LIST OF EXPERIMENTS

Experiment – 1

Calibration of AC Energy Meter at different loads.

Contents:-

1. Objectives:

To find out error in energy meter readings for following cases:

1. Quarter load
2. Half load
3. Full load

2. Expected Outcomes of Experiment:

- Understanding the use of energy-meter
- In depth knowledge on Energy metering
- Understanding the calculation of energy meter error in three types of loading conditions.

3. Theory:

The wattmeter is an instrument for measuring the electric power (or the supply rate of energy) in watts of any given circuit. Energy meter is an electric measuring device, which is used to record electric energy consumed over a specified period of time in terms of units. The energy measurements by energy meters involve errors owing to many sources and reasons are as follows:

Errors in driving system include errors due to incorrect magnitude of flux values, phase, angles etc. and lack of symmetry in magnetic circuit.
Errors in braking system such as changes in the strength of brake magnet, changes in disc resistance, self-braking effect of series magnet flux and abnormal friction of the moving parts.
Errors in registering system are also expected to be present since they involve mechanical parts. They are taken care of by calibration of the meter. **Other errors** include errors caused due to friction, overloads, phase angle variations, temperature effects, creeping of the meter, etc. These errors are avoided by correct

adjustments made using the various compensator facility provided on the meter. The energy meters read accurately if the errors fall within the allowable limits. In other words, for the energy meter to be adaptable, the registration of the meter should be with in ± 0.5 % of the true value of the measured.

Adjustments

For the energy meters to read accurately, it is needful to make some adjustments on the meter. The adjustments to be made in sequence are: preliminary light load adjustment, full load UPF adjustment, lag or LPF adjustment, light load UPF adjustment and creep adjustment.

Preliminary Light Load Adjustment: Rated voltage is applied to potential coil with no current in the current coil. The light load device is adjusted until the disc just fails to start. In this adjustment, care should be taken to see that the disc is positioned in such a way that the holes do not come under the electromagnet.

Full Load UPF Adjustment: The potential coil is connected across rated supply voltage and rated full load current at unity power factor is passed through the current coil. The brake magnet position is adjusted to vary the braking torque so that the moving system moves at correct speed.

Lag or LPF adjustment: It is clear from equation (8.10) that the energy meter will register correct value only if the angle between the shunt magnet flux, fP and the supply voltage, V is 900 (D = 900). Hence the pressure coil should be designed to be highly inductive. Also, various lag adjustment devices are made use of for this purpose. For LPF adjustments, the pressure coil is connected across the rated supply voltage and rated full load current at 0.5 lagging power factor is passed through the current coil. The lag device is adjusted until the meter runs at true speed.

Light Load UPF Adjustment: Firstly, full load UPF and LPF adjustments are made on the meter until it runs at correct speed. Then rated supply voltage is applied across the pressure coil and a very low current of 5-10 % of full load value is passed through the meter at unity power factor. The light load adjustment is done so that the meter runs at proper speed.

Creep Adjustment: Firstly, full load UPF and light load adjustments are made for correct speeds at both the loads and the performance is rechecked at 0.5 power factor. Then, as a final check on all the above adjustments, the pressure coil is excited by 110 % of the rated voltage with zero load current. If the light load adjustment is proper, the meter should not creep under these conditions. If the error still persists, then all the above adjustments are carried out once again.

4. Equipment required:

Sr. No.	Items	Specifications	Quantity
1	AC Energy Meter	5 - 10A, 230V, 1500 revs/KW-Hr	**1**
2	Voltmeter AC	0 - 300V	**1**
3	Ammeter AC	0 - 5 -10A	**1**
4	Stop Watch	0 - 60 Sec	**1**
5	Lamp Load	1 ϕ (10A,230V)	**1**
6	Single Phase Variac	0-270V AC	**1**

