Measurement Laboratory

MANUAL

Aliah University
আলিয়া বিশ্ববিদ্যালয়
جامعة عالية

ELECTRICAL ENGINEERING DEPT.

EEN 2nd Year

4th Semester | EENUGPC06

Measurement Laboratory

MANUAL

Electrical Engineering Dept. | EEN 2nd Year | 4th Semester | EENUGPC06

Name of the Program: **B. Tech (EE).** Year: **II** Semester: **IV**

Course/Subject: **Measurement Lab** Course code: **EENUGPC06**

Electrical Measurement Laboratory is one of the few labs which are critical for both 'Electrical Engineering' & 'Electronics & Communication Engineering' under graduate students. In this lab hardware-based experiments are conducted. Here students study how to measure resistance, inductance, capacitance, voltage, current, power, energy practically with help of various measuring techniques also learn to demonstrate various bridges using hardware set ups and compare them with the theoretical results.

On completion of this Subject, the student shall be able:

1. How to visualize and work on laboratory and multidisciplinary tasks.
2. To demonstrate various Bridges using hardware set ups.
3. To Measure Voltage, Current, Power, Energy.

The expected outcomes of the Subject are:

1 Have knowledge, to demonstrate the designing and conducting experiments, to analyze and interpret data.

2 Provides the ability to visualize and work on laboratory and multidisciplinary tasks.

3 Measurement of R, L, C, Voltage, Current, Power, Energy.

4 Measurement uses PMMC and Moving Iron type Instruments

6 Measurement of power using LPF and UPF methods.

7 Ability to balance AC Bridges to find unknown values.

Assessment Criteria:

1. Instrumental operation skill and familiarization of hardware.

2. Experimental procedure, simulation results, internal observation, lab record.

3. End semester final examinations.

~: LIST OF EXPERIMENTS: ~

Experiment No: 1

Measurement of Three Phase Power by Two Wattmeter Method for balanced load.

Experiment No: 2

Measurement of Three Phase Power by Two Wattmeter Method for unbalanced load

Experiment No: 3

Calibration of Dynamometer Type Wattmeter– by direct loading

Experiment No: 4

Calibration of Dynamometer Type Wattmeter- by Phantom Loading

Experiment No: 5

To determine the low value unknown resistance by Kelvin Double Bridge

Experiment No: 6

To determine the unknown value of capacitance by De Sauty's Bridge

Experiment No: 7

To determine the frequency of audio frequency oscillator by Wien Bridge

Experiment No: 8

Study of Single-Phase Digital Energy Meter

Experiment No: 9

To determine the self-inductance of a coil using Anderson Bridge

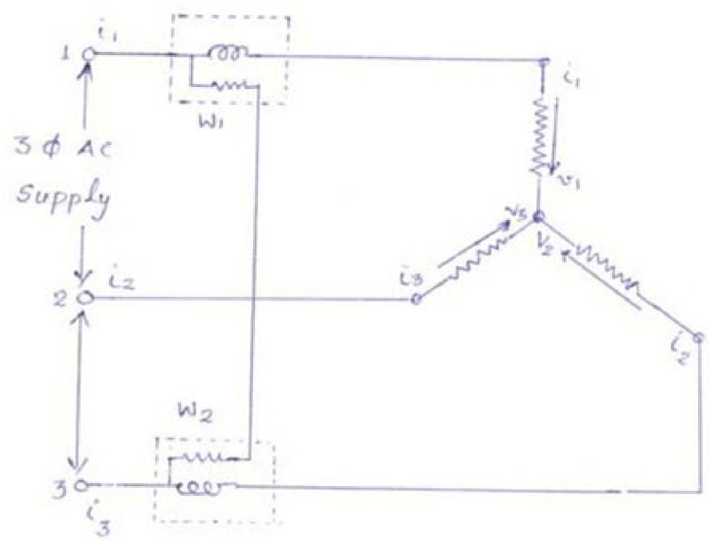
Experiment No: 1 & 2

Title: **M**easurement of power in a three phase system by two wattmeter method (for balanced load & unbalanced load)

Objective: To determine the value of 3-ph power using two Wattmeter.

Theory: Surprisingly, only two single phase wattmeters are sufficient to measure the total power consumed by a three-phase balanced circuit. The two wattmeters are connected as shown in figure. The current coils are connected in series with two of the lines. The pressure (or voltage) coils of the two wattmeters are connected between that line and reference.

Circuit Diagram:



Procedure:

1. Connect the circuit as shown in figure.
2. Keep the three phase variac at its zero position.
3. Switch on the main supply.
4. Increase the voltage supplied to the circuit by changing the positions of variac so that all the meters give readable deflection.
5. Note down readings of all the meters

Apparatus Used: Three phase variable load, ammeters 0-10 A, MI type, 2no's, wattmeters 0-5 A, 300V,2 no's, voltmeter 0-300V, MI type

Observation Table:

Sl. No	V	I	W_1	W_2	$P= W_1 + W_2$

Precautions:

1. Connections should be tight.
2. Take the readings carefully.
3. Switch off the circuit when not in use.

Discussion:

(Teacher's Signature)

Questions/answers: -

Q.1. How many coils are there in a single in a single-phase wattmeter?
A. In general, there are two coils in the wattmeter. One coil is known as current coil and othercoil is known as pressure coil or voltage coil.

Q.2. What do you understand by phase sequence in reference to 3-phase circuits?
A. Phase sequence in three phase circuits means the order in which the phase voltages attain their respective maximum positive voltages.

Q.3 What is the phase sequence of a 3-phase system in general?
A. The phase sequence of a three-phase system is R, Y, B.

Q.4 How the phase sequence of a three-phase system can be changed?
A. If the connections of any two phases are interchanged, the phase sequence can be changed.

Q.5 Is the method used in this experiment applicable to unbalanced loads?
A. Yes, we can use this method for unbalanced loads.

Q.6 Can you measure reactive power in a three-phase circuit using thismethod?
A. Yes the reactive power is given by the relation.

$$Q=\sqrt{3}\,(W1 - W2)$$

Q.7 Which type of wattmeter is generally used for measuring power in a.c. circuits?
A. Dynamometer type of instruments are generally used for measurement of power.

Q.8 How a wattmeter is connected in an a.c. circuit?
A. There are four terminals in wattmeter. There are two coils in wattmeter one is current coil (low resistance) in wattmeter and other is pressure coil (higher resistance). The current coil is always connected in series and pressure coil is connected in parallel.

Q.9 What is the relation between line voltage and phase voltage in star connected system?
A. Line voltage is equal to √3 times of phase voltage.

Q.10 In a star connected 3-phase balanced load with neutral available, how many wattmeters are necessary to measure power?
A. Only one wattmeter is sufficient

Experiment No: 3

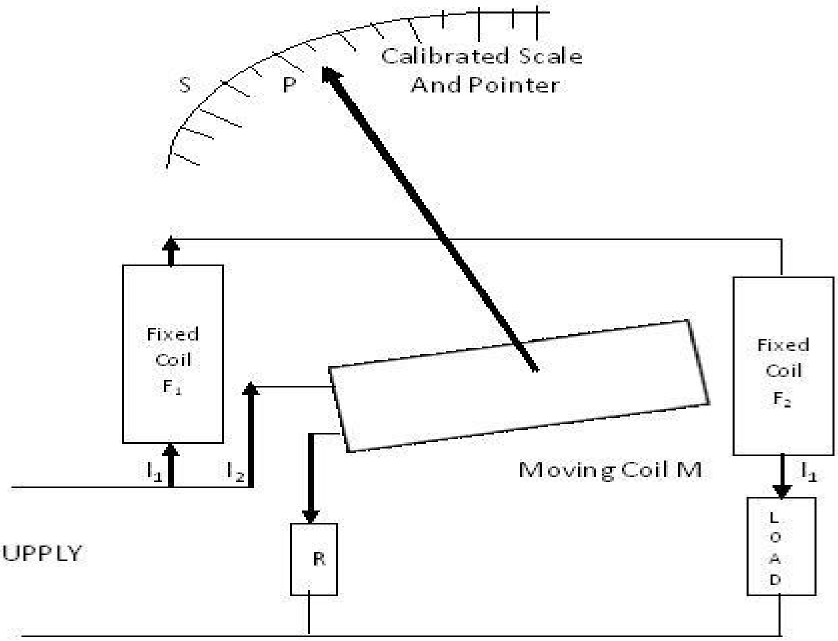
TITLE: Calibration of Dynamometer Type Wattmeter– by direct loading.

