracy.

1.2. Measure the speed using a Proximity Sensor

Measure the speed using a proximity sensor-Hardware setup i.e. Thermister as shown in figure 2. The proximity sensor sends an electromagnetic beam that hits the object and comes back. The time of flight is used to measure the distance.

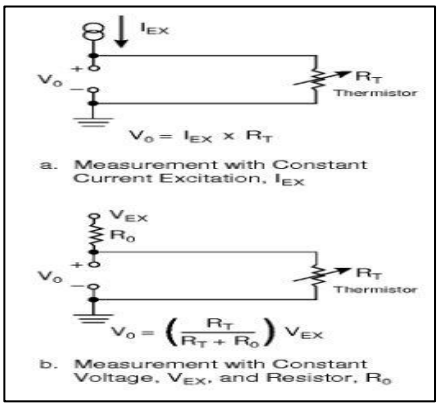

Fig. 2. Thermister

Try

1. Measure the speed by using a Tacho meter.
2. Measure the speed by using optical techniques.

2. Measure the Resistance using Kelvin's Double Bridge circuit.

Measure very small values of resistances using Kelvin's double bridge circuit. A Kelvin bridge or kelvin double bridge is a modified version of the Wheatstone bridge, which can measure up to 1 to 0.00001 ohm with high accuracies. It is named because it uses another set of ratio arms and a galvanometer to measure the unknown resistance value.

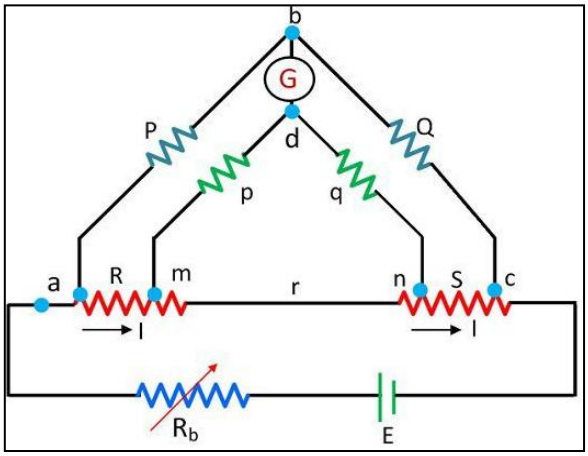

Fig. 3. Kelvin's double bridge

Try

1. Measure a small resistance value of up to 1mΩ
2. Measure a small resistance value by Ammeter-Voltmeter method.

3. Measure the Strain and Pressure.

3.1. Strain measurement.

Strain measurement using strain gauge trainer kit, shown in figure4. The instrument displays exact micro strain, strained by the cantilever beam. Strain is used to describe the measurement of deformation of a material. The material of a certain component or object can be elongated (tractioned) or contracted (compressed), thus experiencing strain due to the following factors: the effect of an applied external force (mechanical strain).

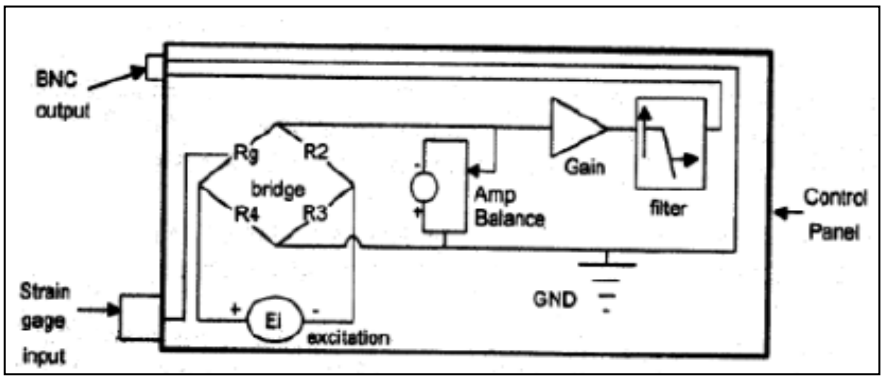

Fig. 4. Strain Gauge

Try

1. Evaluate the strain using micrometer and resistance strain gauge methods.
2. Measure the strain using Digital image correlation (DIC).
3. Find the strain using manual methods.