5. Methodology for experiment:

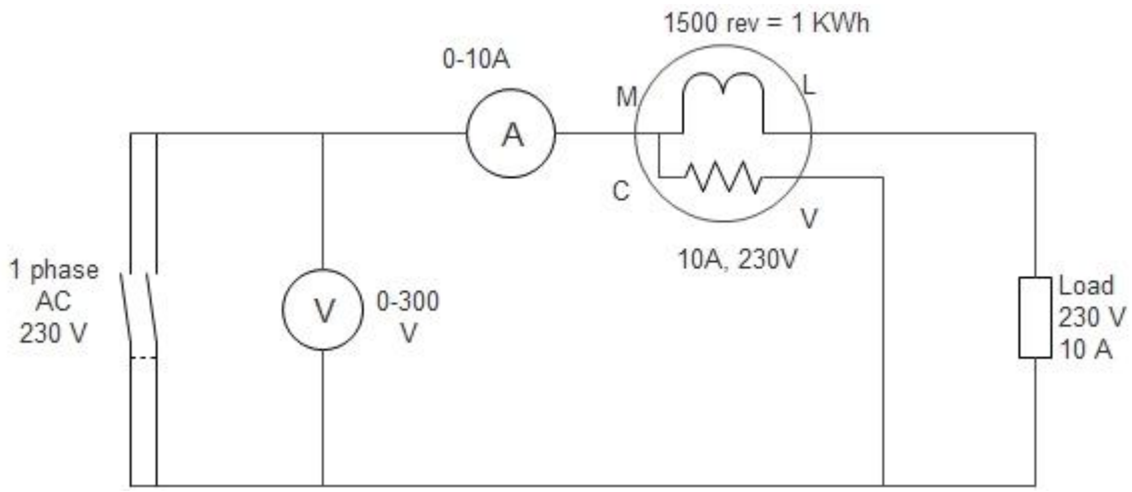


Fig.1 (a): Circuit Diagram

- ❖ Connect the circuit as shown in the figure.
- ❖ Adjust the load for the full load current and take the Ammeter, Voltmeter readings. Also note the time taken for 20 revolutions of the disc.
- ❖ Repeat step2 for half load and quarter load.
- ❖ Calibrate the energy meter by drawing graph between Load and % error.

6. **Measurements:**

S. No	Load Current (I)	Supply Voltage (V)	Power (W)	Time in hours	Calculated Energy (Kwh)	No. of rev.	Recorded Energy (Kwh)	% Error
Full Load								
Half Load								
Quarter Load								

7. **Results and Discussion:**

$$\%\text{Error}=\frac{Recorded\ \ Energy\ -Calculated\ \ Energy}{Calculated\ \ Energy}\times 100$$

8. **Conclusion:**

Errors in reading shown by the energy meter during full load, half load, and quarter load have been calculated.

EXPERIMENT NO - 2

Study of Selsyn

CONTENTS:

1. OBJECTIVE:

To study Selsyn and generate sine wave.

2. EXPECTED OUTCOME OF EXPERIMENT:

- Understanding the function of selsyn.
- Tricks to generate sine wave using selsyn.
- Able to analyze sine wave and its various attributes.

3. THEORY:

A Selsyn is an electromagnetic transducer commonly used to convert an angular position of a shaft into an electrical signal. The basic synchro is called synchro transmitter. Its construction is similar to that of three phase alternator. Let an A.C voltage $Vr(t)=Vr \sin wt$…. (1) is applied to the rotor of the synchro transmitter. This voltage causes a flow of magnetizing current in the rotor coil which produces the air gap along the stator periphery. Because of transformer action, voltages are induced in each of the stator coils. As the air gap flux is sinusoidal distributed, the linking any stator coil is proportional to the cosine of the angle between rotor and stator coil axis. Let Vs1n, Vs2n, Vs3n respectively be the voltages induced in the stator coils S1,S2,S3 with respect to the neutral. Then with respect to the rotor position as shown in the fig 2 (a), rotor makes an angle degrees with stator S2 .

$$Vs1n= Kvr \sin wct \cos [\theta +120] \quad (2.2)$$
$$Vs2n= Kvr \sin wct \cos (\theta) \quad (2.3)$$
$$Vs3n= Kvr \sin wct \cos [\theta +240] \quad (2.4)$$

Three terminal voltages of the stator are

$$Vs1s2= Vs1n-Vs2n$$
$$=3\, KVr \sin (\theta +240) \sin wct \quad (2.5)$$
$$Vs2s3= Vs2n-Vs3n$$
$$=3\, kvr \sin (\theta +120) \sin wct \quad (2.6)$$
$$Vs3s1= Vs3n-Vs1n$$
$$=3\, kvr \sin (\theta) \sin wct \quad (2.7)$$

When θ=0 from equations 2.2 & 2.3 it is seen that maximum voltage is induced in the stator coils S2 while it follows from equation [2.7] that the terminal voltage Vs3s1 is zero. The position of the rotor is defined as ELECTRICAL ZERO POSITION.

4. EQUIPMENT REQUIRE:

Sr. No.	**Items**	**Specifications**	**Quantity**
1	Selsyn Kit	0-115 V AC	**1**
2	Voltmeter	0-150 V AC	**2**
3	Ammeter AC	0-270 V AC	**1**

5. METHODOLOGY FOR EXPERIMENT:

- Make the connections as shown in the circuit diagram. Give 115V AC Supply.
- Hold the transmitter at zero and change the angle of receiver until the receiving end voltmeter shows zero voltage.
- Change the angle of transmitter and note the corresponding output.
- Transmitter angle on zero voltage and maximum voltage should be taken.
- Draw a graph between angular displacement and output voltage it will follow a sine curve.

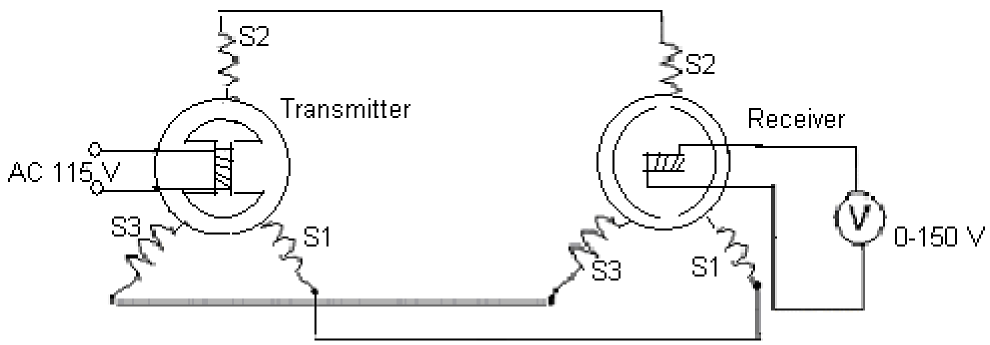


Fig 2(a): Schematic diagram of Selsyn

6. MEASUREMENT:

Sr. No	**Angular Displacement**	**Voltage**
1		
2		

3		

7. RESULT AND DISCUSSION:

The properties of Selsyn are studied and graphs are plotted. Students should be able to understand that because of transformer action, voltages are induced in each of the stator coil. The rotor of control transformer is made cylindrical so that air gap is practically uniform. This feature of control transformer minimizes the change in the rotor impedance with rotation of the shaft.