AIM:

To calibration of dynamometer type wattmeter by connecting direct loading.

THEORY:

An electrodynamometer wattmeter consists of two fixed coils, **F1** and **F2** and a moving coil **M** as shown below.



The fixed coils are connected in series with the load and hence carry the load current. These fixed coils form the *current coil* of the wattmeter. The moving coil is connected across the load and hence carries a current proportional to the voltage across the load. A highly non- inductive resistance R is put in series with the moving coil to limit the current to a small value. The moving coil forms the *potential coil* of the wattmeter.

The fixed coils are wound with heavy wire of minimum number of turns. The fixed coils embrace the moving coil. Spring control is used for movement and damping is by air. The deflecting torque is proportional to the product of the currents in the two coils. Theses watt meters can be used for both DC and AC measurements. Since the deflection is proportional to the average power and the spring control torque is proportional to the deflection, the scale is uniform. The meter is free from waveform errors.

Wattmeter reading = Actual reading

Theoretical reading P = V I cosΦ

P = Voltmeter reading X Ammeter reading X power factor reading

$$\text{Since percentage of error} = \frac{\text{Actual reading} - \text{Theoretical reading}}{\text{Theoretical reading}} \times 100$$

Advantages of Electrodynamometer Type Wattmeter

1. Scale is uniform up to a certain limit.
2. They can be used for both to measure ac as well dc quantities as scale is calibrated for both.

Errors in Electrodynamometer Type Wattmeter

1. Errors in the pressure coil inductance.
2. Errors may be due to pressure coil capacitance.
3. Errors may be due to mutual inductance effects.
4. Errors may be due connections. (i.e. pressure coil is connected after current coil)
5. Error due to Eddy currents.
6. Errors caused by vibration of moving system.
7. Temperature error.
8. Errors due to stray magnetic field.

CIRCUIT DIAGRAM: (for AC wattmeter)

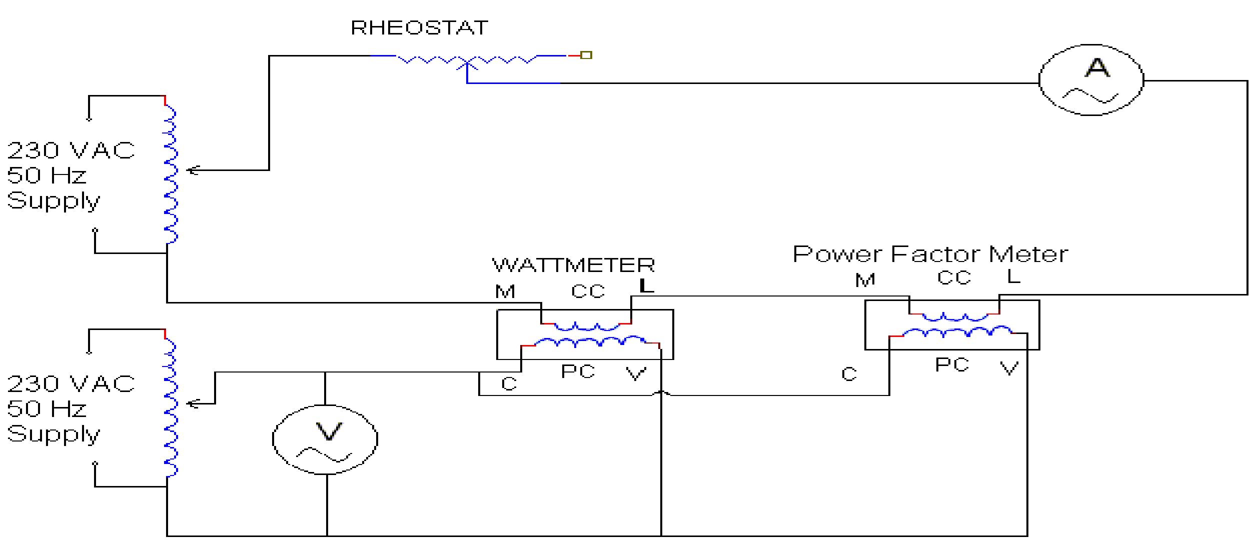


Figure:1

CIRCUIT DIAGRAM (for DC wattmeter)

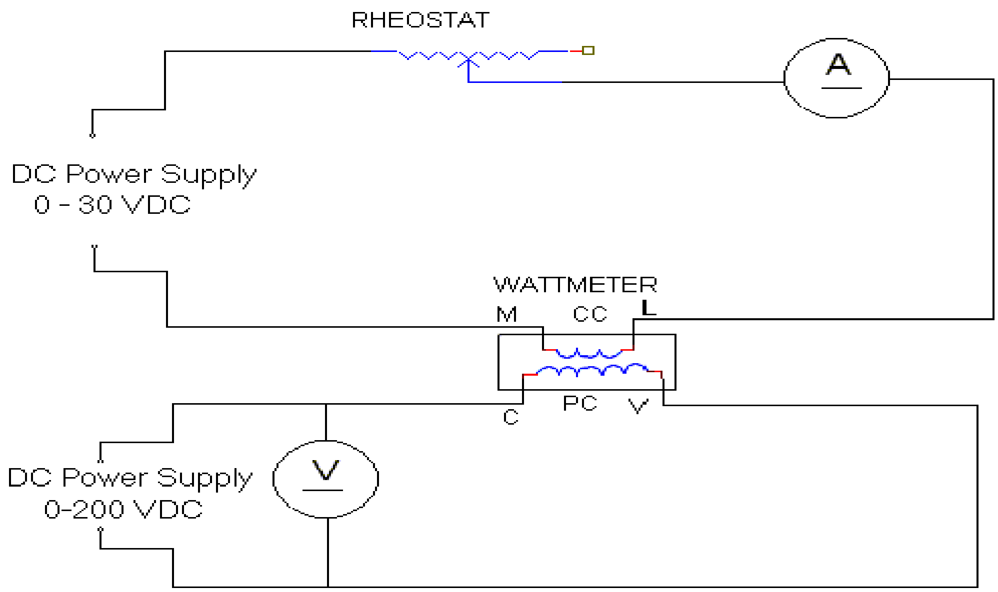


Figure:2

PROCEDURE (For AC Wattmeter):

1. Keep the Autotransformer at zero position.
2. Make connections as per the Circuit diagram.
3. Switch on the 230 VAC, 50 Hz. power supply.
4. Increase the input voltage gradually by rotating the Autotransformer in clockwise direction.
5. Adjust the load rheostat so that sufficient current flows in the circuit. Please note that the current should be less than 4A.
6. Note down the Voltmeter, Ammeter, Wattmeter and power factor meter readings for different voltages as per the tabular column.
7. Find out the percentage error by using above equations.

PROCEDURE (For DC Wattmeter):

1. Make connections as per the Circuit diagram.
2. Switch on the 230 VAC, 50 Hz. power supply.
3. Increase the input voltage of the power supply
4. Adjust the load rheostat so that sufficient current flows in the circuit.

5. Note down the Voltmeter, Ammeter, and Wattmeter meter readings for different voltages as per the tabular column.
6. Find out the percentage error by using above equations.