3.2. Pressure Measurement.

Measure the value of pressure using differential pressure transducer trainer kit. Scientech 2308 Pressure Transducer Explorer is designed to explain concept of Pressure measurement. It helps students & industry professionals to understand operation of Pressure Transducer in detail. Built-in On/Off Controller is also provided with audio & visual indicators.

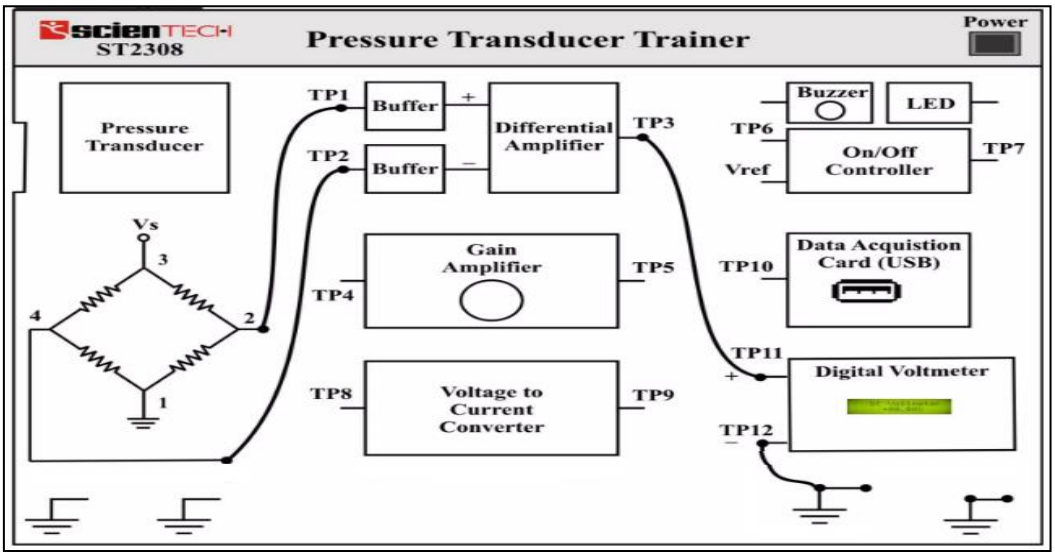

Fig. 5. Pressure Transducer Trainer Kit

Try

1. Calculate the pressure by gauge, sealed and absolute methods.
2. Find the pressure by manual methods.

4. Measure the position and level using LVDT.

4.1 Positional Measurement.

Measure the displacement using linear variable differential transformer i.e. LVDT Trainer Kit. LVDT (Linear Variable Differential Transformer) is the most widely used inductive transducer for displacement measurement. LVDT is a secondary transducer which converts the displacement directly into an electrical output proportional to the displacement.

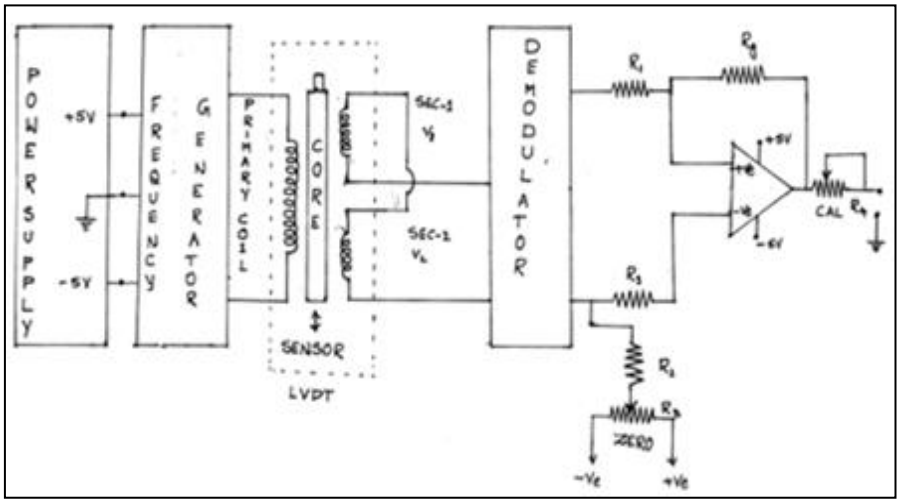

Fig. 6. LVDT Trainer Kit

Try

1. Positional measurements by optical methods.
2. Positional measurements by null methods.

4. 2. Level Measurement.