8. CONCLUSION:

The Selsyn has been studied and a graph has been plotted between input rotor position and output stator voltage.

EXPERIMENT NO – 3 (a)

Measurement of Inductance by Maxwell's Bridge.

CONTENTS:

1. OBJECTIVE:

To measure Inductance using Maxwell's Bridge.

2. EXPECTED OUTCOME OF THE EXPERIMENT:

- Knowledge on Measurement of inductance.
- Ability to know storage factor, loss factor.
- Suitable for estimating Q factor of low Q-coils.

3. THEORY:

This bridge is an AC bridge used to measure the inductance. This bridge circuit measures an inductance by comparison with the variable standard self-inductance. In this bridge at the balance in condition there is no current is flow in the galvanometer hence the balance equation for the bridge using the admittance of the arm 1 instead of the impedance.

$Zx = (Z2 * Z\ 3 * Y1)$

Where the Y1 is the admittance of the arm-1.

$Z2 = R2$

$Z3 = R3$

$Y_1 = (1/R_1) + j\omega C_1$

By separating the real and imaginary term the unknown value of the resister (Rx) and the unknown value of the capacitor (Cx) have given below.

$Rx = (R_2 * R_3 / R_1)$

$L_X = (R_2 * R_3 * C_1)$

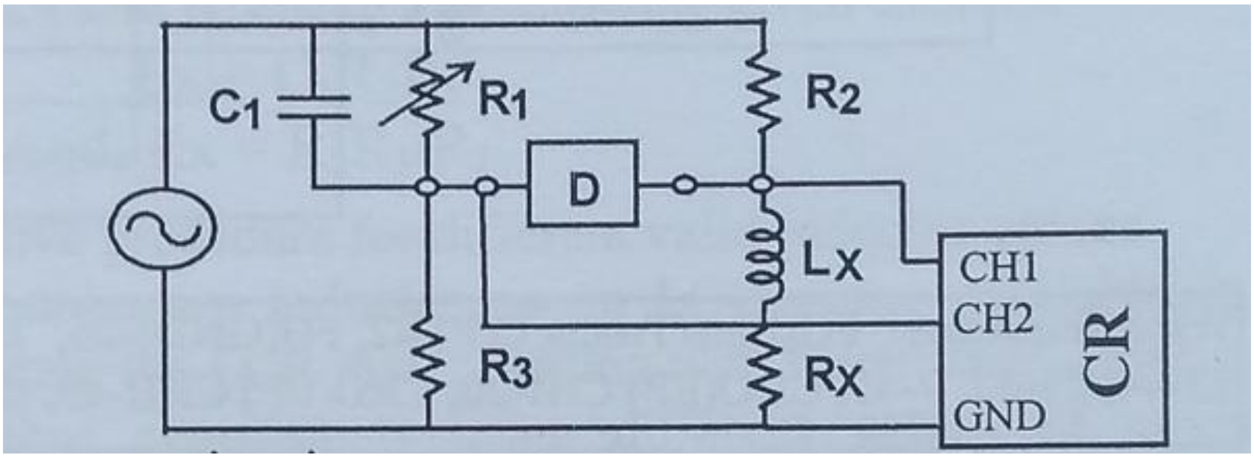


Fig 3a(a): Maxwell's Bridge

4. EQUIPMENT REQUIRED:

Sr. No.	Items	Quantity
1	AC/DC Bridge Trainer Kit	1
2	CRO (Dual Trace) with MONO-ADD-INVERT facility	1
3	Function Generator	1
4	Digital Multimeter	1
5	100 mm patch cords	

5. METHODOLOGY FOR EXPERIMENT:

Construct the Maxwell's bridge as shown in the following figure to determine inductance of primary of a transformer.