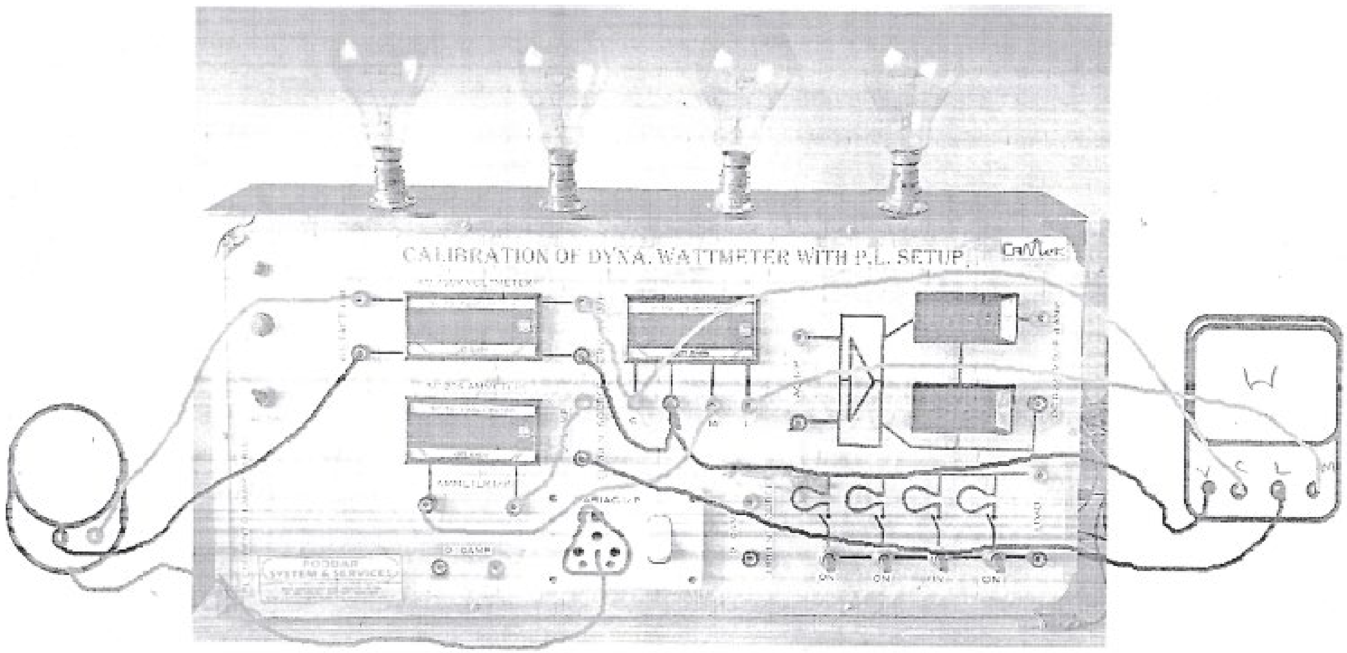


Figure:3 Wattmeter connection using AC power in direct loading

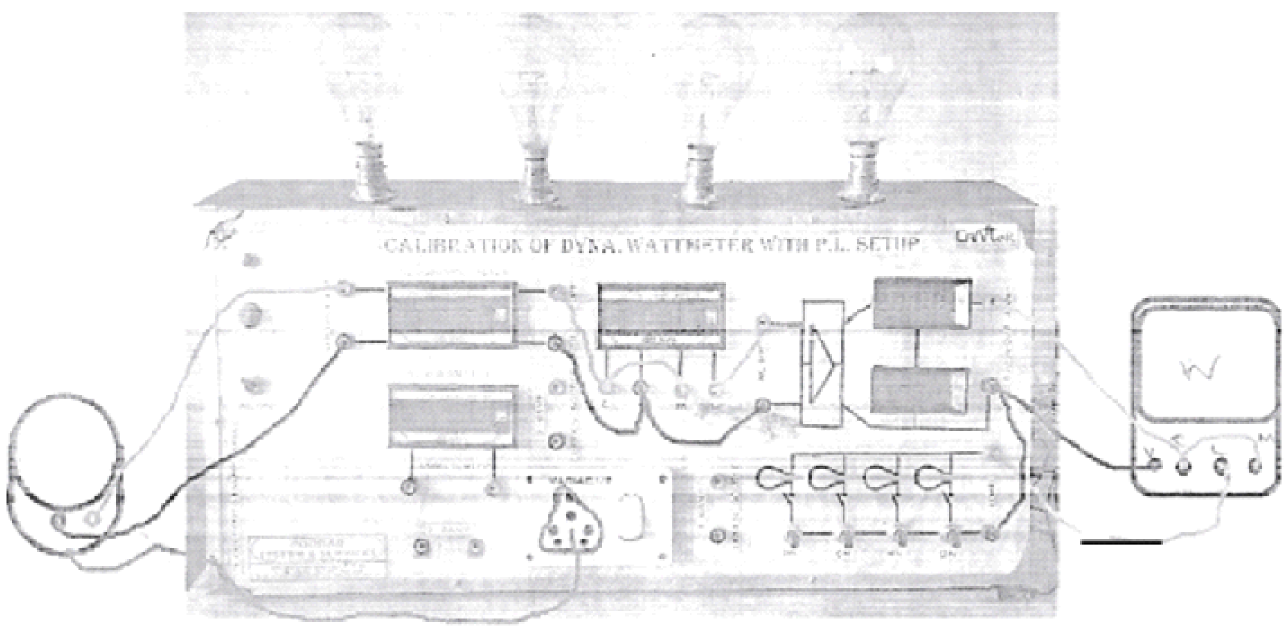


Figure:4 Wattmeter connection using DC power in direct loading

TABULAR COLUMN (for AC wattmeter):

S. No.	I in Amp	V in Volts	Power factor	Wattmeter Reading	% Error

TABULAR COLUMN (for DC wattmeter):

S. No.	I in Amps	V in Volts	Wattmeter Reading	% Error

PRECAUTIONS:

1. Avoid loose connections.
2. Take readings without the parallax error.

RESULT:

Hence calibrated the wattmeter by direct loading test and the corresponding percentage error.

% Correction factor at different loads are calculated.

Experiment No: 4

TITLE: Calibration of Dynamometer Type Wattmeter– by phantom loading.

AIM:

To calibration of dynamometer type wattmeter by phantom loading.

THEORY:

When the current rating of a meter under test is high a test with actual loading arrangements would involve a considerable waste of power. In order to avoid this "Phantom" or Fictitious" loading is done.

Phantom loading consists of supplying the pressure circuit from a circuit of required normal voltage, and the current from a separate low voltage supply as the impedance of this circuit very low. With this arrangement the total power supplied for the test is that due to the small pressure coil current at normal voltage, plus that due to the current circuit current supplied at low voltage. The total power, therefore, required for testing the meter with phantom loading is comparatively very small.

Wattmeter reading = Actual reading

Theoretical reading $P = V\,I\cos\Phi$

P = Voltmeter reading X Ammeter reading X power factor reading

$$\text{Since percentage of error} = \frac{\text{Actual reading - Theoretical reading}}{\text{Theoretical reading}} \times 100$$

Advantages of Electrodynamometer Type Wattmeter

1. Scale is uniform up to a certain limit.
2. They can be used for both to measure ac as well dc quantities as scale is calibrated for both.

Errors in Electrodynamometer Type Wattmeter

1. Errors in the pressure coil inductance.
2. Errors may be due to pressure coil capacitance.
3. Errors may be due to mutual inductance effects.
4. Errors may be due connections. (i.e. pressure coil is connected after current coil)
5. Error due to Eddy currents.
6. Errors caused by vibration of moving system.
7. Temperature error.
8. Errors due to stray magnetic field.

CIRCUIT DIAGRAM: (for AC wattmeter)

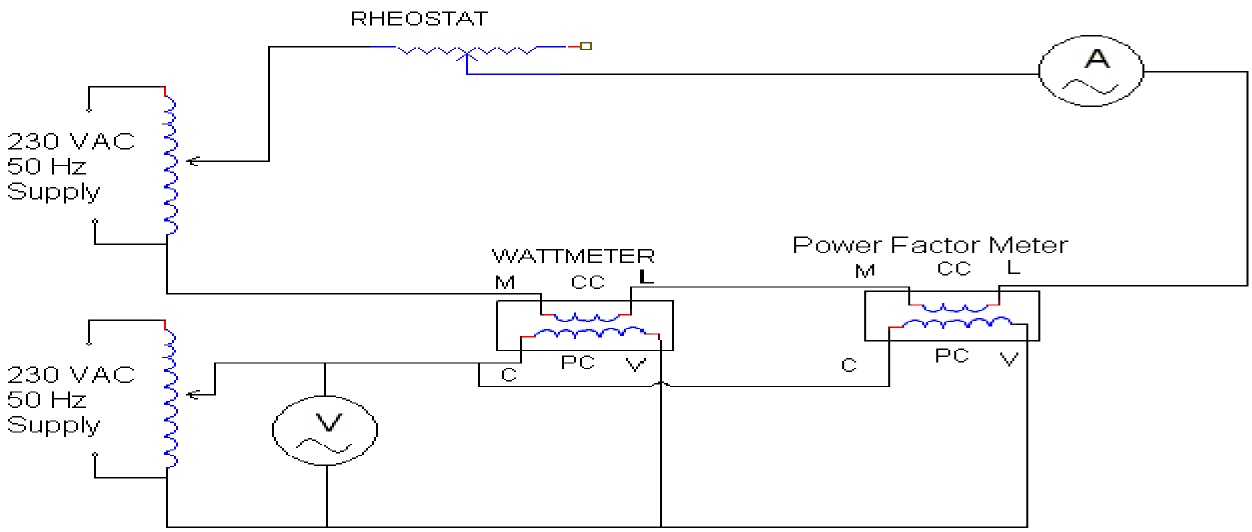


Figure:1

CIRCUIT DIAGRAM (for DC wattmeter)