Measure the level of water by using capacitor transducer. The capacitive transducer used here is cylindrical in shape. It has an inner metallic rod insulated with Teflon covering and an outer stainless steel pipe is acting as an outer electrode. There are some small holes at the bottom of the outer pipe through which the water enters in to the cylindrical capacitor. Capacitor is formed with inner rod acting as one electrode, water acting as the dielectric and outer stainless steel pipe acts as other electrode. The water acts as the dielectric, which gets changed when water level is changed. The cylindrical capacitor is placed inside a plastic container, where water is poured for level measurement. There is an mm marking scale pasted over the container and a pipe is fitted at the bottom of the container with a flow control switch attached with it, to drain the water.

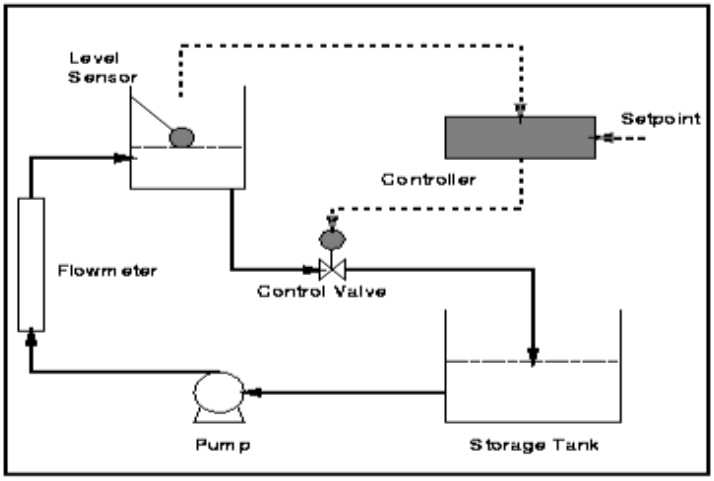

Fig. 7. Measurement of water level by using capacitor transducer

Try

1. Water level measure by using Electric water level meters – referred to as sounders.
2. Water level measure by using digital alarm indicator.

5. Phantom loading on LPF wattmeter

Calibrate the LPF wattmeter by phantom load testing method. Phantom loading is the phenomena in which the appliances consume electricity even when they turn off**.** The disc of the energy meter rotates which increases the reading of the meter, but the devices do not consume power**.** This type of loading is also known as the vampire or virtual loading**.** The phantom loading mainly occurs in the "electronic" appliances.

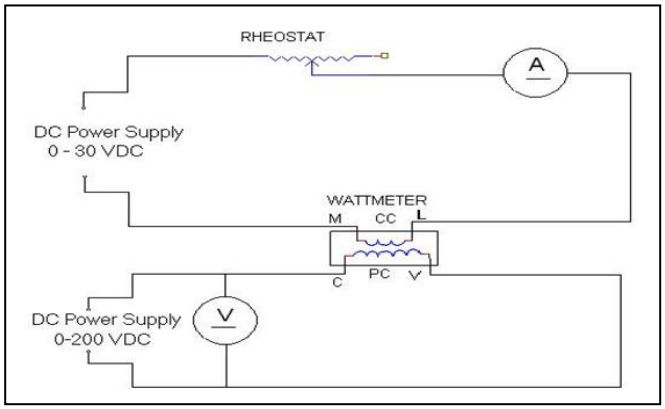

Fig. 8.LPF wattmeter

Try

1. Calibrate LPF wattmeter – by Direct Loading Method.
2. Calibrate LPF wattmeter – by Standardization Method.

6. Calibrate single phase energy meter and power factor meter.

6.1. Calibration of single phase energy meter.

Calibrate and test the single phase induction type energy meter. Induction Type Energy meter is widely used for the measurement of energy consumed in domestic as well as in industrial installations. Induction instruments possess lower friction and higher torque/weight ratio and these instruments cost less and are accurate over a wide range of loads and temperatures.