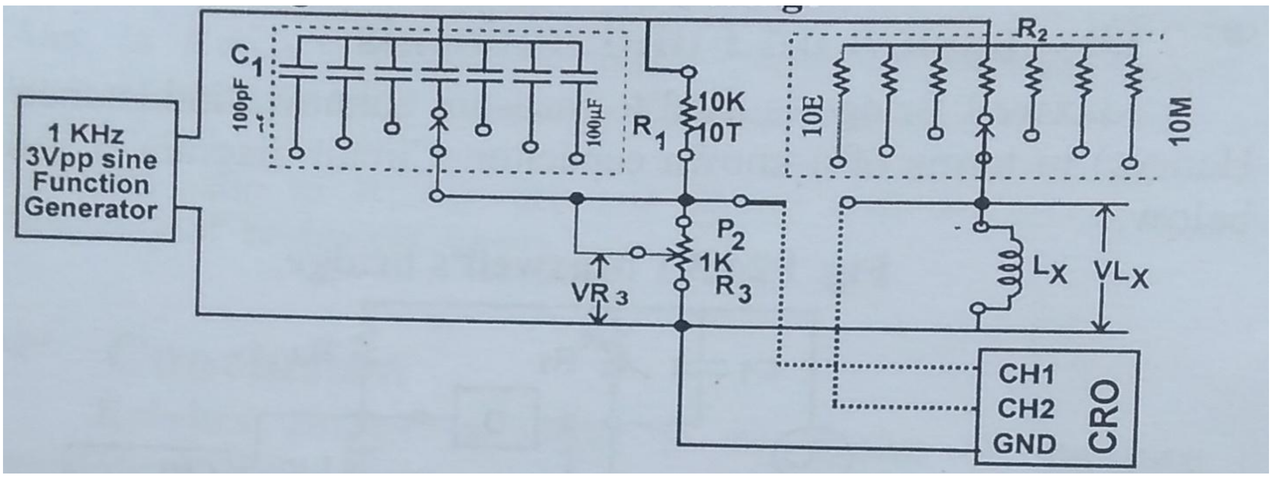


Fig 3a(b): Maxwell's Bridge on PCB

Wire sequence: FG(Sine/Triangle O/P)-42, FG(GND)-26, 15-41, 16-6, 19-24,23-44,25-52,7-49, CRO(I/P)CHI-20,CRO(I/P)CHI-49< CRO(GND)-26, (Lx (unknown)-between 50 & 51).

NOTE: As the measuring range of this bridge is 1-1000 H .you are required to measure inductance greater than 1H.

- Do the connection as per the above wiring sequence and place an unknown inductance L_x on 50 & 51.
- Connect function generator output of 5Vpp & 1KHz sine wave to the bridge input as shown and use CRO in MONO-AND-INVERT mode (refer the CRO setting point in introduction unit) to measure the difference of both CRO channels and set amplitude knobs of both channels to 0.5mV/cm.
- Here in Maxwell's bridge R_1 POT having constant value of 10K and R_1 POT is used as fine adjustment to adjust the output waveform to minimum or zero level after accurately adjustment of R_2 & C_1 selector switches.
- The R_2 & C_1 switches are so adjusted to get minimum level of output signal to be measures on CRO (rotate these knobs again and again to get minimum 0 level output value on measurement).
- By the use of R_3 (fine adjustment pot), adjust the output signal to minimum level (output will vary from some maximum value to min the again to maximum by the variation of R_3, so adjust it at minimum level measurement to balance the bridge.)
- Now, at bridge balance condition, note down the values of R_1, R_2, R_3 & C_1 from dials/switch positions respectively.
- And, calculate L_x and R_x using the following given formula

$$\mathbf{Lx=C_1R_2R_3}$$

And $$\mathbf{Rx=R_2R_3/R_1}$$

- Repeat the above procedure for different valid inductor values.
- Measure the unknown inductance on LCR meter available in the laboratory compare the LCR meter reading with calculated values.
- Do some more experiments using different values of unknown inductances.

6. MEASUREMENTS:

Sr. No.	Unknown LCR meter measured component value (L_x)	C_1	R_2	R_3	R_1	Calculated $Lx=R_2R_3C_1$	%error
1.							
2.							
3.							

7. RESULT:-

Unknown inductance measured using Maxwell's bridge is found to be L_x=____.

8. CONCLUSION:

Value of unknown inductance found and calculated from bridge readings are near to the readings on digital LCR meter.

EXPERIMENT NO. 6

Determination of the Current Ratio and Phase Angle of the given current transformer using direct deflection method.

CONTENTS:

1. Objective:

- To determine the Current Ratio of current transformer.
- To determine the Phase angle of current transformer.

2. Expected Outcome Of experiment:

- Understanding of Direct Deflection Method and its uses.
- Ability to calculate current ratio of current transformer.
- Ability to calculate Phase angle of current transformer.

3. Theory:

Testing of Instrument Transformers

Methods for finding ratio and phase angle errors experimentally are broadly classified into two groups:

1) Absolute method:

In these methods the transformer errors are determined in terms of constants i.e., resistance, inductance and capacitance of the testing circuit.

2. Comparison method:

In these methods, the errors of the transformer under test are compared with those of a standard current transformer whose errors are known. Each of the two methods can be classified, according to measurement technique employed as

(a) Deflection Method:

These methods use the deflections of suitable instruments for measuring quantities related to the phasors under consideration or to their deflection. The required ratio and phase angles are then found out from the magnitudes of deflection. These methods may be made direct reading in some cases.

(b) Null Methods:

These methods make use of a network in which the appropriate phasor quantities are balanced against one another. The ratio and phase angle errors are then found out from the impedance elements of the network. The method may be made direct reading in terms of calibrated scales on the adjustable elements in the network.

Testing of Current Transformer:

There are three different methods.

1. Mutual Inductance method: This is an absolute method using null deflection.
2. Silsbee's Method: This is a comparison method. There are two types; deflection and null.
3. Arnold's Method: This is a comparison method involving null techniques.