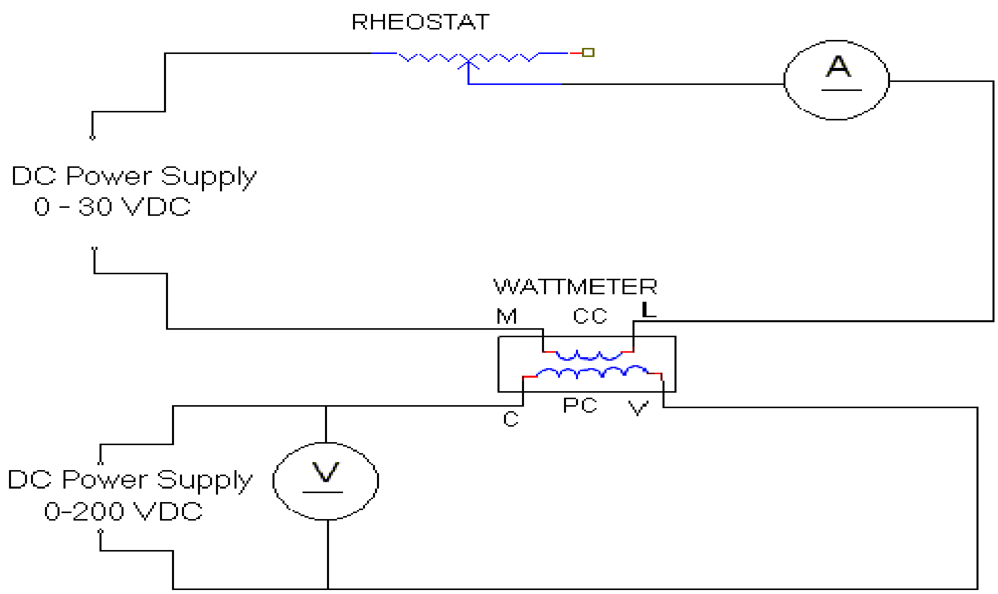


Figure:2

PROCEDURE (For AC Wattmeter):

1. Keep the Autotransformer at zero position.
2. Make connections as per the Circuit diagram.
3. Switch on the 230 VAC, 50 Hz. power supply.
4. Increase the input voltage gradually by rotating the Autotransformer in clockwise direction.
5. Adjust the load rheostat so that sufficient current flows in the circuit. Please note that the current should be less than 4A.
6. Note down the Voltmeter, Ammeter, Wattmeter and power factor meter readings for different voltages as per the tabular column.
7. Find out the percentage error by using above equations.

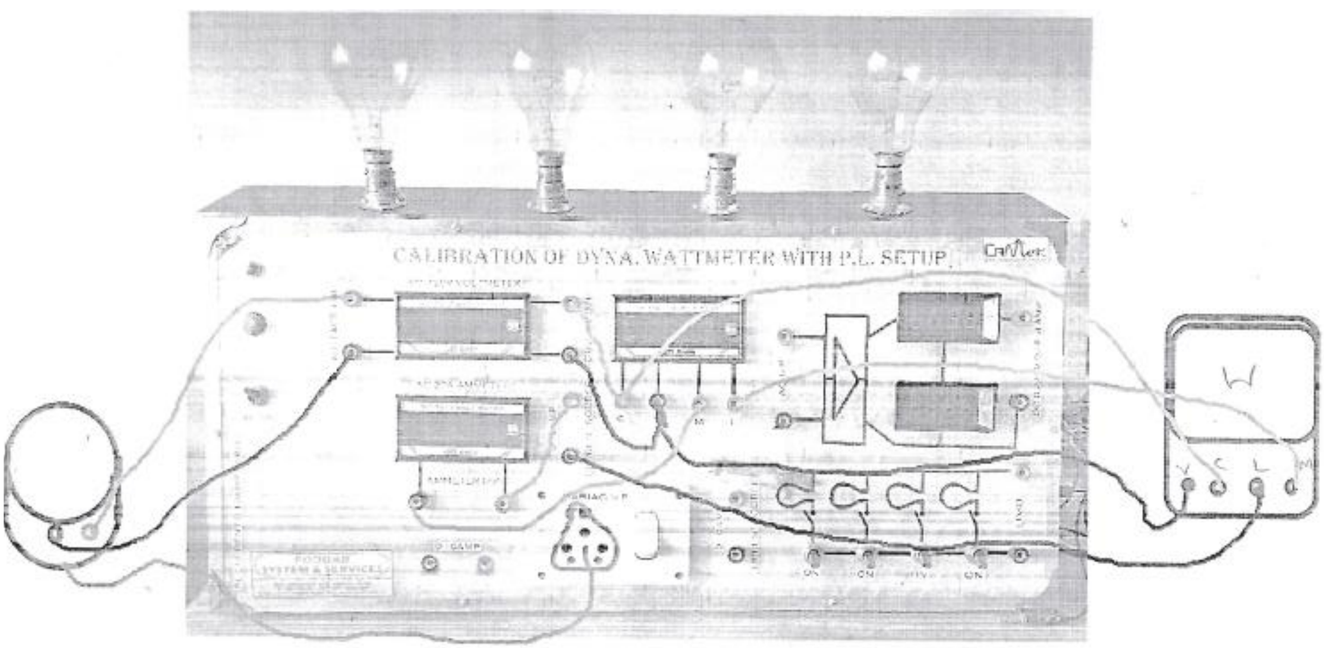


Figure:3 Wattmeter connection using AC power using phantom loading

PROCEDURE (For DC Wattmeter):

1. Make connections as per the Circuit diagram.
2. Switch on the 230 VAC, 50 Hz. power supply.
3. Increase the input voltage of the power supply
4. Adjust the load rheostat so that sufficient current flows in the circuit.
5. Note down the Voltmeter, Ammeter, and Wattmeter meter readings for different voltages as per the tabular column.
6. Find out the percentage error by using above equations.

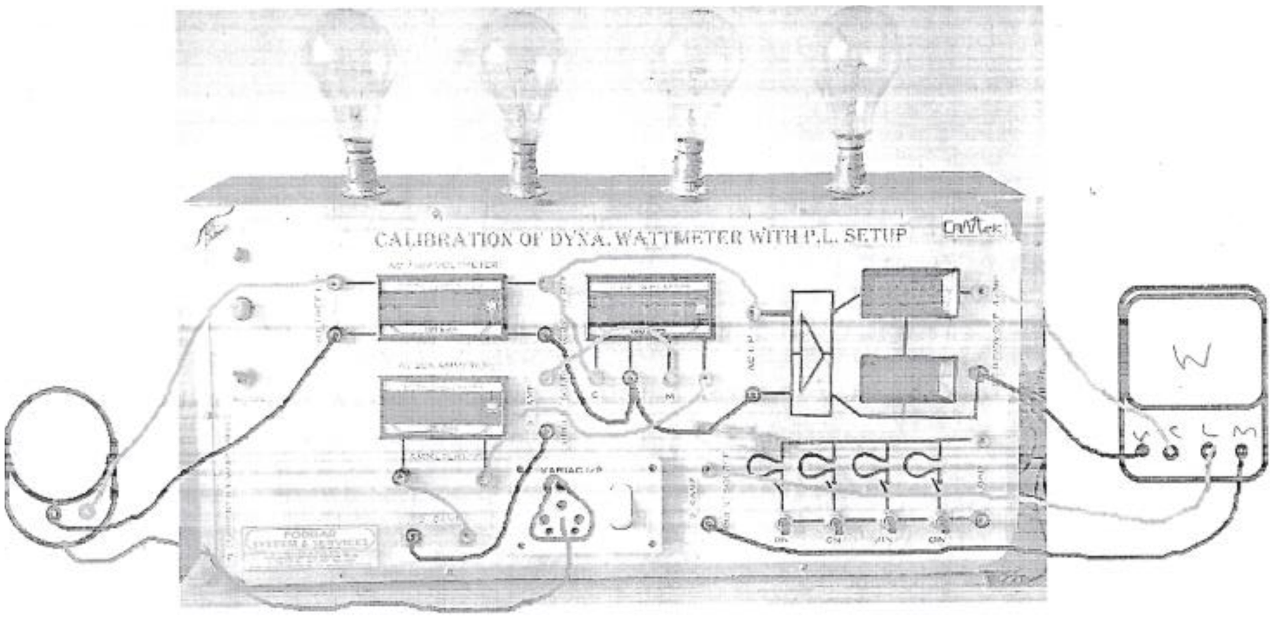


Figure:4 Wattmeter connection using DC power using phantom loading

TABULAR COLUMN (for AC wattmeter):

S. No.	in Amp	V in Volts	Power factor	Wattmeter Reading	% Error

TABULAR COLUMN (for DC wattmeter):

S. No.	I in Amps	V in Volts	Wattmeter Reading	% Error

PRECAUTIONS:

1. Avoid loose connections.
2. Take readings without the parallax error.

RESULT:

Hence calibrated the wattmeter by direct loading test and the corresponding percentage error.