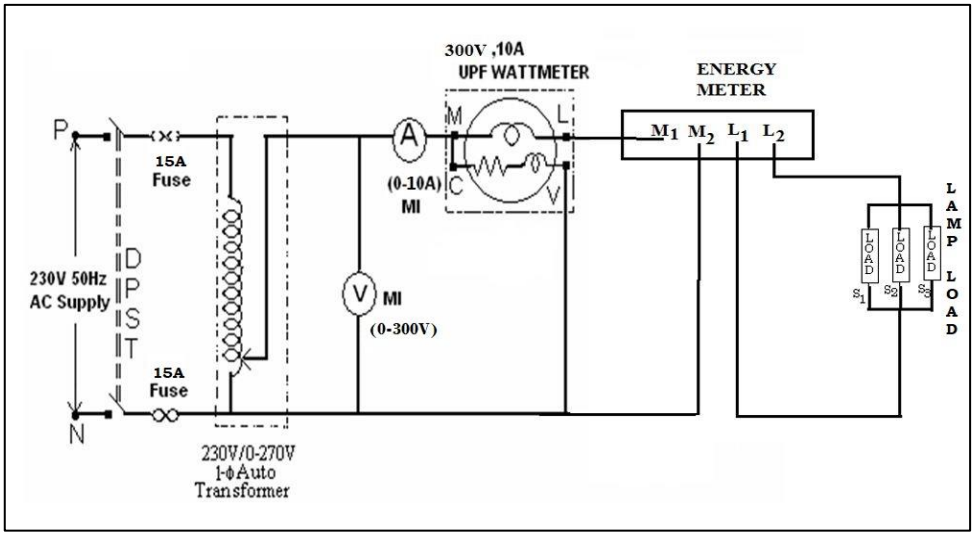

Fig. 9. Calibration and Testing of Single Phase Energy Meter

Try

1. Calibrate watt-hour type meter.
2. Calibrate 3- Phase Energy Meter

6.2. Calibrate power factor meter.

To calibrate power factor meter. A power factor meter is an electric instrument which is used to measure the power factor of various electrical machines like DC Generator, AC Motor, Transformer etc and for measuring the power factor of various transmission and distribution lines of various electric power supplies.