Silsbee's Method:

The arrangement for Silsbee's deflection method is shown in Fig.1. Here the ratio and phase angle of the test transformer 'X' are determined in terms of that of a standard transformer 'S' having the same nominal ratio.

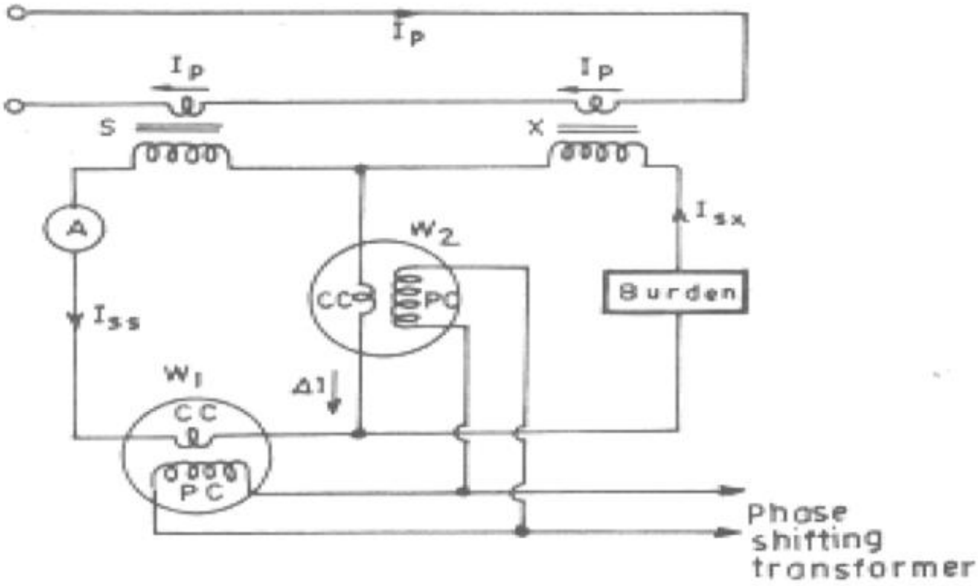


Fig 6(a): Silsbee's deflection method

The two transformers are connected with their primaries in series. An adjustable burden is put in the secondary circuit of the transformer under test. An ammeter is included in the secondary circuit of the standard transformer so that the current may be set to desired value. W1 is a wattmeter whose current coil is connected to carry the secondary current of the standard transformer. The current coil of wattmeter W2 carries a current I which is the difference between the secondary currents of the standard and test transformer. The voltage circuits of watt meters are supplied in parallel from a phase shifting transformer at a constant voltage V.

4. Equipment required:

S.NO.	NAME	RANGE	QTY.	Remarks (A.C./D.C.)
1.	Current Transformer	1:4	1	A.C.
2.	Phase Shifter		1	A.C.
3.	Rheostat	50Ω,5A	2	---
4.	Ammeter	0-5A	2	A.C.
5.	Voltmeter	0-300V	1	A.C.
6.	Wattmeter	300V,5A ,UPF	2	A.C.

5. Methodology for Experiment:

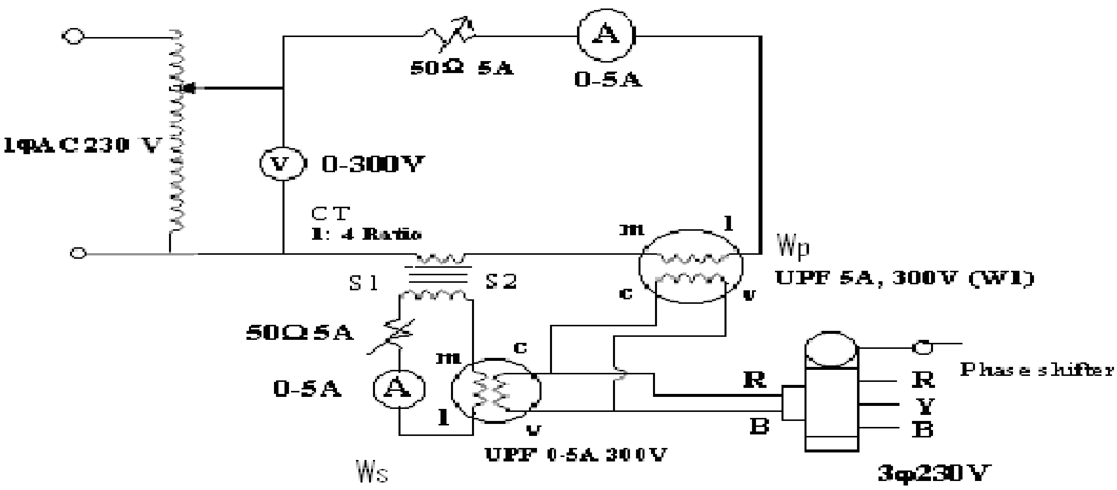


Fig 6(b): Silsbee's deflection method

1) Make the connections as shown in the diagram.

2) The phase of supply voltage is changed until the wattmeter in the primary (Wp1) reads zero. Corresponding secondary wattmeter reading is Ws1.