% Correction factor at different loads are calculated.

APPLICATIONS:

It is used in energy meter testing in order to avoid power wastage.

VIVA QUESTIONS:

1. What is meant by direct loading & phantom loading?
2. State a few errors in dynamometer wattmeter?
3. Applications of LPF wattmeter?
4. What are the different methods used for measurement for 3-phase power?
5. What is meant by correction factor?

Experiment No: 5

Title: KELVIN DOUBLE BRIDGE

Objective: To determine the low value unknown resistance by Kelvin Double Bridge.

Circuit Diagram:

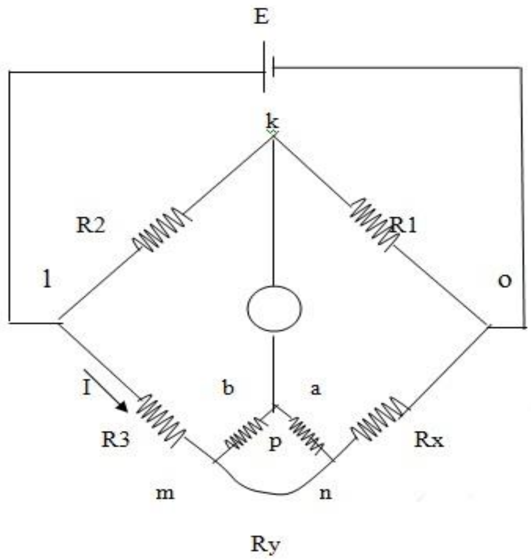


Fig.1. Basic Kelvin double bridge circuit

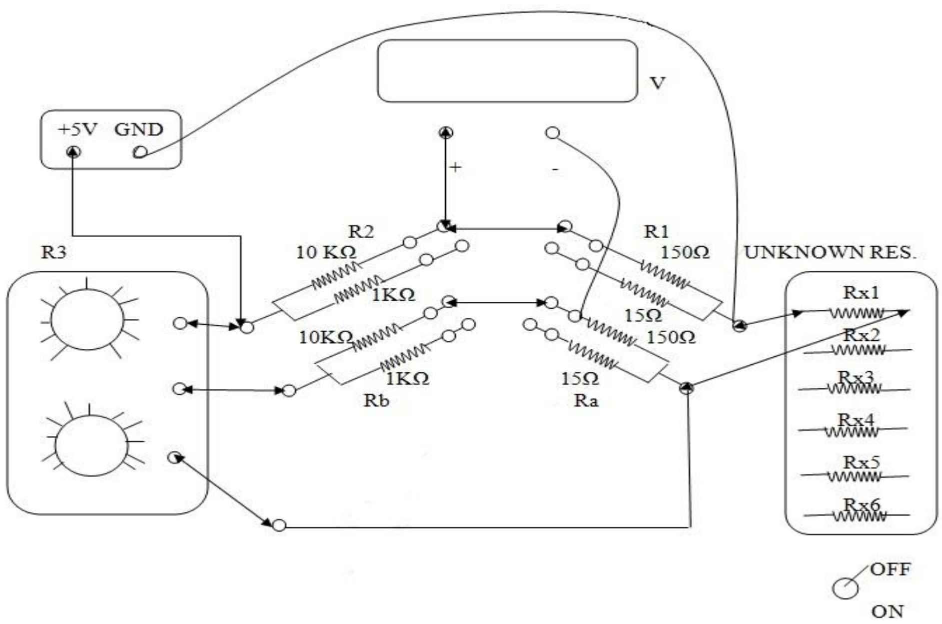


Fig 2 : Circuit connection for Kelvin Double Bridge

Procedure:

1. Connect the circuit as shown in Fig.2.
2. Bridge is balanced by adjustment of decade Resistance, R3.
3. At balanced condition, Null detector shows zero or minimum value.
4. Note down the balancing resistance R3.
5. Calculate low value unknown resistance, Rx = R3R1 / R2.
6. Replace Rx1 by other values of unknown resistances.
7. Repeat the steps from 2 to 5.
8. Connect Rx1 & Rx2 in parallel and repeat the process 2 to 5.
9. If bridge is unbalanced after the adjustment of R3, replace R1 [viz , 1KΩ] and R2 [viz, 15Ω] .
10. Repeat the process 2 to 5.

Apparatus Used:

Observation Table:

Sl. No.	Unknown resistances Rx	R1 in Ω	R2 in Ω	Decade Resistance, R3 in Ω	Unknown resistance, $R_x = R_3R_1 / R_2$ in Ω
1	Rx1				
2	Rx2				
3	Rx3				
4	Rx4				
5	Rx5				
6	Rx6				

Discussion:

(Teacher's Signature)

Experiment No: 6

Title: DESAUTY'S BRIDGE

Objective: To determine the unknown value of capacitance, Cx.

Circuit Diagram:

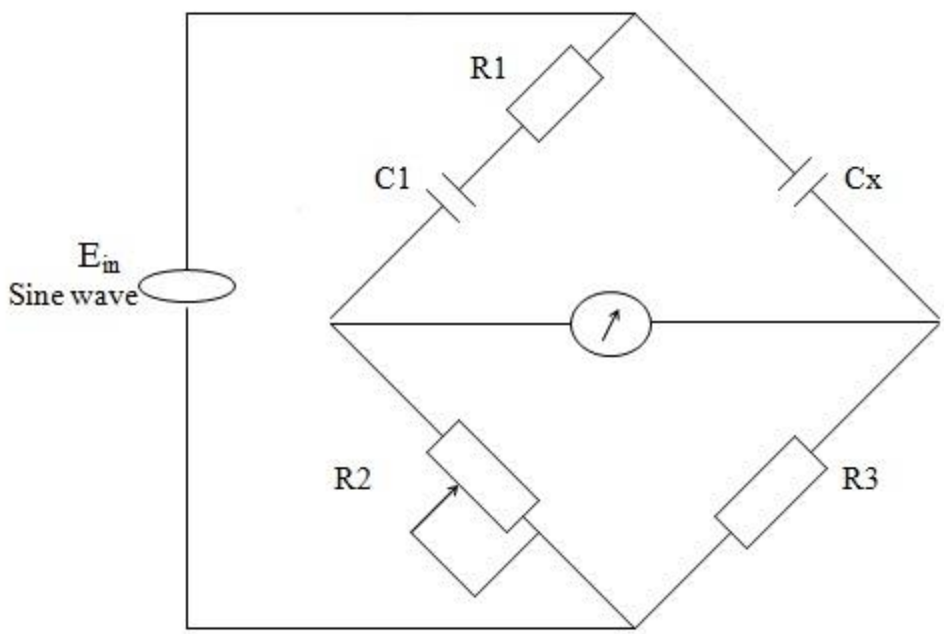


Fig 1 : DESAUTY'S BRIDGE

Theory:

$$Z1 = R1 - \frac{j}{\omega C1} \qquad Z2 = R2$$

$$Z3 = R3 \qquad Z4 = Rx - \frac{j}{\omega Cx}$$

Substituting these impedance in general equation for a bridge.

$$Z1Z3 = Z2Z4$$

$$\left[R1 - \frac{j}{\omega\, C1}\right] . R3 = R2 \left[Rx - \frac{j}{\omega\, Cx}\right]$$

$$R1R3 - \frac{j}{\omega\, C1} R3 = R2\, Rx - \frac{j}{\omega\, Cx} R2$$

Equating real and imaginary part

$$R1R3 = R2Rx$$

$$Rx = \frac{R1R3}{R2} \quad \text{--------------- (1)}$$

$$\frac{R3j}{\omega\, C1} = \frac{R2j}{\omega Cx}$$

$$Cx = \frac{R2C1}{R3} \quad \text{------------------ (2)}$$

Cx represents the unknown capacitance and Rx is the leakage resistance of the capacitor.