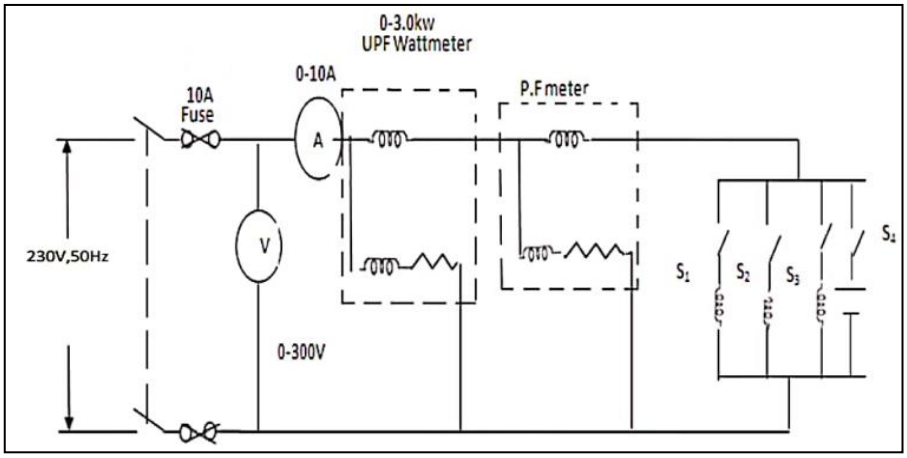

Fig. 10. Calibration and Testing of Power Factor Meter

Try

1. Calibrate Electrodynamometer type meter.

2. Calibrate Moving Iron Type meter.

7. Turn's ratio Measurement using A.C bridge.

To find the turns ratio of transformer by using A.C bridge. It consists of four arms of impedance, a sine wave generator, Detector or Headgear set. The sine wave generator is provided with frequency selection switch from 1 KHz to 40KHz. Low frequency signal is used for measuring primary inductance (Lp) and high frequency for secondary inductance (Ls). Thus by measuring primary and secondary inductances of transformer with A.C bridge, the turns ratio is decided.

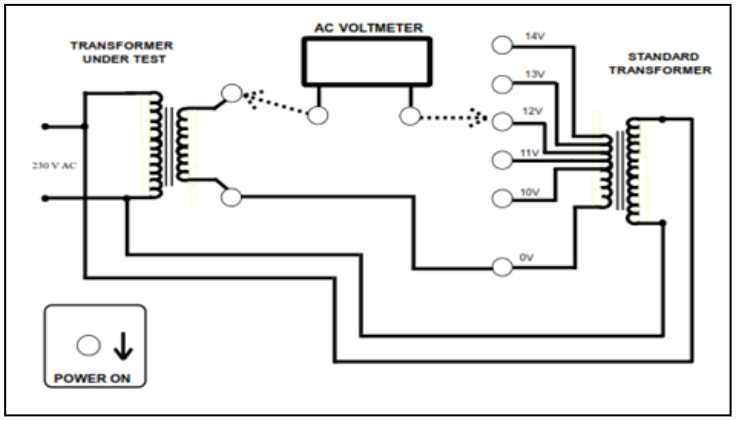

Fig. 11.Turns Ratio Measurement for a transformer by using A.C Bridge

Try

1. Energize the HV winding of a transformer and measuring the voltage on the LV winding.
1. Normalize the HV winding of a transformer and measuring the voltage on the LV winding.

8. Measurement of Reactive power using single phase wattmeter.

To measure 3 - phase reactive power using single phase wattmeter. The measurement of reactive power is essential because the value of reactive power shows the total power loss in the circuit. If the value of reactive power is low, the power factor of the load becomes poorer and more loss occurs in the system.

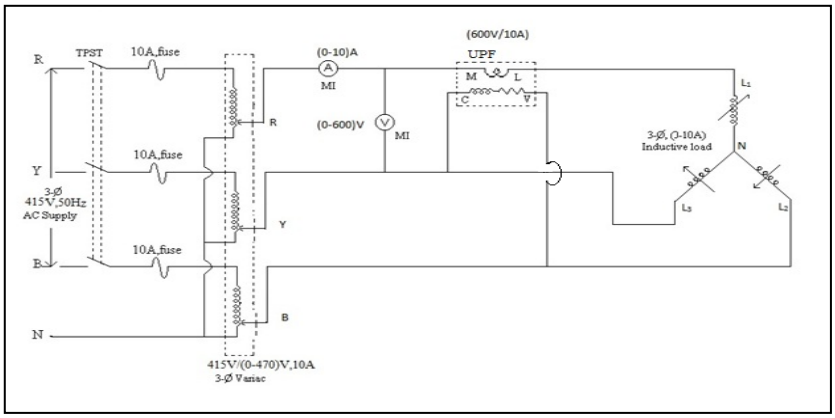

Fig .12. Circuit Diagram of Measurement of 3-Phase Reactive Power using Single Wattmeter

Try

1. Measure 3 - phase reactive power using 2- wattmeter method.
2. Measure 3 - phase reactive power using 3- wattmeter method.