3) Phase is again changed so that the primary wattmeter reading is maximum (Wp2) and corresponding secondary reading is Ws2.

6. Results and Discussion:

Current ratio:

$$\frac{W_{p2}}{\sqrt{(W2_{s1}+W2_{s2})}} = \frac{W_{p2}}{W_{s2}}$$

Phase Angle:

$$\frac{W_{s1}}{W_{s2}} =$$

7. Conclusion:

Current ratio and phase angle of current transformer have been calculated.

Experiment- 8

Determination of the unknown capacitance using schering bridge.

Contents:-

1 Objective:

To determine the unknown value of capacitance using schering's bridge.

2 Expected Outcome of experiment:

- Understanding of **Schering Bridge** and its uses.
- Able to measure unknown capacitance of a capacitor.

3 Theory:

This bridge is used to measure to the capacitance of the capacitor, dissipation factor and measurement of relative permittivity. Let us consider the circuit of **Schering bridge** as shown below:

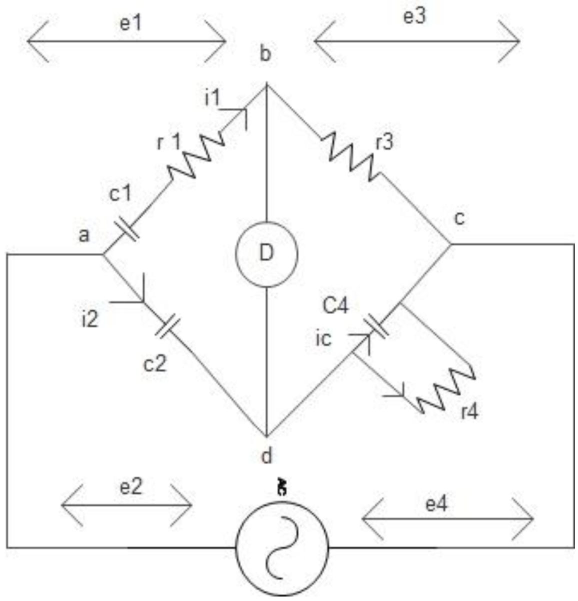


Fig 8(a): Schering bridge

Here, c_1 is the unknown capacitance whose value is to be determined with series electrical resistance r_1.

c_2 is a standard capacitor.

c_4 is a variable capacitor.

r_3 is a pure resistor (i.e. non inductive in nature).

And r_4 is a variable non inductive resistor connected in parallel with variable capacitor c_4. Now the supply is given to the bridge between the points a and c. The detector is connected between b and d. From the theory of ac bridges we have at balance condition,

$$l_1 \frac{1}{N^2 A}$$

Substituting the values of z_1, z_2, z_3 and z_4 in the above equation, we get

$$(r_1 + \frac{1}{j\omega c_1})r_4 = \frac{r_3}{j\omega c_2}(1 + j\omega c_4 r_4)$$

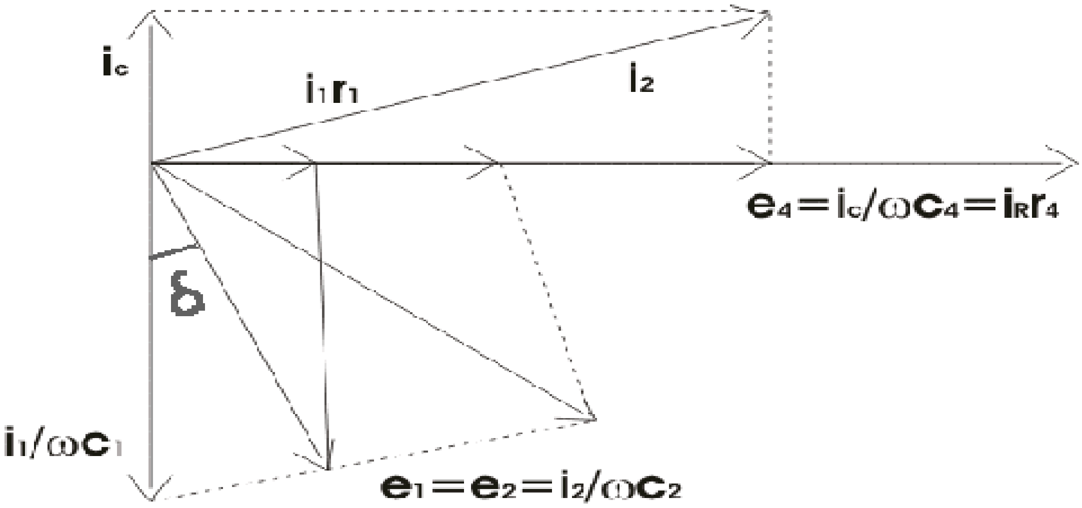
$$r_1 r_4 - \frac{jr_4}{\omega c_1} = -\frac{jr_3}{\omega c_2} + \frac{r_3 r_4 c_4}{c_2}$$

$$\left(r_1 + \frac{1}{j\omega c_1}\right)\left(\frac{r_4}{1 + j\omega c_4 r_4}\right) = \frac{r_3}{j\omega c_2}$$

$$r_1 = \frac{r_3 c_4}{c_2}$$

$$c_1 = c_2 \frac{r_4}{r_3}$$

Equating the real and imaginary parts and the separating we get



Let us consider the phasor diagram of the above Shering bridge circuit and mark the voltage drops across ab,bc,cd and ad as e_1, e_3,e_4 and e_2 respectively. From the above Schering bridge phasor diagram, we can calculate the value of tanδ which is also called the dissipation factor.

$$tan\delta = \omega c_1 r_1 = \omega \frac{c_2 r_4}{r3} \times \frac{r_3 c_4}{c_2} = \omega c_4 r_4$$

The equation that we have derived above is quite simple and the dissipation factor can be calculated easily.