Procedure:

1. Connect the circuit as shown in Fig.1
2. Connect the test capacitor in the arm marked by Cx.
3. Switch on the Bridge circuit.
4. Select any particular value of R3.
5. Vary R2 from the minimum position in a clockwise direction.
6. If the selection of R3 is correct, the balance point can be observed on the ac voltmeter; i.e. the output voltage comes to a minimum for a particular value of R2 and then again increases by varying R2 in the same direction.
7. If that is not the case select another value of R3.
8. Since we are measuring an unknown capacitor whose resistive effects could be very small, the first adjustment should be made for capacitive term and R2 is therefore adjusted for a minimum output.
9. For balancing the resistive component of the capacitor R1 is adjusted; i.e. to reduce the output to a further minimum or R1 is adjusted.
10. The process of manipulation of R2 and R3 is typical of the general balancing procedure for AC bridge and is said to cause convergence of the balance point. It should also be noted the frequency of the voltage source does not enter either of the balance equations and the bridge is therefore said to be independent of the frequency of the applied voltage. Finally calculate the value of the unknown capacitance using equation 2 by substituting the values of R2 and R3 obtained at the balance point.

Apparatus Used:

Observation Table:

No of Obs.	R1	C1	R2	R3	Rx	Cx
1						
2						
3.						

Discussion:

(Teacher's Signature)

Experiment No: 7

Title: WIEN BRIDGE

Objective: To determine the frequency of audio frequency oscillator by Wien Bridge.

Circuit Diagram:

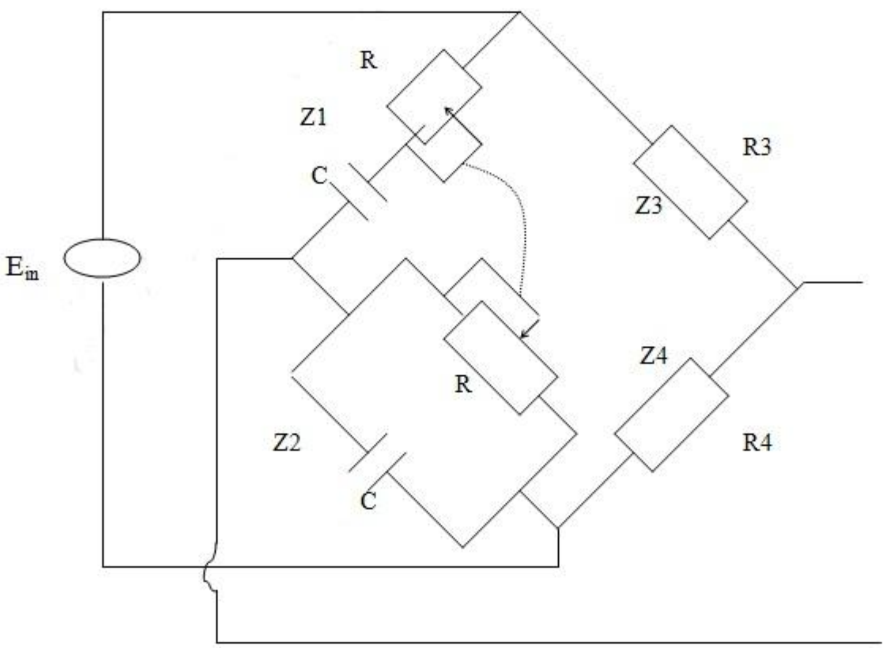


Fig 1 : Circuit connection for Wien Bridge

Theory:

$$Z1 = R + 1 / jwC$$

$$= jwCR + 1 \; / \; [jwC]$$

$$Z2 = R \; || \; 1 / jwC$$

$$= \frac{R \,.\, 1 / jwC}{R + 1 \, jwC}$$

$$= \frac{R}{1 + jwCR}$$

$$\frac{Z1}{Z2} = \frac{1 + 2\,jwCR \ - w^2 C^2 R^2}{jwCR} \quad \text{--------------------} \quad (1)$$

$$\frac{Z3}{Z4} = \frac{R3}{R4} \quad \text{------------------------} \quad (2)$$

From Eq. (1) & (2) , we get ,

$$\frac{1 + 2\,jwCR \ - w^2 C^2 R^2}{jwCR} = \frac{R3}{R4}$$

Equating Real & Imaginary part

$f = 1 / [\ 2\pi\ R\,C\ ]$

and $\dfrac{R3}{R4} = 2$

In practice, Resistances in arm Z1 & Z2 are slightly different . Therefore frequency will be

$f = 1 / [\ 2\pi \sqrt{(R1\,R2)}$

where , R1 is the resistance in Z1 and R2 is the resistance in Z2.

Procedure:

1. Connect the circuit as shown in Fig. 1
2. Select a suitable frequency of a sine wave through a function generator. V pp < 2V.
3. The sine wave appears at the bridge output terminals (viz. 4 & 2) which is connected to the CRO.
4. Adjust the dual variable resistance R until the bridge output (peak to peak of sine wave) will be minimum .
5. Switch off the function generator.
6. Disconnect R from the two arms of the bridge.
7. Measure R from Z1 and Z2 arms of the bridge . It may slightly mismatch.
8. Using $f = 1 / [\ 2\pi \{\sqrt{(R1\ R2)}\}\ C\ ]$
9. Connect another set of capacitor (0.22uF)
10. Repeat steps 1 to 8.

Apparatus Used:

Observation Table:

No of Obs.	R1 in Ohm	R2 in Ohm	C in uF	R in Ohm	$f = 1 / [2\pi \{\sqrt{(R1\ R2)}\}\ C]$ in Hz
1					
2					
3					
4					
5					

Discussion:

(Teacher's Signature)

Experiment No: 8

TITLE: Study of Single-Phase Digital Energy Meter.

AIM:

To study of 1ph digital energy meter and calculate the percentage error.

THEORY:

An energy meter is an essential device that goes with consumption of commercially distributed energy. It enables systematic pricing of energy consumed by individual consumer as it measures the amount of electrical energy consumed by a residence, business, or an electrically powered device.

Generally, electricity meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (Joules, Kilowatt-hours etc.). Meters for smaller services (such as small residential customers) can be connected directly in-line between source and customer. For larger loads, more than about 200 amps of load, current transformers are used, so that the meter can be located other than in line with the service conductors. The meters fall into two basic categories, electromechanical and electronic/digital.

The conventional mechanical energy meter is based on the phenomenon of "Magnetic Induction". It has a rotating aluminium wheel and many toothed wheels. Based on the flow of current, the wheel 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). ASIC is constructed only for specific applications using Embedded System Technology. Similar ASIC are now used in Washing Machines, Air Conditioners, Automobiles, Digital Camera etc.

In addition to ASIC, analogue circuits, Voltage transformer, Current transformer etc. are also present in EEM to "Sample" current and voltage. The 'Input Data' (Voltage) is compared with a programmed "Reference Data' (Voltage) and finally a 'Voltage Rate' will be given to the output. This output is then converted into 'Digital Data' by the AD Converters (Analogue- Digital converter) present in the ASIC.

ADVANTAGES OF ELECTRONIC ENERGY METERS:

Electronic energy meters or digital energy meters are accurate, precise and reliable type of measuring instruments when compared to electromechanical induction type meters. When connected to loads, they consume less power and start measuring instantaneous.