9. Test the C.T using Mutual inductor & Measure percent ratio error and phase angle error of a given C.T by Null-method.

Conduct an experiment on CT testing using mutual inductor for measurement of percent ratio error and phase angle by null method. Here the ratio and phase angle of the transformer are determined. In terms of that of a standard transformer having the same nominal ratio. The two transformers are connected with their primary in series. W1 is wattmeter whose current coil is connected to carry the secondary current of the standard transformer.' the current coil do the wattmeter W2 carries a differential current I which is the difference between a secondary currents of the standard and test transformers. The voltage circuits of the wattmeters are supplied from a phase shifting transformer voltage.

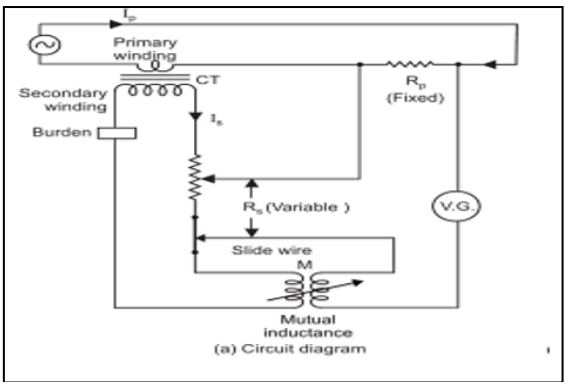

Fig .13. Mutual inductance method

Try

1. Conduct an experiment on CT testing using polarity test.
2. Conduct an experiment on CT testing using insulation resistance test.

10. DC Crompton Potentio meter

To calibrate PMMC Voltmeter and Ammeter by DC Crompton's potentiometer. A potentiometer is a device used for measuring the emf of a cell or potential difference between two points in a circuit. It works on the principle of comparison i.e., comparing the unknown voltage with the known voltage and makes use of balanced condition. DC Crompton's potentiometer is the laboratory-type potentiometer that is used to measure unknown emf effectively with a great degree of precision.

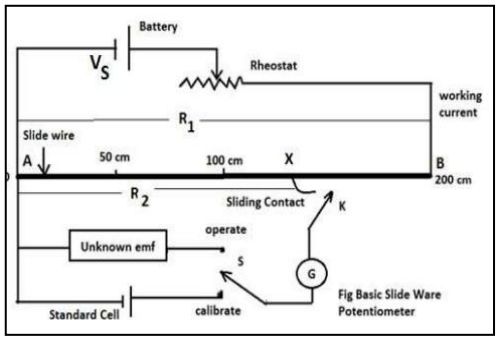

Fig. 14.DC Crompton's potentiometer

Try

1. Conduct an experiment on linear potentiometers for PMMC calibration.
2. Conduct an experiment on rotary potentiometers for PMMC calibration.

11. Analyze waveforms, frequency and THD using digital simulation.

Measurement of different parameters for given standard ac signals using LAB VIEW. Lab VIEW is a graphical programming environment that provides unique productivity accelerators for test system development, such as an intuitive approach to programming, connectivity to any instrument, and fully integrated user interfaces.