4 Equipment required:

Sr. No.	Items	Quantity
1	Function generator	1
2	CRO (dual trace) with MONO-ADD-INVERT facility.	1
3	Earphone.	1
4	Strictly 100 mm patch cords.	1

5 Methodology for Experiment:

Construct Schering's bridge as shown in below figure,

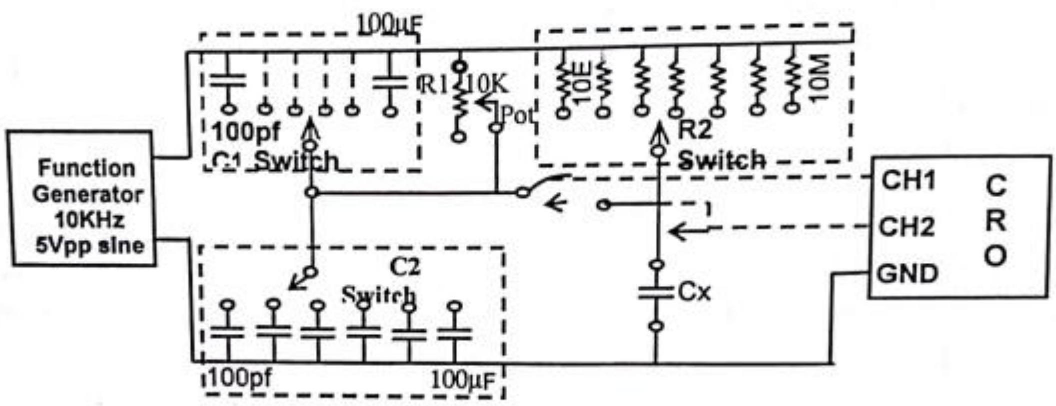


Fig 8(b): Schering bridge model

For balancing of this bridge follow the below procedures;

1. Do the connection as per the above wiring sequences and place an unknown capacitance 'Cx' on 50 & 51.
2. Connect FG output of 5Vpp & 1KHz sine wave to the bridge input as shown and use CRO in MONO-ADD-INVERT mode (Refer the CRO setting point in introduction unit) to measure difference of both CRO channels and set amplitude knobs of both channels to 0.1V/cm.
3. Here in Schering' bridge; R1 POT is used as fine-adjust the output waveform to minimum or level after accurately adjustment of R2, C1, C2 selector switches.
4. The R2, C1, C2 switches are so adjusted to get minimum level of output signal to be measured on CRO (rotate these knobs again and again to get minimum level output

value on measurement). By the use of R1(fine adjustment pot),adjust the output signal to minimum level (output will vary from some minimum value to min then again to maximum by the variation of R1, so adjust it at minimum level measurement to balance the bridge).

5. Now, at bridge balance condition; note down the values of R1,R2,C1&C2 from dials/switch positions respectively.

   And, calculate C_x & R_x using the following given formula,

   $$C_x=R_1C_2/R_2$$

   $$\text{And, } R_x=R_2C_1/C_2.$$

   NOTE: The Di-electric loss can be calculated as,

   $$\delta = \tan^{-1} R_x \omega C_x.$$

6. Repeat the above procedure for different valid capacitor values.
7. Measure the unknown capacitance on LCR meter available in the laboratory. Compare the LCR meter reading with calculated values.

6 Measurement:

Sr.	**Unknown component value(C_x)**	**C_1**	**C_2**	**R_1**	**R_2**	**Calculated $C_x=(R_1/R_2)C_2$**	**% error**
1							
2							
3							

7. Results and discussion:

Based on the experiment, following results are obtained.

C=................µF

Standard value=................µF

8. Conclusion:

Value of unknown capacitance has been found.

EXPERIMENT No.10

Measurement of resistance of order of 5Ω.

Contents:-

1. Objective:

To measure the of resistance of order of 5Ω using following methods

1. Ammeter-voltmeter method.
2. Substitution method.
3. Carey- Foster Bridge.

2. Expected outcome of experiment:

- Understanding of Ammeter-voltmeter method and its uses.
- Understanding of Substitution method and its uses.
- Understanding of Carey- Foster Bridge and its uses.
- Ability to perform experiment for calculation of Resistance of order 'R' by all the above methods.

3. Theory:

Ammeter Voltmeter method- The magnitude of resistance can be measured by different methods. One method is to measure the voltage drop V across a resistance n a circuit with a volt meter and the current I through the resistance with an ammeter. Then using Ohm's Law, R = V/I. ... Two circuits will be used to measure the resistance using this method.