BLOCK DIAGRAM:

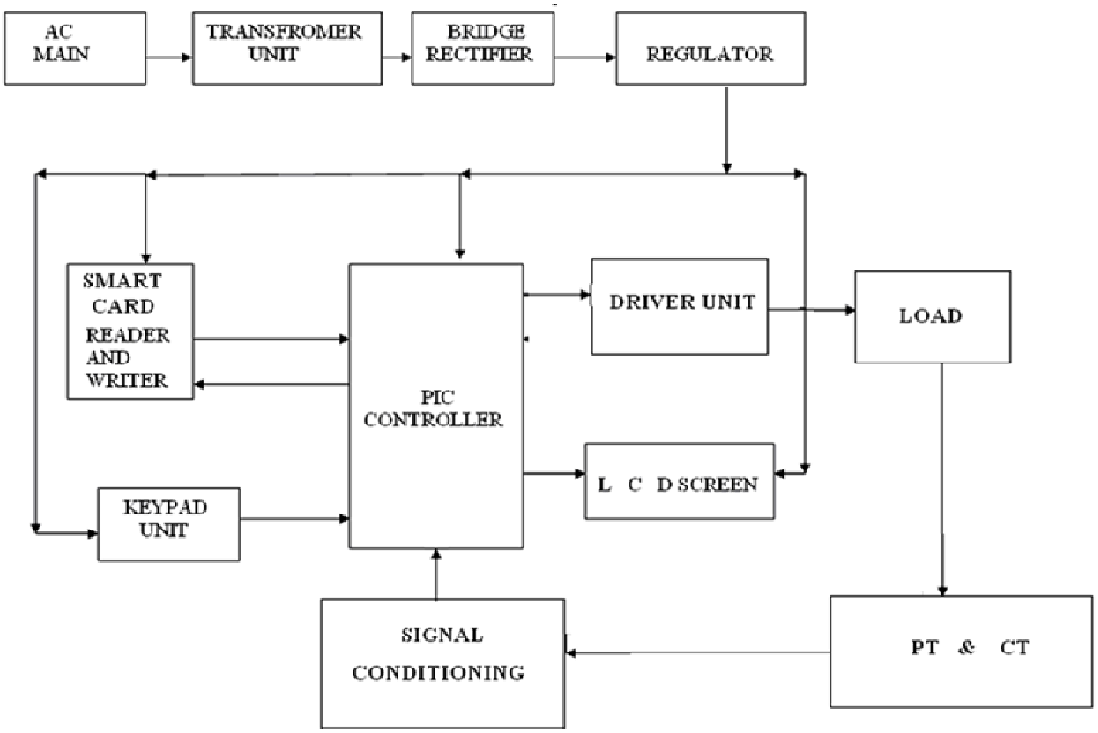


Figure:1

CONNECTION DIAGRAM:

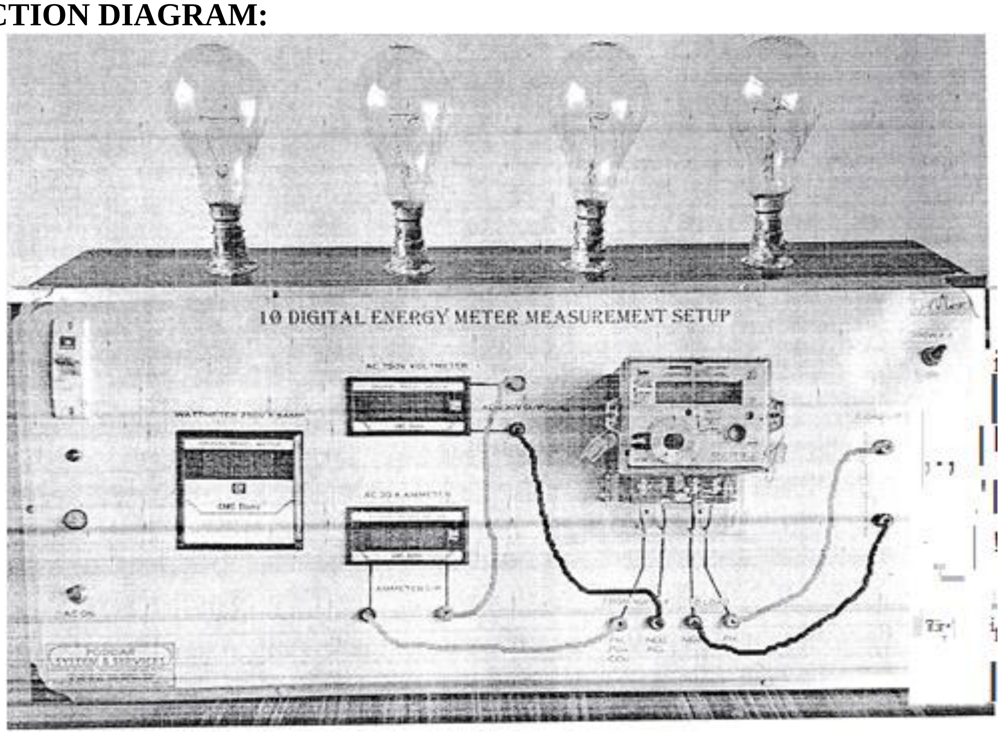


Figure:2

PROCEDURE:

- Connect according to the connection diagram.
- Push START switch for power ON.
- Switch ON 1st 200-WATT lamp load and take V & I reading.
- Wait for 30 minutes for 0.1-unit change and watt.
- Switch ON 2nd 200-WATT lamp & Wait for 15 minutes for again 0.1-unit change.
- Take readings.
- Again add 3rd lamp & wait for 10 minutes for 0.1-unit change.
- Now add 4th lamp & wait for 7.5 minutes for 0.1-unit change.
- Experiment time can be set through timer or manually by the help of wrist watch.
- Now compare V & I readings for exact watt & set time by the help of following calculation (Unity PF).

Time required for 0.1-unit change in minutes –

$$= \frac{\text{1000-watt X 60 Minutes}}{\text{V X I (Actual watt) X 10}} \text{ Minutes}$$

TABULAR COLUMN:

	Actual 'V' (Volts)	**Actual 'I' (Amps)**	**W=V*I (Watts)**	**CAL RQD T=T1**	**EM Reading (Previous)**	**EM Reading (End of the time)**	**EM Actual time taken to change of 0.1 unit (T2)**

ERROR CALCULATION:

CALCULATED TIME FOR APPLIED KWh FOR THE CHANGE OF O.1 UNIT = TI

& ACTUAL TIME TAKEN BY EM =T2

$$\text{NOW \%OF ERROR} = \frac{\text{(T2-T1) X 10}}{100}$$

If it is "+" means lower reading & "-" value means high reading.

PRECAUTIONS:

1. Avoid loose connections.
2. Be Careful while observing the reading with stop watch.
3. Do not apply more current, more than the rated energy meter current.
4. Take readings without error.
5. Live terminals should not be touched.

APPLICATIONS:

Energy meters measure and display power consumption in residential, industrial, and commercial dwellings, as well as sub-stations in the electric grid. They are evolving rapidly, and different solutions and architectures are required to meet varying regional utility requirements.

VIVA QUESTIONS:

1. What is an energy meter?
2. What are the types of energy meter?
3. Which type of energy meters are used in dc circuits?
4. Energy meter is an__________(i) integrating instrument (ii) indicating instrument
5. Can the measured percentage error be negative?

Experiment No: 9

Title: ANDERSON BRIDGE

Objective: To determine the self inductance of a coil using Anderson Bridge.