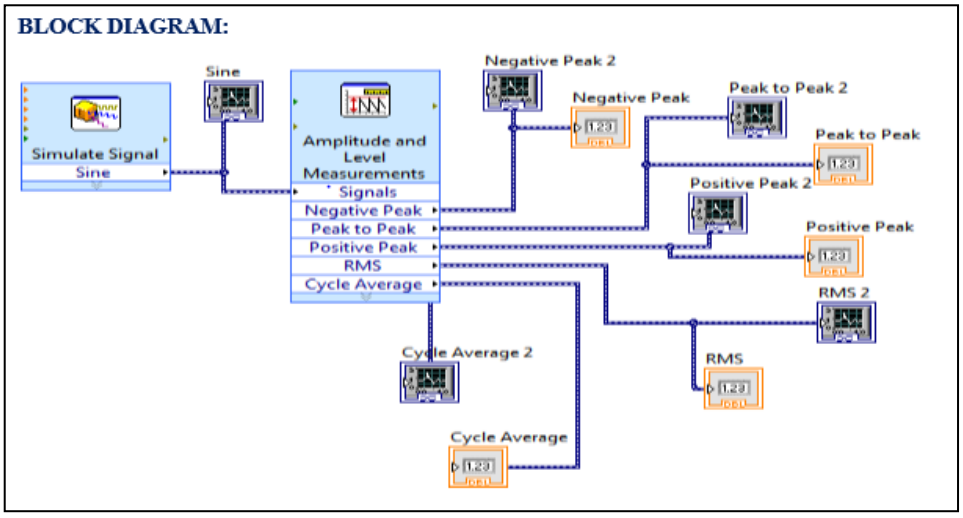

Fig. 15. MATLAB view of Measuring Parameters of AC signals

Try

1. Analyse waveforms, frequency and THD using CRO.
2. Analyse of waveforms, frequency and THD using DSO.

12. Three phase power Measurement.

Measure 3- phase power by using 1- phase wattmeter and two Current Transformers (CTs). In this method the power absorbed in a 3-φ balanced circuit is measured using a single wattmeter in conjunction with 2 CT's. Usually 2-Wattmeter method is used measure the 3-φ power for both balanced and unbalanced load, but method like this requires only one wattmeter. The CT's used for this method should be of 1:1 ratio.

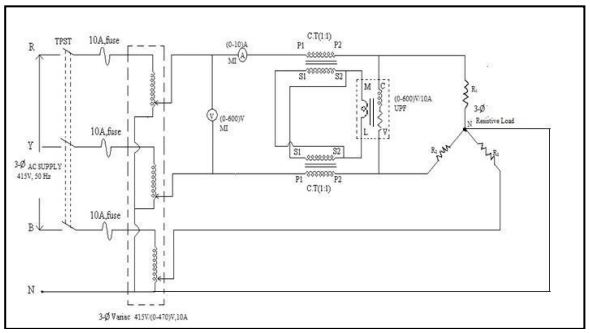

Fig. 16. 1-Phase Wattmeter and Two Current Transformers (CTs).

Try

1. Measure 3- phase power by using 1- wattmeter method.
2. Measure 3- phase power by using 2- wattmeter method.

13. Static energy meter using digital simulation.

Measure the energy using a static energy meter and verify using Lab VIEW Software. Static energy meters provide utilities with the much needed technology to measure electricity consumed for monetization purposes.

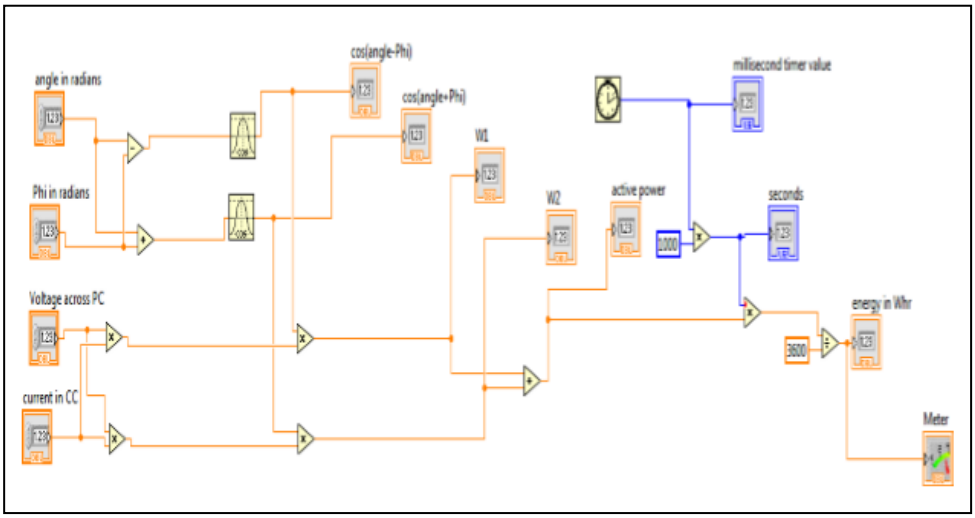

Fig .13. Lab VIEW Model for Measurement of energy using a static energy meter

Try

1. Energy measurement using a dynamic energy meter.
2. Energy measurement using a digital energy meter.

14. Passive parameters measurement using digital simulation.

14.1. Capacitance measurement.

Capacitance measurement using Schering bridge using Lab VIEW. Lab VIEW is a graphical programming environment that provides unique productivity accelerators for test system development, such as an intuitive approach to programming, connectivity to any instrument, and fully integrated user interfaces.