Substitution method-R is the unknown resistance to be measured, S is the standard variable resistance, 'r' is the regulating resistance and 'A' is an ammeter. There is a switch for putting S and R in a circuit.

Carey- Foster Bridge- The Carey Foster's bridge is an electrical circuit that can be used to measure very small resistances. It works on the same principle as Wheatstone's bridge, which consists of four resistances, P, Q, R and S. In this circuit, G is a galvanometer, E is a lead accumulator, and K1 and K are the galvanometer key and the battery key respectively. If the values of the resistances are adjusted so that no current flows through the galvanometer, then if any three of the resistances P, Q, R and S are known, the fourth unknown resistance can be determined by using the relationship P R Q S =

$$P/Q = R/S$$

4. Equipment required:

Sr. No.	Items	Ranges	Quantity
1	D.C. Supply	(0-30 V)	**1**

2	Fixed Standard Resistance		**4**
3	Decade resistance box		**1**
4	Ammeter	(0- 1 A) D.C.	**1**
5	Voltmeter	(0- 10 V) D.C.	**1**
6	Galvanometer	(0- 30 –0)	**1**

5. Methodology of experiment:

(a) AMMETER VOLTMETER METHOD:

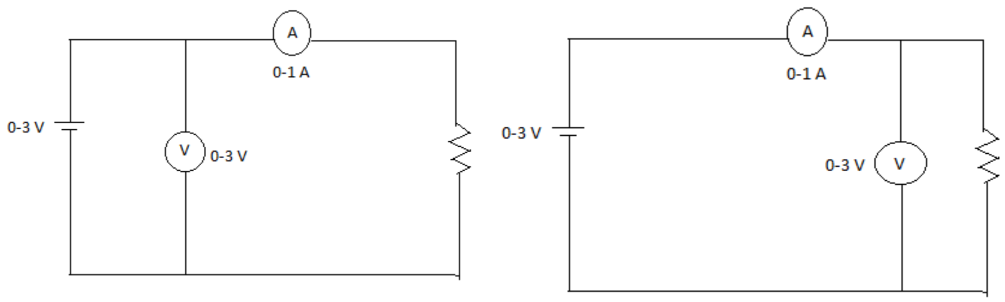


Fig 10(a): Ammeter Voltmeter method circuits

Two types of connections are possible Connect the circuit for both the circuit diagram one by one. Find the resistance by ohm's law i.e. R = V / I .

(b) SUBSTITUTION METHOD:

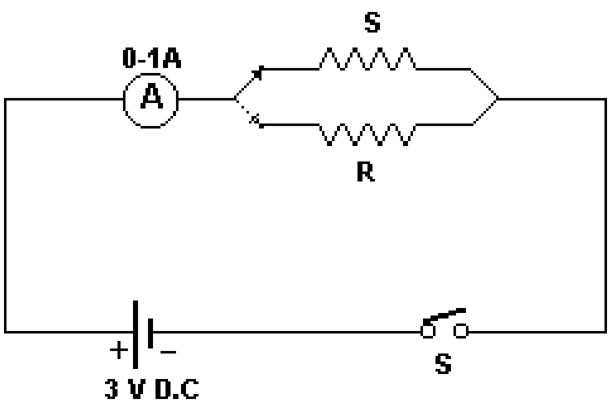


Fig. 10(b) Substitution method

1. First connect the unknown resistance in the circuit and observe the ammeter reading corresponding to that.
2. Then connect the standard resistance and adjust it to get the same ammeter reading.
3. In the connection for same current the unknown resistance R = Standard resistance S.

(c) CAREY FOSTER BRIDGE:-

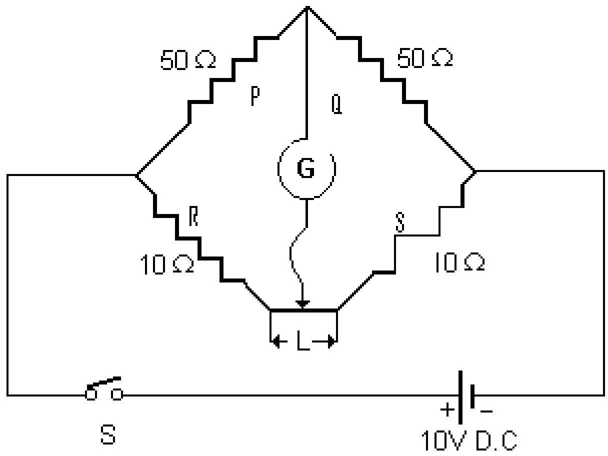


Fig. 10(c) Carey foster bridge

1. Make the circuit as shown.
2. Adjust P/Q = R/S
3. Find the balance point on the slide wire for null deflection. Measure the length L1.
4. Then interchange R and S and repeat step 3 to get length L2.

6. Measurements:

(a) AMMETER – VOLTMETER METHOD:

Sr. No.	V(Volts)	I (Amp.)	R=V/I

(b) Substitution method: R = S

(c) Carey foster bridge:

First length L1 = __________cm.

Second length L2 = __________cm.

R = S - (L1 –L2) r

Where r is the resistance of slide wire per unit length

7. Results and discussion:

The value of resistance by three methods =

8. Conclusion:

Values of resistance by three methods are found.