Circuit Diagram:

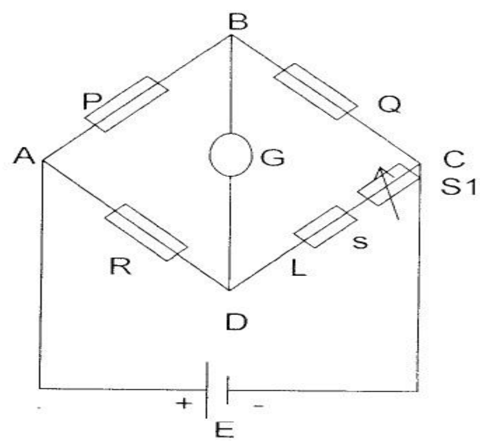


Fig.1: Anderson Bridge with DC source

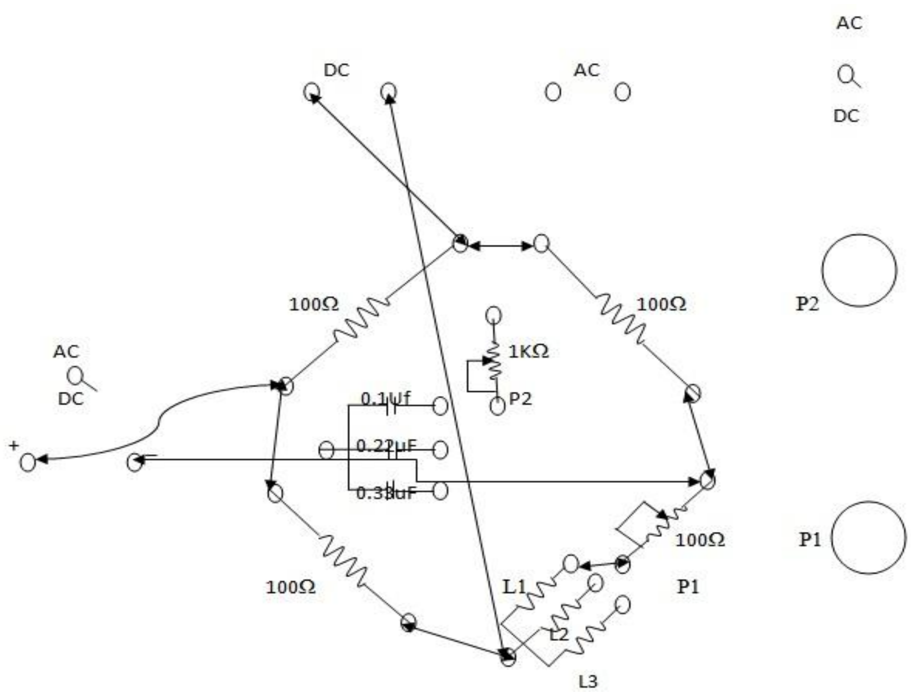


Fig 2: Circuit connection for DC balance of Anderson Bridge

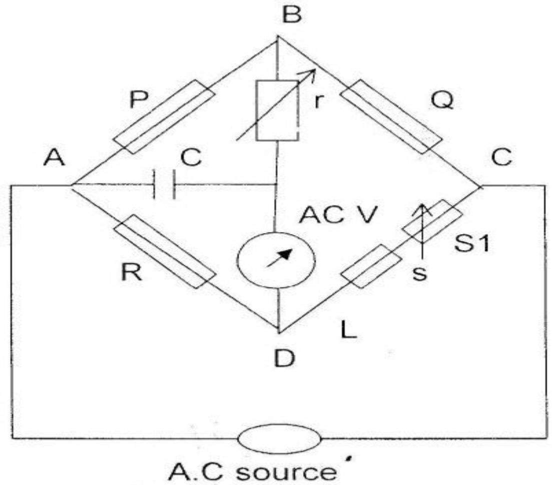


Fig.3: Anderson Bridge with AC source

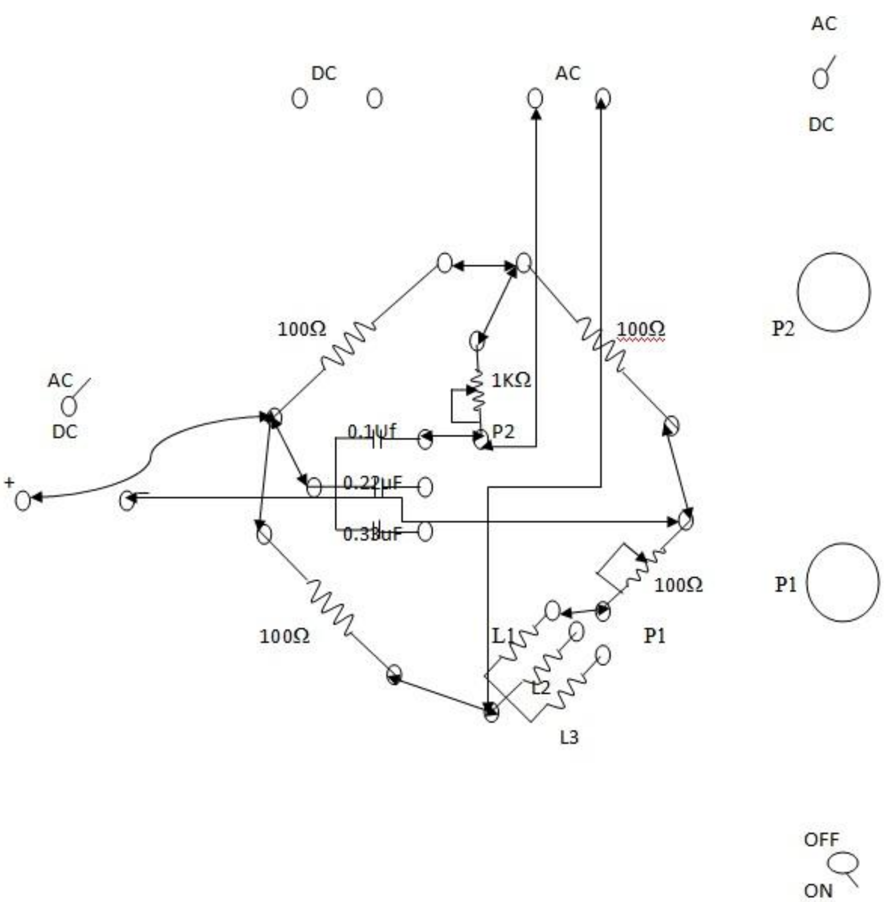


Fig.4: Circuit connection for AC balance of Anderson Bridge

Theory:

For low frequencies a practical coil can be represented by a self inductance in series with a resistance which accounts for the losses in the coil. The self inductance of a coil can be measured with the help of Anderson Bridge

Let L be the self inductance of a coil and s be its resistance. A variable resistance S1 is inserted in the arm CD of the bridge in which the coil is placed.

In Fig. 3. S (= s + S1) is the total resistance of the arm CD; P,Q,R are non-inductive resistance; C is a standard capacitor; and detector is an AC Voltmeter or a head phone.

At balance, i.e., for no flow of current through the AC Meter, we have

$$S = R\,Q / P \qquad \text{------------------(i)}$$

And

$$L = CR\,[\,Q + r\,(\,1 + Q/P\,)\,] \qquad \text{-------------------(ii)}$$

Equations (i) and (ii) are respectively referred to as DC and the AC balance conditions

of the bridge.

If P = Q , Eq.(ii) reduces to

$$L = CR\,(\,Q + 2r\,) \qquad \text{-------------------(iii)}$$

The ac balance represented by Eq. (iii) can be achieved only when L > RCQ; otherwise , the resistance r will be negative. If C is expressed in Farad , R, Q and r are expressed in ohm, then L will be obtained in Henry from eq.(iii).

Procedure:

(a) <u>Attainment of DC balance:</u>

(i) Set up the circuit as shown in Fig .1. Here G is a Galvanometer .

(ii) The resistances P, Q and R are all equal ; here P=Q=R= 100 Ohm.

(iii) Place the selector switch in DC mode.

(iv) Switch ON the power supply.

(V) Vary the resistances S1 each time to test the balance condition . When the Galvanometer reading changes in the opposite direction for 1 ohm variation in S1 to achieve exact null of the galvanometer (or shows minimum value) . The total resistance in the arm CD of the bridge will then be

$S = 100$ ohm $= S + S1$
Therefore the coil resistance S will be $S = (100 - S1)$ Ohm

By this arrangement , the resistance in the four arms of the Wheatstone Bridge are made equal, e.g. 100 Ohms. Under this condition the bridge is most sensitive.

(b).<u>Attainment of ac balance:</u>

(i) Set up the circuit as shown in Fig 3.

(ii) Place the selector switch in AC mode.

(iii) Switch on the power supply .

(iv) Vary the resistance r until the sound in the headphone is zero or minimum . Note the corresponding value of r

(v) Calculate L using Eq. (ii).

(vi) Repeat steps (ii) to (vii) for different value of C and calculate the mean value of L.

Apparatus Used:

Observation Table:

For D.C. balance:

Resistance in Ohms			Galvanometer deflection	Value of S1 at null point	Coil resistance S = 100 – S1
P	Q	R			

For A.C. balance:

Frequency of AC source = 1.1 KHz, P = 100 Ω, Q = 100 Ω, R = 100 Ω, S' = S1 + S

Capacitance C (μF)	Value of r (Ω)	Minimum ac voltage	Value of r at null point	L (mH)	Mean L (mH)

Discussion:

(Teacher's Signature)