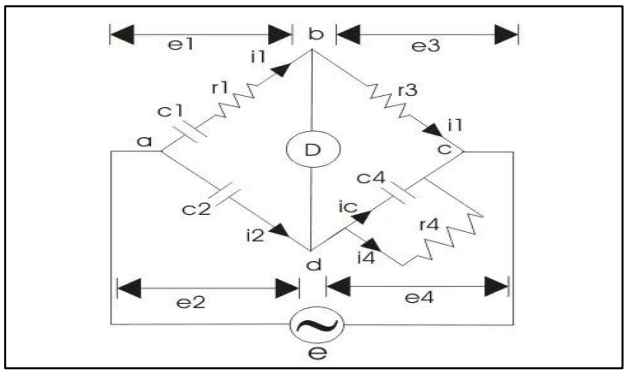

Fig. 14. Schering Bridge

Try

1. Capacitance measurement using galvano static charging method.
2. Capacitance measurement using cyclic volt ammetry method.
3. Capacitance measurement by impedance spectroscopy methods.

14.2. Andersons bridge.

Measure the inductance using Anderson Bridge using Lab VIEW. Anderson Bridge is the higher form of Maxwell's inductance capacitance bridge. It is an AC Bridge. With the help of Anderson Bridge, we can determine the self-inductance of an inductor in the circuit.

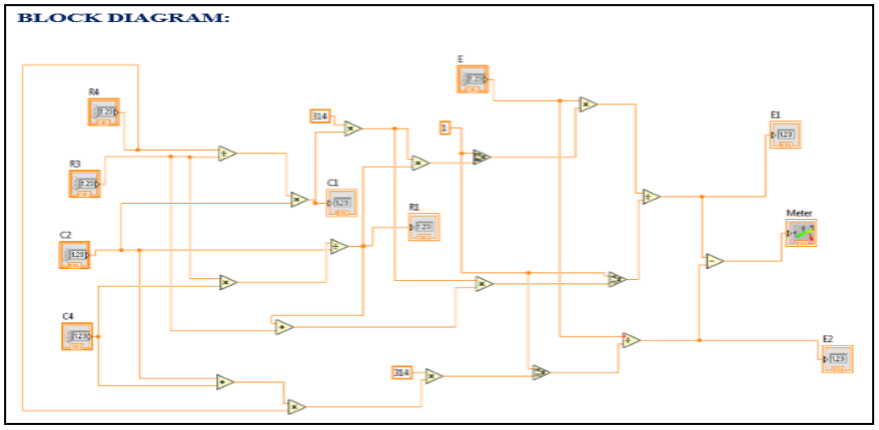

Fig. 15. Lab VIEW Model for Inductance measurement using Anderson Bridge

Try

1. Inductance measurement using a frequency generator.
2. Inductance measurement using an oscilloscope or an LCM multimeter.

V. REFERENCE BOOKS:

1. https://www.bookpump.com/bwp/pdf-b/2335004b.pdf.
2. https://www.bambang.lecturer.pens.ac.id/rekayasa%20sensor%20aktuator/sensor%20&%20Trans.
3. https://www.sae.org/images/books/toc_pdfs/BELS036.pdf.

VI. WEB REFERENCES:

1. https://www.gnindia.dronacharya.info/EEEDept/Downloads/Labmanuals/EMI_Lab.pdf
2. https://www.scribd.com/doc/25086994/electrical-measurements-lab

VII. ELECTRONICS RESOURCES:

1. https://www.allaboutelectricalmeasureements.com/textbook/
2. https://onlinecourses.nptel.ac.in/noc22_ee93/preview
3. https://www.iare.ac.in

VIII. MATERIALS ONLINE

1. Course template
2. Lab manual.